SARAC II

CEA
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Quality Criteria for the Safety Assessment of Cars Based on Real-World Crashes

Analysis of Pedestrian Crash Data from Great Britain, Germany and France

Report of Sub-Task 3.4

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Analysis of Pedestrian Crash Data from Great Britain, Germany and France

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Analysis of pedestrian crash data from Great Britain, Germany and France

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Abstract

The analysis conducted in this sub-task explores the feasibility of assessing pedestrian injury outcomes as a function of the colliding vehicle model using real crash data sources from Great Britain, France and Germany. In addition, the analysis considers the relationship between the estimated real crash pedestrian safety ratings and EuroNCAP pedestrian star ratings. It is concluded that there is no evidence of a relationship between the relevant EuroNCAP pedestrian star ratings and the pedestrian injury severity estimates generated from real world crash data from the three countries. Potential factors that may contribute to the lack of relationship between the two measures of injury outcome are explored.

The second component of the study is a descriptive analysis of pedestrian crash data from Great Britain, France and Germany. The analysis examines the distribution of crashes across vehicle models by road and demographic characteristics that influence pedestrian injury outcome. The results demonstrate that there is evidence of variation in these non-vehicle factors across vehicle models

Keywords

PEDESTRIAN, NEW CAR ASSESSMENT PROGRAM (NCAP), REAL-WORLD DATA, INJURY SEVERITY, CORRELATION

The views expressed are those of the authors and do not necessarily represent those of CEA or any of the participants of the SARAC committee.

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EXECUTIVE SUMMARY

SARAC II sub-tasks 2.1 and 2.2 produced individual estimates of vehicle crashworthiness for all crash types, front impact crashes and side impact crashes. The analysis reported here explores the feasibility of assessing pedestrian injury outcomes as a function of the colliding vehicle model using real crash data sources from Great Britain, France and Germany. The second component of this study is a descriptive analysis of pedestrian crash data from Great Britain, France and Germany. The analysis examines the distribution of crashes across vehicle models by road and demographic characteristics that influence pedestrian injury outcome. Additional factors that were not found to influence injury outcome in the logistic regression analysis are also presented.

Police reported pedestrian crash data from Great Britain for the period 1993 to 2001, from France for the period 1999 to 2001 and from Germany for the period 1998 to 2002 is used as the basis of this analysis. Adopting the criteria of at least 80 pedestrian injuries for each EuroNCAP tested vehicle model 42, 16 and 24 vehicle models from the British, French and German data respectively had sufficient data to be included in the analysis.

Just as vehicle crashworthiness ratings were calculated for occupants of EuroNCAP vehicles involved in real crashes in sub-tasks 2.1 and 2.2, the same methods can be used to rate the injury likelihood to pedestrians as a function of the colliding vehicle model. The measure of pedestrian injury outcome used here is that developed by Cameron et al (1998) which they termed a measure of vehicle aggressivity towards unprotected road users. However, in this study the measure is applied to pedestrians only. As all or nearly all unprotected road users involved in Police reported crashes are injured to some degree Cameron et al (1998) defined their measure of aggressivity towards unprotected road users as the risk of death or serious injury given some level of injury is sustained. In the same way as for vehicle injury severity, pedestrian injury severity is estimated via logistic regression techniques where the pedestrian injury status (death or serious injury/other injury) is the dependent variable and is modelled as a function of the colliding vehicle make and model. In order to obtain estimates of pedestrian injury severity unbiased by factors other than vehicle make and model, a number of crash and pedestrian characteristics thought to influence pedestrian injury severity were included in the logistic regression model.

In assessing the relationship between the real crash pedestrian safety ratings and the EuroNCAP pedestrian star ratings the method adopted in sub-tasks 2.1 and 2.2 for all crash types, front impact crashes and side impact crashes has been used. This method is

described in detail in Section 4.4 of the SR-248. The pedestrian test protocol is described in detail in EuroNCAP(2002) and the relevant EuroNCAP tested star ratings were taken from the EuroNCAP website (www.euroncap.com). All vehicle models included in the analysis were tested prior to 31 December 2001 so the star ratings obtained for each vehicle model are comparable. However, it is noted that changes in the testing procedure were experienced at Phase 3. From this time, changes to the assessment criteria occurred and manufacturers were also allowed to select some of the vehicle test sites themselves. In addition, the analysis reported here considers one and two star pedestrian rated vehicles only as no three star pedestrian rated vehicles were available for analysis at the commencement of this study.

Vehicle injury severity ratings for pedestrian crashes

Tables 1 to 3 below present the estimates of relative pedestrian injury severity for Great Britain, France and Germany respectively. The severity estimates are interpreted as the adjusted probability of pedestrian death or serious injury given some injury was sustained in a police reported crash.

Table 1. Injury severity estimates for EuroNCAP tested vehicles for pedestrian crashes only: Great Britain

Index	Make	Model	Severity	Lower 95% CI	Upper 95% CI	Width of CI
1	Fiat	Punto 55S	25.42	22.52	28.55	6.03
2	Ford	Fiesta 1.25 LX 16V	24.04	22.07	26.14	4.07
3	Nissan	Micra 1.0L	24.50	21.06	28.30	7.24
5	Rover	100	25.03	21.77	28.60	6.83
6	Vauxhall	Corsa 1.2LS	31.30	23.03	40.96	17.93
7	Volkswagen	Polo 1.4L	21.16	18.13	24.54	6.41
8	Audi	A4 1.8	26.14	19.16	34.59	15.43
9	BMW	316i	23.93	20.80	27.37	6.58
10	Citroen	Xantia 1.8i Dimension	26.25	22.39	30.52	8.13
11	Ford	Mondeo 1.8LX	26.58	23.89	29.47	5.58
12	Mercedes	C180 Classic	28.81	21.59	37.29	15.71
13	Nissan	Primera 1.6GX	16.48	11.89	22.39	10.50
14	Peugeot	406 1.8LX	21.06	17.69	24.87	7.17
15	Renault	Laguna 2.0RT	21.48	17.25	26.41	9.16
16	Rover	620 Si	22.92	18.78	27.66	8.88
18	Vauxhall	Vectra 1.8iLS	25.83	23.28	28.54	5.26
21	Citroen	Xsara 1.4i (LHD)	20.31	13.03	30.26	17.24
22	Daewoo	Lanos 1.4SE (LHD)	21.63	13.95	31.96	18.01
23	Fiat	Brava 1.4S	26.04	22.18	30.30	8.11
24	Honda	Civic 1.4i	23.33	20.09	26.91	6.82
25	Hyundai	Accent 1.3GLS (LHD)	26.16	18.52	35.58	17.06
27	Peugeot	306 1.6GLX	25.90	22.54	29.57	7.04
28	Renault	Megane 1.6RT (LHD)	23.84	19.92	28.26	8.34
30	Toyota	Corolla 1.3 Sportif (LHD)	22.42	16.63	29.51	12.88
37	Vauxhall	Omega 2.0Gl/GLS (LHD)	22.54	18.17	27.62	9.45
39	Ford	Focus 1.6 (LHD)	25.99	22.04	30.38	8.34
41	Vauxhall	Astra 1.6i Envoy	26.50	23.45	29.80	6.35
42	Ford	Escort 1.6 LX	24.65	22.96	26.44	3.48

43	Nissan	Almera 1.4GX	30.98	23.50	39.61	16.11
56	Vauxhall	Corsa 1.0 12v Club	24.96	21.11	29.26	8.15
63	Ford	Ka 1.3 (LHD)	26.53	22.35	31.18	8.83
64	Volvo	S40 1.8	24.73	17.54	33.66	16.12
65	Toyota	Avensis 1.6S	22.44	16.60	29.61	13.02
66	Citroen	Saxo 1.1 SX (LHD)	28.24	24.98	31.74	6.76
70	Ford	Fiesta 1.25 Zetec	25.78	20.59	31.75	11.17
72	Peugeot	206 1.3 XR Presence (LHD)	28.07	22.06	34.97	12.91
73	Renault	Clio 1.2 RTE (LHD)	21.68	16.27	28.28	12.01
84	BMW	316i (LHD)	23.64	16.88	32.05	15.17
89	Peugeot	406 (LHD)	21.16	14.85	29.24	14.39
93	Vauxhall/Opel	Vectra 1.8 (LHD)	21.39	16.68	27.00	10.33
94	Volkswagon	Passat 1.9 Tdi (LHD)	24.60	17.50	33.43	15.93
102	Renault	Scenic 1.4 (LHD)	25.38	17.67	35.03	17.35

Table 2. Injury severity estimates for EuroNCAP tested vehicles for pedestrian crashes only: France

Index	Make	Model	Severity	Lower 95% CI	Upper 95% CI	Width of CI
1	Fiat	Punto 55S	24.07%	18.79%	30.28%	11.49%
2	Ford	Fiesta 1.25 LX 16V	21.97%	16.59%	28.50%	11.91%
7	Volkswagen	Polo 1.4L	23.69%	16.46%	32.85%	16.40%
10	Citroen	Xantia 1.8i Dimension	26.08%	19.83%	33.49%	13.66%
14	Peugeot	406 1.8LX	21.38%	15.54%	28.67%	13.13%
15	Renault	Laguna 2.0RT	22.86%	15.78%	31.91%	16.13%
21	Citroen	Xsara 1.4i (LHD)	25.12%	17.61%	34.49%	16.88%
27	Peugeot	306 1.6GLX	30.71%	25.48%	36.49%	11.01%
28	Renault	Megane 1.6RT (LHD)	29.24%	20.53%	39.80%	19.27%
41	Vauxhall	Astra 1.6i Envoy	23.98%	15.90%	34.48%	18.58%
42	Ford	Escort 1.6 LX	22.64%	16.49%	30.24%	13.74%
44	Renault	Espace 2.0RTE (LHD)	25.57%	17.11%	36.38%	19.27%
56	Vauxhall	Corsa 1.0 12v Club	17.53%	10.78%	27.22%	16.44%
66	Citroen	Saxo 1.1 SX (LHD)	26.95%	21.38%	33.36%	11.98%
73	Renault	Clio 1.2 RTE (LHD)	22.81%	17.24%	29.53%	12.29%
89	Peugeot	406 (LHD)	24.86%	17.63%	33.83%	16.20%

Table 3. Injury severity estimates for EuroNCAP tested vehicles for pedestrian crashes only: Germany

Index	Make	Model	Severity	Lower 95% CI	Upper 95% CI	Width of CI
1	Fiat	Punto 55S	39.84%	33.90%	46.10%	12.20%
3	Nissan	Micra 1.0L	37.46%	31.00%	44.39%	13.40%
4	Renault	Clio 1.2RL	42.78%	32.41%	53.83%	21.42%
6	Vauxhall	Corsa 1.2LS	38.95%	34.46%	43.64%	9.18%
7	Volkswagen	Polo 1.4L	42.92%	36.66%	49.42%	12.76%
8	Audi	A4 1.8	34.24%	27.71%	41.44%	13.73%
9	BMW	316i	39.43%	29.57%	50.23%	20.66%
11	Ford	Mondeo 1.8LX	39.94%	30.32%	50.41%	20.08%
12	Mercedes	C180 Classic	35.75%	31.30%	40.46%	9.16%
18	Vauxhall	Vectra 1.8iLS	44.34%	37.10%	51.82%	14.71%

19	Volkswagen	Passat 1.6L (LHD)	35.33%	27.05%	44.60%	17.54%
20	Audi	A3 1.6	37.70%	29.06%	47.20%	18.13%
24	Honda	Civic 1.4i	42.11%	34.14%	50.51%	16.38%
28	Hyundai	Accent 1.3GLS (LHD)	44.35%	35.43%	53.64%	18.21%
31	Volkswagen	Golf 1.4 (LHD)	39.06%	32.95%	45.55%	12.60%
33	BMW	520i (LHD)	43.00%	33.50%	53.04%	19.53%
40	Mercedes	A140 Classic (LHD)	30.18%	21.18%	41.01%	19.83%
41	Vauxhall	Astra 1.6i Envoy	32.49%	27.68%	37.71%	10.03%
42	Ford	Escort 1.6 LX	46.63%	40.99%	52.37%	11.38%
43	Nissan	Almera 1.4GX	41.85%	32.22%	52.14%	19.91%
53	Volkswagen	Lupo 1.0 (LHD)	41.51%	31.54%	52.24%	20.70%
54	MCC	Smart (LHD)	40.63%	32.17%	49.68%	17.52%
56	Vauxhall	Corsa 1.0 12v Club	42.30%	36.49%	48.34%	11.85%
63	Ford	Ka 1.3 (LHD)	39.48%	33.09%	46.25%	13.15%

Although there was sufficient real world crash data to enable the estimation of pedestrian injury severity estimates, the width of the associated confidence intervals was large making it difficult to differentiate the pedestrian safety performance of individual vehicle models. This is primarily of function of the relatively small amounts of pedestrian crash data available for analysis.

The relationship between pedestrian injury outcomes in real crashes and EuroNCAP pedestrian protection ratings

The analysis that follows considers the relationship between pedestrian safety ratings based on real world crash data and thee EuroNCAP pedestrian star ratings available from the EuroNCAP website. The results of the graphical analysis are presented below in Figures 1 to 3.

Figure 1. Pedestrian EuroNCAP star rating vs Adjusted injury severity: Great Britain

