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D4.2.1

A posteriori evaluation of Safety Functions effectiveness - Methodologies

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Author(s): Yves Page, LAB, F - Carine Rivière, LAB, F - Sophie Cuny, LAB, F - Tobias Zangmeister, TU Braunschweig, D
Participant(s): LAB - TU Braunschweig - LMS
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Abstract:

The main objective of task 4.2 in TRACE WP4 is to estimate, by means of statistical calculation, the proportion of injury accidents that could be avoided and/or the proportion of accidents which severity could be mitigated, by existing safety functions (or a combination of functions), selected from the WP6 list, would all cars be equipped with these functions that are already on the market (for instance Electronic Stability Control or Emergency Brake Assist). This kind of effectiveness is called *observed effectiveness* or a *posteriori effectiveness*.

This deliverable D4.2.1 is addressing 3 issues:

- General considerations about data needed for the evaluation
- Methodologies used to evaluate the a posteriori effectiveness of safety functions
- A simulated example

The first section of the deliverable D4.2.1 is reporting about the data needs. The second section presents different methodologies used for evaluating the effectiveness of one ore several safety functions. The last section of this report presents numerical application of the selected methodology.

Methods will then be fully applied in the second half of 2007 and the results will be presented, interpreted and discussed in Deliverable D4.2.2.

Keyword list: Evaluation - Safety Systems - Statistics - Road Accidents - Effectiveness - Safety Benefits

Table of Contents

1	<i>Executive Summary</i>	3
2	<i>Introduction</i>	5
2.1	Objective	5
2.2	Means and Challenges	6
2.3	Expected Results	6
2.4	General Methodology	7
2.5	Relations with others TRACE WP's	8
2.6	Work Plan	8
3	<i>General considerations about data</i>	9
3.1	Origin of the accident database	9
3.2	Necessary information in the accident database	9
3.3	Selection of some car models	9
3.4	Bias in the selection of cars	10
4	<i>Methodologies used to evaluate the effectiveness of safety function</i>	11
4.1	First type of methodology: comparison between observed/expected number involvement of equipped vehicles	11
4.2	Second methodology: evaluation of crash relative risk	14
4.2.1	Evaluation of one safety function	14
4.2.1.1	Via the calculation of relative risk and crude odds ratio	14
4.2.1.2	Via the calculation of an adjusted odds ratio	17
4.2.2	Evaluation of multiple safety function	19
5	<i>Data example</i>	20
5.1	Example of the evaluation of one safety function using the calculation of the odd ratio	20
5.2	Example of the evaluation of a combination of safety functions using the calculation of the odd ratio	21
6	<i>Conclusions</i>	24
	<i>References</i>	25

1 Executive Summary

In spite of countless amounts of research and development, road safety is still one of the main societal concerns today. It is not only a matter of concern for the European Commission and National Governments but also for the vehicle industry, insurance companies, driving schools, non-governmental organisations and more generally for every single road user. Car manufacturers have made strong efforts and have dramatically improved passive (and also active) safety of their vehicle for the past 15 years. However, current road safety research has shown that an asymptote is about to be reached on this aspect in most countries and many experts agree that preventive (prevention of accidents) and active safety (recovery of an emergency situation) should now, particularly, be brought forward.

In this context, the TRACE project has 2 major objectives:

The first one addresses the determination and the continuous up-dating of the aetiology (i.e. analysis of the causes) of road accidents and injuries, and the definition of the real needs of the road users as they are deduced from accident and driver behaviour analyses.

The second one aims at identifying and assessing, among possible technology-based safety functions, the most promising solutions that can assist the driver or any other road users in a normal road situation or in an emergency situation.

The aim of Workpackage 4 is to investigate this impact of advanced safety functions on reducing several types of accidents involving passenger cars or mitigating accident consequences.

The evaluation is performed from two different perspectives:

- Assessment of the potential proportion of accidents that could be avoided and of the potential proportion of accidents whose severity could be reduced, for each safety function (this is the so-called *a priori effectiveness*) (Task 4.1).
- Assessment of the actual proportion of accidents that could be avoided and of the actual proportion of accidents whose severity could be reduced, for each safety function (this is the so-called *a posteriori effectiveness*) once the cars are equipped with existing functions (Task 4.2).

The main objective of this task 4.2 of WP4 is to estimate, by means of statistical calculation, the proportion of injury accidents that could be avoided and/or the proportion of accidents which severity could be mitigated, for existing safety functions (or a combination of functions), selected from the WP6 list, would all cars be equipped with these functions that are already on the market (for instance Electronic Stability Control or Emergency Brake Assist).

This kind of effectiveness is called *observed effectiveness* or *a posteriori effectiveness*.

The challenges of task 4.2 are the following:

- Identify the right epidemiological methodologies that can help in achieving the objective, integrating the so-called 'driver adaptation phenomenon' (the driver can adapt his behaviour to the safety function in a way that it can decrease the expected effectiveness) if any.

Especially it is essential to work on the effectiveness of a package of safety functions and not only on a safety function independently from the others. Moreover, it is also important that the effectiveness can be split into effectiveness due to the preventive or active safety functions, the passive safety functions, and the interaction between the two natures of functions (preventive/active and passive).

- Apply the methodologies to existing data (disaggregated or grouped data), which we know from previous studies that there are a lot of data problems (including absence of information about existence of safety functions in the crashed cars), and lack of exposure data.

This deliverable D4.2.1 is addressing 3 issues:

- General considerations about data needs. Lessons learned from the literature review
- Methodologies used to evaluate the a posteriori effectiveness of safety functions
- A simulated example

The first section of Deliverable D4.2.1 is reporting about the data needs, as learned from literature review. The second section presents various methodologies used for evaluating the effectiveness of one or several safety functions. The last section of this report presents numerical application of those methodologies.

As for the methodology, the approach preliminary claims for:

- The identification, in the national accident data file, of accident-involved cars for which the determination of whether or not the car was fitted with the function is possible.
- The identification of accident situations for which we can determine whether or not the function is pertinent (for example ESC is pertinent for loss of control accidents whilst it is not for cars pulling out of a junction) or neutral (no influence)
- The calculation, via a statistical model, of the relative risk of being involved in a safety function-pertinent accident for safety function equipped cars versus unequipped cars, divided by the relative risk of being involved in a non safety function- pertinent accident for safety function equipped cars versus unequipped cars. This relative risk is assumed to be the best estimator of safety function effectiveness.

Moreover, it is of major interest to be not only able to evaluate a single safety function but as well a whole package of multiple safety functions. The above method offers a well interpretable way of comparing any two (or even more) different safety equipments. The very same approach may be applied if not looking at a single active or not active safety function but instead at some safety configurations. A safety configuration is considered to be a set of different safety functions such as "any car that is equipped with anti-lock braking system, airbags and emergency brake assistant but does not contain ESC". So a safety configuration means that certain safety functions are always included, certain safety functions may be excluded and no information on other safety functions are of interest.

