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Comparative Accident Rates of Vehicles Equipped with Stability Control – Field Experience

Abstract

This paper uses the national accident statistics of Great Britain to evaluate the effectiveness of Electronic Stability Control Systems (ESC) to reduce crash involvement rates. The crash experience of 8,951 cars is analysed and compared to a closely matching set of non-ESC cars using case-control methods. This is one of the largest ESC samples analysed to date. Overall the cars with ESC are involved in 3% fewer crashes although the effectiveness is substantially higher under conditions of adverse road friction. ESC equipped cars are involved in 15% fewer fatal crashes although this reduction represents the combined effect of ESC and passive safety improvements.

Introduction

The introduction of new active safety technologies promises substantial future reductions in vehicle collisions, by reducing overall crash numbers fatalities, injured road users and property damage can potentially be reduced. Some systems may merely aid the driving task increasing driver comfort levels and enhancing the driving experience. Other systems can have an advisory function and feed information to the driver on road conditions and route directions for example. Additionally they may take control over aspects of the operation of the car modifying the dynamic performance in response to road conditions. When introducing a new system that has the intention of improving safety it is important that these systems are targeted to achieve high levels of casualty reduction to ensure that consumer expectations are fulfilled and confidence is maintained. Analysis of high frequency and high risk crash conditions can give clear prioritisation of the functionality of new technologies before they enter the car fleet on the road. Once on the road in sufficient numbers it is important to measure the true casualty reduction effectiveness in order to confirm the value of the technology and to avoid high profile technologies with little real-world value.

New technology systems are normally designed to operate under a range of driving conditions and this can determine the evaluation method. While it can be gratifying to have high effectiveness values in certain conditions, if these conditions are relatively rare there may be little overall effect. For that reason it is necessary to evaluate the overall effectiveness, the effectiveness under specified conditions and the exposure to those conditions as part of the same evaluation. In the absence of suitable multi-centre studies evaluation has to take place when the numbers of equipped vehicles are large in a particular country or study area. The more effective the system the more difficult it is to evaluate.

Electronic stability control (ESC) is a system that modifies the vehicle dynamics to reduce the incidence of over-steer and under-steer and hence reduce loss of control crashes. There have been evaluations of the system effectiveness but mostly these address the design conditions excluding the overall effect (BECKER [1],AGA and OKADA [2],FARMER [3], and DANG [4]). This analysis uses the UK National Accident Database STATS 19 to evaluate the overall casualty reduction effectiveness of ESC together with the exposure to a variety of real-world conditions.

Crash Data

Crashes occurring in Great Britain, resulting in injury and reported to the police are entered onto the national register called STATS 19 [5]. The data for 2002–2004 has been combined electronically with vehicle licensing information so that the make, model, variant and manufacture year is known. The data were further enhanced with details extracted from standard car data texts [6] and the final dataset comprised 890,648 cars of which 8,685 were equipped with ESC. This represents one of the largest datasets available for this type of analysis.

The analysis utilises a case-control approach based on methods of induced exposure [7]. A set of case vehicles was defined so that each car was known to have been equipped with ESC. Models where the equipment was optional were excluded from the case vehicle group. A comparable group of

control car models was defined and in general the previous version of a case vehicle not equipped with ESC was selected. There were 41,318 control cars in the dataset. In some cases ESC was first introduced to relatively high performance variants of a model so the control vehicles were themselves the previous unequipped high performance variants. It should be noted that the case-control method compares the two groups of vehicles in total and thus any differences in crash risk reflect all of the differences between the case and control cars. Cars equipped with ESC will also have anti-lock braking systems (ABS) and probably traction control as these functions can be achieved by the same software and hardware, also a more recent model may have other improvements to the suspension and handling performance that are not identified and the case control method is not able to separate out these effects. Previous examinations on the effectiveness of ABS have shown the effects to be small e.g. EVANS [8] and this analysis makes the assumption that differences in crash involvement between case and control cars are predominantly due to the presence of ESC.

The case control approach also requires a set of crash types where there is an expectation that ESC will have no effect to be used as a control group. If the control crashes are sensitive to the presence of ESC then its effectiveness may be under- or over-estimated. The GB STATS 19 data includes several categories of vehicle manoeuvres where one car was essentially stationary before the crash and these were selected to be the control group of manoeuvres. These are listed in Table 1 together with the other collision types in the case group where ESC is not assumed to have no effect.

Using the case-control methodology the cars in the sample are distributed between the four case-control categories as shown in Table 2.

