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Accident Analysis and Prevention 40 (2008) 167–173

ACCIDENT ANALYSIS & PREVENTION

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Effects of electronic stability control (ESC) on accidents: A review of empirical evidence

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Received 7 October 2006; received in revised form 22 March 2007; accepted 5 May 2007

Abstract

This study summarizes evidence from empirical studies on the effects of electronic stability control (ESC) on accidents in a meta-analysis. Large reductions of single vehicle accidents have been found (−49%; 95% confidence interval: [−55%; −42%]), and smaller but still significant reductions of head-on collisions (−13%; 95% confidence interval: [−17%; −8%]). Multi-vehicle fatal accidents are also significantly reduced (−32%; 95% confidence interval: [−43%; −20%]). The effects can be explained with the potential of ESC to improve driving dynamics and to reduce the probability of loss of control. However, there are significant amounts of heterogeneity in the results, especially for single vehicle accidents, and a sensitivity analysis shows that the results for single vehicle accidents are likely to be affected by publication bias. The results for single vehicle accidents are in excess of what might be expected based on studies that have estimated the total amount of accidents that may be affected by ESC. Consequently, the proportions of accidents that can be avoided by ESC is assumed to be somewhat smaller than suggested by most empirical studies. Properties of the vehicles, time trends, and driver behaviour may have contributed to the large empirical effects.

Keywords: Electronic stability control; ESC; Accident; Meta-analysis; Single vehicle accident; Head-on collision

1. Introduction

The objective of this study is to summarize empirical evidence of the effects of electronic stability control (ESC) on accidents by reviewing studies that have estimated proportions of different types of accidents that may be affected by ESC, and by calculating summary effects from studies that have investigated empirical effects of ESC on accidents by means of meta-analysis. The results are compared in order to assess the size of the effects and to provide an indication of the presence of factors that may affect the size of the effects.

Electronic stability control is an active safety device for motor vehicles which aims at improving driving dynamics and at preventing accidents which result from loss of control. There exists a large variety of ESC systems. They have in common that they enhance the controllability of vehicles and that they can prevent skidding and loss of control in cases of oversteering or understeering. These are movements of the vehicle which go beyond the steering input by the driver (oversteering) or where the vehicle does not wholly follow the drivers steering input (understeering). Both may be caused by too high speed in curves, collision avoidance manoeuvres, low friction conditions, or combinations of these (Sferco et al., 2001). ESC systems differ with respect to how they regulate driving parameters (yaw characteristics, and sideslip), how they counteract deviations (e.g. by braking individual wheels and reducing engine power), and in what way drivers take notice of the activities of the systems (Alliance of Automobile Manufacturers, 2005). ESC cannot overrun physics, and may not always prevent the vehicle from sliding or spinning (Insurance Institute for Highway Safety, 2005).

ESC was first introduced as optional safety equipment in passenger cars on the European market in 1995. Its publicity increased in 1997 after an event with a rollover of a new vehicle model in a double lane change manoeuvre on a driving course (“moose-test”). The proportion of new cars that are equipped with ESC increased steadily. In 1995, the proportion of new cars equipped with ESC was only 5% (in Germany); in 2004, the proportion was 36% in Europe, and much higher in some European countries, e.g. 67% in Germany (Deutscher Verkehrssicherheitsrat, 2006), and 70% in Sweden (according to lists published by the Swedish insurance company Folksam).

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doi:10.1016/j.aap.2007.05.002

The proportion of all vehicles that are equipped with ESC in Europe has been estimated by the European Commission (2005) to be 9% in 2005, and is predicted to reach 50% by 2025 (if no legal requirements for ESC are introduced).

