Study of the Relationship between Injury Outcomes in Police Reported Crash Data and Crash Barrier Test Results in Europe and Australia

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ABSTRACT

This paper reports on the use of police reported crash data from Great Britain, and Germany to estimate injury risk and injury severity measures for European vehicles. The relationship between these measures and EuroNCAP test results is evaluated for vehicles tested under the EuroNCAP test program. Additional analysis focuses on front impact and side impact police reported crashes and evaluates the relationship between EuroNCAP test results and injury outcome in police reported crashes for each of these crash types in Great Britain.

Results using the combined German and UK real world crash data point to improving average vehicle crashworthiness with increasing EuroNCAP star rating. Analysis of the component measures of the crashworthiness metric shows this result stems from an association between average injury severity and overall EuroNCAP star rating and not the injury risk component of the crashworthiness measure. Comparison of average crashworthiness ratings based on frontal impact crashes within EuroNCAP offset frontal impact star rating categories showed no trends whilst a strong association between average crashworthiness in side impact crashes and the side impact EuroNCAP score was observed.

INTRODUCTION AND AIMS

The Australian NCAP program has been assessing the relative occupant protection performance of vehicles through a crash barrier test program since the early 1990s. Around 1998, the Australian NCAP program harmonised their test protocol and scoring system with that used by EuroNCAP in Europe. A principal benefit in harmonisation was to increase the number of vehicle models rated for Australian consumers by being able to republish EuroNCAP test results in Australia alongside results of testing undertaken by ANCAP. The broad aims of both the ANCAP and EuroNCAP vehicle test programs is to pressure manufacturers into improving vehicle safety performance through providing consumer information on relative vehicle safety performance.

Assessing the relationship specifically between ANCAP results and real crash outcomes in Australia has traditionally been difficult due to the limited quantities of crash data available in a country the size of Australia. In addition, because the Australian vehicle fleet is relatively old, it takes many years to accumulate sufficient crash experience on ANCAP tested vehicles to undertake a meaningful analysis. Since ANCAP is fully harmonised with EuroNCAP, using much larger European real crash databases to assess the relationship between EuroNCAP assessment of relative vehicle safety and real crash outcomes was considered an appropriate way to achieve a meaningful analysis in a shorter time frame. It was considered that results of a European analysis would still be relevant and interpretable in the context of the ANCAP program.

Consequently, the broad aim of this study was to assess the relationship between EuroNCAP test results and risk of serious injury in real world crashes as measures from the analysis of injury outcomes in police reported crashes in Europe. The feasibility and potential for undertaking the study using extensive European police reported crash databases has been shown by Newstead et al (2001). Assessment has been made at two levels. Firstly, the overall EuroNCAP test score has been compared with serious injury risk from crashes of all types. This analysis aimed to assess how well he overall EuroNCAP score represented serious injury risk in the full range of real world crash configurations. Secondly, the relationship between EuroNCAP scores for the specific crash configurations used in the test protocol and serious injury risk in real world crashes of comparable configurations has been assessed.

This paper summarises the representative key results of a comprehensive study undertaken as part of the European Commission funded SAfety Ratings Advisory Committee (SARAC) research program (Newstead et al, 2006).

DATA SOURCES

EuroNCAP Test Results

The EuroNCAP Executive supplied EuroNCAP data for use in this study covering all tests completed up to mid 2003. Results supplied from the EuroNCAP program covered the two main test procedures comprising the program. These were the 64km/h 40% offset barrier test and the 50km/h side impact test using 950kg mobile barrier. Pole test results and pedestrian impact test outcomes were also supplied but not used in the study. For details of the test protocols and scoring systems see Hobbs et al(1999) and Williams(1997). Test results were available for a total of 138 different vehicle models. Analysis in this study focused on the overall EuroNCAP score out of 32 points derived from the offset frontal (16 points) and side impact (16 points) tests, the star rating category calculated from this as well as the individual offset frontal and side impact scores.