It should be noted the case-control method does not assume that vehicles are in the same collision. The case control method calculates the odds of a case car being involved in the two crash types (Eq. 1) and the odds ratio is used to compare the two groups of cars (Eq. 2). The effectiveness of ESC is defined in (Eq. 3) and the standard deviations are given in (Eq. 4).

$$\text{Odds}_{ESC}\left(\frac{Control}{Case}\right) = \frac{N_{00}}{N_{01}} \qquad [1]$$

Control Manoeuvre types (assumed no ESC effect)	Other Manœuvres (ESC effect possible)
Reversing	U turn
Parked	Turning left
Waiting to go ahead but held up	Turning right
Stopping	Changing lane to left
Starting	Changing lane to right
Waiting to turn left	Overtaking moving vehicle on its offside
Waiting to turn right	Overtaking stationary vehicle on it's offside
	Overtaking on nearside
	Going ahead left hand bend
	Going ahead right hand bend
	Going ahead other

Table 1: Case and control collision types

	Control manoeuvre types	Other manoeuvre types
Case vehicle (ESC)	N_{00}	N_{01}
Control vehicle (no ESC)	N_{10}	N_{11}

Table 2: Case and control contingency table

$$\text{Odds ratio} = \left(\frac{Odds_{ESC}}{Odds_{noESC}}\right) = \frac{N_{00}}{N_{01}} \bullet \frac{N_{11}}{N_{10}} \qquad [2]$$

$$\text{Effectiveness}_{ESC} = (1-\text{Odds ratio}) \bullet 100\% \qquad [3]$$

$$SD = \text{Odds ratio} \bullet \exp\left(\sqrt{\frac{1}{N_{00}} + \frac{1}{N_{10}} + \frac{1}{N_{01}} + \frac{1}{N_{11}}}\right) \qquad [4]$$

These methods were used to evaluate the effectiveness of ESC in reducing crashes under a range of collision circumstances and for a range of injury severity outcomes.

Results

The UK accident data record the severity of the injuries sustained in the crash. Fatal crashes include at least one casualty that has died within 30 days of the crash, seriously injured casualties have sustained at least a fracture or have been detained in hospital at least overnight while slightly injured casualties have sustained lower severity injuries, normally lacerations and contusions. The distribution of accident severity in the data is shown in Figure 1.

Figure 1 shows that 88% of all crashes involved casualties which sustained only slight injuries while casualties were killed in only 1%. The reductions of these casualties in vehicles equipped with ESC are shown in Figure 2 for all crashes, crashes where a car occupant was either killed or seriously injured (KSI) and fatal crashes. Overall ESC equipped cars were involved in 3% fewer crashes than non-equipped vehicles but KSI crashes were 19% lower and fatal crashes were 15% lower, although this result was not statistically significant.
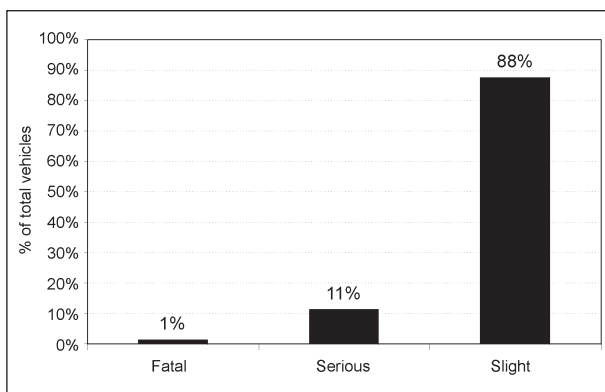
Figure 1: Accident severity
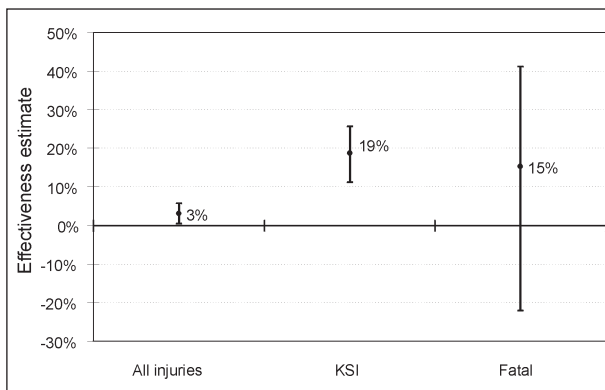
Figure 2: Reduction in crash rates for ESC equipped cars
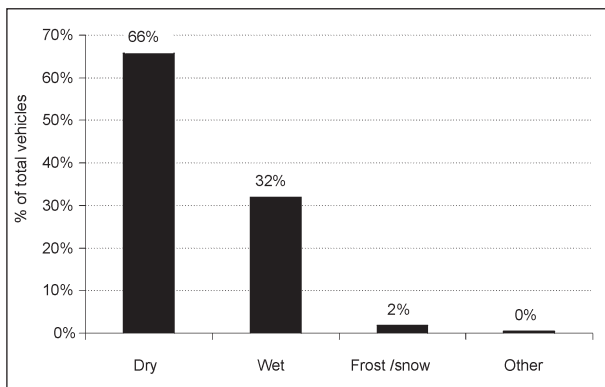
Figure 3: GB crashes and road surface conditions

