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Forecasting the public health effect of a national road safety programme

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ABSTRACT

A common understanding of evidence-based policy is that any new measures should have been proven to be effective. At best, these kinds of methodologically sound evaluation studies show the effect of a measure in a given situation. The results are then an essential basis for the design of a broader safety policy. However, at present there is generally little understanding of the effect of the measure in another situation, or of how it would interact with other measures in a programme. Yet, it is precisely such questions that need to be answered if the requirements of policy makers are to be met. Politicians need to be able to estimate whether the expected benefits of a programme justify the investment. Therefore, evidence-based road safety policy should not rely solely on evaluation studies of single measures and ex-post assessments of safety programmes. The method outlined here is for the ex-ante estimation of the potential of a road safety programme in reducing the number of severe and fatal injuries, i.e. the most relevant indicator from a public health point of view. Results of a case study show that the potential of the Swiss road safety programme VIA SICURA is 1/3 of fatalities and ¼ of severe injuries referring to 2010.

1 INTRODUCTION

In some countries, authorities are required by law to prove the effectiveness of changes in legislation and of capital investment in road safety or other public health programmes. In Switzerland, for example, article 170 of the Federal Constitution of the Swiss Confederation states: “The Federal Assembly shall ensure that federal measures are evaluated with regard to their effectiveness” (introduced 1 January 2000). With the rapid spread of New Public Management in many areas of public administration, the concept of the effectiveness of state interventions in the public sphere has gained much prominence in recent years. The main hypothesis of New Public Management is that a more market-oriented public sector will lead to greater cost-efficiency for governments, without having negative side effects on other objectives and considerations (e.g. Boston et al., 1996).

Alongside the increasingly complex problems that need to be addressed by the state plus the continual improvements in the capability of evaluation instruments, there is increased scrutiny of the effectiveness of the state’s ever more complex interventions, whether they are measures or policies (e.g. prevention efforts). Despite this impressive development and expansion of the evaluative function, the outcome-oriented approach has not become a systematic planning instrument. There are various reasons for this. An international comparison of the evaluative function in 22 countries reveals that only in those countries that already developed their evaluation policy in the late sixties or early seventies (e.g. USA, Canada, Sweden, the Netherlands) it has consolidated at a high standard over the last 20 years (Furubo et al., 2002). Another reason why evaluation is not yet a planning instrument has to do with the nature of the political system, which can lead to a diffusion of responsibility for planning and outcomes. In Switzerland, for example, road safety matters are the joint responsibility of federal, cantonal and local authorities. Under these conditions it would be unrealistic to expect to find long-term, outcome-oriented strategies. Most importantly, what is missing is a body that can assume overall responsibility, that can commission evaluations and, based on these results, is then committed to defining and implementing the next steps. A third reason is related to the limited use of results for single measures. Results for single measures provide information about the effects of a certain measure in a certain situation. Rarely do they provide information about how comprehensively the measure was implemented, the original level of safety, other measures that were launched at the same time, etc. Therefore, it is not possible to plan a road safety programme solely on the basis of existing evaluation results for single measures. Given the wealth of available and consolidated evaluation results for single safety measures in road traffic (particularly Elvik et al. (2009)), as well as the absence of a method for estimating the impact of a measure in another context, results are all too often adopted without due care, and used as the sole basis for planning. Not uncommonly, this leads to unrealistic forecasts and expectations that ultimately cannot be met, and thus the evaluation results are not afforded their rightful significance. A method for estimating the safety outcomes of intervention programmes could fill an important gap, thereby enhancing the planning of state interventions. To date, efforts in this direction have been few. Jagtman et al. (2006) introduce an interesting method of ex-ante assessment of safety measures. The method, known as Hazard and Operability analysis (HAZOP), is, however, primarily about the detection of possible safety problems associated with new technologies. Other evaluations focus on just one aspect, such as cost-efficiency of measures (e.g. Yannis et al., 2008). Some also do ex-ante assessments; however, they use quantified safety effects of prevention measures that are determined solely on existing evaluation results. No systematic description of a measure for ex-ante evaluation of road safety programmes is to be found in the literature.