British Real Crash Data

The STATS19 database covering all crashes in Great Britain reported to Police over the period 1993 to 2001 was supplied by the UK Department for Transport (DfT – formerly the Department of Environment, Transport, and the Regions - DETR) for use in the study. Full details of that data are provided in Newstead et al(2001) and DETR(2000). Generally, only crashes involving injury are reported to police in Great Britain. After selecting passenger cars only, complete information for the variables required for analysis (driver age, driver sex, junction type, point of impact and speed limit of the crash site) was available for 1,635,296 crashes. Estimation of injury risk considered 973,613 two-car crashes whilst estimation of injury severity considered a total of 775,972 injured drivers.

Crashed vehicles with primary impact to specific areas of the vehicle could be identified in the British data using the "1st Point of Impact" variable in the vehicle section of the database. Selecting from the final data set described above, 551,841 crashes were available for use in the estimation of driver injury risk for front impact crashes. Estimation of the injury severity measure for front impact crashes involved the analysis of 411,691 cases. For side impact crashes 129,639 were available for use in the estimation of driver injury risk whilst injury severity was estimated from 137,433 injured drivers.

Vehicle models for comparison with EuroNCAP test results were identified in the British crash data through use of the detailed make and model codes appearing in the British data and information from WhatCar?(2004) on vehicle model details.

German Real Crash Data

In Germany, every road accident attended by the police must be reported and is recorded in a database held at the German Federal Statistical Office. There are no strict injury criteria for inclusion in the database and accidents involving material damage or slight personal injuries are included where the accident was reported to the police. A copy of this database for the period 1998 to 2002 was supplied for use in this study.

The data covered 804,589 two-car and single vehicle crashes with complete information concerning the variables required for analysis. Estimation of injury risk considered 364,939 two-car crashes. Estimation of injury severity considered a total of 273,421 injured drivers involved in either single vehicle or two-car crashes. Information on the primary point of impact on the vehicles was not sufficient to identify front and side impact crashes with certainty. Therefore, analysis of these crash types could not be conducted using the German data. Vehicle models for comparison with EuroNCAP test results were identified in the German crash data using a method developed by the BaST on the basis of variables describing vehicle make and model that were available in the data.

METHODS

Vehicle Safety Measures Based on Real Crashes

The real crash measure estimated is the risk of serious injury (including death) to a vehicle driver given involvement in a crash where at least one person was injured. It is computed as a product of two components, the first being the risk of driver injury given involvement in an injury crash, the second being a risk of serious injury given that some level of injury to the driver was sustained. Separate sets of real crash measures were estimated based on all crash types, frontal impact crashes and crashes to the driver's side of the vehicle. This approach to representing real crash outcomes has been used successfully in previous studies correlating real crashes with NCAP-style barrier crash test results from Australia and the USA (Newstead and Cameron, 1999; Newstead et al, 2003).

The measure of serious injury risk in police reported crashes was estimated as a product of injury risk and injury severity measures. The injury risk measure is a modified version of that used by the DfT to estimate vehicle passive safety ratings in the UK and is based on the analysis of crashes between two light passenger vehicles. The injury severity measure is similar to that used by the Monash University Accident Research Centre in producing vehicle safety ratings in Australia and is based on the analysis of both multi vehicle and single vehicle crash outcomes. Both components were estimated using logistic regression analysis, adjusting for the influence of driver sex and age, point of impact on the vehicle, road junction type, and speed limit or level of urbanisation, along with first and higher order interactions between these factors. In addition, estimates of injury severity were adjusted for the number of vehicles involved in the crash. When the two components were multiplied, they represented the risk of serious injury to drivers, a measure commonly used internationally for rating cars in terms of their crashworthiness. A broad description of the methods can be found in Newstead et al (2004).