We intend to compare the effectiveness of some safety configuration SC I with the effectiveness of some safety configuration SC II. Methods will then be fully applied in the second half of 2007 and the results will be presented, interpreted and discussed in Deliverable D4.2.2.

2 Introduction

2.1 Objective

In spite of countless amounts of research and development, road safety is still one of the main societal concerns today. It is not only a matter of concern for the European Commission and National Governments but also for the vehicle industry, insurance companies, driving schools, non-governmental organisations and more generally for every single road user. Car manufacturers have made strong efforts and have dramatically improved passive (and also active) safety of their vehicle for the past 15 years. However, current road safety research has shown that an asymptote is about to be reached on this aspect in most countries and many experts agree that preventive (prevention of accidents) and active safety (recovery of an emergency situation) should now, particularly, be brought forward.

In this context, the TRACE project has 2 major objectives:

The first one addresses the determination and the continuous up-dating of the aetiology (i.e. analysis of the causes) of road accidents and injuries, and the definition of the real needs of the road users as they are deduced from accident and driver behaviour analyses.

The second one aims at identifying and assessing, among possible technology-based safety functions, the most promising solutions that can assist the driver or any other road users in a normal road situation or in an emergency situation.

The aim of Workpackage 4 is to investigate this impact of advanced safety functions on reducing several types of accidents involving passenger cars or restricting accident consequences.

The evaluation is performed from two different perspectives:

- Assessment of the potential proportion of accidents that could be avoided and of the potential proportion of accidents whose severity could be reduced, for each safety function (this is the so-called *a priori effectiveness*) (Task 4.1).
- Assessment of the actual proportion of accidents that could be avoided and of the actual proportion of accidents whose severity could be reduced, for each safety function (this is the so-called *a posteriori effectiveness*) once the cars are equipped with existing functions (Task 4.2).

Therefore, the main objective of this task 4.2 of WP4 is to estimate, by means of statistical calculation, the proportion of injury accidents that could be avoided and/or the proportion of accidents which severity could be mitigated, for existing safety functions (or a combination of functions), selected from the WP6 list, would all cars be equipped with these functions that are already on the market (for instance Electronic Stability Control, navigation systems or Emergency Brake Assist).

This kind of effectiveness is called *observed effectiveness* or *a posteriori effectiveness*.

This objective is very different from the objective of the WP4 Task 1 which is addressing the expected safety benefit of non existing functions, the ones which are near market, under development, or eventually at a research stage.

There are actually two kinds of observed effectiveness. We have to distinguish between the real effect of a safety function since its introduction (which is much depending on the penetration rate of the safety function in the registrations), and the potential safety benefit of an existing safety function would all cars be equipped with such a function. Let's take an example. Let's say that the safety function is present in 10 % of the car fleet. If the effectiveness of the function is, say, 10 % less accident involvement for the cars equipped with such a function, it means that the real effect is 1 %: 10 % effectiveness out of 10 % of the fleet. But the potential benefit is 10 % would the whole fleet be fitted with the equipment.

Task 4.2 will work on the second estimation exclusively. This is what we will call the potential observed safety benefit in the rest of the task.

2.2 Means and Challenges

The challenges of this task are the following:

- Identify the right epidemiological methodologies that can help in achieving the objective, integrating the so-called 'driver adaptation phenomenon' (the driver can adapt his behaviour to the safety function in a way that it can decrease the expected effectiveness) if any.

Especially it is essential to work on the effectiveness of a package of safety functions and not only on a safety function independently from the others. Moreover, it is also important that the effectiveness can be split into effectiveness due to the preventive or active safety functions, the passive safety functions, and the interaction between the two natures of functions (preventive/active and passive).

- Apply the methodologies to existing data (disaggregated or grouped data¹), which we know from previous studies that there are a lot of data problems (including absence of information about existence of safety functions in the crashed cars), and lack of exposure data.

At the moment, only French and eventually German data are used. However, WP7 has been assigned at the beginning of the TRACE project to improve the existing methodologies developed so far (essentially for the evaluation of the effectiveness of ESC) and to identify, if possible, methods for expanding the results from a few countries to EU 25.

2.3 Expected Results

Table 1 shows the final expected outcome of this task. It displays the potential observed safety benefits of a selection of safety functions, for a selection of so-called *safety problems*. A safety problem can be an accident configuration (i.e. intersection accidents) or a risk factor (i.e. speed or alcohol). Consequently the basic idea is to take from WP's 1, 2 and 3 the main accident causation problems and to make the correspondence between the problems and the potential solutions (Safety functions) and to estimate their potential safety benefits by means of appropriate epidemiological methods. Combination of problems will also be addressed.

	%	Safety Function 1			Safety Function j ...			Total		
Safety Problem 1										
Safety Problem i	A _i	B _{i1}	C _{i1}	D _{i1}	B _{ij}	C _{ij}	D _{ij}			
....										
Total	100 %									

Table 1. Expected outcomes of Task 4.2

- A_i : Percentage of injury accidents corresponding to safety problem i.

- B_{ij} : Percentage of injury accidents corresponding to safety problem i for which the safety function j is relevant (for example, brake assist can only address some kind of accidents where the driver brakes and the brake force is at a certain level).

- C_{ij} : Percentage of injury accidents of safety problem i that could be avoided by safety function j

¹ Actually, the methods currently used to estimate the safety benefits of technologies rely on accident disaggregated data (i.e. data where parameters describing the accident, the road users and the vehicle are available for each statistical unit, i.e. the crash, the user or the vehicle) and not on aggregated data (i.e. statistical tables). However, TRACE members agreed not to work on disaggregated data for property reasons. Therefore, it is highly likely that, at the end of the day, only members of WP4 who have access to disaggregated data, can conduct the analysis of their own disaggregated data. Unless methodologies to use aggregated data are available during the course of the project from WP7.

- D_{ij} : Percentage of injuries of safety problem i that could be mitigated or by safety function j

Table 1 will be, in D4.2.2, the main summary outcome of WP4 Task 4.2

2.4 General Methodology

Most frequently, the evaluation of the a posteriori effectiveness of a safety function in terms of reduction of injury accidents consists of 3 steps:

- The identification, in the national accident data file, of accident-involved cars for which the determination of whether or not the car was fitted with the function is possible.
- The identification of accident situations for which we can determine whether or not the function is pertinent (for example ESC is pertinent for loss of control accidents whilst it is not for cars pulling out of a junction).
- The calculation, via a statistical model, of the relative risk of being involved in a safety function-pertinent accident for safety function equipped cars versus unequipped cars, divided by the relative risk of being involved in a non safety function- pertinent accident for safety function equipped cars versus unequipped cars. This relative risk is assumed to be the best estimator of safety function effectiveness.