In recent years, the increase in the number of vehicles for which ESC is available seems to have slowed down, but the proportion of vehicles for which ESC is standard equipment (instead of optional equipment) is still increasing according to lists published by the US-government (www.safercar.dot.gov). The proportion of new sport utility vehicles (SUVs) with ESC is increasing faster than the proportion of cars (Farmer, 2006). In 2004, nearly 70% of all new SUVs on the US-market have been equipped with ESC (Motor and Equipment Manufacturers Association, 2006). The proportion of smaller cars that are equipped with ESC is much lower, and ESC is mostly only optional, not standard equipment (Deutscher Verkehrssicherheitsrat, 2006). The costs for the installation of ESC depend on the standard of the technical equipment of a car (e.g. antilock brakes, antislip regulation, brake assistant). Estimations of costs for the installation of ESC as standard equipment vary therefore widely, between ca. $100 and $800 per vehicle (Insurance Institute for Highway Safety, 2006; NHTSA, 2006), or between €150 and €500 per vehicle (European Commission, 2005). ESC is not mandatory in any European country, but recommended by the European new car assessment programme (EuroNCAP). In the US there are plans to make ESC mandatory from 2011.

2. Potential effects of ESC on accidents

ESC aims at reducing the probability of loss of control. Loss of control often results in accidents with severe consequences (Langwieder et al., 2003; Unselt et al., 2004): road departure, collisions with objects or vehicles, or turnover. These collisions are relatively likely to be side collisions, and/or collisions with oncoming traffic. Side collisions usually have severe consequences because vehicles provide only little protection. Head-on collisions often involve high (relative) speed. Accidents may not always be avoided, but the severity may be reduced, e.g. when a side collision is replaced by a front collision, when a collision with oncoming traffic is replaced by road departure, and when impact speed is reduced. Collisions in junctions, overtaking accidents, and rear-end collisions are less likely to be prevented by ESC. Accidents which involve loss of control, but in which the driver was driving extremely fast, very sleepy, or driving under the influence of alcohol or drugs, are also less likely to be affected by ESC.Proportions of different types of accidents that might be affected by ESC have been estimated in several studies based on accident reports and in-depth accident analyses. These studies are summarized in Table 1 in order to provide a basis of comparison for results from empirical accident studies that are presented in the next section. The summary of the results in Table 1 gives a rough estimate of the magnitude of the potential effects. Accidents are usually not classified in official accident statistics according to whether or not skidding or loss of control has been a contributing factor. The study of Campbell et al. (2003) is based on a total of ca. 73,000 accidents from two US databases. Accidents of all severities are included in their analysis. In about half of all single vehicle off-road accidents, skidding has been a major contributing factor, and in about half of these accidents speeding (driving above the speed limit) has been an additional contributing factor. The study of the Insurance Institute for Highway Safety (2005) has estimated the proportions of different types of accidents that may be prevented by ESC. Langwieder et al. (2003) have analyzed reports of ca. 1500 injury accidents in Germany in order to estimate the proportions of accidents which involved skidding. Sferco et al. (2001) have investigated ca. 2700 accidents in the European accident causation survey (EACS, based on data from five European countries). They have estimated quite large amounts of accidents which involve loss of control and which may be affected by ESC. The proportion of accidents which actually may be avoided by ESC is assumed to be much smaller. The proportion of accidents which would definitely have been avoided is estimated to be 2% for injury accidents, and 3% for fatal accidents. The proportion of accidents which would probably have been avoided is estimated to be 9% for injury accidents, and 18% for fatal accidents. Unselt et al. (2004) have analysed data from a representative sample of over two million accidents in Germany in 2002 and estimated how many accidents involved

Table 1
Proportions of accidents in which contributing factors may be affected by ESC

Study	Accident contributing factor	Proportion of accidents involving contributing factor (%)		
		Single vehicle	Multi-vehicle	All
Campbell et al. (2003)	Skidding	50 (single vehicle off-road)	1 (rear-end) 8 (lane change)	
Insurance Institute for Highway Safety (2005)	ESC-relevant	56	17	34
Langwieder et al. (2003)	Skidding	39	12	
Sferco et al. (2001)	Loss of control, ESC-relevant			42 (injury accident) 67 (fatal accident)
Unselt et al. (2004)	Loss of control			21 (injury accident) 43 (fatal accident)
Zobel et al. (2000)	Skidding			44 (very severe injury accident)
Summary	ESC-relevant	40–50	10	20–40