This paper will investigate the question of how evaluation studies can be of greater benefit in the planning and political realization of road safety programmes. It will outline a method of ex-ante evaluation of prevention programmes that systematically encompasses not only existing evidence, but also a defined starting point, an estimation of the speed and penetration of implementation, and possible interactions between individual measures.

2 EVALUATION OF SINGLE FULL-COVERAGE MEASURES

The evaluation of single full-coverage safety measures is often the only way to learn about the effectiveness of an intervention. From a scientific point of view, this kind of evidence is somewhat weaker than that gained from experimental case-control-studies. Nevertheless, time series designs or designs using an external comparison group can also produce useful information (e.g. Cook and Campbell, 1979) if the following preconditions are assured: the programme is based on a theoretical, causal model of how the measure is thought to work, and the evaluation assesses the process, as well as the impact and the outcome of the measure. If the results show a homogeneous picture and if there are good arguments ruling out external influences as being responsible for the effect, then there is a high probability that changes in safety performance indicators (mainly severe and fatal injuries) are due to the scrutinized measure.

For many state interventions it is not possible to define a control group. In addition to the methodological challenges of quasiexperimental studies mentioned above, important performance criteria of an evaluation study include the correct use of the appropriate statistical procedure as well as the accurate identification of the accidents influenced by the measure. The latter point, in particular, is all too often neglected; its importance is noted by experts such as Hauer (1997, p. 44): “Thus, the task of identifying target and comparison accidents properly overshadows in its importance the statistical questions ...”. This task must be carefully completed for both the evaluation of single measures and the adoption of results from studies of other contexts. As will be shown in Section 4, the theoretical potential of a measure to reduce injuries (defined as severe and fatal injuries) can be determined in two steps. To determine the target number of injuries, the total number of injuries is reduced to only those that should be reduced by the measure. For example, the aim of obligatory bicycle helmets for children up to the age of 14 is to reduce all cranio-cerebral injuries incurred as a result of a bicycle accident by children in this age group, for a given year. The number of injuries that can be influenced by the measure is, in fact, lower, for which there may be a number of reasons. In the example given, those cranio-cerebral injuries incurred as a result of bicycle accidents despite the wearing of a helmet must be subtracted from the number of target injuries, for the reference year.

The results of effectiveness studies are transferable to other situations only if there is a plausible rationale for doing so. Thus, it is necessary to know what the base line was for the safety level before the introduction of the measure, the quality and quantity of the realization of the measure, and to what extent the safety aspects relevant to the reduction in road crashes changed in the desired way. Pure accident analysis reveals too little about whether the measure in question can produce similar results in another situation.

However, such multi-level evaluations are time consuming and require a large budget. The investigation, for example, of a new system of driver education takes many years. The increasing importance of evaluation research means that funding for a measure often will not even be discussed without an accompanying evaluation. Often, however, there is not enough time and money for a satisfactory evaluation, which means that many evaluation results are difficult to interpret due to a lack of in-depth analysis. The benefits would be greater, both in terms of knowledge and in terms of planning road safety programmes, if fewer but more comprehensive evaluations of measures were conducted, which drew the correct conclusions from the results.

In addition to public health outcomes, policy makers are interested in the cost-effectiveness of a measure. To date, cost-benefitanalysis (CBA) generally have shown that the return on investment (ROI) is in many cases positive. Abelson et al. show that the average ROI is positive and significant in Australia: “The road safety programs have saved governments an estimated $750 million a year in the late 1990s” (Abelson et al., 2003). It would make sense if cost-benefit-analysis of single measures all used the same method, thereby making the results easier to compare. Initial formulations towards such a standardization for the calculation of the CBA of single measures have already been made within the framework of the EU project ROSEBUD (2005).

3 EX-ANTE EVALUATION: FORECASTING THE EFFECTS OF A NATIONAL ROAD SAFETY PROGRAMME

Scientific evaluations of single measures or broader programmes are retrospective in nature. Therefore they do not meet the needs of national decision makers. Policy makers want to make sure, in advance, that an investment has the desired impact on public health as well as on the national economy.