Eventual alternative method coming from WP7 will be tested on a selection of functions coming from WP6. It was initially expected that a minimum of 5 functions and a package of 2 or 3 of the main ones would be evaluated. Unfortunately the first data runs show that there are not so many newer safety functions and not so many cars fitted with newer safety functions involved in accidents. Consequently the first number of functions we wanted to evaluate could be lowered down. First analyses were run for simultaneous existence/absence of:

- Electronic Stability Control (ESC),
- Brake Assist
- and 5 stars at the EuroNcap rating (passive safety)².

Additional runs will be tested with the existence/absence of speed limiters and tire pressure monitoring if the information is available in the accident data files.

² Nowadays, the whole car is designed to offer an overall protection. Car structure is stiffer than in the past in order to avoid intrusion in the compartment, which was proved to be one of the major causes of injuries. Load limiters prevent from belt webbing; airbags prevent the head and the chest to hit the steering wheel or another hard element of the compartment; pretensioners couple the occupant to his seat in order to reduce submarining and a hump over the seat and under the base also prevent the pelvis to rotate under the belt. In some cases, knee airbags also prevent from submarining by stopping the legs and then the occupant body displacement under the belt during the crash. Other devices such as padding and non aggressive structures in the door panel, the dashboard, the windshield, the seats, the head rest also participate in supplying more protection. The whole package is then very difficult to evaluate separately, one element independently from the others. We have then decided to consider that we would evaluate in TRACE the safety of the whole package (5 stars against 4 or 3 stars) and then the additional safety benefits of active or preventive safety functions, given that the car is 5 stars rated at the EuroNcap. This is considered to be a safety pre-requisite for most of the forthcoming new cars.

2.5 Relations with others TRACE WP's

WP's 1, 2 and 3 are expected to identify the relevant safety problems as shown in table 1. There is no specific demand or pressure on these WP's, literature, work available so far on accident configurations and the WP's interim and final reports should be sufficient.

It is expected from WP5 the relevant methodologies for a pertinent integration of human factors in the evaluation process

It was expected that WP6 would deliver the most promising safety functions with a thorough list of existing functions, from which some of them would be selected for WP4 task 4.2. As stated before, there are not so many existing safety functions fitted in cars and the safety functions that will be evaluated in WP 4 Task 4.2 are only those presented in 2.4.

It is expected from WP7 the relevant methods for the evaluation of a package of these safety functions including grouped data analysis. The evaluation of a package of safety functions is the main innovation of this WP4 task 4.2, all studies reviewed so far having evaluated the effectiveness of safety functions independently from the existence of other functions.

2.6 Work Plan

Work has started at LAB in March 2006 by a systematic review of the existing literature. A second step of the work started in October 2006 with a strong connection with WP7. Especially, the cooperation addressed the following issues:

- How to get rid of the data problems (recognition of the safety function embedded in cars involved in injury crashes in the national or in-depth accident databases³)
- How to evaluate at the same time the effectiveness of the preventive/active safety functions and the passive safety functions

This deliverable D.4.2.1 is addressing 3 issues:

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Methods will then be fully applied in the second half of 2007 and the results (Table 1) will be presented, interpreted and discussed in Deliverable D.4.2.2.

³ For example, in France, the identification of cars involved in an injury accident is not that easy. Cars are recorded in the national accident census via a code, the so-called CNIT code, which the police copies from the vehicle registration document. Unfortunately, 50 % of the codes are not directly identifiable due to errors in the completion of the statistical form. Furthermore, for the remaining 50 %, there is no bijection between the CNIT code and the determination of whether a car is or is not equipped with a given device. Consequently, instead of identifying whether a car, selected from the accident-involved cars is safety function-equipped, the solutions often consists in choosing a set of cars for which the information is easily accessible and then identifying these cars in the accidents according to their make and model, which is easier via the CNIT. For example, in the French ESP study this data limitation led the authors to retain only one make and model: the Renault Laguna. There are two versions of this car. The Laguna 1, was produced in the late 1990s and early 2000s without ESP. In January 2001, Renault launched the Laguna 2, with ESP as standard equipment. It was then possible to distinguish the two Laguna's in the accident census using the CNIT (make and model) and the first registration date (Page and Cuny, 2004).

3 General considerations about data

There are a lot of studies addressing the a posteriori evaluation of safety functions. The first studies date 1990's [Kullgren et al. 1994] and principally concern the assessment of ABS (AntiLock Braking System) : [Evans 1995], [Evans and Gerrish 1996], [Hertz et al. 1995] [Padmanaban, Lau 1996] [Farmer et al. 1997]....

Ten years later, in the 21st century, some studies were conducted about the safety effect of the ESP (Electronic Stability Program): [Aga, Okada, 2003] [Unsel et al. 2004] [Farmer 2004] [Lie et al. 2004] [Page et al. 2004] [Lie et al. 2006] [Page, et Cuny 2004, 2006]

The studies about evaluation of safety functions are quite numerous, and consequently, different methodologies have been used in this perspective. Nevertheless, the different studies have all a common issue: an accident database is necessary to the evaluation. The considerations will then focus on the database and its crucial characteristic needed to carry out effectiveness analysis.

3.1 Origin of the accident database

The accident database can be supplied:

- by the Police [Kullgren et al. 1994] [Lie et al. 2004] [Lie et al. 2006],
- by the insurances [Cooper 1994]
- or by bodies such as the NHTSA (National Highway Traffic Safety Administration) [Hertz et al. 1995] [Farmer et al. 1997] [Farmer 2001] [Farmer 2004], the Highway Loss Data Institute [Evans 1995], [Evans, Gerrish 1996], [Evans 1999], the ITARDA (Institute for Traffic Accident Research and Data Analysis, Japan) [Aga, Okada 2003], the Federal Statistical Office Germany [Unsel et al. 2004] or the LAB (Laboratoire d'Accidentologie, de Biomécanique et d'études du comportement humain PSA Peugeot Citroën-Renault) [Page et al. 2004]. These bodies can themselves collect the accident cases or treat the data supplied by the Police or the insurances.

3.2 Necessary information in the accident database

The accident database must include:

- Information identifying the vehicle and determining if the vehicle is equipped or not with the safety function: vehicle model and make, model year and VIN (Vehicle Identification Number).
- Information about the severity of the crash, the type of crash, the accident mechanisms, the accident configuration, ...
- Information characterising the accident: number of involved vehicles, dry/wet road surface, circumstances of the accident, accident types, collision type, etc.

3.3 Selection of some car models

Some authors [Kullgren et al. 1994] [Evans 1995], [Evans, Gerrish 1996] [Farmer et al. 1997] [Page et Cuny, 2004], [Page et al., 2005] assess the effectiveness of safety functions from a selection of car models. This choice has two main reasons:

- First, in the accident database, it is not always easy to determine if the crashed vehicle was equipped with the safety function or this information is simply not available in the dataset. Some databases record only a vehicle identification number (VIN or something similar). It is then necessary to get a correspondence between this number and the presence/absence of safety functions. This

correspondence is hardly available since VIN varies from a country to another and no database making this correspondence is available.