Road surface conditions

ESC systems are intended to give benefit under poorer road surface conditions where friction is reduced such as wet or icy. The frequency these conditions occur under normal driving depends on the prevailing climate and local conditions. Figure 3 shows the proportion of accident occurring in the GB on dry, wet and snow/icy road surfaces. The majority, 66%, of crashes took place on dry roads while ice and snow was a factor in only 2%.

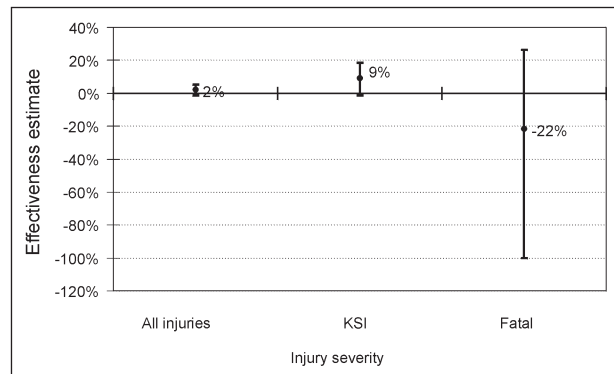Figures 4 to 6 show the effectiveness of ESC for each accident severity level on each condition of road surface.

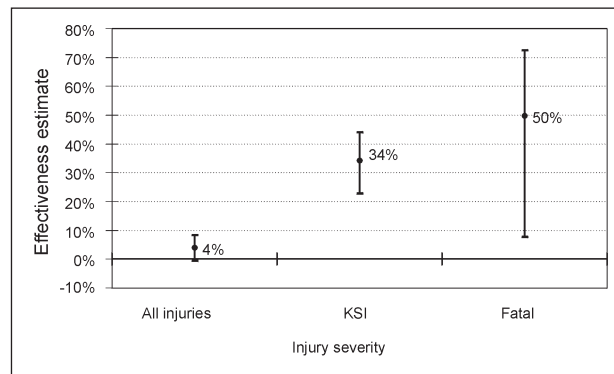**Figure 4:** ESC effectiveness on dry roads

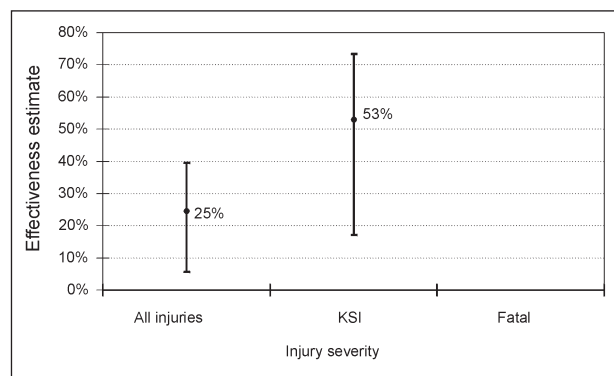**Figure 5:** ESC effectiveness on wet roads

Figure 6: ESC effectiveness on snow or icy roads

On dry road conditions ESC equipped cars were involved in 2% fewer crashes overall and 9% fewer KSI crashes. Fatal crashes were 22% more common although none of these changes was statistically significant.

On wet roads ESC systems showed lower involvement rates for crashes of all severities. Fatal crashes showed a 50% reduction while KSI crashes were 34% fewer.

On snow or icy road conditions ESC equipped cars had substantially fewer crashes. Overall there were 25% fewer crashes while KSI crashes were reduced by 53%. There were insufficient cases to evaluate fatal crash reductions of ESC fitted vehicles.

