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Validation of a method to evaluate future impact of road safety interventions, a comparison between fatal passenger car crashes in Sweden 2000 and 2010

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ABSTRACT

When targeting a society free from serious and fatal road-traffic injuries, it has been a common practice in many countries and organizations to set up time-limited and quantified targets for the reduction of fatalities and injuries. In setting these targets EU and other organizations have recognized the importance to monitor and predict the development toward the target as well as the efficiency of road safety policies and interventions.

This study aims to validate a method to forecast future road safety challenges by applying it to the fatal crashes in Sweden in 2000 and using the method to explain the change in fatalities based on the road safety interventions made until 2010. The estimation of the method is then compared to the true outcome in 2010. The aim of this study was to investigate if a residual of crashes produced by a partial analysis could constitute a sufficient base to describe the characteristics of future crashes.
Result: show that out of the 332 car occupants killed in 2000, 197 were estimated to constitute the residual in 2010. Consequently, 135 fatalities from 2000 were estimated by the model to be prevented by 2010. That is a predicted reduction of 41% compared to the reduction in the real outcome of 53%, from 332 in 2000 to 156 in 2010. The method was found able to generate a residual of crashes in 2010 from the crashes in 2000 that had a very similar nature, with regards to crash type, as the true outcome of 2010. It was also found suitable to handle double counting and system effects. However, future research is needed in order to investigate how external factors as well as random and systematic variation should be taken into account in a reliable manner.

1. Introduction

When targeting a society free from serious road traffic injuries, it has been a common practice in many countries and organizations to set up time-limited and quantified targets for the reduction of fatalities and injuries (Organization for Economic Co-operation and Development, 2008). In 2010 EU adopted a road safety program to cut road death in half by 2020 (European, 2010) and is furthermore aiming to move close to zero fatalities by 2050 (European, 2011). In setting these targets EU and other organizations recognize the importance of monitoring and predicting the development toward the target as well as the efficiency of road safety policies and interventions (European, 2010; Swedish Transport Administration, 2012). Predicting the future status of the road transport system is, however, important not only with respect to target monitoring; also it plays an important role in the process of operational planning and in the prioritization of future actions (Tingvall et al., 2010). In the process of managing road safety it is essential to provide guidance for stakeholders in the choice of the most effective safety measures. Methods to estimate future benefits of road safety interventions have been introduced and used in, for example, Sweden and Australia. In Sweden a model suggested by the Institute of Transport Economics in Norway was used to forecast the number of lives saved by different road safety interventions introduced 2007 and beyond (Swedish Road Administration, 2008). This was done to facilitate the decision on an interim road safety target in Sweden which should be ambitious but achievable. The effect of the individual interventions was calculated as the exposure multiplied by the effectiveness. One example is the increase of cyclists wearing a helmet multiplied by the helmet effectiveness in reducing head injuries and fatalities. The number of saved lives from all interventions were then estimated by the total

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sum multiplied by a factor of 0.6 to adjust for double counting (Swedish Road Administration, 2008). In South Australia a model was developed for the South Australian Government by Anderson and Ponte (2013) which aimed to quantify the benefit from a number of safety improvements until 2020. The model takes implementation rate and time into account and relates every intervention to its relevant target population. In this study the target population is defined as the group of fatalities prevented by a specific intervention. Other external factors such as traffic growth and changes in the vehicle fleet are also taken into consideration.

A model developed by Vulcan and Corben (1998) was numerically implemented by Corben et al. (2009) in Western Australia and used the same approach. The overall benefit from all intervention (I_1,I_2, . . . , I_n) in the Australian models was calculated as $1-(1-I_1)\times(1-I_2)\times\ ...\ \times(1-I_n)$. Hence, the interventions were treated as independent, as Elvik (2009) identified as the most common principle.

Although the assumption of an independent relationship could sometimes be true and applied in retrospective evaluations, it has shown in some cases to be invalid and therefore not applicable to describe the future. One such case is seat belt use and alcohol related crashes that according to Tingvall et al. (2010) should not be treated as independent. In the future, several interventions to reduce health loss, sometimes called Safety Performance Indicators (SPIs), such as road improvement and vehicle safety systems, will interact and sometimes also address the same target groups. Hence, there is a need for methods that have a deeper knowledge of the interacting properties among the SPIs and have the ability to logically handle system effects and double counting.