By selecting several car models for which this information is known (for example, all Renault Laguna are fitted with brake assist since 2001), we precisely know if the crashed vehicle was equipped with the safety function or not, as far as the Make, Model and model year are recorded in the data file [Page et Cuny, 2004, 2006].

- Moreover, limiting the survey to a few car models often allows comparing two sets of vehicles nearly similar (same performance, same dimensions...), where the main difference concerns the equipment or not with the safety function.

3.4 Bias in the selection of cars

Several authors [Kullgren et al. 1994] [Evans 1995] [Page, Cuny 2006] put forward other potential **biases** in the analysis.

First, according to [Kullgren et al. 1994], a bias can be introduced by the fact that a car equipped with ABS has been chosen, and the population of drivers which has chosen the ABS can be different from the population of drivers which has not chosen the ABS. Indeed, ABS cars were fairly new at that time and were pretty large cars, contrary to non-ABS cars which were older and not necessarily large.

Secondly, according to Evans [Evans 1995] [Evans, Gerrish 1996], two additional biases can alter the analysis:

- they called the first one, the « **model year effect** ». The vehicles equipped with the safety function are more recent than those which are not equipped. In its study, Evans compares a set of non-ABS vehicles of model year 1991 with a set of ABS vehicles of model year 1992. And, it has been established that the accident rate depends on the age of the vehicle [Kahane 1989]. Evans proposed a methodology to take into account this bias, the methodology is presented further in this report.

- The second bias is called the « **ramp-up effect** ». Evans compares vehicles of model year 1991 and 1992 which have been crashed in 1992 and 1993. And, in 1992, nearly all the vehicles of model year 1991 were already registered, but few vehicles of model year 1992 had been registered. During the year 1992, the number of vehicles of model year 1992 registered steadily increased. Consequently, the vehicles of model year 1991 are all exposed to risk in 1992, although the vehicles of model year 1992 are steadily exposed to risk during this year.

As Evans, [Page, Cuny 2006] stress the problem of the bias caused by the difference of age between the set of vehicles equipped with the safety function and the set of vehicles non-equipped. [Page, Cuny 2006] compare the Laguna 1 and the Laguna 2 to evaluate the effectiveness of ESP: the Laguna 2 is a newer car and benefits from other significant improvements such as Emergency Brake Assist, a tire pressure monitoring system and passive safety improvements. Thus, an accident avoided with the Laguna 2 can be due to the ESP and eventually, also, to other improvements of the vehicle.

4 Methodologies used to evaluate the effectiveness of safety function

Given these introductory considerations, the methodologies used in the literature to evaluate the effectiveness of safety functions are each one more or less complex and have each one their particularities. Nevertheless, after an in-depth investigation into the literature, two methods appear to be the most interesting ones:

- The first methodology relies on the comparison between the observed and the expected number of crash involvements of equipped vehicles in a certain period of time [Farmer et al. 1997] [Farmer 2001] [Farmer 2004].
- The second one concerns the evaluation of the effectiveness of the safety functions via an internal case control study (rely only on accident data) and the estimation of the odds ratio [Evans 1995] [Evans, Gerrish 1996] [Page et al. 2004] [Page, Cuny 2006].

These methodologies are of significant interest because they allow not only the evaluation of a single safety function, but can be applied to the evaluation of a set of safety function, and it is possible to extend these methodologies to a multivariate analysis via the logistic regression to take into account the potential influence of external variable on the calculated effectiveness.

4.1 First type of methodology: comparison between observed/expected number involvement of equipped vehicles

This methodology was used for the first time by Farmer et al. in 1997 [Farmer et al. 1997] in order to evaluate the effectiveness of antilock braking systems. This methodology follows a several steps process:

In a first step, two fleets of vehicles are selected:

- A set of vehicles equipped with ABS
- And a set of vehicles unequipped with ABS

These vehicles are chosen according to accurate criterions:

- The ABS must not be available in one model year and be available in standard equipment in one of the next two model years without any concurrent changes in engineering design, including design of the passenger restraint systems.
- Furthermore, the car models with optional ABS in either model year were excluded.

For these two fleets of vehicles, several data is collected for a time period:

- The observed number of fatal crashes involvements for each type of vehicles (with and without ABS). A fatal crash involvement is defined as involvement of the vehicle in a crash that resulted in at least one fatality.
- The exposure for each type of vehicles (with and without ABS). The exposure is the number of vehicles registered (or the number of miles driven).

From these data, the involvement rate is calculated for each type of vehicles, for the study period:

$$\text{Involvement rate} = \frac{\text{observed number of fatal crashes involvements}}{\text{exposure}}$$

In this first step, a database is constituted. Table 2 gives an outline of this database.

	Models without ABS			Models with ABS		
Vehicle group	Observed involvement	Exposure	Involvement rate	Observed involvement	Exposure	Involvement rate
Saab	$x_{1,noABS}$	$y_{1,noABS}$	$IR_{1,noABS} = \frac{x_{1,noABS}}{y_{1,noABS}}$	$x_{1,ABS}$	$y_{1,ABS}$	$IR_{1,ABS} = \frac{x_{1,ABS}}{y_{1,ABS}}$
Pontiac	$x_{2,noABS}$	$y_{2,noABS}$	$IR_{2,noABS} = \frac{x_{2,noABS}}{y_{2,noABS}}$	$x_{2,ABS}$	$y_{2,ABS}$	$IR_{2,ABS} = \frac{x_{2,ABS}}{y_{2,ABS}}$
...						

Table 2. Database at the end of step 1.

In a second step, the expected number of fatal crash involvements for equipped vehicles is computed. Expected fatal crash involvement for vehicle equipped with ABS is calculated from the involvement rate for vehicles without ABS and the exposure of vehicles with ABS. In other words, for each group of vehicles, the **expected number** of fatal crash involvements with ABS is calculated as follows:

$$\text{Expected number of fatal crash involvements with ABS} = \text{Involvement rate of vehicle without ABS} \times \text{exposure of vehicles with ABS}$$

The calculation of this data allows adding a column to table 2 (Table 3):

	Models without ABS			Models with ABS			
Vehicle group	Observed involvement	Exposure	Involvement rate	Observed involvement	Exposure	Involvement rate	Expected involvement
Saab	$x_{1,noABS}$	$y_{1,noABS}$	$IR_{1,noABS}$	$x_{1,ABS}$	$y_{1,ABS}$	$IR_{1,ABS}$	$IR_{1,noABS} \times y_{1,ABS}$
Pontiac	$x_{2,noABS}$	$y_{2,noABS}$	$IR_{2,noABS}$	$x_{2,ABS}$	$y_{2,ABS}$	$IR_{1,ABS}$	$IR_{2,noABS} \times y_{2,ABS}$
...							