Behind every considerable improvement in road safety there lays a political decision. Sometimes it is necessary to convince politicians that road safety is an important issue and to show them that effective measures to enhance safety are available. However, that is by no means enough. Even if politicians are convinced that road safety can and should be improved, there are other fields of policy competing for attention. An investment in one sector sometimes means that investment in another cannot be realized. Politics is thus a question of priority setting. Therefore road safety specialists are expected to forecast the effects of a programme in order to show to what extent an investment in road safety is worthwhile. Post hoc evaluation of single measures and broader programmes is an essential, but not sufficient, basis for planning a road safety action programme.

What does evidence-based policy mean when it comes to the development of a comprehensive road safety programme? Evidence-based policy making, according to Sanderson (2004), means that public policy is derived from rigorously established objective evidence. It is an extension of the idea of evidence-based medicine to all areas of public policy. An important aspect of evidence-based policy is the use of scientifically rigorous studies such as randomized controlled trials to identify programmes and practices capable of improving policy relevant outcomes. This rational approach is widely accepted; decision makers often want to know at the outset whether a measure has been proven to be effective.

Common sense would indicate that those measures that have been proven to be effective should be used in evidence-based policy making. However, translating one result to another situation is a process that needs to be done carefully. The reduction of injuries and fatalities due to the introduction of a measure is the result of various factors. The actual effectiveness of the safety measure is only one such factor. Section 3.1 will outline the parameters that need to be taken into consideration when evaluating the expected safety benefits of a measure in a new context. Such an evaluation should be carried out for all measures that come under discussion.

Additionally, programmes consist of several measures that interact when they are implemented at the same time. In the past, there have been many cases where these kinds of factors were not assessed systematically, nor was there discussion about what a “golden standard” for such an evaluation would be. Forecasting the effects of a programme entails answering the following questions:

- What is the estimated effect of a measure in a given situation (a situation that is, of course, different to that where the measure has been previously applied)? (Section 3.1).
- What will be the net effect of the whole programme? (Section3.2).
- What will be the return on investment for the national economy? (Section 4).

A method for answering the first two of these questions will be outlined below, as applied in the drafting of the Swiss road safety policy (bfu, 2002). This method focuses on the absolute number of severe injuries, so to speak the real burden of accidents. Any substitute (like number of actions taken, attitudes, conflicts etc.) or cost-benefit analysis are very interesting indicators as well. But all of them are of secondary importance, as from a public health point of view the main interest will always be the absolute number of persons suffering from a defined impairment.

3.1 Estimating the effect of a single measure

The calculation of the effects of a measure takes into account five parameters. A safety measure is relevant when it addresses a high priority accident type (A), when it is applicable (B) and effective (C), when it achieves a wide spread (D), and when compliance – where applicable – is sufficient (E). The corresponding key questions are:

A. Potential number of (severe and fatal) injuries that could be influenced by the measure: What is the target number of serious injuries and fatalities (theoretical potential of a measure)? (e.g. measure 'evidential breath testing': all injuries where alcohol may have played a role).
B. Area of theoretical impact: What proportion of the target number of injuries can the measure actually be applied to (because the measure has not already been realized for this proportion, or because there are no limitations on its application)? (e.g. measure 'obligatory bicycle helmets for children': all cranio-cerebral injuries incurred by children as a result of bicycle accidents (A), reduced by the share of children already wearing helmets).
C. Effectiveness: What share of serious injuries and fatalities can be prevented if the measure is implemented? (e.g. measure 'zero alcohol for novice drivers': all alcohol-related injuries – caused by novice drivers – that would not occur if there were no new drivers driving under the influence of alcohol [attributable risk]).
D. Degree of implementation: In the given circumstances, what is the maximum and the average spread of the measure that can be expected over a certain period of time? (e.g. measure 'improvement of ungated railway crossings': the proportion that have been improved within a certain timeframe).
E. Degree of compliance: What is the maximum and the average uptake by road users that can be expected over a certain period of time, assuming that a way of circumventing the measure exists? (e.g. measure 'campaign to increase the wearing of seatbelts': the proportion of drivers and passengers who buckle up as a result of the intervention).