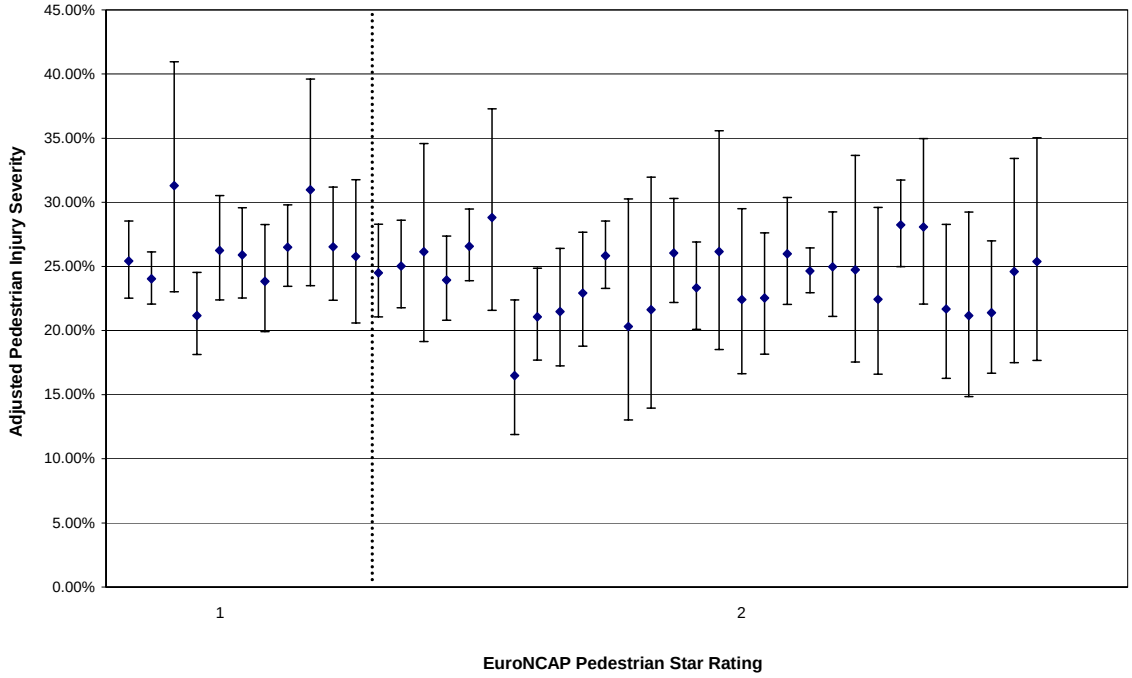


Figure 2. Pedestrian EuroNCAP star rating vs Adjusted injury severity: France

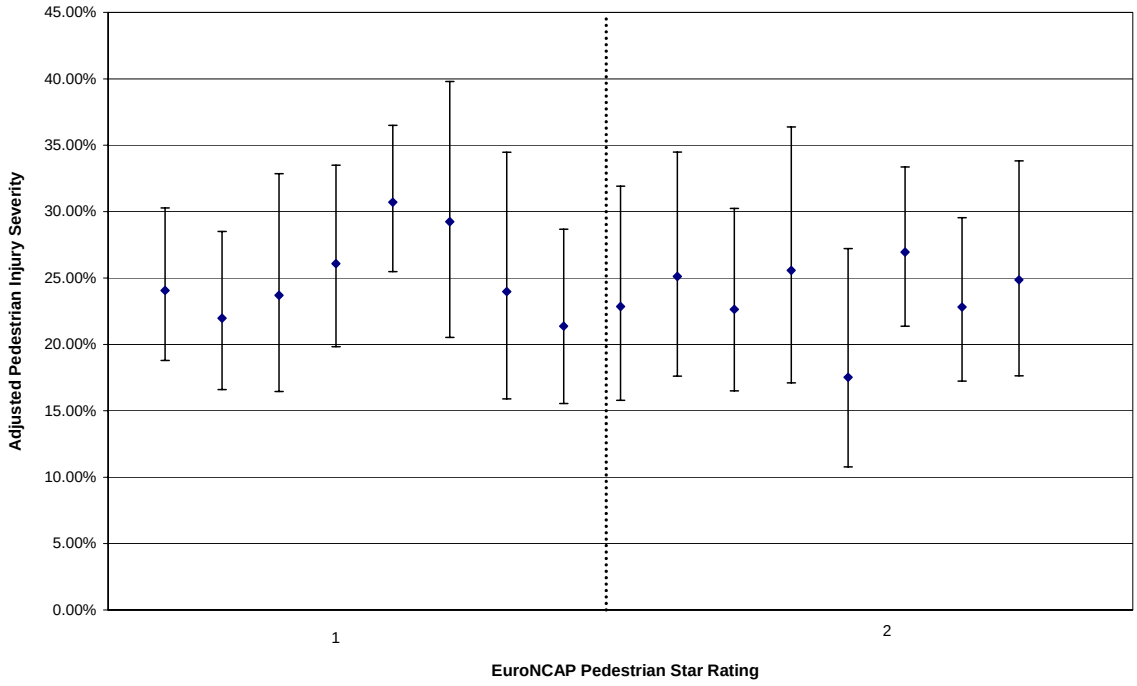
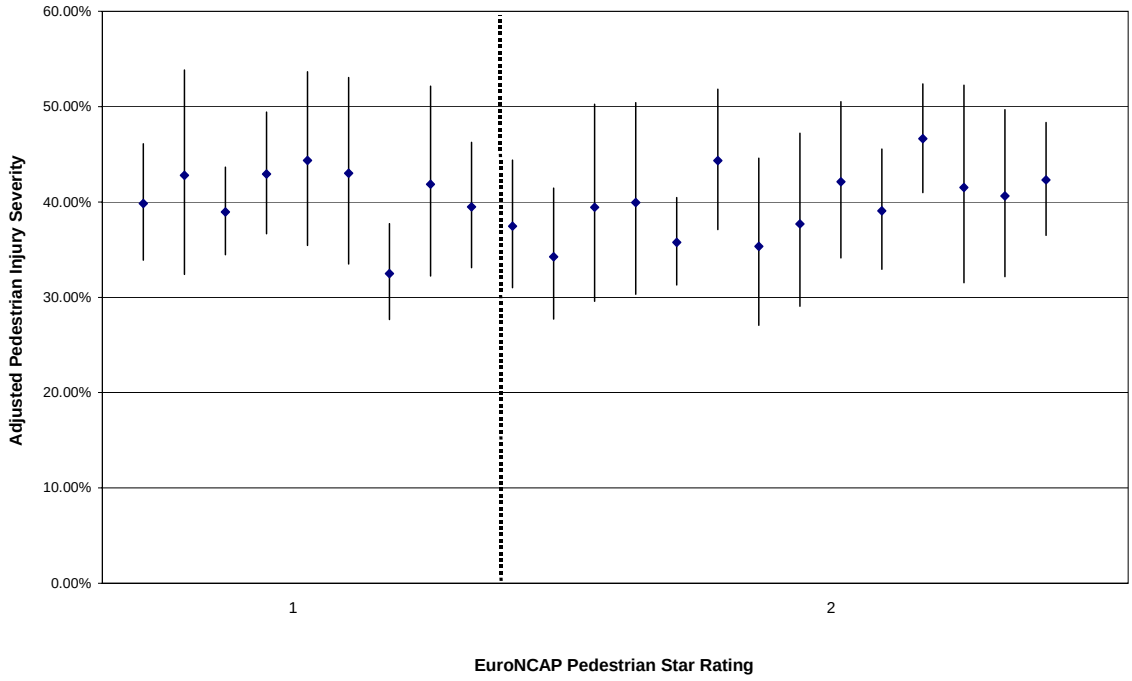


Figure 3. Pedestrian EuroNCAP star rating vs Adjusted injury severity: Germany



Each of the figures shows significant variation in the point estimates of pedestrian injury severity within each overall EuroNCAP star rating. Nevertheless, the overlapping confidence limits for one star and two star rated vehicles indicates that there is no evidence of a relationship between EuroNCAP pedestrian star ratings and the pedestrian injury severity estimates generated from real world crash data from any of the three countries. These results are confirmed by a formal logistic regression analysis of the relationship between the two measures of injury outcome.

There are a number of potential factors that may contribute to the lack of significant evidence of a trend to improving real world pedestrian injury outcome with increasing EuroNCAP pedestrian star ratings in the British, French and German data. It is possible that there is in fact no relationship between the two measures of pedestrian protection. At Phase 3 of EuroNCAP testing, vehicle manufacturers were allowed select some of the vehicle test sites themselves. This may have resulted in changes in test scores without any corresponding change in the level protection offered to pedestrians by the vehicle. A full description of changes to the EuroNCAP pedestrian test protocol and their effect on test scores can be found in Ponte et al. (2004).

A second possible reason for the lack of relationship between EuroNCAP star ratings and real world pedestrian safety ratings is the method of test site selection under EuroNCAP. The selection of test sites is not directly related to the relative frequency of real world crashes involving those sites. Therefore, the selection of a poor performing test site will be reflected

in the EuroNCAP pedestrian test score and star ratings regardless of the relative frequency of a pedestrian hitting that site. Similarly, the selection of a well performing test site will be reflected in the EuroNCAP pedestrian test score and star ratings regardless of the relative frequency of a pedestrian hitting that site. In contrast, real world pedestrian safety ratings implicitly account for the relative frequency of point of pedestrian impact. Given the difference in the relationship between pedestrian point of impact and measured outcome for EuroNCAP and real world safety ratings, it is perhaps unsurprising that no correlation between the two measures of pedestrian safety has been found.

Finally it is noted that the analysis reported here considers one and two star rating vehicles only as no three star rated vehicles were available for analysis at the commencement of this study.

Descriptive analysis

The final component of this study provides a descriptive analysis of the pedestrian data used to generate the estimates of pedestrian injury severity presented above. The analysis examines the distribution of non-vehicle factors across the EuroNCAP tested vehicles used in the preceding analysis.

Plotting the distribution of pedestrian injury severity across vehicle models using data from France, German and Great Britain reveals variation in unadjusted pedestrian injury severity by vehicle model across the three countries. Some of this variation may be explained in the following analysis of factors likely to influence pedestrian injury severity.

Crash characteristics

Crash impact severity is likely a significant influence on pedestrian injury outcome. However, as this variable is not directly available in any of the data sources alternative measures such as the speed zone or urbanisation of the crash location and an intersection indicator are used as proxies for impact severity. Analysis of the British data reveals that a higher proportion of fatalities and serious injuries occur in speed zones of 60 mph or above than in speed zones of less than 60 mph. In contrast, there is little apparent difference between the proportion of pedestrians killed or seriously injured in crashes with passenger vehicles at intersections compared with crashes not occurring at intersections.

Given these variations, it is interesting to also consider the distribution of these proxy measures by vehicle model. Significant variation in these measures by vehicle model would suggest that it is necessary to adjust for these factors in estimating pedestrian injury severity estimates such as those presented previously. The analysis of the French, German and British data shows that there is variation in the urbanisation and speed limit of the crash site

by vehicle model. Similarly, there is variation in the location of the crash site by vehicle model. The analysis by speed zone of the British pedestrian crash data provides additional information about the average distribution of pedestrian crashes by speed zone. It is evident that across all vehicle models, the vast majority of pedestrian crashes occur in 30mph speed zones. Across the other speed limit zones there is some variation by vehicle model.

When viewed in combination these results support the need to adjust for impact severity proxy factors when estimating pedestrian injury severity estimates. This is particularly so for the speed limit (or urbanisation) of the crash site where there is evidence of an influence of crash location on pedestrian injury outcome.

Pedestrian characteristics

In addition to crash site variables, the characteristics of the pedestrian may influence pedestrian injury outcome in a collision with a vehicle. Investigation of the influence of pedestrian characteristics on injury outcome reveals illustrates that the proportion of pedestrians killed or seriously injured in collisions with a passenger vehicle differs by the age of the pedestrian. It is evident that a higher proportion of elderly pedestrians suffer fatal or serious injuries compared to pedestrians aged under 65. In contrast, there is little apparent difference between the proportion of male and female pedestrians killed or seriously injured in crashes with passenger vehicles.

Given these variations, variation in pedestrian age and pedestrian sex by vehicle model are examined for France, Germany and Great Britain respectively. Significant variation in these measures by vehicle model would suggest that in estimating pedestrian injury severity estimates such as those presented previously, it is necessary to adjust for these factors. Analysis reveals that there is some variation in the proportion of male and female involvement in pedestrian crashes by vehicle model particularly in the French and German data. There is also variation in the proportion of male and female involvement in pedestrian crashes by vehicle model in the British data. However, for all vehicle models examined, the majority of the pedestrians hit in Police reported crashes are male.

The analysis of pedestrian age indicates that in France for each vehicle model the majority of pedestrians involved in Police reported crashes are aged between 0 and 15 years or aged over 60 years. In Germany, the highest proportion of crash involved pedestrians for each vehicle model are aged under 25 years. In Great Britain, those aged between 0 and 15 represent the highest proportion

Conclusion

Using the pedestrian data supplied to MUARC as part of the SARAC II study, it has been possible to investigate the nature of pedestrian crashes in Great Britain, Germany and France. Three key conclusions arise from this analysis.

First, sufficient data from these countries was made available to enable the estimation of pedestrian injury severity in collisions with passenger vehicles by vehicle model for each country adjusted for effects of non-vehicle factors on injury outcome. These estimates represent the risk of death or serious injury to a crash involved pedestrian given that some injury was sustained in a Police reported crash. However, although there was sufficient data to enable the estimation of these measures, the width of the associated confidence intervals was large. Therefore, it difficult to differentiate the pedestrian safety performance of individual vehicle models. The width of the confidence limits is primarily a function of the still relatively small amounts of pedestrian crash data available for analysis. More data would be required to increase the precision of the estimates.

Second, no clear evidence of a relationship between EuroNCAP pedestrian star rating and the pedestrian injury severity estimates generated from real world crash data from Great Britain, Germany and France was found. This indicates that the EuroNCAP pedestrian star rating is not significantly associated with pedestrian injury severity estimates based on real crash data. Further, given past estimates of the relationship between these two measures of pedestrian injury outcome, it is unlikely that the inclusion of additional data would alter this result.

Finally, the descriptive analysis reported highlights the influence of non-vehicle factors by pedestrian injury outcome and provides evidence of variation in these non-vehicle factors across vehicle models. This confirms that the adjustment of pedestrian injury severity ratings for such factors through the logistic regression technique is required. This adjustment ensures, as far as possible, that the pedestrian safety ratings estimated reflect the safety performance of the vehicle model colliding with the pedestrian and are not influenced by external, non-vehicle factors.

1 INTRODUCTION

SARAC II sub-tasks 2.1 and 2.2 produced individual estimates of vehicle crashworthiness for all crash types, front impact crashes and side impact crashes. The analysis reported here explores the feasibility of assessing pedestrian injury outcomes as a function of the colliding vehicle model using real crash data sources from Great Britain, France and Germany. Logistic regression techniques, similar to those used in sub-tasks 2.1 and 2.2, are used and adjustments made for a range of factors available in the data that influence pedestrian injury outcome. In addition, the potential to meaningfully compare these injury outcomes to the results of EuroNCAP pedestrian testing is examined.

The second component of this study is a descriptive analysis of pedestrian crash data from Great Britain, France and Germany. The analysis examines the distribution of crashes across vehicle models by road and demographic characteristics that influence pedestrian injury outcome. Additional factors that were not found to influence injury outcome in the logistic regression analysis are also presented.

2 DATA SOURCES

Police reported pedestrian crash data from Great Britain for the period 1993 to 2001, from France for the period 1999 to 2001 and from Germany for the period 1998 to 2002 is used as the basis of this analysis. A description of each of the data sets follows and a full descriptive analysis of the data is presented in Section 6.

2.1 British Data

In Britain, data for crashes involving pedestrians were identified using the *casclass* variable for the period 1993 to 2001. In total, 331,454 cases were coded as *pedestrian*. Of these, 323,216 contained complete information on pedestrian age and sex, speed limit and junction type. All the pedestrians recorded in the crash data were injured to some degree. Adopting the criteria of at least 80 pedestrian injuries for each EuroNCAP tested vehicle model, the minimum number for which it was considered a reliable analysis could be conducted, 42 vehicle models had sufficient data to be included in the analysis. Table 1 below summarises the number of pedestrian injuries in the British data by severity level for each of the 42 EuroNCAP vehicle models considered.

Table 1. Number of pedestrians involved in crashes with EuroNCAP tested vehicles in the British data.

Index	Make	Model	Minor Injury	Fatal/Serious Injury	Total Injured
1	Fiat	Punto 55S	680	216	896
2	Ford	Fiesta 1.25 LX 16V	1654	481	2135
3	Nissan	Micra 1.0L	453	136	589
5	Rover	100	518	160	678
6	Vauxhall	Corsa 1.2LS	72	31	103
7	Volkswagen	Polo 1.4L	543	136	679
8	Audi	A4 1.8	94	33	127
9	BMW	316i	542	161	703
10	Citroen	Xantia 1.8i Dimension	350	123	473
11	Ford	Mondeo 1.8LX	825	279	1104
12	Mercedes	C180 Classic	94	36	130
13	Nissan	Primera 1.6GX	175	31	206
14	Peugeot	406 1.8LX	422	107	529
15	Renault	Laguna 2.0RT	256	67	323
16	Rover	620 Si	287	79	366
18	Vauxhall	Vectra 1.8iLS	928	301	1229
21	Citroen	Xsara 1.4i (LHD)	66	17	83
22	Daewoo	Lanos 1.4SE (LHD)	65	17	82
23	Fiat	Brava 1.4S	359	120	479
24	Honda	Civic 1.4i	503	142	645
25	Hyundai	Accent 1.3GLS (LHD)	83	25	108
27	Peugeot	306 1.6GLX	483	161	644
28	Renault	Megane 1.6RT (LHD)	339	95	434
30	Toyota	Corolla 1.3 Sportif (LHD)	136	35	171
37	Vauxhall	Omega 2.0Gl/GLS (LHD)	241	68	309
39	Ford	Focus 1.6 (LHD)	352	111	463
41	Vauxhall	Astra 1.6i Envoy	637	204	841
42	Ford	Escort 1.6 LX	2449	763	3212
43	Nissan	Almera 1.4GX	90	38	128
56	Vauxhall	Corsa 1.0 12v Club	365	109	474
63	Ford	Ka 1.3 (LHD)	308	103	411
64	Volvo	S40 1.8	84	27	111
65	Toyota	Avensis 1.6S	135	34	169
66	Citroen	Saxo 1.1 SX (LHD)	564	201	765
70	Ford	Fiesta 1.25 Zetec	193	59	252
72	Peugeot	206 1.3 XR Presence (LHD)	144	51	195
73	Renault	Clio 1.2 RTE (LHD)	157	38	195
84	BMW	316i (LHD)	96	28	124
89	Peugeot	406 (LHD)	101	26	127
93	Vauxhall/Opel	Vectra 1.8 (LHD)	204	51	255
94	Volkswagon	Passat 1.9 Tdi (LHD)	90	27	117
102	Renault	Scenic 1.4 (LHD)	81	23	104

2.2 French Data

Data for crashes involving pedestrians in the French data are only available for the data supplied specifically for SARAC II covering the period 1999-2001 which significantly limited the number of available crashes for analysis. Within this period there were 41,578 pedestrians involved in crashes.