Table 3. Database at the end of the step 2.

The expected involvements correspond to the number of fatal crash by taking account the involvement rate of vehicles unequipped and the exposure of vehicles equipped. Thus, the expected involvements correspond to the number of crashes if the vehicles were not equipped with ABS.

In order to compare the observed number of fatal crash involvements and the expected number of fatal crashes involvements for equipped vehicles, [Farmer et al. 1997] compute an index, the **risk ratio**:

$$\text{risk ratio} = \frac{\text{observed number of fatal crash involvements}}{\text{expected number of fatal crash involvements}}$$

If this ratio is roughly equal to 1, that means that there is no change before and after adding ABS. ABS does not influence the fatal crash risk.

If the risk ratio is less than 1, that means that ABS is effective in reducing fatal crash involvements.

If the risk ratio is above 1, that means ABS is ineffective and increases the fatal crash involvements.

A confidence interval is computed on the risk ratio too.

Once the risk ratio computed, [Farmer et al. 1997] searched to **correct this index**. Indeed, there is an age difference between the set of vehicles unequipped with ABS and the set of vehicles equipped with ABS: equipped vehicles are generally newer than unequipped vehicles. It is then possible that the decreasing of observed number of crashes for equipped vehicles is due to ABS but to the fact that the vehicle is newer too. And one does not want to take into account the decreasing of crashes due to the age difference of vehicles. In order to correct for this bias, [Farmer et al. 1997] proposed to compute a control ratio based on observed and expected fatal crash involvements. This control ratio is calculated as follows :

During the studied period, there are:

n_{11} registered vehicles of model year 1

n_{12} fatal crash involvements of vehicles of model year 1

Then, the involvement rate of vehicles of model year 1 is:

$$IR_1 = \frac{n_{12}}{n_{11}} \quad (1)$$

During the same period, there are:

n_{21} registered vehicles of model year 2

If the involvement rate stays the same, the expected number of involvements of vehicles of model year 2 is:

$$n_{22,exp} = IR_1 \cdot n_{21} \quad (2)$$

This expected number is compared to the observed fatal crash involvements of vehicles of model year 2, $n_{22,obs}$. Then, the control ratio is:

$$\text{control ratio} = \frac{n_{22,obs}}{n_{22,exp}} \quad (3)$$

This control ratio allows correcting for the risk ratio for possible vehicle age effects. The adjusted risk ratio can be compute as follows:

$$\text{adjusted risk ratio} = \frac{\text{original risk ratio}}{\text{control ratio}} \quad (4)$$

The adjusted risk ratio is computed for:

- Different types of crash: multiple vehicles, single vehicle, rollover...
- Different conditions of road surfaces : dry, wet, icy, snowy roads

Example:

Let's take the example of the group of vehicles Chevrolet Beretta, which the model 1991 was not equipped with ABS and the model 1992 was equipped with ABS. one wants to evaluate the effectiveness of ABS for this model.

In the fleet of unequipped vehicles (model 1991), there are 61.475 registered vehicles and 22 observed number of fatal crashes. Then the fatal involvement rate for unequipped vehicle is:

$$IR_{noABS} = \frac{22}{61475} \quad (5)$$

The involvement rate is 3,6 accidents for 10.000 unequipped vehicles.

In the fleet of equipped vehicles (model 1992), there are 44.642 registered vehicles. If the involvement rate was the same, 16 accidents would have been expected. The actual number of fatal crash involvements of the 1992 Chevrolet Beretta is 15, approximately 7% lower than expected.

$$\text{risk ratio} = \frac{15}{16} = 0.93$$

With a control ratio of 1.004, the adjusted risk ratio is: $\frac{0.93}{1.004} = 0.926$

This method is fully relevant as long as crash involvement and exposure can be well defined with the data available. The main **inconvenience** of this methodology is that a large database is needed since the involvement rate of a car fleet in fatal (or injury) accidents is relatively small. This database must include the exposure and the observed crash involvements for each group of vehicles.

4.2 Second methodology: evaluation of crash relative risk

To counter this drawback, another general approach is necessary. This is the one which is presented here below and that WP4 has selected for extensive use in the TRACE project.

In the first sub section the methodology related to the estimation of the effectiveness of one safety function is presented and its application to a set of safety function is shown in the second sub section.

4.2.1 Evaluation of one safety function

4.2.1.1 Via the calculation of relative risk and crude odds ratio

The first researcher to use the methodology of the evaluation of the crash relative risk is Evans [Evans 1995] [Evans, Gerrish 1996]. Then, other researchers followed this methodology with some changes [Page et al. 2004] [Page, Cuny 2006].

The methodology follows a several steps process.

- In a first step, two sets of vehicles are selected:

- a set of crashed vehicles unequipped with the safety function
- a set of crashed vehicles equipped with the safety function, as standard equipment⁴.

In the database, a **case group** of accidental situations⁵ is selected. All accidental situations that may be affected by the safety function under study are part of this group (for example loss of control for ESC). Then an internal **control group** is selected. The control group is a group of accidental situations for which the safety functions has normally no effect. This group include the accidental situations for which the safety function would not allow to avoid the crash. These situations are called “non-pertinent” or “neutral” accidental situations. The control group allows to make comparisons.

For instance, to evaluate the safety effect of ABS on wet surface road, [Evans 1995] adopts the assumption that the risk on dry road is unchanged if the vehicle is equipped with ABS. Then, the crashes on dry road constitute the control group.

In the same way, to evaluate the safety effect of ABS on frontal and rear impact crashes, [Evans, Gerrish 1996] use side crashes as comparison group. They assume that these impacts are unaffected by ABS.

[Page, Cuny 2006] wanted to evaluate the effectiveness of ESP. They identify ESP-pertinent situations and ESP-non pertinent situations from a list of 40 accidental situations drawn from the French accident National file. ESP-pertinent situations are generally loss of control crashes.

Figure 1. illustrates how the case group and the internal control group are constituted. All cars are crashed cars. Cars in the circles and outside the squares are involved in safety function pertinent crashes whereas cars in the squares are involved in safety function non pertinent crashes.