Each of these values is to be determined using, where possible, research results. The source of information as well as the level of evidence thereby needs to be clearly documented:

A. Even the potential number of (severe and fatal) injuries is not always easy to determine. The quantification is easier the more precisely the measure is defined and the more detailed the available accident and injury data are.
B. The further reduction to the area of theoretical impact should be based on information from surveys, where possible. The measure 'daytime running light' (technical solution), for example, has no additional effect for those vehicles whose drivers already voluntarily use the headlights during the day. If the proportion of these drivers is 30%, then a maximum of 70% of the potential injuries (caused by collisions during the day involving a car) are theoretically preventable. As the effect of the measure is then already given when one of the two vehicles in a possible collision has the headlights on, the theoretical potential impact is even lower, approximately 60%.

C. Ideally, effectiveness is known from studies which show how great the probability is of preventing serious harm. In the case of seatbelts it is even possible to obtain specific values for accidents resulting in serious injury and in death. In other cases, the judgement of experts must be relied upon. The effectiveness derived in this way must be declared as an estimation.
D. The degree of implementation to be achieved within a certain time period can be estimated by consulting various sources, i.e. process evaluation results achieved for similar measures; questionnaires with experts and authorities tasked with implementation; and assessment of the practical and financial issues that could be met during implementation.
E. The degree of compliance is relevant when some adaptation is required of road users, i.e. without their cooperation or acceptance the measure has no effect. Indispensable sources of information here are questionnaires on acceptance and on possible psychological barriers. If no representative questionnaire results are available, qualitative target group interviews should at least be conducted.

The theoretical potential (A) for prevention of injuries and fatalities reduced by the values (in %) B–E. The actual potential to reduce (severe and fatal) injuries is calculated using the following formula:

Actual reduction = A x (B/100) x (Cx100) x (D/100) x (E/100)

Separate calculations are made to determine maximum and average values that can be achieved after a defined period of time. The values for (D) and (E) can change over time (while A and B refer to a defined reference year and C is a constant value derived from studies or educated guesses). From the four possible results, the maximum number of preventable fatalities per year is the relevant criterion for the selection of the most important measures.

For the calculation of the achievability of the target with, for example, a 10-year timeline, it is the average number of preventable fatalities during the period that is relevant. Both values D and E can vary for measures which achieve their full effect only after 10 years because spread is slow due to cost factors, for example, or because behaviour al change takes place slowly. Whether a national safety target will be reached depends not only on the net effect of new measures but also on the ongoing trend. Therefore some sort of baseline estimation for the coming years is necessary. Due to space limitations this will be discussed only briefly here. For their calculation for Switzerland, Schlatter and Merz (2001) assume there will be no major change in the trend for the rate of accidents either as a result of external influences (e.g. comparable to the oil crisis of the early 1970s) or through a significant decline in efforts to promote road safety (institutions, manpower, finances, etc.). For their forecast, trend analyses were carried out and the results weighted according to assumptions about the development of relevant factors of influence (population level, traffic volume, etc.). The result was a decrease in road fatalities of 33% (from 600 to 400) and in severe injuries of 35% (from 5700 to 3700), for the period between 2000 and 2010.

The procedure can be exemplified with the “obligatory seatbeltignition- interlock-system” (immobilizing system). With this measure, the engine cannot be started until all occupants of the vehicle have their seatbelts fastened. In Switzerland, in the reference year (2000), there were 445 cases of serious injury and 136 fatalities, where victims were not wearing a seatbelt (A). The area of impact (B) of the measure is 100% as it is known that the victims in these accidents were not wearing a seatbelt. The effectiveness (C) of seatbelts has been well researched, in relation to fatalities it is 45%, and in relation to serious injuries it is 35% (Evans, 1996). It is assumed that the measure will be completely realized by the year 2020. The average degree of realization between 2001 and 2020 is approximately 50% (D). Although the measure would be obligatory and involve a technical solution, it cannot be assumed that all drivers would observe the measure. There can be exemptions for the disabled, and some drivers would purposely dismantle the system. Accordingly, the degree of compliance (E) is estimated at 95%. The result is the following two formulas for the calculation of preventable fatalities:

Maximum number of preventable fatalities per year

= 136 x 1 x 0.45 x 1 x 0.95 = 58

Average number of preventable fatalities per year

= 136 x 1 x 0.45 x 0:5 x 0.95 = 29

This kind of calculation as well as a cost-benefit-analysis was done for 92 measures (bfu, 2002). Fifteen measures were excluded because their safety benefit was too small (e.g. confiscation of number plates upon cancellation of a driver’s licence). Measures shown to be highly effective are those in the area of driver assistance (e.g. Intelligent Speed Adaptation);

measures with mid-level effectiveness are particularly those in the area of enforcement (zero alcohol for new drivers, higher fines). Measures with low safety benefits come from various areas of intervention (e.g. higher insurance premiums, Road Pricing, campaigns without accompanying police enforcement).

Results obtained in this way are subject to certain limitations. The accuracy of the results is highly variable as it depends on the available data. While some measures are well known and their effects have been scientifically investigated, for others all the parameters (B–E) must be estimated. A further difficulty is that the total number of preventable injuries and fatalities for all assessed measures exceeds the total number of actual road injuries and fatalities in a given year. The main reason for this is that single measures overlap both in terms of their content and their effect.

A further use of the results lies in the systematic collection of existing knowledge, in the close examination of the arguments for individual measures as well as in a general differentiation between effective and less effective measures.

3.2 Estimating the effect of a safety programme

The reduction in the number of fatalities over a 10-year period can be estimated in a three-step procedure. The average effect of the suggested measures in the following 10 years is the first figure of interest. This value must then be adjusted downwards to account for the degree in which the measures overlap in their effects. However, in the third step, the synergies created by the measures must be taken into account, and therefore the interim result must be adjusted upwards again. The procedure is as follows.

3.2.1 Step one

The average number of preventable fatalities per year, over a period of, for example, 10 years can be determined using the procedure described above. For measures that are fully realized during the 10-year period and reach their maximum effect (maximum spread, maximum compliance) within that time, the average effect is the same as the maximum effect. For all other measures, an average value is estimated for the degree of implementation and compliance for the 10-year period. This is particularly necessary for technical measures (implementation is time-intensive) and measures requiring behavioural change (compliance increases slowly).

Calculated in this way, the reduction of the number of fatalities per year represents the average effect during the time period, and can generally be assigned to the median year. Earlier, the effect is smaller, later it is greater.

3.2.2 Step two

The resultant average benefit is a theoretical value, which needs to be adjusted to account for the extent to which the effects of the measures overlap. Thus, for example, for the development of the Swiss road safety programme, 29 measures with effects on vehicle occupants were appraised for the overlap in their potential to reduce injuries and fatalities; similarly, seven measures for motorcycle riders and pedestrians, and four measures for cyclists were also looked at. A good example is given by the measures ‘speed limit 70 km/h on selected stretches of rural road’ and ‘central barriers on selected stretches of rural road’. Given the type of measures here, it is important to know the proportion of road covered by both measures and the proportion of preventable injuries that occur on these sections. The number of injuries derived in this way will appear twice in the forecasted figures of the safety programme, and this double effect needs to be removed. The results reveal considerable overlap, particularly for vehicle occupants, which means that the value of the effect obtained in step one must be reduced by more than half. For the other risk groups, the reduction due to overlapping is less pronounced. In total, the average reduction factor was 45% for the example of the Swiss road safety programme.

3.2.3 Step three

The introduction of multiple safety measures leads to synergy effects, which can increase the effects of the single measures. These additional effects are not taken into account in step one. A synergy effect can arise when a government policy has a more positive influence on the awareness of a problem and prevention behaviour than that seen previously for single activities. Synergies also arise as the activities are being carried out, know-how and organizational solutions that are developed for one measure can be carried over to others. Considering this, the 45% reduction from step two can be reduced to an estimated 35%. The effect calculated in step one must, therefore, be reduced by a third. The forecasted effect of the programme of measures over 10 years plus the estimated trend in road safety would result in a decrease in road accident fatalities of almost 50% (bfu, 2002). So, if the programme were to be realized for 2010, the forecast would be 300 fatalities; for 2020 it would be 200 fatalities.