After removing those cases in which the age and sex of the pedestrian, the point of impact on the target vehicle, the location of the crash site (i.e. whether or not it occurred at an intersection and the type of intersection at which it occurred) or the level of urbanisation of the crash site was not complete, 38,797 pedestrians remained. Of these 3,683 were involved in crashes with EuroNCAP tested vehicles. Adopting the criteria of at least 80 pedestrian injuries for each EuroNCAP tested vehicle model, 16 vehicle models had sufficient data to be included in the analysis. Table 2 summarises the number of pedestrian injuries in the French data by severity level for each of the 16 vehicle models considered.

Table 2. Number of pedestrians involved in crashes with EuroNCAP tested vehicles in the French data.

Index	Make	Model	Minor Injury	Fatal/Serious Injury	Total Injured
1	Fiat	Punto 55S	188	53	241
2	Ford	Fiesta 1.25 LX 16V	152	42	194
7	Volkswagen	Polo 1.4L	89	23	112
10	Citroen	Xantia 1.8i Dimension	127	42	169
14	Peugeot	406 1.8LX	127	32	159
15	Renault	Laguna 2.0RT	79	25	104
21	Citroen	Xsara 1.4i (LHD)	82	25	107
27	Peugeot	306 1.6GLX	214	95	309
28	Renault	Megane 1.6RT (LHD)	63	24	87
41	Vauxhall	Astra 1.6i Envoy	67	19	86
42	Ford	Escort 1.6 LX	119	33	152
44	Renault	Espace 2.0RTE (LHD)	61	20	81
56	Vauxhall	Corsa 1.0 12v Club	72	14	86
66	Citroen	Saxo 1.1 SX (LHD)	177	61	238
73	Renault	Clio 1.2 RTE (LHD)	158	42	200
89	Peugeot	406 (LHD)	89	27	116

2.3 German Data

Data for crashes involving pedestrians in the German data are available for the period 1998 to 2002. Within this period, there were 53,265 pedestrians involved in collisions between pedestrians and single vehicles of which 53,052 could be matched with the vehicle involved. After removing those cases for which the age and sex of the pedestrian, the urbanisation indicator and the crash costs were not complete, 38,994 pedestrians remained. Of these 2,963 were involved in crashes with a EuroNCAP tested vehicles. Adopting the criteria of at

least 80 pedestrian injuries for each EuroNCAP tested vehicle model, 24 vehicle models had sufficient data to be included in the analysis.

Table 3 summarises the number of pedestrian injuries in the German data by severity level for each of the 24 vehicle models considered.

Table 3. Number of pedestrians involved in crashes with EuroNCAP tested vehicles in the German data.

Index	Make	Model	Minor Injury	Fatal/Serious Injury	Total Injured
1	Fiat	Punto 55S	86	58	144
3	Nissan	Micra 1.0L	65	53	118
4	Renault	Clio 1.2RL	156	96	252
6	Vauxhall	Corsa 1.2LS	57	42	99
7	Volkswagen	Polo 1.4L	59	25	84
8	Audi	A4 1.8	255	117	372
9	BMW	316i	175	144	319
11	Ford	Mondeo 1.8LX	55	41	96
12	Mercedes	C180 Classic	52	37	89
18	Vauxhall	Vectra 1.8iLS	79	47	126
19	Volkswagen	Passat 1.6L (LHD)	173	117	290
20	Audi	A3 1.6	140	88	228
24	Honda	Civic 1.4i	86	58	144
28	Hyundai	Accent 1.3GLS (LHD)	65	53	118
31	Volkswagen	Golf 1.4 (LHD)	156	96	252
33	BMW	520i (LHD)	57	42	99
40	Mercedes	A140 Classic (LHD)	59	25	84
41	Vauxhall	Astra 1.6i Envoy	255	117	372
42	Ford	Escort 1.6 LX	175	144	319
43	Nissan	Almera 1.4GX	55	41	96
53	Volkswagen	Lupo 1.0 (LHD)	52	37	89
54	MCC	Smart (LHD)	79	47	126
56	Vauxhall	Corsa 1.0 12v Club	173	117	290
63	Ford	Ka 1.3 (LHD)	140	88	228

3 METHOD

Just as vehicle crashworthiness ratings were calculated for occupants of EuroNCAP vehicles involved in real crashes in sub-tasks 2.1 and 2.2, the same methods can be used to rate the injury likelihood to pedestrians as a function of the colliding vehicle model. The measure of pedestrian injury outcome used here is that developed by Cameron et al (1998) which they termed a measure of vehicle aggressivity towards unprotected road users. Although the measure of Cameron et al (1998) was applied to all unprotected road users, including motorcyclists and bicyclists in addition to pedestrians, the measure can be equally applied to pedestrians alone. This approach has been adopted here.

All or nearly all pedestrians involved in Police reported crashes in France, Great Britain and Germany are injured to some degree so it is not possible to measure pedestrian injury risk from such data. In response to this, Cameron et al (1998) defined their measure of aggressivity towards unprotected road users as the risk of death or serious injury given some level of injury is sustained. This measure is analogous to the injury severity component of the crashworthiness measure estimated in SR-248 for vehicle occupants. In the same way as for vehicle injury severity, pedestrian injury severity is estimated via logistic regression techniques where the pedestrian injury status (death or serious injury/other injury) is the dependent variable and is modelled as a function of the colliding vehicle make and model.

Use of logistic regression techniques also allows the effects of non-vehicle factors, such as pedestrian demographics and crash circumstances, to be controlled for in the analysis. The non-vehicle factors entered into the logistic regression models are the same as those used in sub-tasks 2.1 and 2.1 and detailed in Section 3 of the associated report (SR-248). The exception to this is the replacement of the driver age and driver sex variables with pedestrian age and pedestrian sex variables. Table 4 identifies the non-vehicle factors and interactions between them that were found to be statistically significantly related to pedestrian injury outcome in the logistic models.

Table 4. Significant factors in the logistic regression models of pedestrian injury severity derived using data from Britain, France and Germany.

	Britain	France	Germany
Main Effects	Pedestrian age (pdage) Pedestrian sex (pdsex) Junction type (jun) Speed limit (sl)	Pedestrian age Pedestrian sex Intersection Urbanisation (urb) Year of crash	Pedestrian age Crash cost Crash location (loc) Year of crash Intersection (int)
First Order Interactions	pdage x pdsex pdage x sl pdage x jun jun x sl pdsex x jun	pdage x pdsex pdage x urb	

In assessing the relationship between the real crash pedestrian safety ratings and the EuroNCAP pedestrian star ratings the method adopted in sub-tasks 2.1 and 2.2 for all crash types, front impact crashes and side impact crashes has been used. This method is described in detail in Section 4.4 of the SR-248. The pedestrian test protocol is described in detail in EuroNCAP(2002) and the relevant EuroNCAP tested star ratings were taken from the EuroNCAP website (www.euroncap.com). All vehicle models included in the analysis were tested prior to 31 December 2001 so the star ratings obtained for each vehicle model

are comparable. However, it is noted that changes in the testing procedure were experienced at Phase 3. From this time, changes to the assessment criteria occurred and manufacturers were also allowed to select some of the vehicle test sites themselves. In addition, the analysis reported here considers one and two star rating vehicles only as no three star rated vehicles were available for analysis at the commencement of this study.

4 VEHICLE INJURY SEVERITY RATINGS FOR PEDESTRIAN CRASHES

4.1 British Data

Each of the significant covariates and their interactions identified in Table 4 were included in a logistic model along with the vehicle model colliding with the pedestrian to produce the adjusted pedestrian injury severity ratings for Great Britain provided in Table 5. For each vehicle model the severity estimate gives the adjusted probability of pedestrian death or serious injury given some injury was sustained in a Police reported pedestrian crash in Great Britain. The 95% confidence limits and confidence limit width are given for each estimate.

Table 5. Injury severity estimates for EuroNCAP tested vehicles for pedestrian crashes only.

Index	Make	Model	Severity	Lower 95% CI	Upper 95% CI	Width of CI
1	Fiat	Punto 55S	25.42	22.52	28.55	6.03
2	Ford	Fiesta 1.25 LX 16V	24.04	22.07	26.14	4.07
3	Nissan	Micra 1.0L	24.50	21.06	28.30	7.24
5	Rover	100	25.03	21.77	28.60	6.83
6	Vauxhall	Corsa 1.2LS	31.30	23.03	40.96	17.93
7	Volkswagen	Polo 1.4L	21.16	18.13	24.54	6.41
8	Audi	A4 1.8	26.14	19.16	34.59	15.43
9	BMW	316i	23.93	20.80	27.37	6.58
10	Citroen	Xantia 1.8i Dimension	26.25	22.39	30.52	8.13
11	Ford	Mondeo 1.8LX	26.58	23.89	29.47	5.58
12	Mercedes	C180 Classic	28.81	21.59	37.29	15.71
13	Nissan	Primera 1.6GX	16.48	11.89	22.39	10.50
14	Peugeot	406 1.8LX	21.06	17.69	24.87	7.17
15	Renault	Laguna 2.0RT	21.48	17.25	26.41	9.16
16	Rover	620 Si	22.92	18.78	27.66	8.88
18	Vauxhall	Vectra 1.8iLS	25.83	23.28	28.54	5.26
21	Citroen	Xsara 1.4i (LHD)	20.31	13.03	30.26	17.24
22	Daewoo	Lanos 1.4SE (LHD)	21.63	13.95	31.96	18.01
23	Fiat	Brava 1.4S	26.04	22.18	30.30	8.11
24	Honda	Civic 1.4i	23.33	20.09	26.91	6.82
25	Hyundai	Accent 1.3GLS (LHD)	26.16	18.52	35.58	17.06
27	Peugeot	306 1.6GLX	25.90	22.54	29.57	7.04
28	Renault	Megane 1.6RT (LHD)	23.84	19.92	28.26	8.34
30	Toyota	Corolla 1.3 Sportif (LHD)	22.42	16.63	29.51	12.88
37	Vauxhall	Omega 2.0Gl/GLS (LHD)	22.54	18.17	27.62	9.45
39	Ford	Focus 1.6 (LHD)	25.99	22.04	30.38	8.34

41	Vauxhall	Astra 1.6i Envoy	26.50	23.45	29.80	6.35
42	Ford	Escort 1.6 LX	24.65	22.96	26.44	3.48
43	Nissan	Almera 1.4GX	30.98	23.50	39.61	16.11
56	Vauxhall	Corsa 1.0 12v Club	24.96	21.11	29.26	8.15
63	Ford	Ka 1.3 (LHD)	26.53	22.35	31.18	8.83
64	Volvo	S40 1.8	24.73	17.54	33.66	16.12
65	Toyota	Avensis 1.6S	22.44	16.60	29.61	13.02
66	Citroen	Saxo 1.1 SX (LHD)	28.24	24.98	31.74	6.76
70	Ford	Fiesta 1.25 Zetec	25.78	20.59	31.75	11.17
72	Peugeot	206 1.3 XR Presence (LHD)	28.07	22.06	34.97	12.91
73	Renault	Clio 1.2 RTE (LHD)	21.68	16.27	28.28	12.01
84	BMW	316i (LHD)	23.64	16.88	32.05	15.17
89	Peugeot	406 (LHD)	21.16	14.85	29.24	14.39
93	Vauxhall/Opel	Vectra 1.8 (LHD)	21.39	16.68	27.00	10.33
94	Volkswagon	Passat 1.9 Tdi (LHD)	24.60	17.50	33.43	15.93
102	Renault	Scenic 1.4 (LHD)	25.38	17.67	35.03	17.35

4.2 French Data

Logistic regression analysis, including adjustment for each of the significant non-vehicle factors identified in Table 4 produced the estimates of relative pedestrian injury severity for France provided in Table 6. The severity estimates are interpreted as the adjusted probability of pedestrian death or serious injury given some injury was sustained in a Police reported pedestrian crash in France.

Table 6. Injury severity estimates for EuroNCAP tested vehicles for pedestrian crashes only.

Index	Make	Model	Severity	Lower 95% CI	Upper 95% CI	Width of CI
1	Fiat	Punto 55S	24.07%	18.79%	30.28%	11.49%
2	Ford	Fiesta 1.25 LX 16V	21.97%	16.59%	28.50%	11.91%
7	Volkswagen	Polo 1.4L	23.69%	16.46%	32.85%	16.40%
10	Citroen	Xantia 1.8i Dimension	26.08%	19.83%	33.49%	13.66%
14	Peugeot	406 1.8LX	21.38%	15.54%	28.67%	13.13%
15	Renault	Laguna 2.0RT	22.86%	15.78%	31.91%	16.13%
21	Citroen	Xsara 1.4i (LHD)	25.12%	17.61%	34.49%	16.88%
27	Peugeot	306 1.6GLX	30.71%	25.48%	36.49%	11.01%
28	Renault	Megane 1.6RT (LHD)	29.24%	20.53%	39.80%	19.27%
41	Vauxhall	Astra 1.6i Envoy	23.98%	15.90%	34.48%	18.58%
42	Ford	Escort 1.6 LX	22.64%	16.49%	30.24%	13.74%
44	Renault	Espace 2.0RTE (LHD)	25.57%	17.11%	36.38%	19.27%
56	Vauxhall	Corsa 1.0 12v Club	17.53%	10.78%	27.22%	16.44%
66	Citroen	Saxo 1.1 SX (LHD)	26.95%	21.38%	33.36%	11.98%
73	Renault	Clio 1.2 RTE (LHD)	22.81%	17.24%	29.53%	12.29%
89	Peugeot	406 (LHD)	24.86%	17.63%	33.83%	16.20%

4.3 German Data

Logistic regression analysis, including adjustment for each of the significant non-vehicle factors identified in Table 4 produced the estimates of relative pedestrian injury severity for Germany provided in Table 7. The severity estimates are interpreted as the adjusted probability of pedestrian death or serious injury given some injury was sustained in a Police reported pedestrian crash in Germany.

Table 7. Injury severity estimates for EuroNCAP tested vehicles for pedestrian crashes only.