Impact direction

By limiting understeer and oversteer ESC is intended to reduce loss of control collisions and it has been hypothesised that side impacts will be preferentially reduced compared to frontal collisions (REIGER et al. [9]). The GB accident data include an assessment of the first point of impact to the vehicle conducted by the police officer dealing with the crash. This assessment is not as precise as one done by trained crash investigators but it does provide an indication of the impact direction. The frequency of each point of impact is shown in Figure 7 and the reductions in crashes in front and side crashes in Figures 8 and 9.

The car front was the first point of impact of 48% of the cars in the GB accident data while 24% of impacts were to the side of the car.

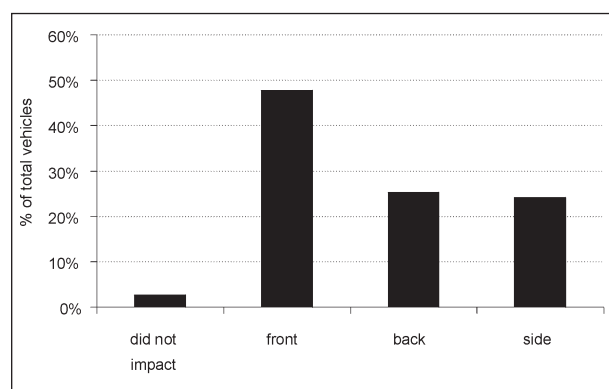Frontal collisions of all severity levels were 10% lower in ESC equipped cars while side impacts reduced by 7%. KSI crashes were 18% lower in collisions to the front of the car and 28% lower in side crashes. Fatal crashes were 38% higher in ESC equipped cars in side impacts although there were insufficient cars to evaluate changes in frontal fatalities. None of these differences between front and side impact was statistically significant as was the apparent increase in fatalities.

Car size class

Generally the first installations of ESC equipped cars tended to be those with higher specifications. More recently the systems have been installed onto less well equipped including family cars. Each of these types of car will attract a different population of drivers and there may be differences in the effectiveness of ESC under these conditions. The size of the car was grouped according to the system used within the EuroNCAP programme and the frequency of these categories is shown in Figure 10 which also shows the total number of different models of car in each group.

It should be noted that only four different models of Superminis were equipped with ESC and all of these were high-performance versions. Therefore effectiveness results of this car size may not be
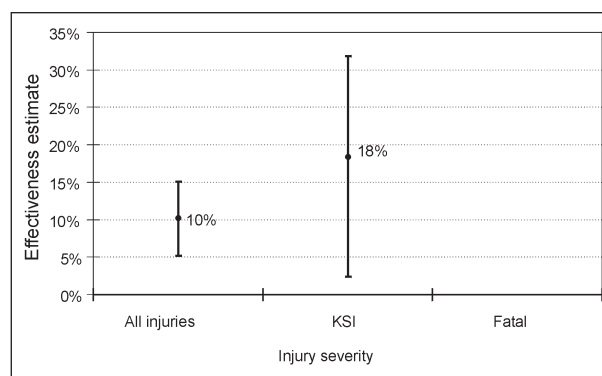
Figure 8: ESC effectiveness in impacts to the car front

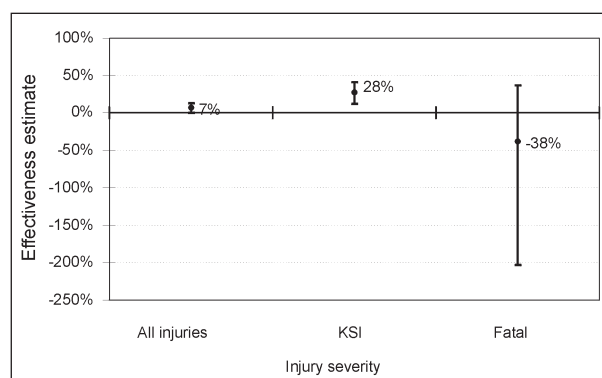**Figure 7:** Frequency of impacts to car surfaces

Figure 9: ESC effectiveness in impacts to the car side

typical of other cars in this category. The most common categories in the GB accident data were small and large family cars together representing 78% of the car fleet.

The effectiveness of ESC in reducing crashes of all injury severities in each of these car size categories is shown in Figure 11. Figure 12 shows the equivalent results for crashes involving fatal or serious injury.

