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The properties of Safety Performance Indicators in target setting, projections and safety design of the road transport system

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ABSTRACT

Road traffic Safety Performance Indicators (SPIs) are becoming increasingly used as an instrument for the planning and monitoring of safety progress. SPIs form an intermediate step between actions and final outcome in terms of casualties in road crashes. It is understood that SPIs are closely related to outcome; and that it is also possible to use them in calculations and predictions of both actions and final outcome. In the present study, it was found that some of the properties assigned to SPIs could be questioned. An assumption of linearity between SPIs and final outcome was partly rejected. It was also found that 100% fulfillment of a set of SPIs could lead to very low mortality, demonstrating the importance of handling SPIs simultaneously.

1. Introduction

In managing road traffic safety, setting quantified, time-limited targets regarding the reduction of fatalities and injuries, has been a common approach in many countries (OECD, 1994, 2002, 2008). However, a long period of time can elapse between countermeasures being taken and their final outcomes in terms of fewer casualties, and it is difficult to manage an effective road safety strategy on causality reduction targets alone. There are too many other factors, for example fluctuating economic trends, which can influence the outcome in terms of casualty reductions. It is therefore becoming more common to use Safety Performance Indicators (SPIs) (Elvik, 2008; ISO, 2008; OECD, 2008; SafetyNet, 2008; SRA, 2008b; Hermans et al., 2009) as a way of effectively linking safety countermeasures with final outcomes in terms of fewer casualties. In general terms, SPI has been defined as "... measures (indicators), reflecting those operational conditions of the road traffic system, which influence the system's safety performance" (Gitelman et al., 2007; SafetyNet, 2008). Managing road safety with SPIs enables countries to develop process-oriented road safety initiatives which take into account the fact that public policy instruments come in vertical, horizontal and chronological packages, rather than in isolation (Bemelmans-Videc et al., 1998). SPI could be an effective tool for managing these packages, ensuring that different countermeasures are combined in order to achieve results.

In management of improved safety, SPIs vary in number from less than 10 to more than 20 (Elvik, 2008; OECD, 2008). In this context, SPIs are understood to represent certain operational conditions that are related to traffic safety, often expressed as the proportion of the traffic volume that fulfills the condition. One example could be "the proportion of car occupants using seat belts"; another example is "the proportion of the traffic volume travelling on divided roads". The SPI therefore both represents a certain safety aspect (seat belt use, divided roads) as well as a value (proportion of traffic volume) of how this aspect has penetrated the traffic system. It is implicitly understood that the SPI should have a proven and well-documented relation to the number of casualties, and could be seen as an intermediate measurement of the traffic safety level for that specific aspect. The combination of several SPIs would then also be an intermediate measurement of traffic safety, representing current or future final outcomes in terms of the number of fatally and severely injured (Elvik, 2008; Hermans et al., 2008, 2009).

For the majority of SPIs, there are several countermeasures that could contribute to their improvement. Taking the above examples of seat belt use, the improvement could (for example) follow as a result of seat belt legislation and enforcement, a demerit point system, occupational health and safety regulations or intelligent seat belt reminders in isolation or in combination.

Existing adopted road safety targets focus on a step-by-step improvement of the fatality situation in the road transport system. However, more recently a new approach towards road safety

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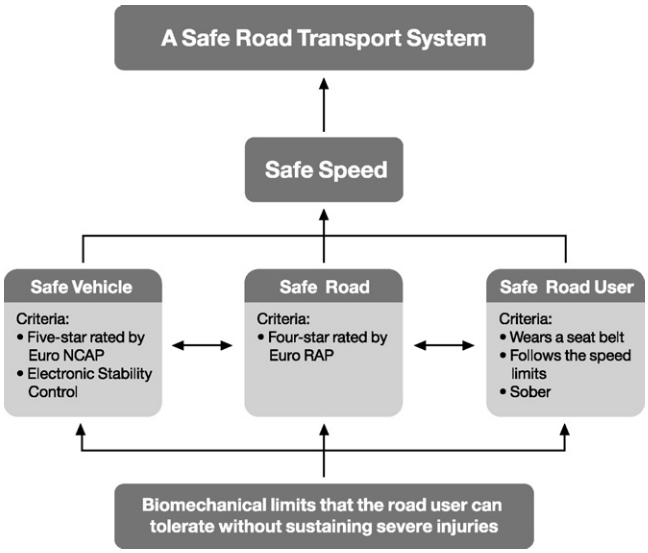

Fig. 1. The model for safe traffic.