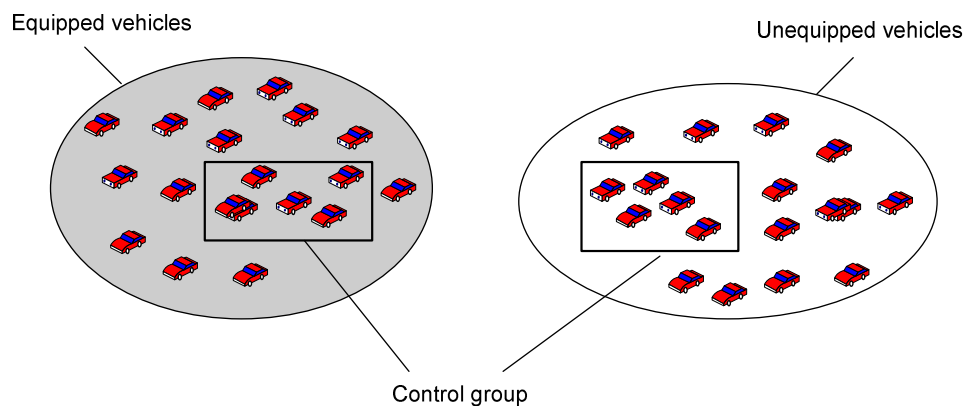


Figure 1. Cars involved in crashes, safety functions, and accidental situations

- In a second step, [Evans 1995] evaluates the effect of ABS in calculating the odds ratio R_1 , so-called crude odds ratio as it does not take into consideration any confounding variable:

⁴ It is important to notice that cars must be fitted with the safety function as a standard. For optional equipment, the method becomes more difficult because it is not possible to distinguish in the crashed cars the ones which are equipped and the ones which are not. The method requires this distinction.

⁵ An accidental situation is defined as a situation with which a driver or a pedestrian is confronted. Consequently, there are as many different accident situations per accident as there are road users involved.

$$R_1 = \frac{n_1}{n_2} : \frac{n_3}{n_4} \quad (6)$$

Where:

n_1 : number of equipped vehicles in pertinent situations

n_2 : number of equipped vehicles in non-pertinent situations (control group)

n_3 : number of unequipped vehicles in pertinent situations

n_4 : number of unequipped vehicles in non-pertinent situations (control group)

The effectiveness of the safety function is then computed by: $1-R_1$

This effectiveness describes the percentage of avoidable situations within the category of pertinent accident situations, which stand only for a part of all situations recorded in the data base. The relative part of the pertinent situations in the data base depends on the safety function that is analysed.

[Page, Cuny 2006] proposed to correct this crude odds ratio by adjusting the effectiveness index with the help of a logistic regression.

In the case of the study of [Evans 1995], Evans compares 1992 model year vehicles (ABS-equipped) to 1991 model year vehicles (non ABS-equipped). In order to correct for this bias (the “**model year effect**” bias), [Evans 1995] proposed to compute a second ratio R_2 :

$$R_2 = \frac{n_5}{n_6} : \frac{n_7}{n_8} \quad (7)$$

Where :

n_5 : number of accidents by 1992 model year vehicles in pertinent crashes

n_6 : number of accidents by 1992 model year vehicles in non-pertinent crashes

n_7 : number of accidents by 1991 model year vehicles in pertinent crashes

n_8 : number of accidents by 1991 model year vehicles in non-pertinent crashes

The adjusted ratio R is computed as follows :

$$R = \frac{R_1}{R_2} \quad (8)$$

If $R = 1$, ABS has no effect on the crash risk

If $R < 1$, that means that ABS decreases the crash risk

If $R > 1$, that means that ABS increases the crash risk

Then, the effectiveness is defined as :

$$E = 100 \cdot (1 - R) \quad (9)$$

This way of estimating the effectiveness of a single safety function via the calculation of an Odd ratio allows evaluating the effectiveness of safety functions with the help of a database of crashed vehicles only. There is no need for exposure data.

However, [Farmer et al. 1997] expressed some reservations concerning this methodology, particularly concerning the assumptions that it imposes. Indeed, this methodology requires some assumptions concerning the selection of pertinent and non-pertinent crash types. For example, we saw that [Evans 1995] [Evans 1999] assume that ABS has no influence on dry road surface, while different studies [Kullgren et al. 1994] [Kahane 1994] [Hertz et al. 1995] show the contrary. Moreover, [Evans, Gerrish 1996] assume that the risk of a vehicle being struck in the side is not affected by ABS, while [Hertz et al. 1995] show that it is not right.

According to [Farmer et al. 1997], « these inconsistencies raise serious questions about the conclusions of studies that are based on assumptions about ABS-relevant and ABS-irrelevant crashes. »

According to us, these restrictions do not hold true if the pertinent and non pertinent cases are well chosen. For example, [Page and Cuny] showed that the effectiveness indicator, i.e. the odds ratio, supposes that there is no driver adaptation to ESP, and especially that the non ESP-pertinent accidents are not affected by the presence of ESP. This is not a major assumption as ESP is relatively badly understood (according to Bosch, only 30 % of drivers know what ESP is) and should not lead to risk compensation, at least by now.

However, the method itself is based on this assumption and therefore it should not be ignored.

Another approach, supported by WP7, states that there is no need to select pertinent situations, the calculation is done on all the situations recorded in the database. The category of neutral accident situations will then be a subset of the group of comparison, but this does not lead to any problems within the calculation. This method leads to the calculation of the overall effectiveness of a given safety function. This method has the advantage that additional effects of the safety function on other than the selected sensitive accidents are not ignored. On the other hand it may be possible to include unwanted external variables in the overall effectiveness calculation. So for example if drivers of vehicles equipped with ESC typically have a parking assistant on board as well, then the calculated overall effectiveness of ESC would include some effectiveness on parking accidents due to the correlation between ESC and parking assistants.

This approach is fully documented in WP forthcoming reports.

4.2.1.2 Via the calculation of an adjusted odds ratio

To be valid, the calculation of the effectiveness of a safety function via the crude OR, assumes that the two populations of cars (cars fitted with safety function and cars not fitted with the safety function) only differ by the presence of the safety function. This is a major assumption.

If this assumption is not true, that is to say there are other differences between the two populations such as driver age, crash severity, location of the crash and so on, the observed effectiveness could be due to the other differences between the two populations and not to the difference on the presence of the safety function. For instance this means that we e.g. assume that all loss of control accidents is almost similar except the equipment with an electronic stability program. Having such an ideal situation at hand, all observed differences in accident outcome between equipped and non-equipped vehicles is due to the electronic stability program for sure. But the above mentioned theoretical assumption is far from being realistic when investigating real world accident data. In reality the equipment of vehicles not only differs up to a single safety function and the driver population rarely is the same for different vehicles. Therefore methodology is needed to deal with this situation.

A way to quantify the influence of external variables in the accident outcome is given by the statistical concept of logistic regression. A detailed explanation of the concept of logistic regression models may be found in any textbook of categorical data (cf. for example Agresti (1996)). A condensed explanation of the logistic regression approach in the context of accident research can be found for example in Kreiss et al. (2006). Logistic regression is a statistical tool which is able to deal with a moderate and

sometimes even high number of external variables by the price of assuming that the influence of the external variables is to some extent easily structured. From a principle point of view logistic regression assumes that the influence of the external variables to a slightly transformed output quantity is just as simple as a linear influence.