Small family cars showed a non-significant increase in crash rates of 2% for the ESC equipped cars while large family cars had a 13% lower crash rate. Large off-roaders showed a 24% increase in crash rates. Small MPVs, with just one model of car,
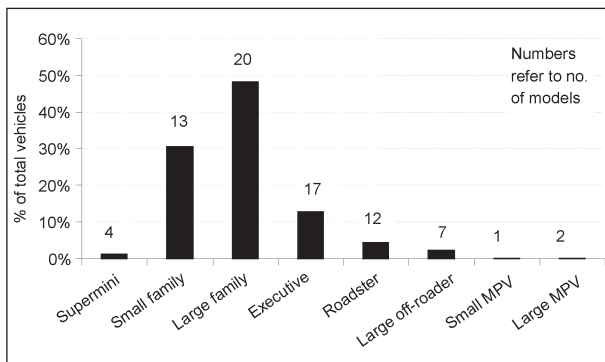
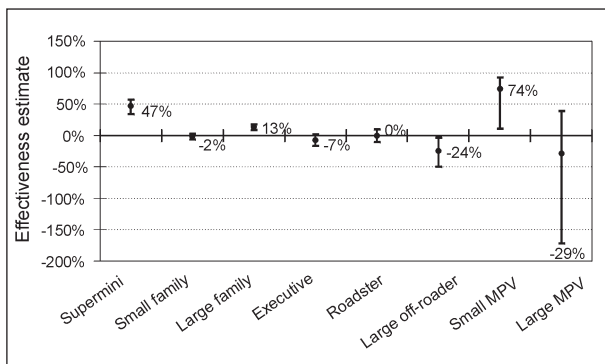**Figure 10:** Car size category and number of models

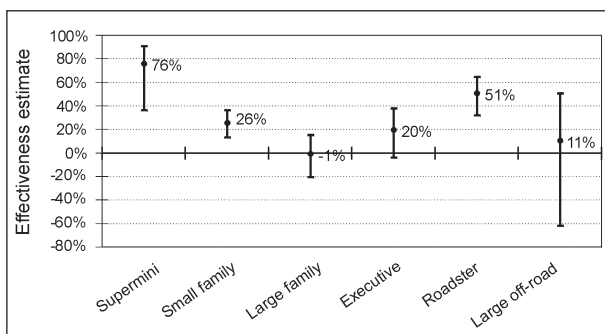**Figure 11:** ESC effectiveness in crashes of all injury severities

Figure 12: ESC effectiveness in KSI crashes

showed a 74% lower crash rate while large MPVs with 2 models showed a 29% increase.

In crashes involving fatal or serious injury small family cars had a 26% lower accident rate while large family cars showed a 1% increase. Executive cars had a 20% lower crash rate and roadsters had a 51% lower rate.

Discussion

This analysis of GB national accident data has indicated that cars equipped with ESC are involved in 3% fewer crashes overall compared to unequipped cars. This compares to 22% effectiveness in Sweden and 45% in Germany using similar methods. The analysis has shown that ESC is most effective under poor road surface conditions such as rain, snow and ice where the effectiveness increases to 25%. The data also indicates that these conditions are relatively rare in Great Britain with only 2% of crashes taking place on snow or icy roads.

Although the benefit to Great Britain from ESC does not appear to be as large as in other countries with more frequent adverse road surface conditions it is nevertheless still significant in financial terms. In 2004 there were 292,000 cars involved in crashes in GB, most of which were not equipped with ESC, these results indicate that if they had been there would have been nearly 9,000 fewer crashes. The UK Department for Transport has estimated the average cost of a crash to be £62,197 in 2004 values [10] so the total saving resulting from uniform fitting of ESC to cars is £544,845,720 (€730,093,265).

Limitations

The methodology used for this analysis, while powerful, does have a number of limitations. Most importantly, it assumes that ESC equipped cars and the control models differ only by the presence of ESC. However when a model of car is replaced by an new version a manufacturer will normally make a collection of changes. There may be other changes to the vehicle dynamics system that also reduce crash involvements – this analysis assumes this factor is negligible. If there are significant effects these will be included in the estimates of crash involvement of the group of all injury severities. In particular a manufacturer may also

make improvements to the passive safety performance of the car by modifying the structure or restraint systems. These improvements will reduce the risk of serious or fatal injury and hence the changes in the rates of these crashes in the analysis will reflect the combination of ESC and passive safety changes. Given the rapid and large improvements to passive safety the magnitude of these effects may not be negligible.

Conclusions

This analysis of the GB national accident data has shown that cars equipped with electronic stability control systems have a lower crash involvement rate than non-equipped cars. The overall reduction for crashes of all injury severity is 3% but on icy roads or snow this rises to 25% but the accident data show that only 2% of crashes occur under these conditions.

Acknowledgements

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