4 EFFECT OF THE SWISS ROAD SAFETY PROGRAMME

The outlined method has been applied on the Swiss road safety programme VIA SICURA (Cavegn et al., 2010). The programme has been adopted by the parliament in 2012. Before taking the decision the politicians were informed about the results of the study. The main results are presented in table 1:

	Per year, as an average during first 10 years	**Per year (after 10 years)**
Prevented fatalities	70 – 80	100 – 120 (*)
Prevented severe injuries	850 – 950	1300 – 1400 (**)
Monetisation of material benefit based on the number of prevented fatalities and severe injuries (***)	210 Mio. CHF	320 Mio. CHF
Monetisation of material benefit in total (including minor injuries, material damage and dark number)	540 Mio. CHF	780 Mio. CHF
Costs	290 Mio. CHF	–
Material net benefit	250 Mio. CHF	–

Table 1: Forecasted effects of road safety programme VIA SICURA, overview

* = 1/3 of fatalities in 2010

** = ¼ of all severe injuries in 2010

*** = 110’330 CHF for severe injuries; 1’496’000 CHF for fatalities

According to the results, the following measures seem to have the largest potential (measure leads to a reduction of more than 5 fatalities and more than 60 severe injuries per year):

- Improving infrastructure (road owners are forced to analyse the safety level of streets and to improve them by using standard measures as black spot treatment or safety audits)
- 0,0 BAC for novice and professional drivers
- fixed and lower thresholds for mandatory diagnostic investigations (e.g. DUI at 1,6 or more)
- fixed and lower thresholds for mandatory attendance in driver rehabilitation courses (e.g. first DUI-offence with BAC 0,8)

5 DISCUSSION AND CONCLUSIONS

Studies verify the benefits and the cost-effectiveness of many safety measures. In this article, it was shown that the results of such studies represent an important, but by no means sufficient, basis for the planning of a national safety programme. Politicians have finite interest in the performance of a measure in another country, at another time and under other circumstances. For this reason, many valuable results are not optimally employed in the planning of safety programmes. This article, therefore, outlines a method whereby the injury reduction potential of a safety programme can be estimated as realistically as possible.

The method outlined makes use of various sources. While those parameters that are based on reliable data can be determined with certainty, others, based on variable, less reliable information, are more approximate. It is therefore important that estimates are clearly declared as such, and the basis also noted, for example, information from local authorities. The more sources of information are available, the more precise the forecast will be. It is, therefore, recommended to collect representative information on safety related indicators. Additionally public opinion should be regularly surveyed. The more information available about future measures, the better the estimates of the values for ‘degree of implementation’ and ‘degree of compliance’.

A further difficulty is that the data records for some measures are very good, while for others they are very poor. Where poor, it is recommended that further research is conducted and further clarification sought as early as the design phase of the programme. Specifically, the estimation of the potential of a measure should make use of as many of the involved persons as possible.

The method suggests to start from the potential number of severe and fatal injuries that could be influenced by the measure (step A). Some measures are very specific and as a consequence the referring number of accidents taken out of the official statistic is quite small, random variations in the accident statistics then have a influence on the result. To minimize the effect of random variations in accident records on the forecasted number of prevented injuries due to a safety measure, one should take the average annual number of accidents from a 5-year-period in step A. The estimation of the combined effect of safety measures was based on the assumption that an effect of a single measure may be correlated with the effect of another measure. Based on studies that have evaluated the effect of multiple road safety measures introduced at the same locations, Elvik (2009) has shown that indeed a conservative estimation of the whole program effect is reasonable. He proposes the dominant common residual model which claims that effects of measures are correlated and that furthermore the most effective road safety measure in a set will more or less dominate the other measures. This view supports the method applied in this article.