Let us describe the essentials of logistic modelling and assume that we have external variables x_1, x_2, \dots, x_d which could take values 0 or 1, in case of gender as an example (0 for male and 1 for female), or could take numbers (like the age of the driver of the vehicle) and so on. One or more of the variables denotes the coding whether a specific safety function in the vehicle is on or off.

Then logistic modelling for the probability $P(A | x_1, x_2, \dots, x_d)$ of having an accident of type A given that the external variables take the specific values x_1, x_2, \dots, x_d reads as follows (Equation 10)

$$P(A | x_1, \dots, x_d) = \frac{\exp(\beta_0 + \beta_1 x_1 + \dots + \beta_d x_d)}{1 + \exp(\beta_0 + \beta_1 x_1 + \dots + \beta_d x_d)}. \quad (10)$$

For the so-called odds this means (Equation 11)

$$\text{logit } P(A | x_1, \dots, x_d) = \ln \frac{P(A | x_1, \dots, x_d)}{1 - P(A | x_1, \dots, x_d)} = \beta_0 + \beta_1 x_1 + \dots + \beta_d x_d, \quad (11)$$

Which just indicates the above mentioned linearity assumption of logistic modelling. Routine statistical theory immediately leads us to estimates of the parameters $\beta_1, \beta_2, \dots, \beta_d$. The value β_k or equivalently $\exp(\beta_k)$, which is nothing else but an odds-ratio, represents the influence of the external variable number k having all other variables $x_i, i \neq k$, under control, i.e. having them similar for all accidents.

It should be stressed again that a specific linear model for the influence of the external variables on the odds is assumed. In various situations this in fact may occur as a strong restriction. For example the logistic approach is not able to describe the behaviour of an external variable for which we have for low and high values a strong influence to the accident outcome and only a moderate influence for moderately large values of the external variable. One external variable for which this in fact is true is belt usage and height of the driver. The safety belt is designed for medium sized people and we indeed observe that rather small and rather tall drivers are less well protected by the safety belt than medium sized drivers.

Moreover it should be mentioned that we really need a class of accidents neutral (control group) to the specific external variable we have in mind in order to be able to compute the above mentioned odds-ratio, namely the quantity $\exp(\beta_k)$, since we only observe specific realizations of the external variables only given that an accident what type ever has happened. In case that A stands for an arbitrary accident situation then the mentioned odds-ratio just quantifies the influence of the specific external variable to the overall accident outcome (overall influence of the specific variable). In case that A stands for a specific type of accidents situation (e.g. loss of control accidents or rear-end accidents) then the above described odds-ratio measures the influence of the specific external variable to accident situation of the prescribed type only. Of course such an accident type specific influence can

be extrapolated to an overall influence just by renormalizing, i.e. multiplying, the accident specific influence coefficient, i.e. the odds-ratio, by the percentage of accidents of type A.

4.2.2 Evaluation of multiple safety function

It is of major interest to be not only able to evaluate a single safety function but as well a whole package of multiple safety functions. Odds-ratios offer a well interpretable way of comparing any two (or even more) different safety equipments. In the above section the odds-ratio is calculated by somehow comparing the probabilities of suffering a certain accident given a safety function Safety function (SF) is active or not active. The very same approach may be applied if not looking at a single active or not active safety function but instead at some safety configurations. A safety configuration is considered to be a set of different safety functions such as “any car that is equipped with anti-lock braking system, airbags and emergency brake assistant but does not contain ESC”. So in our understanding a safety configuration means that certain safety functions are always included, certain safety functions may be excluded and no information on other safety functions are of interest. Let us assume that we intend to compare the effectiveness of some safety configuration SC I with the effectiveness of some safety configuration SC II.

The effectiveness calculated via the odds-ratio then describes the additional gain of safety of SC I compared to equipment SC II. Given that some vehicles equipped with SC I are involved in critical accidental situations that would lead to accidents of type A, then the question is, how many of these accidents could have been avoided if instead of SC I the safety configuration SC II would have been on board.

Of course SC I and SC II do not have to be a single specific safety configuration but as well may each describe classes of safety configurations. For example SC II may stand for “any safety-configuration that includes the safety function SF1 but excludes SF2” and SC I could be “any safety configuration that includes SF1 as well as SF2”. For the sake of an easier interpretation of the results SC I should always include every single safety function that is included in SC II plus some additional safety function(s).

The corresponding effectiveness is $Eff=1-OR$:

$$OR = \frac{n_1}{n_2} : \frac{n_3}{n_4} \quad (12)$$

Where

n1: number of vehicles fitted with SC II in accidental situation A

n2: number of vehicles fitted with SC II in neutral accidental situation N

n3: number of vehicles fitted with SC I in accidental situation A

n4: number of vehicles fitted with SC I in neutral accident situation N

A may represents the whole situation included in the accident database or only a pertinent kind of accidental situation.

This effectiveness describes the additional gain of SF2 within accident type A, given that SF1 is already existent.

Crucial at this point is the neutral accident type N. This type of accident has to be independent on every safety function that distinguishes SC I from SC II on its own.

More detailed about the method can be found in Kreiss et al. (2006) and Zangmeister et al. (2007).

5 Data example

Short data examples are presented in this section. The purpose of this section is only to illustrate the above methods. For the moment, let's consider that the examples come from a fictive accident database of crashed vehicles for which the presence of different safety function is known.

5.1 Example of the evaluation of one safety function using the calculation of the odd ratio

Let us assume that our aim is to evaluate the overall effectiveness of each of two safety functions SF1 and SF2. So in both cases the accident type of interest A is any accidental situation within a fictional data-base, where the information of the equipment with the safety function of interest is at hand.

The first step is to characterize a type of neutral accidental situations for each safety function. The group of neutral accidental situations concerning safety function SF1 is labelled N_1 and the other one accordingly N_2 .

Within our fictive data-base we find for 4632 vehicles the information whether or not they are equipped with SF1 and for 3354 vehicles whether or not they are equipped with SF2. For the calculation of the odds-ratio we simply need to count the number of cases within the following 2x2-contingency-table (Table 4).

all vehicles where SF1 equipment is known		type of accidental situation	
		N_1	A
SF1	Yes	56	641
	No	328	3991
Total		384	4632

Table 4. Type of accidental situation according to the presence of SF1

With this data the overall effectiveness of SF1 may be calculated with the formulas from equation 13:

$$R_1 = \frac{n_1}{n_2} : \frac{n_3}{n_4} \quad (13)$$

So we obtain the effectiveness of SF1 within A, which is the overall effectiveness by

$$\text{eff}(A) = 1 - ((641/56)/(3991/328)) = 5,93\%$$

We have calculated the effectiveness of SF1 to any given accident and not only within the types of accidents, where SF1 is supposed to have the largest effectiveness which typically is much higher than this calculated 6%.