Index	Make	Model	Severity	Lower 95% CI	Upper 95% CI	Width of CI
1	Fiat	Punto 55S	39.84%	33.90%	46.10%	12.20%
3	Nissan	Micra 1.0L	37.46%	31.00%	44.39%	13.40%
4	Renault	Clio 1.2RL	42.78%	32.41%	53.83%	21.42%
6	Vauxhall	Corsa 1.2LS	38.95%	34.46%	43.64%	9.18%
7	Volkswagen	Polo 1.4L	42.92%	36.66%	49.42%	12.76%
8	Audi	A4 1.8	34.24%	27.71%	41.44%	13.73%
9	BMW	316i	39.43%	29.57%	50.23%	20.66%
11	Ford	Mondeo 1.8LX	39.94%	30.32%	50.41%	20.08%
12	Mercedes	C180 Classic	35.75%	31.30%	40.46%	9.16%
18	Vauxhall	Vectra 1.8iLS	44.34%	37.10%	51.82%	14.71%
19	Volkswagen	Passat 1.6L (LHD)	35.33%	27.05%	44.60%	17.54%
20	Audi	A3 1.6	37.70%	29.06%	47.20%	18.13%
24	Honda	Civic 1.4i	42.11%	34.14%	50.51%	16.38%
28	Hyundai	Accent 1.3GLS (LHD)	44.35%	35.43%	53.64%	18.21%
31	Volkswagen	Golf 1.4 (LHD)	39.06%	32.95%	45.55%	12.60%
33	BMW	520i (LHD)	43.00%	33.50%	53.04%	19.53%
40	Mercedes	A140 Classic (LHD)	30.18%	21.18%	41.01%	19.83%
41	Vauxhall	Astra 1.6i Envoy	32.49%	27.68%	37.71%	10.03%
42	Ford	Escort 1.6 LX	46.63%	40.99%	52.37%	11.38%
43	Nissan	Almera 1.4GX	41.85%	32.22%	52.14%	19.91%
53	Volkswagen	Lupo 1.0 (LHD)	41.51%	31.54%	52.24%	20.70%
54	MCC	Smart (LHD)	40.63%	32.17%	49.68%	17.52%
56	Vauxhall	Corsa 1.0 12v Club	42.30%	36.49%	48.34%	11.85%
63	Ford	Ka 1.3 (LHD)	39.48%	33.09%	46.25%	13.15%

5 THE RELATIONSHIP BETWEEN PEDESTRIAN INJURY OUTCOMES IN REAL CRASHES AND EURONCAP PEDESTRIAN PROTECTION RATINGS

The analysis that follows considers the relationship between the real crash pedestrian safety ratings and the EuroNCAP pedestrian star ratings available from the EuroNCAP website and derived from the EuroNCAP pedestrian test scores. First a graphical analysis of the relationship between the two measures is presented followed by a formal logistic regression

comparison using the framework described in Section 4.4 of the SARAC II sub-task 2.1 and 2.2 report (SR-248).

5.1 Graphical Analysis of Pedestrian Safety Ratings and EuroNCAP Pedestrian Star Ratings

The series of figures that follows plots the EuroNCAP pedestrian star ratings against the injury severity estimates for pedestrian crashes in Britain, France and Germany respectively. The 95 per cent confidence limits on the pedestrian injury severity estimates are also included.

Figure 1. Pedestrian EuroNCAP star rating vs Adjusted injury severity: Great Britain

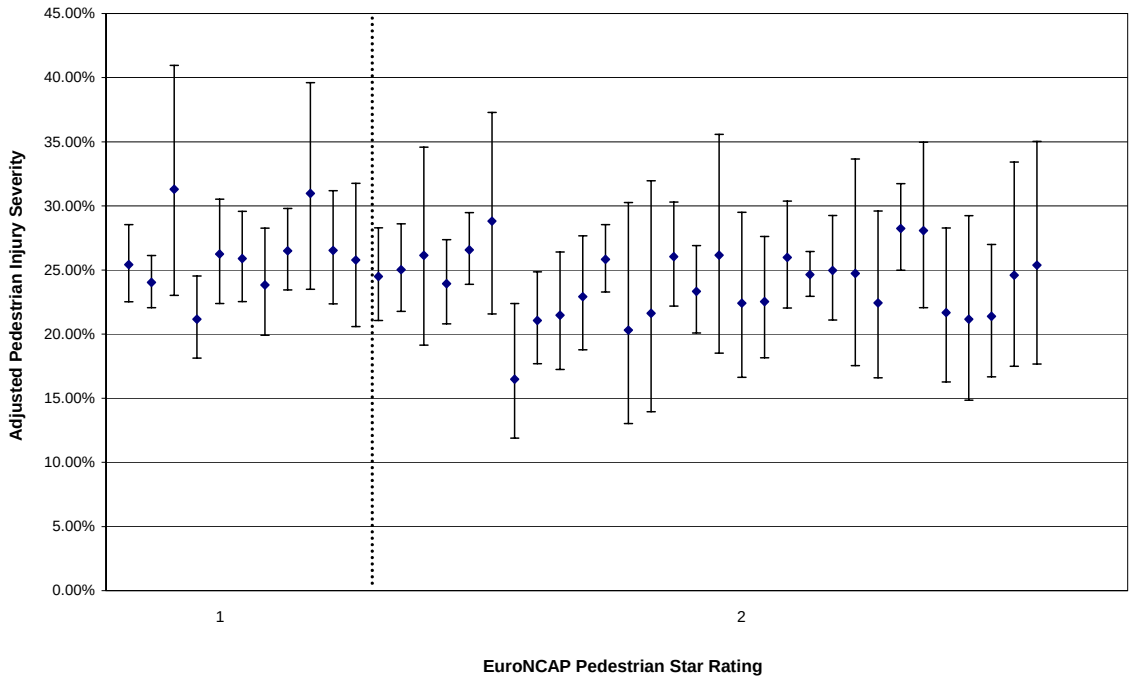


Figure 2. Pedestrian EuroNCAP star rating vs Adjusted injury severity: France

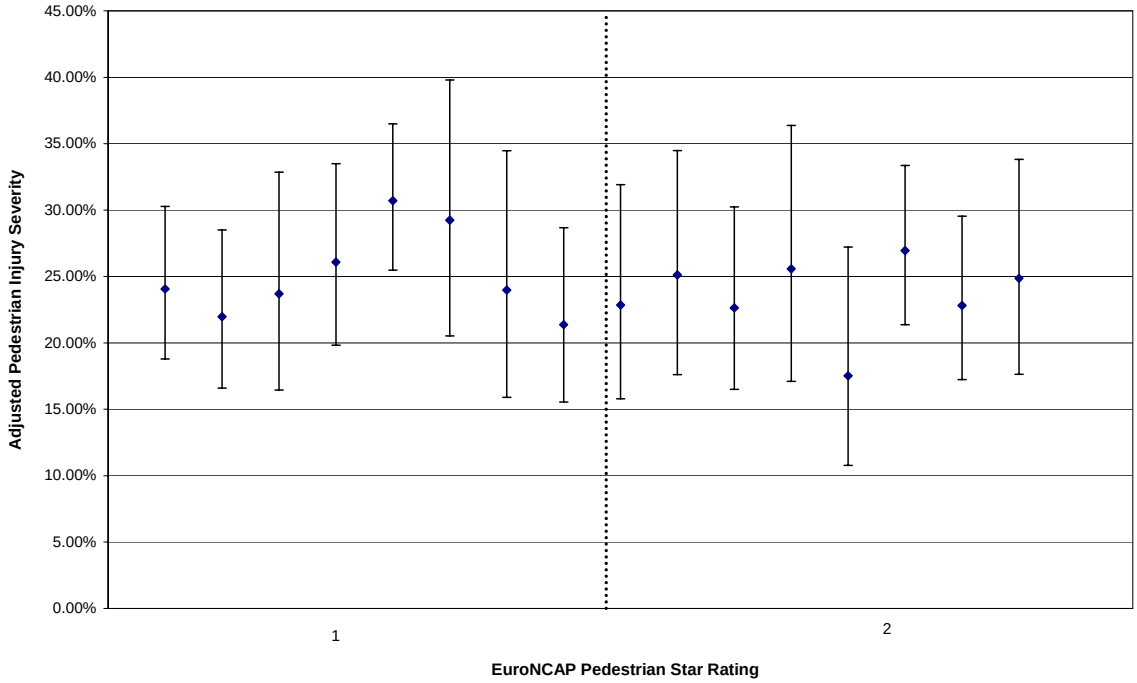
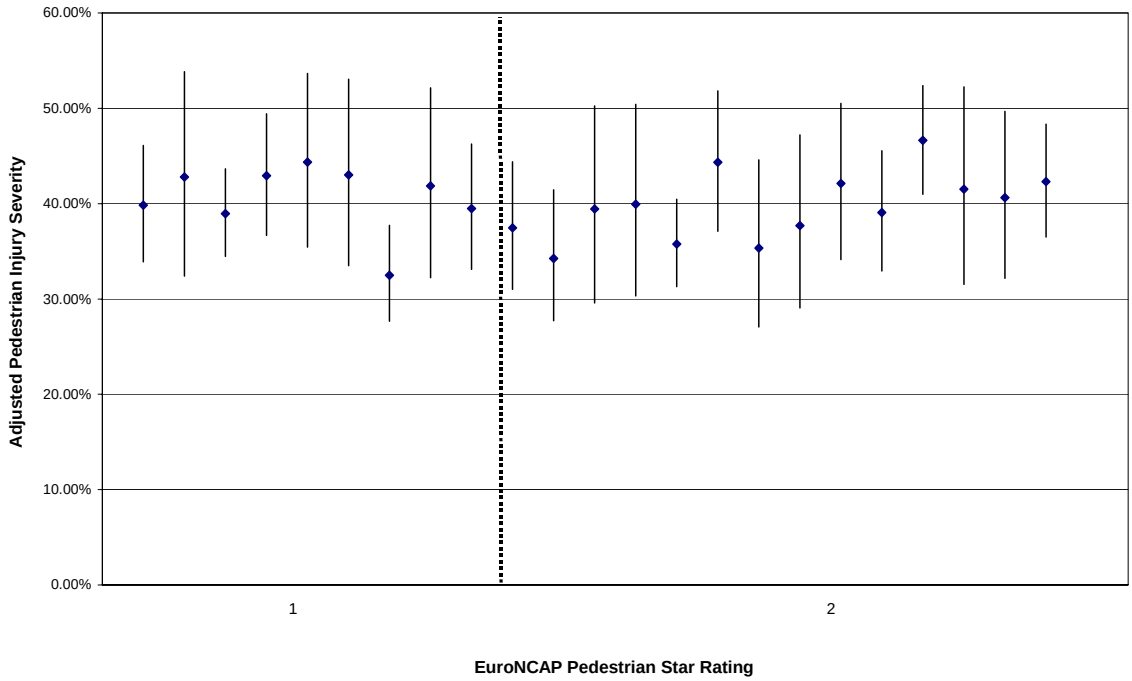


Figure 3. Pedestrian EuroNCAP star rating vs Adjusted injury severity: Germany



Each of the charts shows significant variation in the point estimates of pedestrian injury severity measures within each overall EuroNCAP star rating. Nevertheless, most of the confidence limits around the point estimates overlap both within and across the star rating categories. This variation is partly a product of the estimation error in the injury severity measure, particularly for vehicle models with relatively few records in the crash data. The

overlapping confidence limits for one star and two star rated vehicles indicates that there is no evidence of a relationship between EuroNCAP pedestrian star ratings and the pedestrian injury severity estimates generated from real world crash data from any of the three countries.

5.2 Logistic Regression Comparison of Pedestrian Real Crash Injury Severity and Pedestrian EuroNCAP Star Ratings

Before a more formal assessment of the relationship between the EuroNCAP pedestrian star ratings and the estimated real crash pedestrian severity is conducted using logistic regression, the relationship between vehicle mass and pedestrian crash injury severity is considered to investigate the compatibility of the two safety measures using British, French and German data. The following figures plot the fitted logistic regression curves estimating the relationship between vehicle mass and injury severity for pedestrian crashes.