Methods of Comparing Real Crash Injury Measures with EuroNCAP Scores

Analysis has focused on examining the average crashworthiness ratings derived from the police reported data of vehicles within each overall star-rating category assigned by the EuroNCAP test program. Lie and Tingvall (2000) have used this approach to make basic comparisons of real crash outcomes in Sweden with EuroNCAP test results. Comparison was made for each crash type considered in the real crash data with specific comparisons between the frontal crash ratings and the offset frontal EuroNCAP test results and the side impact crash ratings and side impact test EuroNCAP score. Previous work has highlighted the relationship between vehicle mass and real crash outcome, with vehicles of higher mass generally having better real crash ratings. In contrast, the EuroNCAP score is purported to be independent of vehicle mass. Therefore, analysis including vehicle mass as an extra predictive term in the logistic regression has been conducted to remove the effect of vehicle mass from the analysis.

As well as examining the average injury outcome in police reported crashes within each EuroNCAP star rating, comparisons have also been made on a vehicle by vehicle basis. Comparisons on this basis were made graphically with the underlying EuroNCAP score from which the overall star ratings is derived plotted against the crashworthiness ratings calculated from the police reported data. Comparisons have been made for all crash types as well as for frontal and side impact crashes.

RESULTS

Real Crash Based Ratings for EuroNCAP Tested Vehicle Models

Of the 138 EuroNCAP crash tested vehicle models available for use in this study, there were 70, vehicles with sufficient British and German real crash data from all crash types and 54 and 23 vehicle models with sufficient British real crash data in frontal impact crashes and side impact crashes respectively to be included in the analysis.

Comparison of Average Real Crash Safety Ratings and Overall EuroNCAP Star Ratings

Logistic Regression Analysis

In this study the overall EuroNCAP score and corresponding star rating are calculated based on the driver dummy measurements in the EuroNCAP test only to ensure compatibility with the real crash ratings that relate to driver injury outcome only. The EuroNCAP score is calculated out of 32 possible points – 16 points from the offset frontal crash test and 16 from the side impact crash test. Each vehicle starts with 32 points and points are deducted for high crash test dummy loadings over the 4 body regions assessed or for poor structural performance of the vehicle during each crash test. The vehicle is then given a star rating according to which quartile of the 32 point range the vehicle scored in, with 1 star representing poorest performance and 4 stars representing the best performance. Later EuroNCAP tests included an optional side impact pole test which allocated a further 2 points and a fifth star category. However, only a few of the vehicle models assessed in this study had undergone this test so it was not considered.

Average real crash outcomes in all crash types have been estimated within each EuroNCAP star rating category for each of the real crash outcome measures (crashworthiness, injury risk and injury severity). Table 1 parts a, b, and c show average crashworthiness, injury risk and injury severity respectively for all vehicle models within each EuroNCAP overall star rating category with sufficient real data to be included in the analysis. Comparisons with and without mass adjustment of the real crash measures are given in each table.

The percentages in Table 1a are the estimated average proportions of driver deaths or serious injuries amongst those in reported injury crashes for vehicles within each EuroNCAP star rating category. As described in the Method section, the estimates are adjusted, as far as possible, for differences between vehicles in non-vehicle factors influencing injury outcome. Similarly, the percentages in Table 1b represent the adjusted proportion of injured drivers in injury crashes whilst the percentages in Table 1c represent the adjusted proportion of dead or seriously injured drivers amongst injured drivers. A 95% confidence limit is shown for each estimate.

Table 1a. Crashworthiness estimates and 95% confidence limits across EuroNCAP star rating categories both with and without mass adjustment.

Crashworthiness Ratings								
	All Crash Types (with mass adjustment)				All Crash Types (without mass adjustment)			
	Overall Star Rating				Overall Star Rating			
	1	2	3	4	1	2	3	4
Estimate	8.22%	7.08%	7.28%	6.85%	9.24%	6.92%	7.02%	6.45%
LCL	7.67%	6.85%	7.04%	6.55%	8.66%	6.70%	6.79%	6.17%
UCL	8.79%	7.33%	7.52%	7.16%	9.84%	7.16%	7.25%	6.74%

Table 1b. Injury risk rating estimates and 95% confidence limits across EuroNCAP star rating categories both with and without mass adjustment.