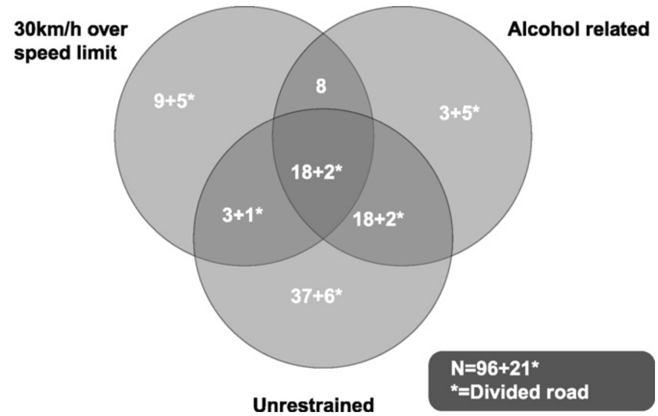

Fig. 2. The number of fatalities not fulfilling SPIs for alcohol, restraint use and speeding.

has been developed. Instead of defining road safety in terms of continuous improvement, road safety is, instead, defined in absolute terms such as numbers of people fatally and seriously injured (Swedish Government, 1997). This new approach facilitates a discussion and definition of a safe system. This model for safe traffic (OECD, 2008), or what is sometimes called 'Vision Zero' (Tingvall, 1995), links the properties of an inherently safe road transport system through Safety Performance Indicators (Stigson et al., 2008). In this approach, a number of SPIs are simultaneously set to a requirement of 100% fulfillment.

Fig. 1 shows a model for a safe road transport system described by the SRA and the OECD (Linnskog, 2007; OECD, 2008; Stigson et al., 2008), where different SPIs are related to the vehicle, the infrastructure and the road user. In this model, the selected SPIs are simultaneously set to a requirement of 100% fulfillment. The hypothesis of the model is that fulfillment of the predefined sets of SPIs would generate an inherently safe system. The difference between a list of SPIs and the model for safe traffic is that the SPIs are more clearly defined and that they are inter-related. Other important properties of the model are that deficiencies in safety are balanced and controlled by adapting the speed limit to the safety level of the system. The model is also based on a few preconditions for the users of the system which would leave some harmful events outside the scope of the model.

Elvik (2009) pointed out that the most common method for estimating combined effect of several SPIs has been performed by assuming that the effect of SPIs are independent. However, Nilsson (2004) has presented correlations between alcohol, seat belt use and speed limit compliance relying on self-reported data. The self-reported data shows that a road user who disobeyed traffic rules more often broke several rules at the same time (almost three times higher) compared with estimations assuming that there were independent. Using SPIs as both a management tool for improving safety, as well as turning them into a design specification for a safe road transport system, raises a number of critical questions. While using SPIs simply as a tool to structure countermeasures does not require much knowledge about the deeper nature of SPIs, using them to predict future progress means that they are used in quite complex calculations. The following questions should therefore be raised:

- Are SPIs independent variables in the sense that they can be treated by simple probability functions, and can simple probability methods be used for predicting the result of multiple improvements of SPIs?
- Could SPIs be considered to have a linear relationship to final outcome?
- Is the combination of SPIs proposed by the model for safe traffic logical in the sense that it produces a high level of safety?

2. Methods and data

Several methods were used to reflect on the aims of the study. In order to study whether SPIs could be considered as statistically *independent*, empirical data were used to demonstrate independence or lack of independence. The empirical data consisted of all in-depth investigated fatal crashes occurring in Sweden 2004 on the state network (i.e. more or less the same as "outside built-up areas") where at least one car occupant was fatally injured. In all, 217 car occupants were fatally injured in those crashes. The crashes and occupants were classified according to the SPIs used in the model for safe traffic, Fig. 1, presented in Stigson et al. (2008). Fig. 2 shows the number of fatalities for divided and undivided roads, with respect to Blood Alcohol Concentration (BAC) over the legal limit in traffic (above 0.02%), seat belt use and speeding. The results in Tables 3–5 are based on Fig. 2.

In the analysis of *linearity* between SPIs and final outcome, seat belt use over time was studied. For this analysis, both in-depth data from 1997 to 2007 collected by SRA in-depth study teams, and observational data in traffic were used. The data on seat belt use in traffic were collected and analysed by the Swedish National Road and Transport Research Institute (VTI) (SRA, 2008a).

The study of the effects of 100% fulfillment of a set of SPIs (divided roads, seat belt use, sober driver and non-excessive speed) combined simultaneously was based on the same empirical data as for independently introduced SPIs. These data were compared with observational data for travelling on divided roads, seat belt use, BAC over the legal limit and speeding (SRAKonsult, 2005; SRA, 2006); 35% travelled on divided roads outside built-up areas, 96% used seat belts in traffic, the proportion who were under the legal alcohol limit was 99.8%, and the proportion driving no more than 30 km/h above the posted speed limit was 99%. The observations are part of a long series produced by VTI and the SRA (SRA, 2008a).

In order to study if SPIs can be treated independently, the method used by Elvik (2008) was used, where the effect of two improved SPIs is described as follows:

> "If two measures influence the same target group of 100 accidents and one of the measures reduces accidents by 30% and the other by 40%, their combined effect was estimated as"