Figure 4. Adjusted pedestrian injury severity vs Vehicle mass: Great Britain

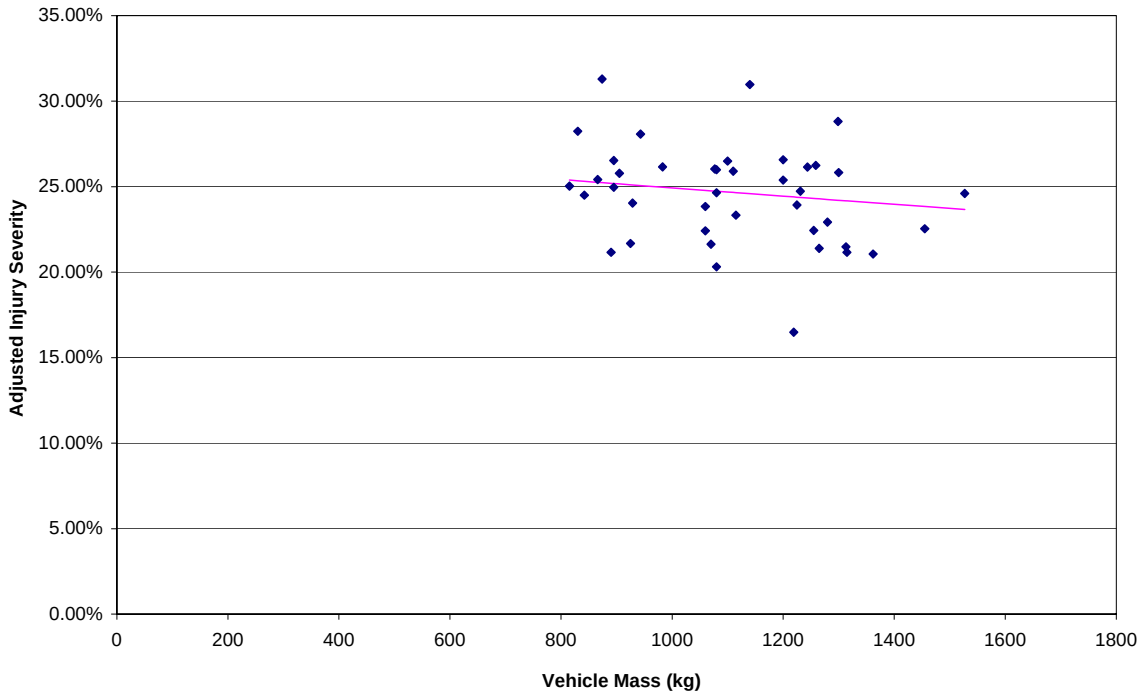


Figure 5. Adjusted pedestrian injury severity vs Vehicle mass: France

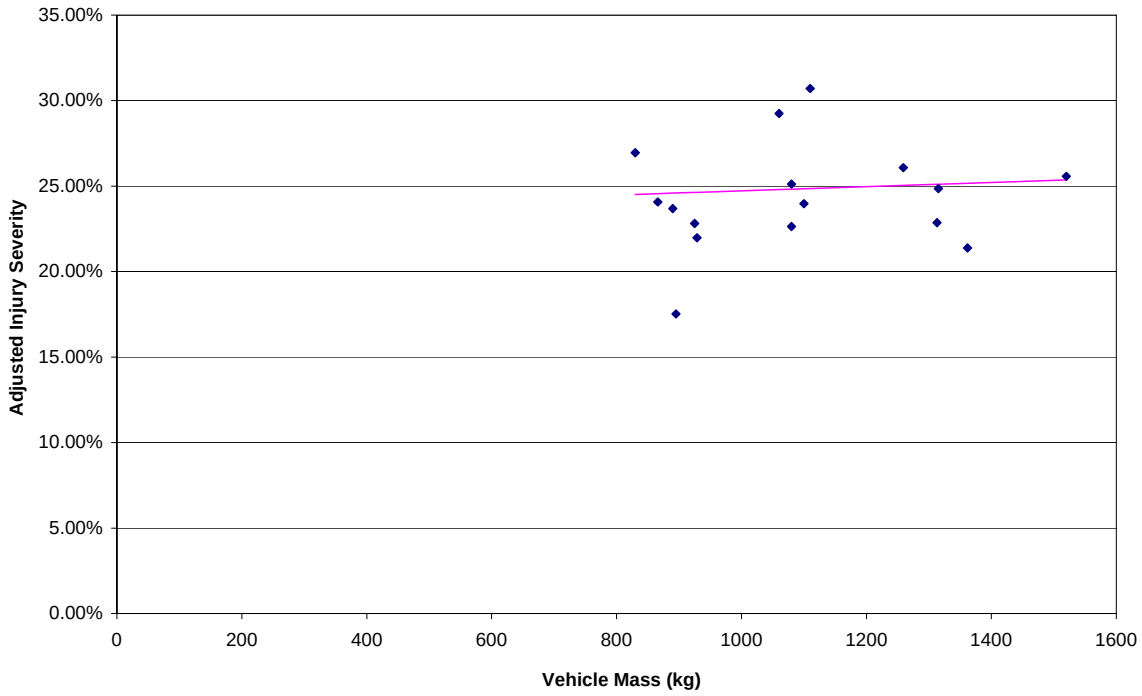
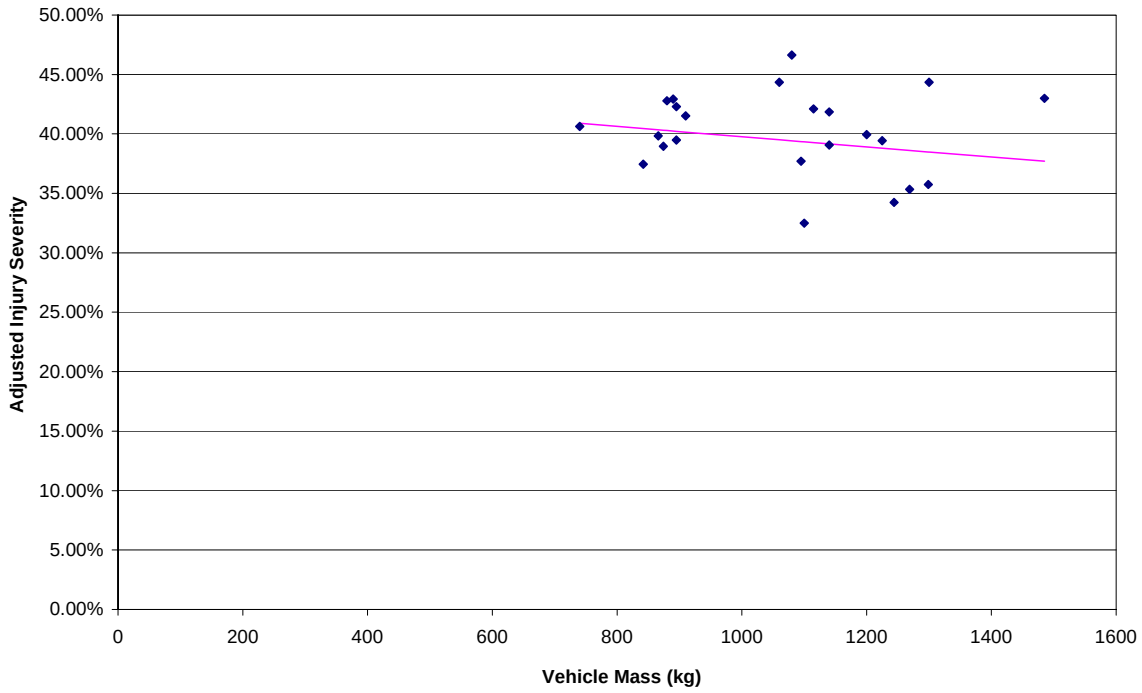


Figure 6. Adjusted pedestrian injury severity vs Vehicle mass: Germany



The figures above provide no clear evidence of a relationship between vehicle mass and estimated pedestrian injury severity. Further, the coefficient of vehicle mass in the logistic regression analysis for all three countries was not statistically significant. Therefore, it is

concluded that there is no evidence of a relationship between vehicle mass and estimated pedestrian injury severity for Great Britain, France or Germany.

Given the lack of a clear relationship between vehicle mass and pedestrian crash injury severity in the analysis no adjustment for vehicle mass is made when exploring the relationship between these measures and the EuroNCAP star ratings. The results of are shown in the tables that follow for Great Britain, France and Germany respectively.

Table 8. Pedestrian injury severity estimates and 95% confidence limits across EuroNCAP pedestrian star rating categories: Great Britain.

	Pedestrian Crashes			
	Pedestrian Impact Star Rating			
	1	2	3	4
Estimate	**24.92%**	**24.52%**		
LCL	24.30%	23.91%		
UCL	25.54%	25.14%		

Table 9. Pedestrian injury severity estimates and 95% confidence limits across EuroNCAP pedestrian star rating categories: France.

	Pedestrian Crashes			
	Pedestrian Impact Star Rating			
	1	2	3	4
Estimate	**26.06%**	**23.61%**		
LCL	24.33%	21.99%		
UCL	27.87%	25.30%		

Table 10. Pedestrian injury severity estimates and 95% confidence limits across EuroNCAP pedestrian star rating categories: non-mass adjusted Germany.

	Pedestrian Crashes			
	Pedestrian Impact Star Rating			
	1	2	3	4
Estimate	**38.88%**	**40.17%**		
LCL	37.37%	38.65%		
UCL	40.41%	41.72%		

There is only very weak evidence of a trend to improving pedestrian injury outcome with increasing EuroNCAP pedestrian star rating in the French data. However, the results for Britain, France and Germany (both mass and non-mass adjusted) show that one star rated

vehicles had an estimated average injury severity not statistically significantly different to two star rated models.

There are a number of potential factors that may contribute to the lack of significant evidence of a trend to improving real world pedestrian injury outcome with increasing EuroNCAP pedestrian star ratings in the British, French and German data. It is possible that there is in fact no relationship between the two measures of pedestrian protection. At Phase 3 of EuroNCAP testing, vehicle manufacturers were allowed select some of the vehicle test sites themselves. This may have resulted in changes in test scores without any corresponding change in the level protection offered to pedestrians. That is, changing the sites selected for testing may have changed the resulting test score, but the underlying safety performance of the vehicle remained constant. A full description of changes to the EuroNCAP pedestrian test protocol and their effect on test scores can be found in Ponte et al. (2004).

A second possible reason for the lack of relationship between EuroNCAP star ratings and real world pedestrian safety ratings is the method of test site selection under EuroNCAP. The selection of test sites is not directly related to the relative frequency of real world crashes involving those sites. Therefore, the selection of a poor performing test site will be reflected in the EuroNCAP pedestrian test score and star ratings regardless of the relative frequency of a pedestrian hitting that site. Similarly, the selection of a well performing test site will be reflected in the EuroNCAP pedestrian test score and star ratings regardless of the relative frequency of a pedestrian hitting that site. In contrast, real world pedestrian safety ratings implicitly account for the relative frequency of point of pedestrian impact. Given the difference in the relationship between pedestrian point of impact and measured outcome for EuroNCAP and real world safety ratings, it is perhaps unsurprising that no correlation between the two measures of pedestrian safety has been found.

Finally it is noted that the analysis reported here considers one and two star rating vehicles only as no three star rated vehicles were available for analysis at the commencement of this study.

6 DESCRIPTIVE ANALYSIS

The final component of this study provides a descriptive analysis of the pedestrian data used to generate the pedestrian injury severity estimates detailed above. The data used is that described in Section 2. The analysis examines the distribution of non-vehicle factors across EuroNCAP tested vehicles used in the preceding analysis.

Throughout the analysis, French data has been used to highlight some of the likely influences of pedestrian injury outcome. The same broad results are also evident in the German and British data. However, it should be noted that the distribution of the various influencing factors across vehicle models are not identical. For example, particular vehicle models that have a high proportion of collisions with female pedestrians in the French data may collide more frequently with male pedestrians in the British data. This and other differences between countries are likely due to differences in the road environment, the use of individual vehicle models and the characteristics of pedestrians in the two countries.

Given the focus of the analysis above, the distribution of pedestrian injury severity across vehicle models is presented first. The following figures plot injury severity by vehicle model using data from France, Germany and Great Britain respectively.

Figure 7. Distribution of INJURY SEVERITY by vehicle model: France

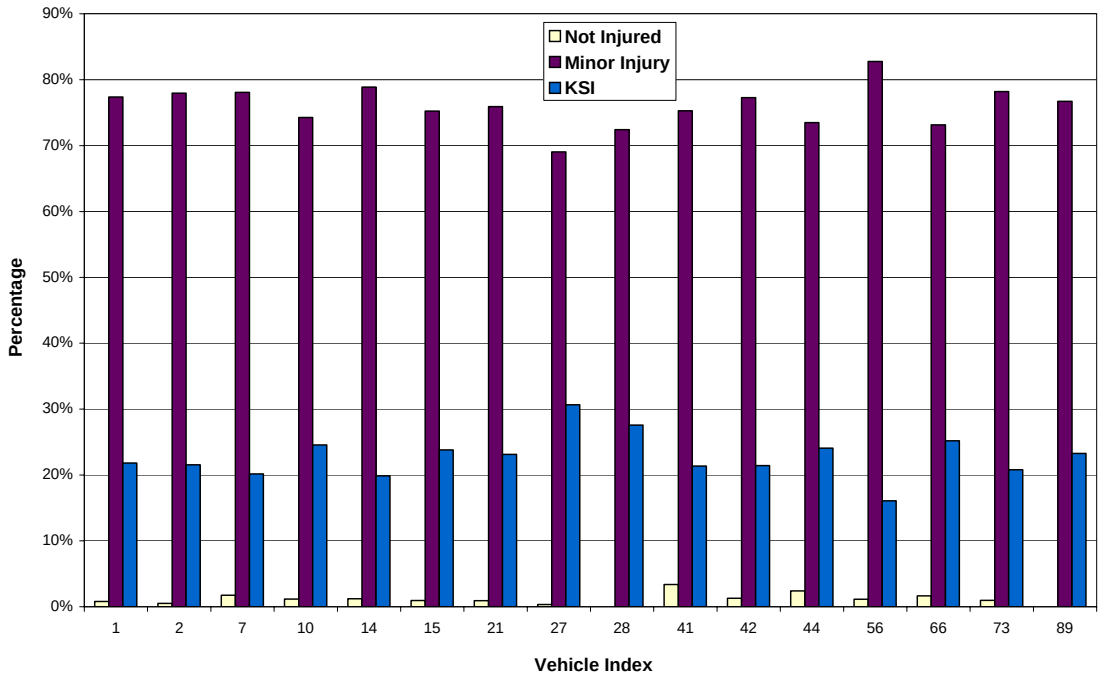


Figure 8. Distribution of INJURY SEVERITY by vehicle model: Germany

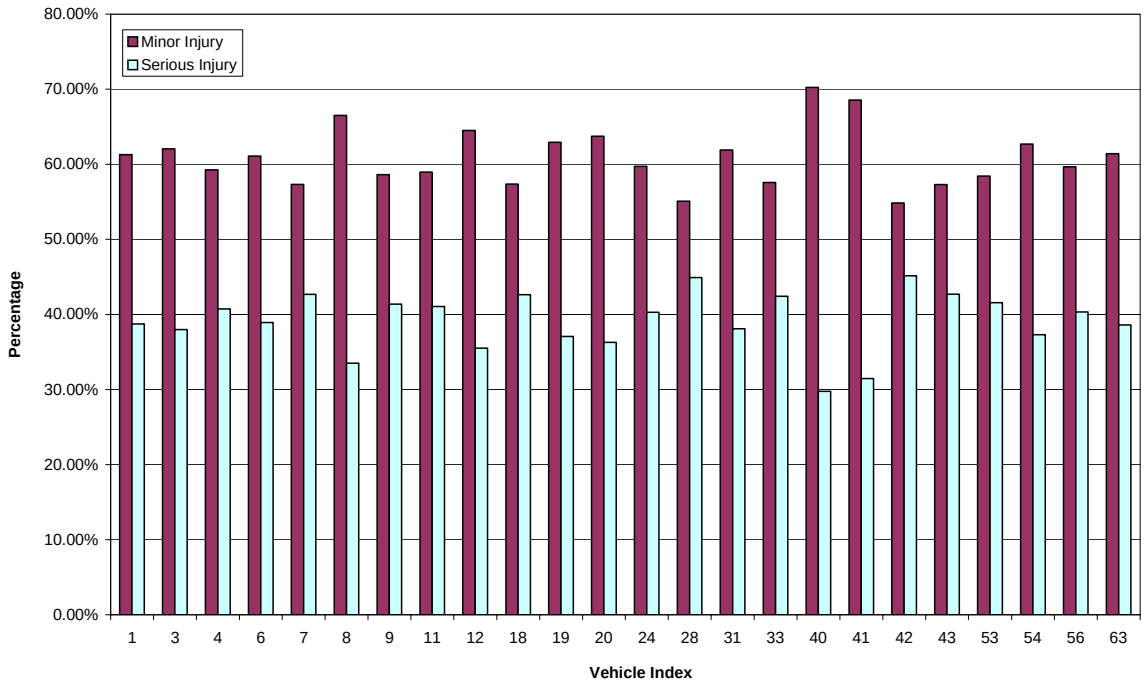
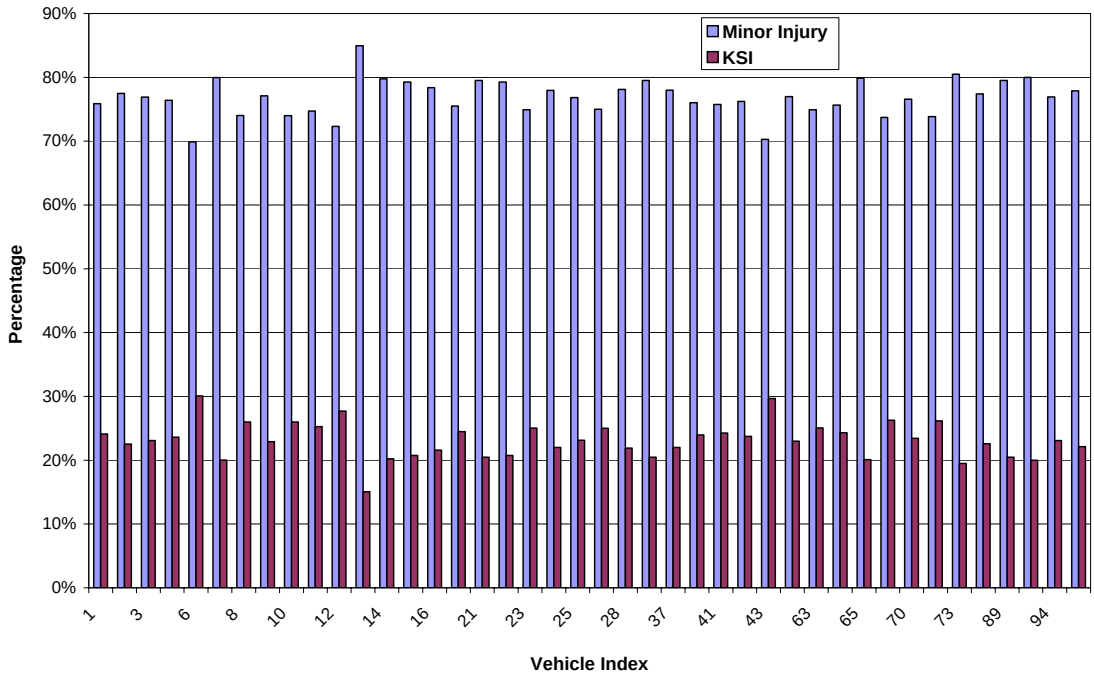


Figure 9. Distribution of INJURY SEVERITY by vehicle model: Great Britain



There is evidence of variation in unadjusted pedestrian injury severity by vehicle model. Considering the French data, vehicle 56 has a relatively low proportion of pedestrian deaths and serious injuries (16%) and a relatively high proportion of minor pedestrian injuries (83%). In contrast vehicle 27 has a relatively low proportion of minor pedestrian injuries (69%) and a relatively high proportion of pedestrian deaths and serious injuries (31%). Variation in pedestrian injury outcome across vehicle models is also evident in the German and British

data. Some of this variation may be explained in the following analysis of factors likely to influence injury severity.

Crash impact severity is likely a significant influence on pedestrian injury outcome. However, impact severity is not directly available in the French, German or British data. Nevertheless, a number of other variables may be used as proxies for impact severity. To examine the potential influence of these proxy measures on pedestrian injury outcome, the following series of figures plot the proportion of pedestrians across each proxy measure category that suffer minor injuries and the proportion that suffer fatal or serious injuries. The data for these figures is drawn from Great Britain only.

Figure 10. The distribution of injury severity by the speed zone at the pedestrian crash site.