Injury Risk Ratings								
	All Crash Types (with mass adjustment)				All Crash Types (without mass adjustment)			
	Overall Star Rating				Overall Star Rating			
	1	2	3	4	1	2	3	4
Estimate	64.38%	64.95%	65.26%	66.11%	70.51%	63.59%	63.31%	62.99%
LCL	62.83%	64.27%	64.60%	65.27%	69.15%	62.91%	62.64%	62.15%
UCL	65.90%	65.62%	65.92%	66.94%	71.84%	64.27%	63.97%	63.83%

Table 1c. Injury severity estimates and 95% confidence limits across EuroNCAP star rating categories both with and without mass adjustment.

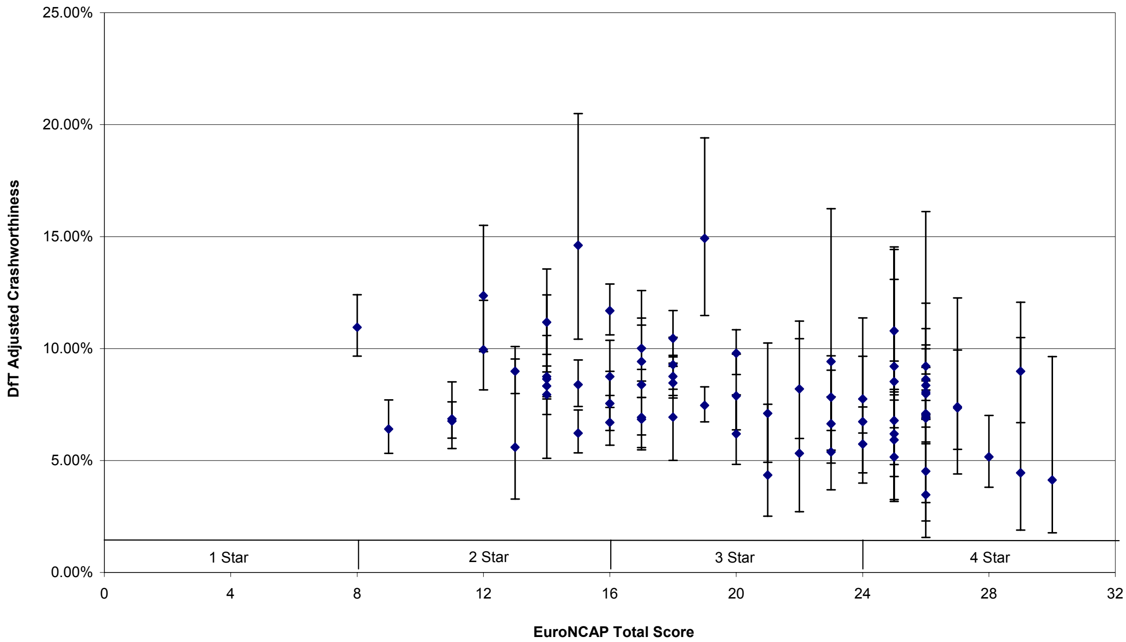
Injury Severity Ratings								
	All Crash Types (with mass adjustment)				All Crash Types (without mass adjustment)			
	Overall Star Rating				Overall Star Rating			
	1	2	3	4	1	2	3	4
Estimate	12.76%	10.82%	11.10%	10.28%	13.09%	10.77%	11.01%	10.15%
LCL	11.78%	10.41%	10.68%	9.75%	12.13%	10.36%	10.60%	9.64%
UCL	13.82%	11.26%	11.54%	10.84%	14.11%	11.20%	11.44%	10.68%

Table 1a shows the average crashworthiness for the 1 star rated cars is significantly worse than that of the 2, 3 and 4-star rated cars which are not significantly different from each other. Statistical significance in the difference between the estimated injury percentages is tested by assessing whether the 95% confidence intervals on the estimates being compared overlap. No overlap indicates a statistical significant difference. Conducted in this way, the significance test is equivalent to a two sided t-test at the 5% level of significance. There is some indication that 4 star cars have average crashworthiness less than 2 and 3 star rated cars, however, this results is only marginally statistically significant. Comparison of results in Tables 1b and c show the general association between EuroNCAP score and crashworthiness observed in Table 1c appears to stem from an association between average injury severity in real crashes and the overall EuroNCAP score category. No general association between injury risk and EuroNCAP score was observed.