In summary, some of the reasons to look forward in time is to; point out what is effective or not, point out what should be prioritized or developed further down the track and finally what system effects that become evident. As a response to this a new method was developed in Sweden to enable stakeholders to prioritize between road safety actions (Strandroth et al., 2012). The method was based on knowledge from in-depth studies of fatal crashes and the key point was to project the fatal crashes of today into a given time in the future. Assumptions regarding future implementation of safety improvements till 2020 were made. A safety improvement was considered applicable if it was not present in the baseline year of 2010 but it would be present in 2020.

These assumptions were then applied to fatal crashes in Sweden involving passenger cars that occurred in 2010. Case by case analysis was made to investigate if a crash from 2010 would still occur in the future, thus be part of the residual crashes 2020. As such, the method is more of a partial analysis based on logical reduction of crashes compared to other prediction models where external factors are included in the model. The method calculated that the number of car occupants killed could be reduced by 53% between 2010 and 2020.

However, the method has not been evaluated to confirm if the model is valid. One possible validation would be to apply the method on fatal crashes occurred in 2000, make estimations for 2010 and then compare the residual with the true outcome of 2010. The aim of this study was to perform such a validation.

Between 2000 and 2010 many factors in the road transport system in Sweden have changed significantly. In the late 1990's and into the following decade major investments were made in the road infrastructure in order to install median barriers on rural roads with a high traffic volume. This resulted in the proportion of traffic volume on public state roads with median barrier from 26% in 2000 to 41% in 2010 (National, 2014). In addition, Audio Tactile Lane Markings (ATLM) have been milled into the middle of the road on 4000 km of rural roads to reduce lane departure crashes (Swedish Transport Administration, 2011). Also, systematic improvements were carried out to improve the road side environment on smaller roads. Road side barriers were installed or the road side area was made clear of fixed objects. In urban areas the strategy to rebuild intersections with transversely moving vehicles into roundabouts have effectively decreased the number of car occupants killed in those situations. With regard to vehicle safety the crashworthiness of new passenger cars has improved and the risk for a car occupant fatality in the case of a collision has decreased by approximately 3% per year between 2000 and 2010 (Folksam, 2013). Also, in this period the share of new passenger cars in Sweden with Seat Belt Reminder (SBR) and Electronic Stability Control (ESC) has increased from almost 0 to close to 100% (Swedish Transport Administration, 2012). Other factors worth mentioning could be that the belt use in traffic among car passengers has increased from 90 to 96% and that the average speed on rural roads has decreased by 4.4% (Swedish Transport Administration, 2014). The overall traffic flow with passenger cars on the Swedish road network increased by approximately 6% in the same period (Transport Analysis, 2014). The number of fatally injured has also decreased significantly. In 2000 the number of passenger car occupants killed in Sweden was 339, while in 2010 it had reduced to 156 (Swedish Transport Administration, 2012). However, it should be noted that 2010 was quite an exceptional year.

The total road toll in 2010 relating to all road users was 266 people killed while the expected number compared to the trend based on 2008–2012 should be around 340.

Largest deviation from the trend is the number of fatalities in single vehicle crashes which was 56 instead of the expected 83 (Swedish Transport Agency, 2014).

This study aimed to take the first step toward a validation of the method used by Strandroth et al. (2012) by apply it to fatal crashes in Sweden 2000 and compare the residual crashes to the true outcome in 2010. The following question was raised; can a residual of crashes produced by a partial analysis constitute a sufficient base to describe the characteristics of future crashes?

2. Method

In the present study the method described in Strandroth et al. (2012) was used. However, the baseline year of 2000 was chosen and 2010 the year of the residual crashes. A validation was then done comparing the residual 2010 to the true outcome of 2010. The number of car occupant fatalities as well as their characteristics were compared.

Naturally, the safety improvements implemented between 2000 and 2010 were different than those assumed to be implemented 2010–2020. Safety aspects of the road environment during the period 2000–2010 related to the fatal crashes was studied using in-depth data collected by the Swedish Transport Administration. Thus, this validation makes the approximation that the fatal crashes occurring ten years later are located to the same area. The road characteristics were studied with regards to the presence and implementation of median barriers, side barriers, road-side improvements, rumble strips, roundabouts and speed-limit changes. The focus in this present study was to identify systematic improvements, such as road-side barriers on a significant road section, rather than local changes, such as cutting down a single tree. After all, the implemented improvements should be of such a nature that they are possible for a model to predict. However, the reduction of crashes in this validation is based on observed improvements rather than assumed improvements which would be the case with future crashes.

For passenger cars, the basic assumption was that the cars involved in fatal crashes 2010 would be ten years newer than the cars involved in fatal crashes 2000. For example, a car of model year (MY) 1993 involved in a fatal crash 2000 is assumed to be MY