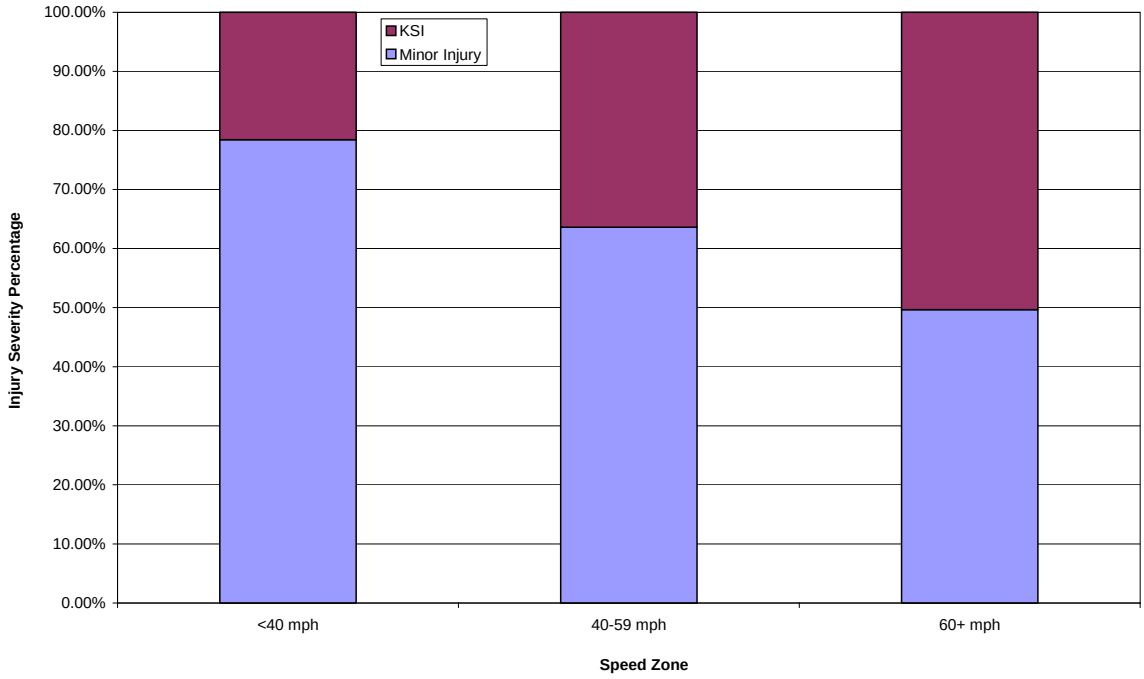


Figure 11. The distribution of injury severity by the location of the pedestrian crash site.

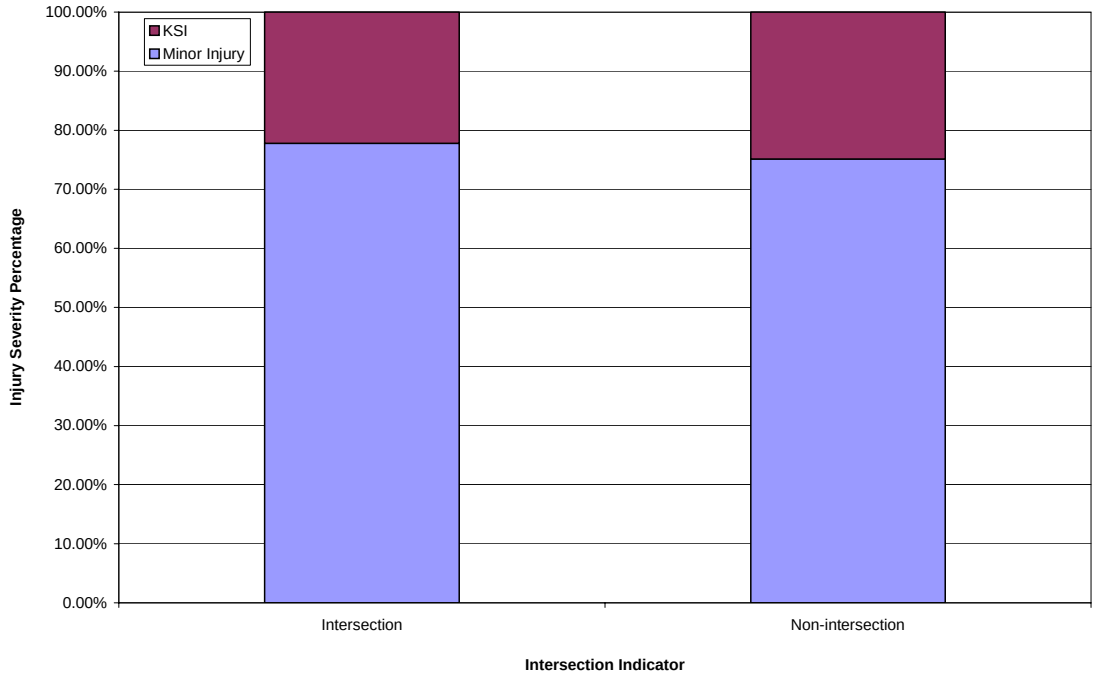


Figure 10 illustrates that the proportion of pedestrians killed or seriously injured in collisions with a passenger vehicle differs according to the speed limit of the crash site. It is evident that a higher proportion of fatalities and serious injuries occur in speed zones of 60 mph or above than in speed zones of less than 60 mph. In contrast, Figure 11 demonstrates that there is little apparent difference between the proportion of pedestrians killed or seriously injured in crashes with passenger vehicles at intersections compared with crashes not occurring at intersections.

Given the variations highlighted above, it is interesting to also plot the distribution of these proxy measures by vehicle model. Significant variation in these measures by vehicle model would suggest that it is necessary to adjust for these factors in estimating pedestrian injury severity estimates such as those presented in Section 4. The following series of figures plot these factors by vehicle model using the French, German and British data respectively. It is noted that the proxy measures available are not consistent across data sets.

Figure 12. Distribution of URBANISATION by vehicle model: France

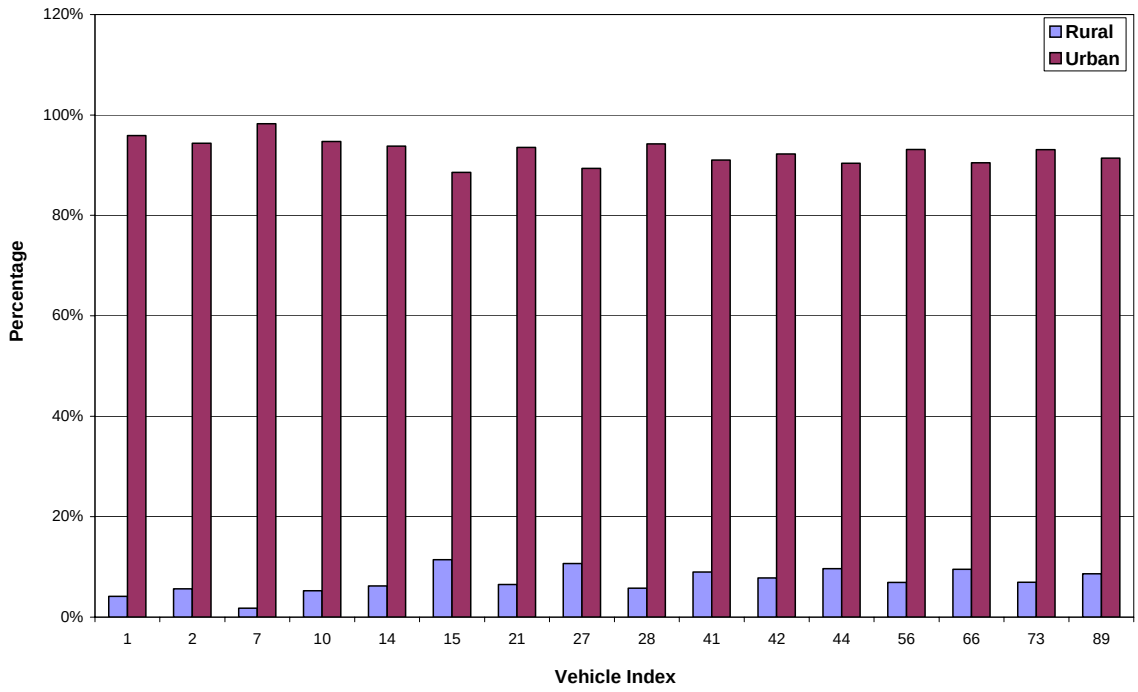


Figure 13. Distribution of URBANISATION by vehicle model: Germany

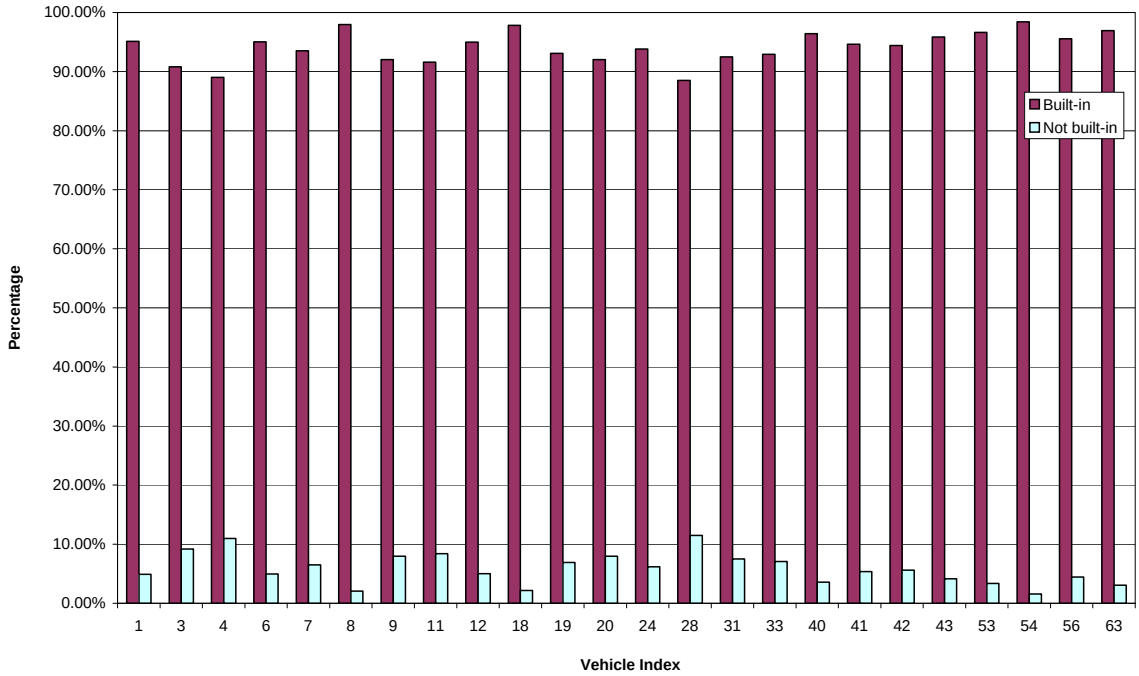
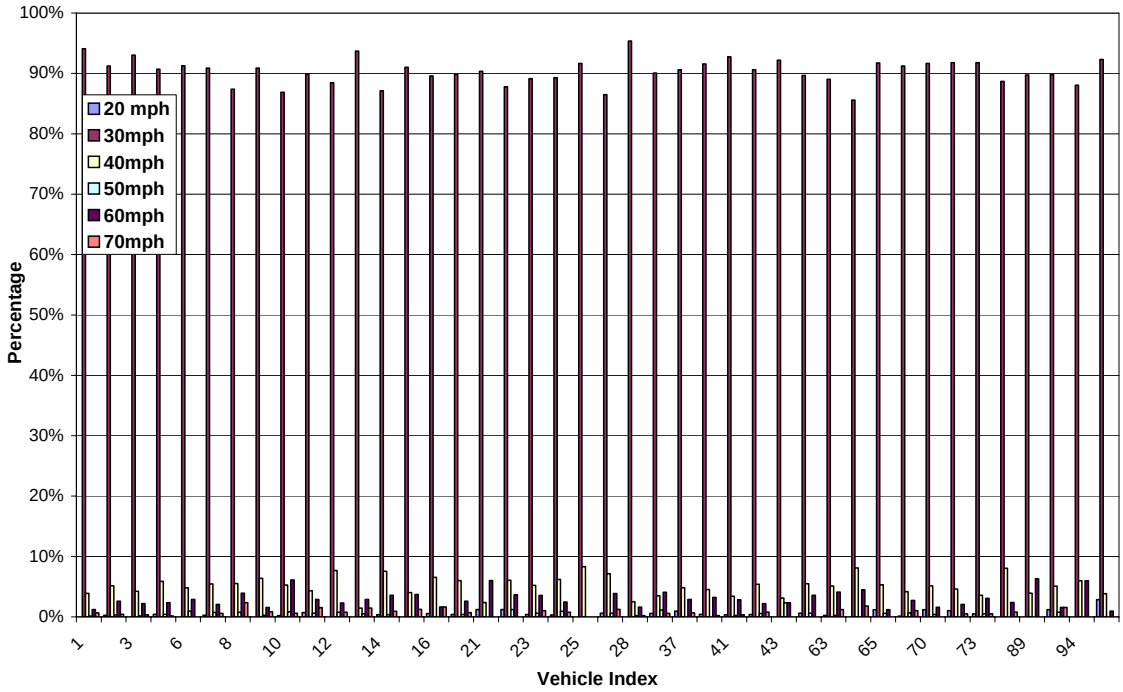


Figure 14. Distribution of SPEED LIMIT by vehicle model: Great Britain



The analysis of the French, German and British data shows that there is variation in the urbanisation of the crash site and speed limit at the crash site by vehicle model. For example, considering the French analysis, vehicle 7 has the lowest proportion of pedestrian crashes occurring in rural areas (2%). This may be expected to reduce the proportion of crashes resulting in pedestrian death or serious injury for that vehicle model given the lower impact speed generally associated with crashes in an urban environment. In contrast,

vehicle 14 and 27 has the highest proportion of pedestrian crashes occurring in rural areas (89%). As a result these vehicle models may be associated with a higher proportion of pedestrian deaths and serious injuries given the higher impact speeds at which rural crashes tend to occur.

The analysis by speed zone of the British pedestrian crash data provides additional information about the average distribution of pedestrian crashes by speed zone. It is evident that across all vehicle models, the vast majority of pedestrian crashes occur in 30mph speed zones. Across the other speed limit zones there is some variation by vehicle model.

The following figures plot an intersection indicator by vehicle model. There is evidence of variation in the location of the crash site across vehicle models.