<u>*Comparison by Individual Vehicle Models*</u>

Figure 1 below shows overall EuroNCAP scores plotted against crashworthiness estimated from all crash types. There is evidence of significant differences in the police reported crash measures between vehicle models within the same EuroNCAP star rating and between vehicle models with almost the same overall EuroNCAP rating score from which the star ratings are derived. This is demonstrated by the non-overlapping confidence limits on the police reported crash measures between pairs of vehicles within the same overall star rating category. Although not shown, this pattern was also observed in the component measures of injury outcome making up the crashworthiness measure.

Figure 1. Overall EuroNCAP test score vs. crashworthiness based on all crash types



This result suggests there are other factors, apart from those summarised in the overall EuroNCAP score that are determining injury outcomes as reported by police. These other factors are also different from those that have already been compensated for in the estimation of the police reported crash based ratings, such as driver age and sex and speed limit at the crash location.

Results by Crash Configuration

Comparison of average crashworthiness ratings based on frontal impact crashes within EuroNCAP offset frontal impact star rating categories showed no trends. This was the case when examining either the average crashworthiness rating or its injury risk or injury severity components. For illustrative purposes this is shown in Table 2 below for estimates of crashworthiness based on British data.

Table 2. Average frontal impact crashworthiness and 95% confidence limits by EuroNCAP frontal impact star rating categories: with and without mass adjustment.

Crashworthiness Ratings								
	Front Impact Crashes (with mass adjustment)				Front Impact Crashes (without mass adjustment)			
	Front Impact Star Rating				Front Impact Star Rating			
	1	2	3	4	1	2	3	4
Estimate	7.30%	7.45%	7.63%	7.71%	7.46%	7.91%	7.31%	7.41%
LCL	6.99%	7.15%	7.26%	7.18%	7.14%	7.61%	6.96%	6.91%
UCL	7.63%	7.77%	8.02%	8.27%	7.79%	8.23%	7.68%	7.96%

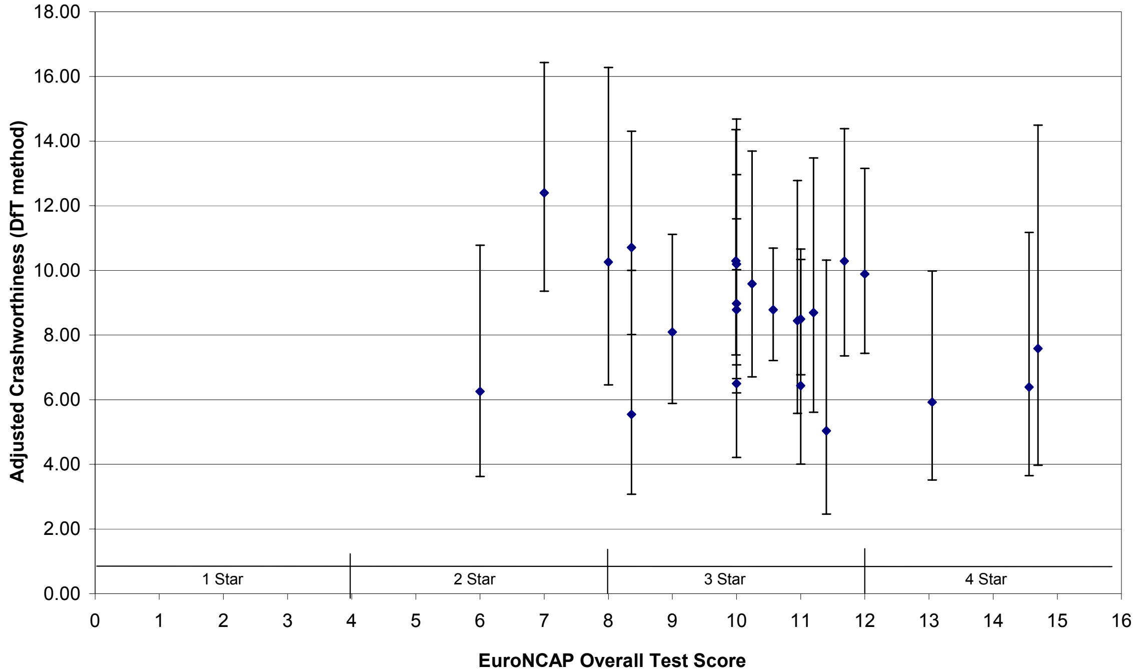
Overall, these results suggest there is little if any association between the results of the EuroNCAP offset frontal impact test and injury outcomes to drivers in frontal crashes reported to police as measured by crashworthiness. In contrast to the frontal impact test, a strong association between average crashworthiness in side impact crashes and the side impact EuroNCAP score was observed in the British data (Table 3).