The question still remains how the calculated potential of a safety programme can take into account the predicted trend in accident rates. In the Swiss study (bfu, 2002) the trend was determined on the assumption that the intensity of work in the area of road safety remained constant. As earlier efforts also included the introduction of new safety measures, at least a part of the benefits of the programme is already included in the general trend. The method described here offers the possibility to determine the potential of a programme. However, adjustment to allow for the trend (as determined by the suggested methodology) cannot be done accurately, as the size of the overlap is not quantified.

Certain prerequisites are required if measures are to achieve their potential to reduce injuries caused by road accidents. Quality assurance measures (e.g. safety related training for engineers, Good Practice obligations such as safety audits) are not true safety measures; they are, however, necessary prerequisites. A national safety programme must also specify these measures, and they must be attributed to the side of ‘costs’ in the cost-benefit-analysis.

Methodological shortcomings limit the validity of the results. The method outlined here nevertheless represents an improvement for forecasts in comparison to the uninformed use of single evaluation results. All relevant parameters are determined for the conditions in a real situation and the connections between them are accounted for in a transparent way.

REFERENCES

Abelson, P., Taylor, R., Butler, J., Gadiel, D. (2003). *Returns on Investment in Public Health: An Epidemiological and Economic Analysis*. Australian Government, Department of Health and Ageing.

bfu (2002). *Erarbeitung der Grundlagen für eine Strassenverkehrssicherheitspolitik des Bundes VESIPO*. Forschungsauftrag ASTRA 2000/477, Federal Roads Office FEDRO, Bern, English Summary IV p. <http://www.bpa.ch/German/strassenverkehr/viasicura/Documents/vesipo_schlussbericht_d.pdf>.

Boston, J., Martin, J., Pallot, J., Walsh, P. (1996). *Public Management: The New Zealand Model*. Oxford University Press, Auckland.

Cavegn, M., Ewert, U., Allenbach, R. (2010). *Auswirkungen der Via sicura-Massnahmen* – Evaluation des Nutzens der Via sicura-Massnahmen für die Verkehrssicherheit sowie deren Kosten, bfu – Beratungsstelle für Unfallverhütung, Bern. bfu-Grundlagen.

Cook, T.D., Campbell, D.T. (1979). *Quasi-Experimental Design & Analysis Issues for Field Settings*. Rand McNally, Chicago and Houghton Mifflin, Boston.

Elvik, R. (2009). An explanatory analysis of models for estimating the combined effects of road safety measures. *Accident Analysis and Prevention* 41, 876–880.

Elvik, R., Høye, A., Vaa, T. and Sørensen, M. (2009). *The handbook of road safety measures*. Second edition. Bingley, U.K.: Emerald Group Publishing Limited.

Evans, L., 1996. Safety-belt effectiveness: the influence of crash and selective recruitment. *Accident Analysis and Prevention* 28 (4), 423–433.

Furubo, J., Rist, R.C., Sandahl, R. (2002). International Atlas of Evaluation. *Transaction Publishers*, New Brunswick, London.

Hauer, E. (1997). *Observational Before–After Studies in Road Safety*. Pergamon.

Jagtman, H.M., Hale, A.R., Heijer, T. (2006). Ex ante assessment of safety issues of new technologies in transport. *Transportation Research Part A: Policy and Practice* 40 (6), 459–474.

ROSEBUD (2005). *Road Safety and Environmental Benefit–Cost and Cost-Effectiveness Analysis for Use in Decision-Making*. EU-Research Project. <http://ec.europa.eu/transport/road_safety/projects/doc/rosebud.pdf>.

Sanderson, I. (2004). *Getting evidence into practice – perspectives on rationality*. Evaluation 10 (3), 366–379.

Schlatter, H., Merz, H. (2001). *Prognose der Strassenverkehrsunfälle 2010*. VESIPO-Teilbericht, Forschungsauftrag ASTRA 2000/477, Federal Roads Office FEDRO, Bern.

Yannis, G., Gitelman, V., Papadimitriou, E., Hakkert, A.S., Winkelbauer, M. (2008). *Testing a framework for the efficiency assessment of road safety measures*. Transport Reviews 28 (3), 281–301.