Figure 15. Distribution of INTERSECTION INDICATOR by vehicle model: France

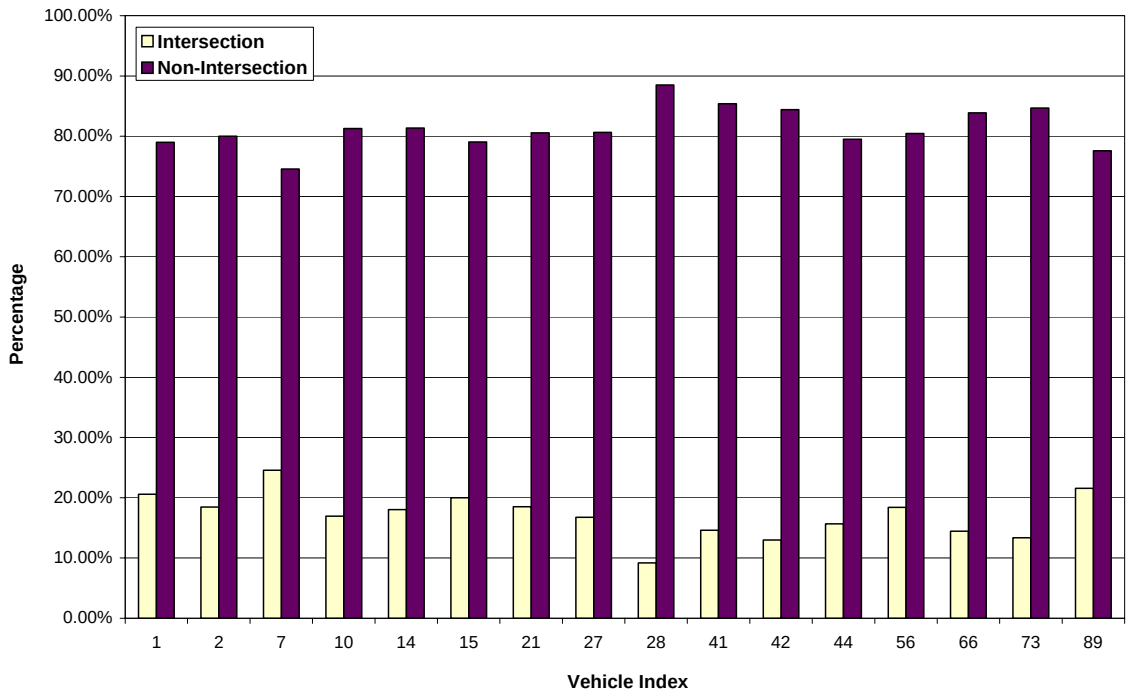


Figure 16. Distribution of INTERSECTION INDICATOR by vehicle model: Germany

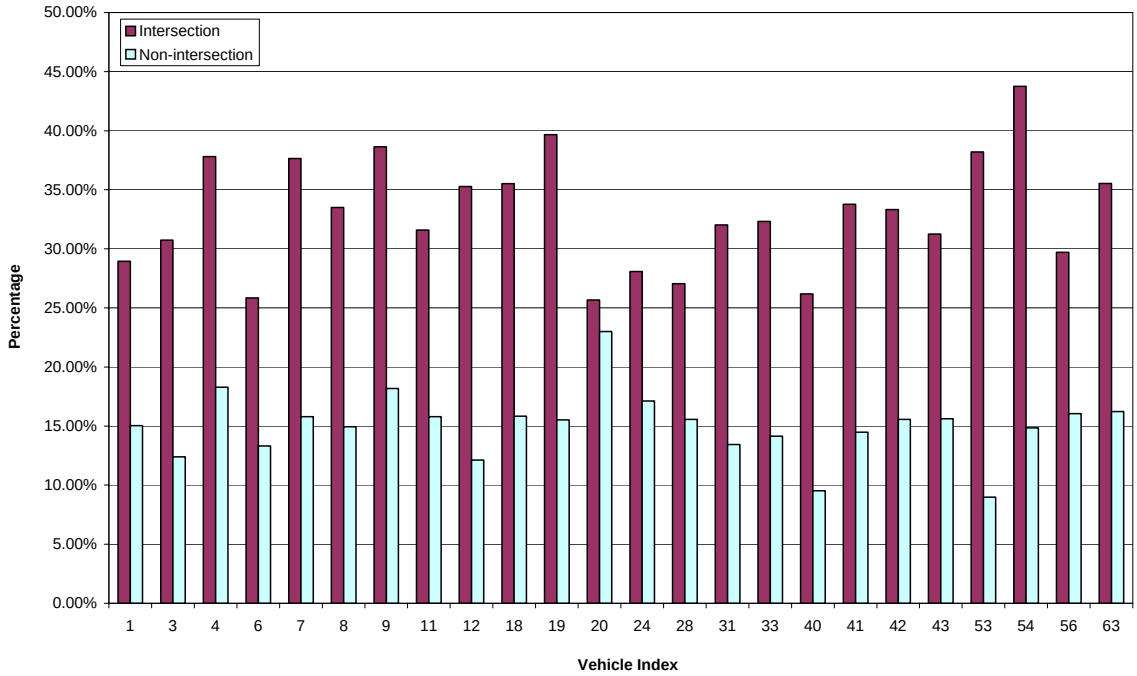
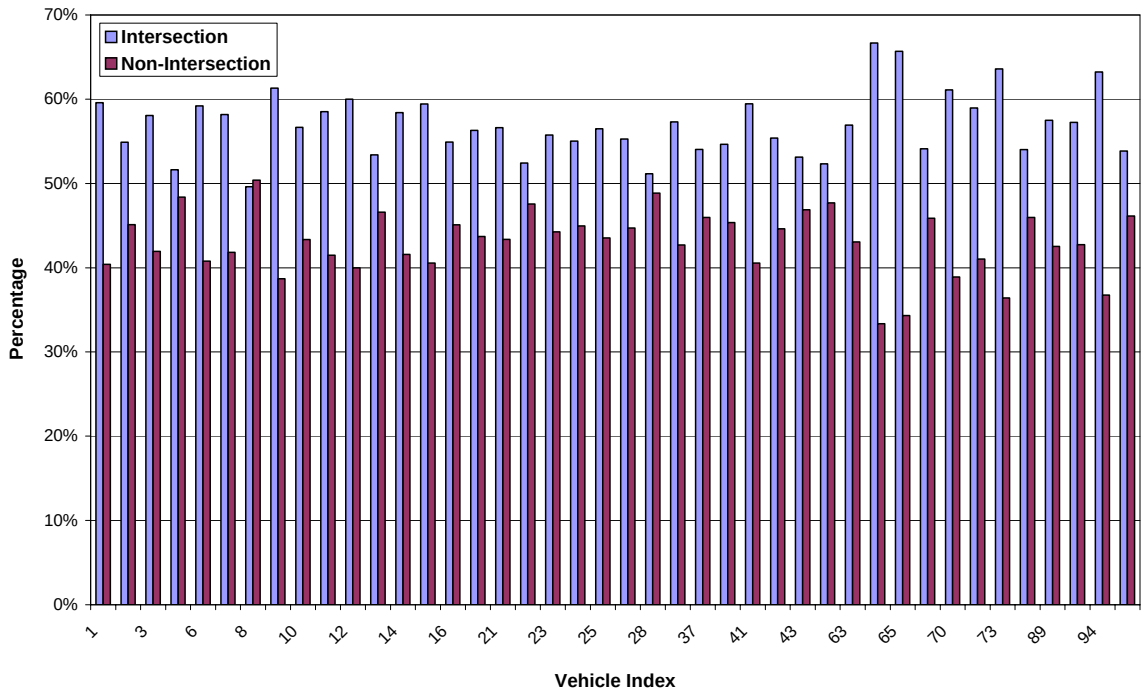


Figure 17. Distribution of JUNCTION INDICATOR by vehicle model: Great Britain



When viewed in combination with Figures 10 and 11 above, there is evidence to support the need to adjust for impact severity proxy factors when estimating pedestrian injury severity estimates. This is particularly so for the speed limit (or urbanisation) of the crash site where there is evidence of an influence of crash location on pedestrian injury outcome.

In addition to crash site variables, the characteristics of the pedestrian may influence the pedestrian injury outcome in a collision with a vehicle. For example, a male may be considered more likely to have a better injury outcome compared to a female involved in an identical pedestrian crash. Similarly, young children and the elderly may be considered more vulnerable than other pedestrians. Therefore, the population with which a vehicle model collides is likely to influence the injury outcome of pedestrians involved in those crashes. To investigate these possibilities the following two figures plot pedestrian injury outcome by pedestrian characteristics. The data included in these figures is drawn from British data only.

Figure 18. The distribution of injury severity by pedestrian age.

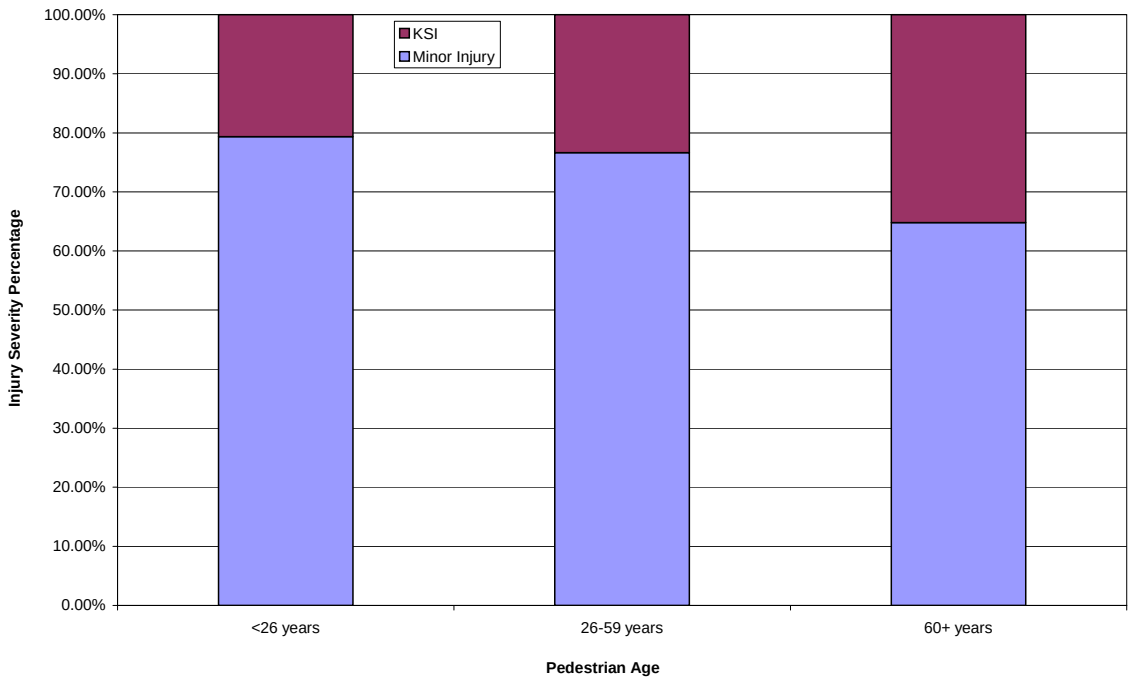


Figure 19. The distribution of injury severity by pedestrian sex.

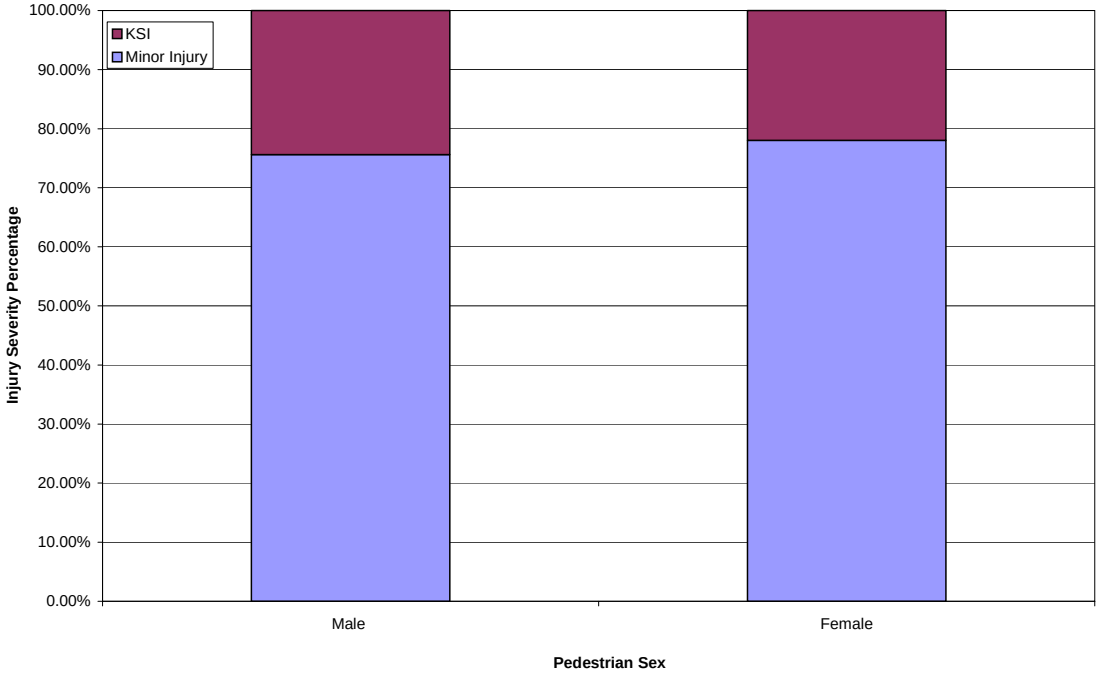


Figure 18 illustrates that the proportion of pedestrians killed or seriously injured in collisions with a passenger vehicle differs by the age of the pedestrian. It is evident that a higher proportion of elderly pedestrians suffer fatal or serious injuries compared to pedestrians aged under 65. In contrast, Figure 19 demonstrates that there is little apparent difference between the proportion of male pedestrians killed or seriously injured in crashes with passenger vehicles and the proportion of female pedestrians killed or seriously injured in crashes with passenger vehicles.

Given the variations highlighted above, variation in pedestrian age and pedestrian sex by vehicle model are examined in the following serious of figures for France, Germany and Great Britain respectively. Significant variation in these measures by vehicle model would suggest that in estimating pedestrian injury severity estimates such as those presented in Section 4, it is necessary to adjust for these factors.