Table 3. Average side impact crashworthiness and 95% confidence limits by EuroNCAP side impact star rating categories: with and without mass adjustment.

Crashworthiness Ratings								
	Side Impact Crashes (with mass adjustment)				Side Impact Crashes (without mass adjustment)			
	Side Impact Star Rating				Side Impact Star Rating			
	1	2	3	4	1	2	3	4
Estimate		10.68%	9.09%	6.89%		10.81%	9.14%	6.77%
LCL		9.33%	8.20%	5.80%		9.45%	8.25%	5.71%
UCL		12.20%	10.06%	8.15%		12.33%	10.11%	8.00%

Interpreting the point estimates of the analysis revealed an approximate 20% drop in average side impact serious injury risk measured from the police reported data with every increase in EuroNCAP side impact star rating category. Analysis of results shows the association with the side impact crashworthiness rating stems largely from the association between average side impact injury severity and side impact EuroNCAP rating. However, comparisons between side impact crashworthiness ratings and side impact EuroNCAP scores on a vehicle by vehicle basis shows significant dispersion suggesting that a high EuroNCAP score is not associated with good side impact crashworthiness and vice versa for all vehicle models (Figure 2).

Figure 2. Side Impact EuroNCAP test score v Adjusted side impact crashworthiness



DISCUSSION

In many aspects, the results of this study hold many similarities to the results of the Pilot study of Newstead et al (2001) carried out under Phase I of the SARAC research program. However, in comparison to Phase I of the SARAC research program, this study is based on much larger quantities of police reported crash data from a wider range of countries with results based on the analysis of up to 70 EuroNCAP tested vehicle models. As such this study provides a much more definitive assessment of the relationship between EuroNCAP test scores and injury outcomes recorded in police reported crash data. The results of this study are also consistent with results of other similar studies comparing real crash outcomes and the results of crash barrier test programs conducted world-wide.

Like most of the previous studies of this type, there are number of limitations to the study that should be noted. There are always concerns when analysing police reported crash data about the accuracy of the data, specifically with the assessment of injury outcome. To attempt to overcome this problem, this study has analysed average injury outcome over many crashed vehicles of each type. Whilst this will compensate for specific reporting errors it will not compensate for systematic biases in data recording. However, for the data sources analysed it is felt that any systematic bias will not be large in the size of the sample analysed and will almost certainly not be related to vehicle model where it would have the most significant effects on the analysis outcome. The analysis is also limit by the resolution of the injury outcome scale available in police data. If EuroNCAP is reflecting relative injury outcome between vehicles on a scale not reflected in the police injury outcome scale this could explain to some degree the lack of strong association between the measures, particularly on a vehicle by vehicle basis. This aspect could only be investigated using an alternative database that facilitated that calculation of different injury outcome scales, such as AIS or ISS. It is not clear whether such a database exists with sufficient number of cases to facilitate meaningful analysis.

Given EuroNCAP, or ANCAP, does not select vehicles for testing at random but rather on the basis of popularity, there is some concern about the effects of selection bias. It is possible that the real crash performance of the tested vehicles in each EuroNCAP star rating class might be different to that for other vehicles in the fleet that would fall into each rating class but have not been assessed. It is difficult to assess the potential effects of selection bias on analysis conclusions. The best way to establish the effects would be to update the analysis after further vehicles are tested by NCAP to assess whether the results are robust.