Similarly we calculate the effectiveness of SF2 by counting the number of cases from the following 2x2-table (Table 5).

all vehicles where SF2 equipment is known		Type of accidental situation	
		N ₂	A
SF2	Yes	30	300
	No	279	3054
Total		309	3354

Table 5. Type of accidental situation according to the presence of SF2

Using a similar formula as in equation (1) we obtain the overall effectiveness of SF2 as follows:

$$\text{eff}(A) = 1 - ((300/30)/(3054/279)) = 8,64\%$$

So far we did not take into account any external variables that may have an influence, such as driver's age, surrounding conditions etc (cf. 4.2.1.2).

5.2 Example of the evaluation of a combination of safety functions using the calculation of the odd ratio

We want now to investigate the interactions of the two safety functions. The methodology related to the effectiveness of a set of safety functions allows us to investigate several types of interactions. We are able to estimate the effectiveness of SF1 added to SF2 compared to no safety function, the effectiveness of SF1 given that the car is fitted with SF2, and the effectiveness of SF2 given that the car is fitted with SF1.

Recall that the effectiveness of SF1 was 5.93% and the effectiveness of SF2 was 8.64%. When analysing the interactions of the two safety functions we again need a group of neutral types of accidental situations. As we already identified some neutral types of accidents for each safety function, e.g. we obtain one possible group of neutral types of accidents concerning both safety functions by using the intersection of N₁ and N₂. Let us assume we obtain the following 2x2-table (Table 6)

all vehicles where SF1 and SF2 equipment is known		type of accidental situation	
		N ₁ ∩ N ₂	A
SF1 and SF2	Yes	18	176
	No	239	2612
Total		257	2788

Table 6 . Type of accidental situation according to the presence of SF1 and SF2

This leads to the effectiveness of having both SF1 and SF2 instead of none of these as it is calculated according to equation 13:

$$\text{eff}(A) = 1 - ((176/18)/(2612/239)) = 10,53\%$$

So the effectiveness of both safety functions is less than the sum of the two single safety function's effectiveness. Obviously there exists some interaction between the two safety functions.

Now we want to find out more details about these interactions and then evaluate the effectiveness of SF1, given that SF2 is already present. As the group of neutral types of accidental situations we may take the whole group N_1 and not only the intersection of N_1 and N_2 because all vehicles of interest are equipped with SF2 (Table 7. Type of accidental situation according to the presence of SF1 given that SF2 is present)

all vehicles equipped with SF2, where SF1 equipment is known		type of accidental situation	
		N_1	A
SF1	Yes	18	176
	No	11	108
Total		29	284

Table 7. Type of accidental situation according to the presence of SF1 given that SF2 is present

So the effectiveness of SF1, given that SF2 is already on board of the vehicle is:

$$\text{eff}(A) = 1 - ((176/18)/(108/11)) = 0,41\%$$

This result may very well be interpreted as given that the vehicle of interest is already equipped with SF2, there is more or less no additional gain of SF1.

We calculated here the overall effectiveness for all the accidents within the database. So there may exist a small group of accidents, where the effectiveness of SF1 given SF2 is much larger. But then necessarily this group of accidents has to be comparatively small as the overall effectiveness is so close to zero. As well we want to point out, that the number of cases considerably decreased in comparison to Table 6 and 7. This is due to the fact we do not only need the knowledge whether a vehicle is equipped with SF2 or not but rather we need cases where the vehicle indeed is equipped with SF2. This effect typically occurs when working with real world accident data.

all vehicles equipped with SF1, where SF2 equipment is known		type of accidental situation	
		N_2	A
SF2	Yes	18	176
	No	29	328
Total		47	504

Table 8.Type of accidental situation according to the presence of SF2 given that SF1 is present

We now want to calculate the effectiveness of SF2, given that SF1 is already existent. According to Table 8.Type of accidental situation according to the presence of SF2 given that SF1 is present, as all vehicles of interest are equipped with SF1, N₂ may be considered to be a group of neutral accidental situations. Let us assume that we obtain from our data-base the following table.

Again the same calculation leads to:

$$\text{eff}(A) = 1 - ((176/18)/(328/29)) = 13,55\%$$

Now the situation is completely different. We obtain a rather high overall effectiveness of SF2, given that SF1 already is existent.

To sum it up: With an effectiveness of 5.9% and 8.6% we observe a moderate effectiveness of SF1 and SF2, considered as single safety functions. The combination of both safety functions shows with an effectiveness of 10.5% that this effectiveness is less than the sum of the single ones, but still larger than the effectiveness of only one of them. By evaluating the interactions we found out that: SF2 is even more effective if SF1 is already existent (13.6%), whereas if SF2 is already existent it does not change much if SF1 is existent as well (0.4%).

Again it is important to point out that for all calculations any external influences were ignored. We may not exclude the possibility that some of the computed results may be explained by some external variable(s). Logistic regression is then absolutely needed.

6 Conclusions

Apart from studies evaluating the expected effectiveness of safety functions (SF), other studies used different methodologies to evaluate the observed effectiveness. The first methodology is a comparison of the accident rates of two car fleets, one composed of SF-equipped cars and the other of similar unequipped cars. This is known in Epidemiology as the *exposed / non-exposed quasi-experimental design*. Since the number of kilometers is usually not available, the denominator of the rate is commonly the number of vehicles sold. The accident rate can be calculated for SF-pertinent accidents only or for all types of accidents.

The second methodology consists of estimating the proportions of SF-equipped cars in SF pertinent crashes and in non SF-pertinent crashes. The effectiveness is computed via the so-called odds ratio, crude or adjusted, depending on the availability of data and the existence of confounding variables. This is known as the *Internal Case-Control design*. The methodology relies only on crashes data. The cases are SF-pertinent crashes and the controls are non SF-pertinent crashes. This methodology allows estimating an overall effectiveness of the safety function by multiplying the effectiveness found on pertinent crashes by the proportion of these pertinent crashes out of the total number of crashes. This method can be extended to the evaluation of a combination of several safety functions at the same time. This is fully explained in a forthcoming WP7 report. Part of this new method has been shortly described in this current report.

TRACE does not have much access to exposure data. Therefore the second methodology will be used in the Deliverable D4.2.2.

For the moment, only French and German data is available and the calculations will be conducted upon the French National accident census and the GIDAS database. Methods for expanding the results to EU 25 countries are currently under research by WP7, and will be applied in case of success.

We also have selected the safety functions that will be evaluated in WP 4 task 4.2:

- Electronic Stability Control (ESC),
- Brake Assist
- and 5 stars at the EuroNcap rating (passive safety).

Additional runs will be tested with the existence/absence of speed limiters and tire pressure monitoring if the information is available in the accident data files.

Finally, TRACE will bring an innovation by proposing to evaluate the effectiveness of a few systems altogether, of the effectiveness of a system given that another system is already active. This is very rarely the case in the other current studies.

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