Figure 20. Distribution of PEDESTRIAN SEX by vehicle model: France

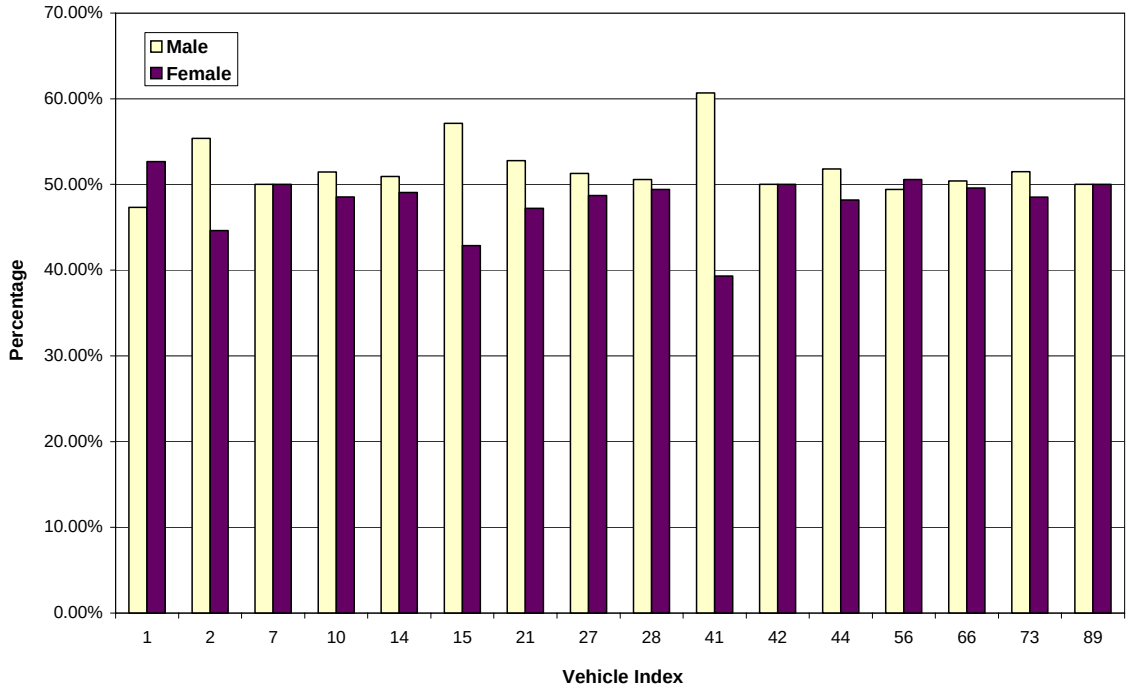


Figure 21. Distribution of PEDESTRIAN SEX by vehicle model: Germany

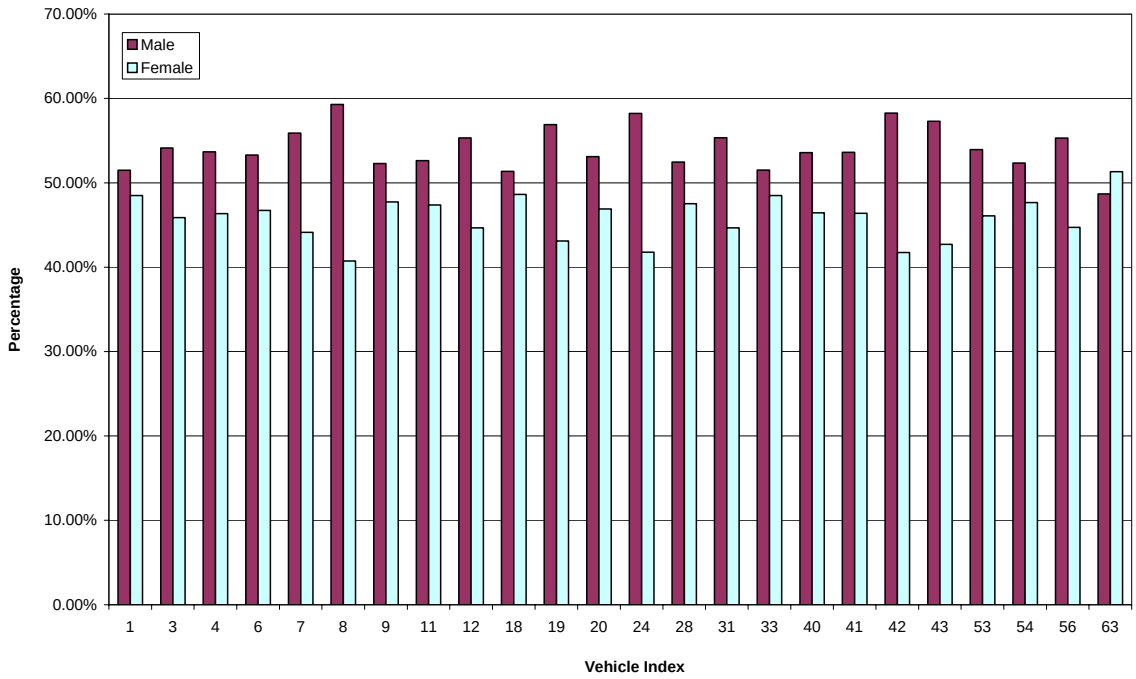
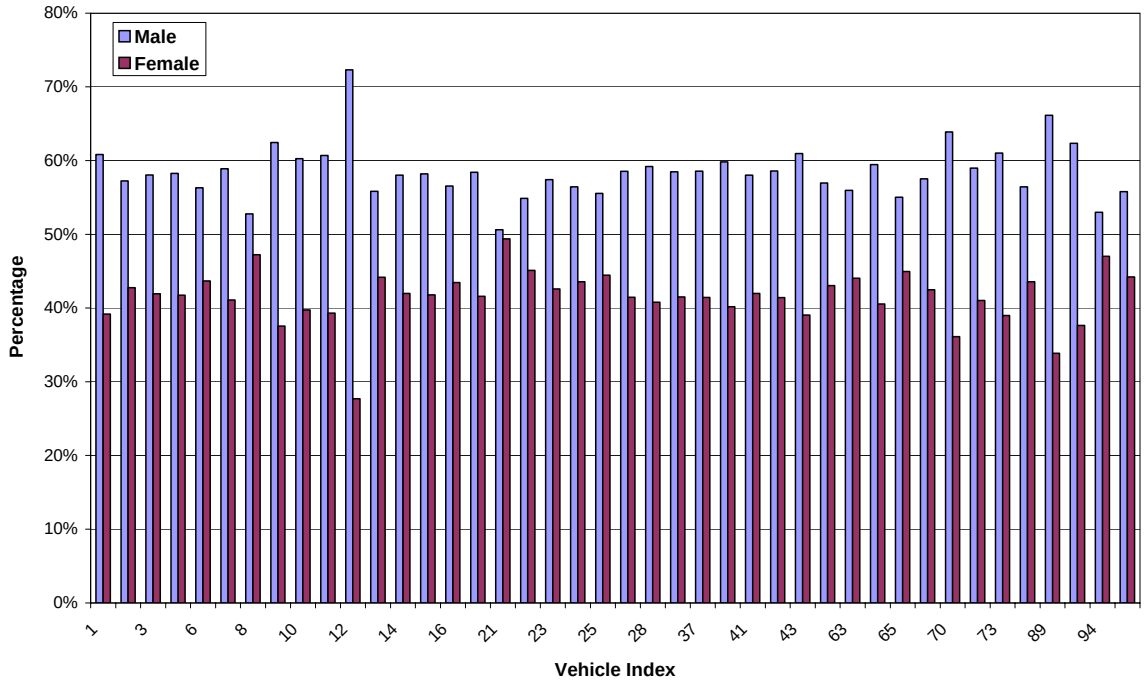


Figure 22. Distribution of PEDESTRIAN SEX by vehicle model: Great Britain



There is some variation in the proportion of male and female involvement in pedestrian crashes by vehicle model particularly in the French and German data. There is also variation in the proportion of male and female involvement in pedestrian crashes by vehicle model in the British data, however, for all vehicle models examined, the majority of the pedestrians hit in Police reported crashes are male.

Figure 23. Distribution of PEDESTRIAN AGE by vehicle model: France

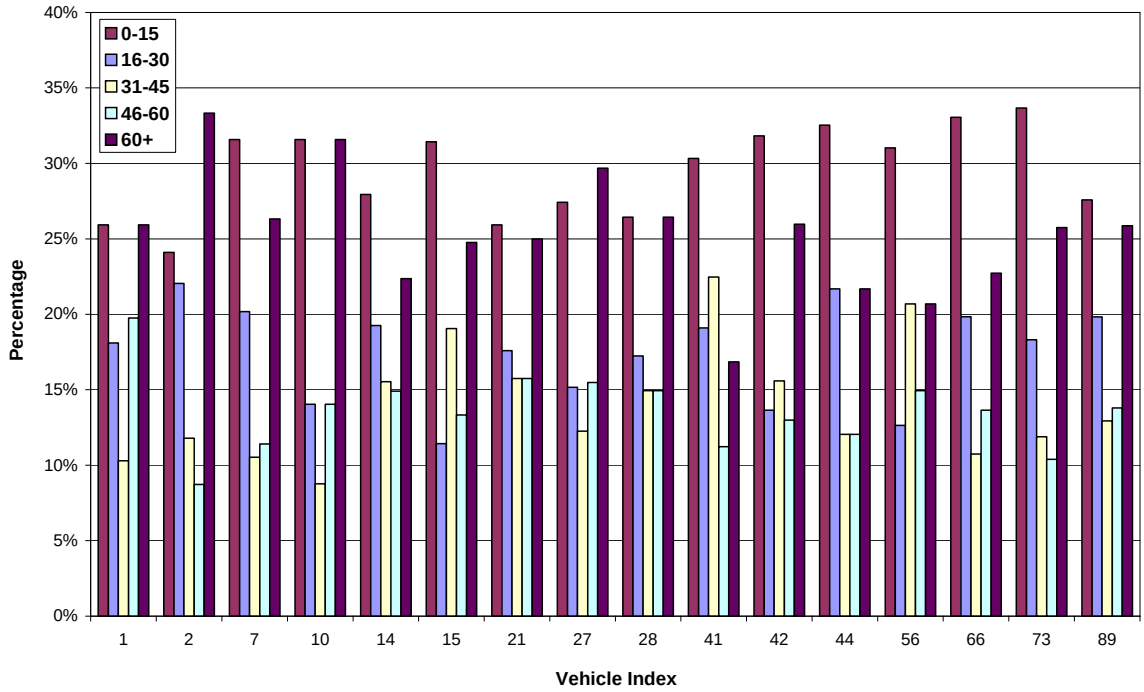


Figure 24. Distribution of PEDESTRIAN AGE by vehicle model: Germany

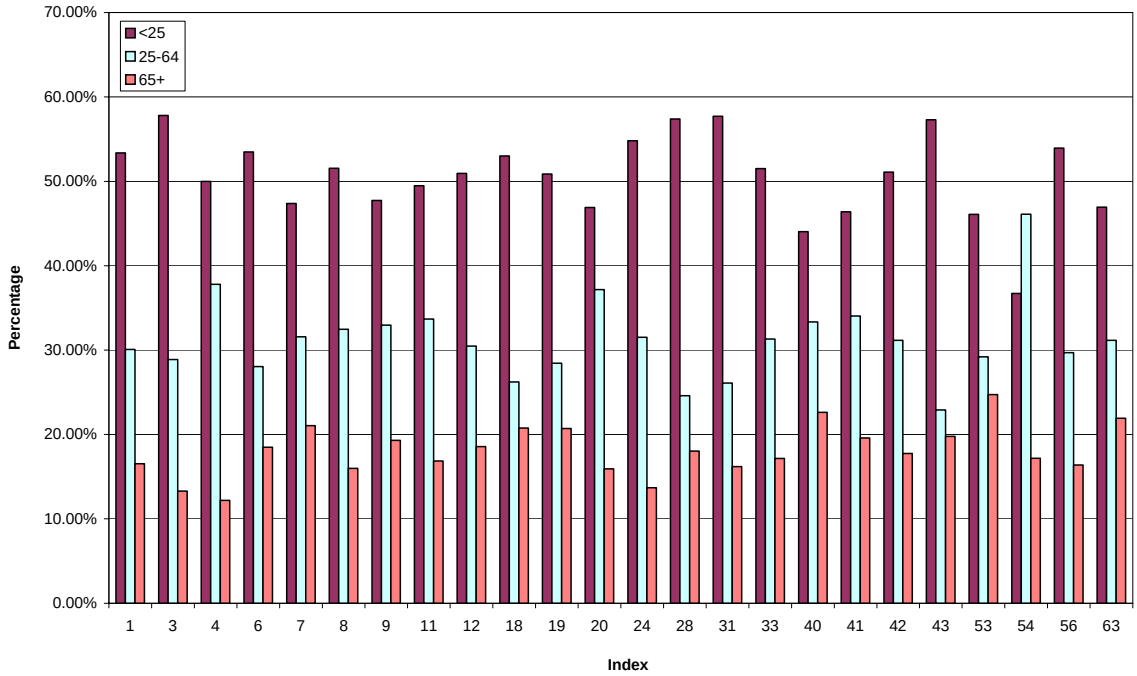
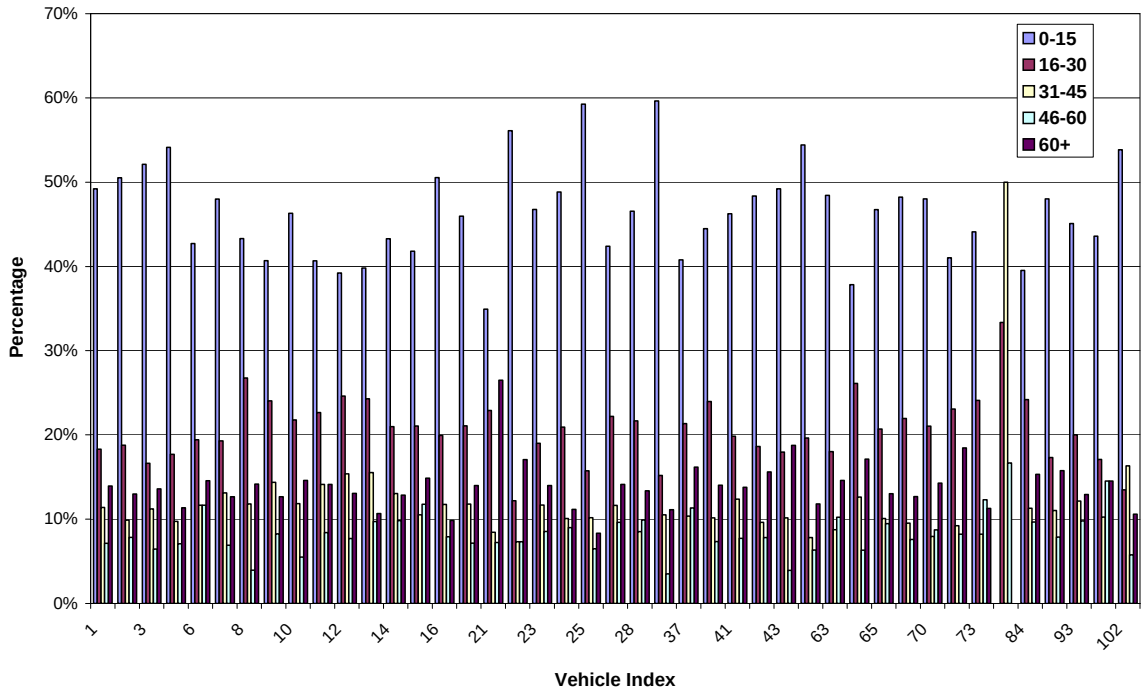


Figure 25. Distribution of PEDESTRIAN AGE by vehicle model: Great Britain



The analysis of pedestrian age indicates that in France for each vehicle model the majority of pedestrians involved in Police reported crashes are those aged between 0 and 15 years or those aged over 60 years. In Germany, the highest proportion of crash involved pedestrians for each vehicle model are aged under 25 years. In Great Britain, those aged between 0 and 15 represent the highest proportion of crash involved pedestrians across all vehicle models.

However, there remains significant variation across the age categories by vehicle model in all data sets.

7 CONCLUSION

Using the pedestrian data supplied to MUARC as part of the SARAC II study, it has been possible to investigate the nature of pedestrian crashes in Great Britain, Germany and France. Three key conclusions arise from this analysis.

First, sufficient data from these countries was made available to enable the estimation of pedestrian injury severity in collisions with passenger vehicles by vehicle model for each country adjusted for effects of non-vehicle factors on injury outcome. These estimates represent the risk of death or serious injury to a crash involved pedestrian given that some injury was sustained in a Police reported crash. However, although there was sufficient data to enable the estimation of these measures, the width of the associated confidence intervals was large. Therefore, it difficult to differentiate the pedestrian safety performance of individual vehicle models. The width of the confidence limits is primarily a function of the still relatively small amounts of pedestrian crash data available for analysis. More data would be required to increase the precision of the estimates.

Second, no clear evidence of a relationship between EuroNCAP pedestrian star rating and the pedestrian injury severity estimates generated from real world crash data from Great Britain, Germany and France was found. That is, across all three countries EuroNCAP one star rated vehicles had an estimated average injury severity not statistically significantly different to EuroNCAP two star rated models. This indicates that the EuroNCAP pedestrian star rating is not significantly associated with pedestrian injury severity estimates based on real crash data. Further, given past estimates of the relationship between these two measures of pedestrian injury outcome, it is unlikely that the inclusion of additional data would alter this result.

Finally, the descriptive analysis reported highlights the influence of non-vehicle factors by pedestrian injury outcome and provides evidence of variation in these non-vehicle factors across vehicle models. This confirms that the adjustment of pedestrian injury severity ratings for such factors through the logistic regression technique is required. This adjustment ensures, as far as possible, that the pedestrian safety ratings estimated reflect the safety performance of the vehicle model colliding with the pedestrian and were not influenced by external, non-vehicle factors.

8 REFERENCES

Cameron, MH., Newstead, SV. and Lee, CM. (1998) *Rating the aggressivity of Australian passenger vehicles towards other vehicle occupants and unprotected road users'* Proceedings, International IRCOBI Conference on the Biomechanics of Impact, Gothenborg, Sweden.

EuroNCAP (2002) Pedestrian Testing Protocol Version 3.1.1 January 2002, European New Car Assessment Programme.

Newstead, S., Cameron, M., Delaney, A. and Watson, L. (2005) Study of the relationship between injury outcomes in police reported crash data and crash barrier test results in Europe and Australia. SARAC II Report Number 248.

Ponte, G., van den Berg, A., Streeter, L and Anderson, R. (2004) 'Pedestrian protection in vehicle impacts: Further results from the Australian New Car Assessment Program' *Proceedings 2004 Road Safety Research, Policing and Education Conference*, November 14-16, Perth, Australia, Vol 1.