One of the main motivations for undertaking this study was to assess the relationship between ANCAP and real world crash outcomes. As noted, harmonisation of ANCAP with EuroNCAP allowed European real crash data sources more extensive than those available in Australia to be analysed. It also provided a wider range of barrier tested vehicle models to be included in the analysis than if only Australian data was examined. Both lead to a study providing more definitive results. Since there is no question about the consistency of the ANCAP and EuroNCAP test protocols, the ability to generalise the results of this analysis to represent the Australian context relies on how representative the European crash data sources are of real crash outcomes in Australia. Injury outcome scales used in Australian police reported crash data are very similar to those used in Germany and Great Britain, as are the range and coding of other variables describing the crash. Although the mix of crash types in European countries are typically different to those found in Australia, this was not considered a particular problem for generalisation of the study results since the estimates of real crash outcomes are standardised for non-vehicle factors, including broad crash type. Although only injury crashes are reported in Great Britain and Germany, the relationships between EuroNCAP and real crash outcomes were largely driven by relative injury severity outcomes in real crashes, a measure not affected by the reporting criteria. Hence there is reasonable confidence that the results of this study obtained from European crash data are applicable to the Australian context.

In drawing final conclusions from this type of analysis it is interesting to revisit the philosophy of the EuroNCAP program. According to those involved in EuroNCAP, the principal purpose of the program is to apply pressure to vehicle manufacturers to improve the safety design and specification of vehicles. Reflecting the aims of the program, the scoring system for EuroNCAP is not designed to necessarily represent an injury risk outcome scale. Instead, the various test measurements are weighted according to how highly it is desired to influence manufacturers on each aspect of vehicle design. Recognising the nature of the EuroNCAP scoring process, a linear relationship between injury outcomes in real world crashes and the EuroNCAP score would not necessarily be expected. However, given the aim of EuroNCAP is to improve vehicle safety generally, a general association between improving crashworthiness and higher EuroNCAP scores would be expected. Considering the analysis of real crash outcomes as the most suitable way of assessing the effectiveness of the EuroNCAP program in meeting its aims, results of this study confirm this general association with average real crash outcomes being better in vehicles with higher EuroNCAP scores than in ones with low scores. Results also confirm that this association is non-linear as expected.

Interpreted in this way, results of analysis in this study indicate that the design priorities for vehicle safety encouraged by the EuroNCAP scoring process are leading to improved real world crash performance on average. Importantly, comparisons suggest that improvement is greatest in the higher severity real world crashes. However, the improvement in real world injury outcome from one EuroNCAP star rating category to the next appears not to be linear. In addition, the results of comparison on a vehicle by vehicle basis also show that achieving these design priorities does not always lead to a safer vehicle. This result suggests that EuroNCAP is not necessarily encapsulating all the factors required to ensure good safety performance in a vehicle. Alternately, it is allowing vehicles to score well on a combination of factors that have relatively low effectiveness in improving real world safety. Whether the EuroNCAP test process can or should be modified to overcome this to some degree remains to be determined.

A lack of absolute consistency between EuroNCAP ratings and crashes based on real world data on a vehicle by vehicle basis is only problematic if ratings from the two systems are presented side by side for consumer information. Fortunately this is rarely possible because of the nature of the ratings. Ratings based on real world data typically lag those published by EuroNCAP by many years as real world crash experience accumulates by which time the EuroNCAP test protocol has often been modified and is not directly comparable.

As noted, EuroNCAP is seen as a tool for driving safety change in vehicle design and providing information to consumers on relative safety at the time of vehicle release.

In contrast, vehicle safety ratings based on real world data are seen as a tool to evaluate the long term safety of vehicles in the full range of real world circumstances. As shown by this study, real world ratings also provide a means to assess whether EuroNCAP testing is achieving its stated aims in improving vehicle safety and to help fine tune the program in future. Viewed as such, both ratings systems have a defined and non-conflicting role in advancing vehicle safety.

CONCLUSIONS

This study has been able to quantify the relationship between injury outcomes in real world crashes reported to police and estimates of relative vehicle safety derived from the EuroNCAP and ANCAP vehicle crash barrier test program. Results point to improving average vehicle crashworthiness with increasing EuroNCAP star rating. When considering specific EuroNCAP test components, comparison of real world injury outcomes to drivers in frontal crashes with EuroNCAP offset frontal ratings showed little if any association. In contrast, a strong association was found between average crashworthiness in side impact crashes and the side impact EuroNCAP score with an approximate 20% drop in average side impact serious injury risk with every increase in EuroNCAP side impact star rating category

Examination of the relationship between overall EuroNCAP test score and injury outcome on an individual vehicle basis showed that whilst there is and association between average vehicle crashworthiness and EuroNCAP score outcome, there is significant variation in the measures of injury outcome in real crashes for specific vehicles within each EuroNCAP score category. It shows that a vehicle with good average real world crash outcomes does not always perform well in EuroNCAP testing and vice versa. Similar conclusions were drawn from vehicle specific comparisons when examining individual crash types.

Despite the inconsistencies on a vehicle by vehicle comparison, it is concluded that, on average, relative vehicle safety ratings from the EuroNCAP system, and by association ANCAP, correlate with the relative risk of serious injury in real world crashes and hence promote safer real world vehicle design.

REFERENCES

DETR (2000) STATS20 *Instructions for Completion of Road Accident Report Form STATS19*, Department of Environment Transport and the Regions, London, UK.

HOBBS, C.A., GLOYNS, P.F. and RATTENBURY, S.J. (1999), *European New Car Assessment Programme (EuroNCAP) Assessment protocol and biomechanical limits, Version2.* Transport Research Laboratory, Crowthorne, UK.

LIE, A. AND TINGVALL, C. (2000), *How does the EuroNCAP test results correlate to real life injury risks – paired comparison study of car to car crashes.* Proceedings of the 2000 IRCOBI conference, Montpellier, France.

NEWSTEAD, S., and CAMERON, M. (1999), *Updated Correlation of Results from The Australian New Car Assesment Program with Real Crash Data from 1987 to 1996.* Report no. 152, Monash University Accident Research Centre, Melbourne, Australia.

NEWSTEAD, S., CAMERON, M., and NARAYAN, S. (2001). *Pilot study of correlation of data from real-world accidents and crash tests in Europe* Report on Sub-Task *2.2*, CEA/EC SARAC Quality Criteria for the Safety Assessment of Cars Based On Real World Crashes, Project No. B99-B2 7020-10-512.5661/P B 3 99 17/SUB CEA, Paris, France.

NEWSTEAD, S. V., FARMER, C. M., NARAYAN, S., and CAMERON, M. H. (2003). "U.S. consumer crash test results and injury risk in police reported crashes." *Traffic Injury Prevention*, 4, pp. 113-127.

NEWSTEAD, S., CAMERON, M. and WATSON, L. (2004), *Vehicle crashworthiness and aggressivity ratings and crashworthiness by year of vehicle manufacture: 1987-1992 data from Australia and New Zealand* Report No. 222, Monash University Accident Research Centre, Melbourne, Australia.

NEWSTEAD, S., DELANEY, A., CAMERON, M. AND WATSON, L. (2006) Study of the relationship between injury outcomes in police reported crash data and crash barrier test results in Europe and Australia, Report on Sub-Tasks 2.1 and *2.2*, CEA/EC SARAC Quality Criteria for the Safety Assessment of Cars Based On Real World Crashes, Project Number: SUB/B27020B-E3-S07.17321-2002

WhatCar? (2004), *WhatCar? Used Car Price Guide May 2004.* WhatCar?, England.

WILLIAMS, D.A. (1997) *European New Car Assessment Programme (EuroNCAP) Testing Protocol Version 1.2* Unpublished project Report PR/SE/249/97, Transport Research Laboratory, Crowthorne, UK.