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Does the influence of risk factors on accident occurrence change over time?

Rune Elvik*

Institute of Transport Economics, Gaustadalleen 21, NO-0349 Oslo, Norway

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ABSTRACT

A large number of studies have been made to assess the relationship between risk factors and accident occurrence. A risk factor is any factor that makes an accident more likely to occur. Very many risk factors have been identified, for example, being under the influence of alcohol while driving, driving on slippery roads, entering complex junctions, or driving in hours of darkness. Few studies have been made to determine whether the associations between risk factors and accident occurrence remain stable over time. This paper presents examples of studies that have replicated estimates of risk. All these studies were made within a given country, using the same method, to ensure that estimates of risk are comparable. The risk factors included in the paper are: daylight, horizontal curves, junctions, road surface conditions, precipitation, drinking and driving and driver age. For all these risk factors, their association with accidents has changed over time, mostly becoming weaker. A protective factor, snow depth, is also included. Its protective effect has become smaller over time. Possible reasons for the weakening influence of risk factors are discussed.

1. Introduction

Studies evaluating the effects of road safety measures are often amenable to a formal synthesis by means of meta-analysis. Studies of the risk factors that contribute to accidents or injuries are often quite heterogeneous and not as easy to summarise. As an example, Johansson et al. (2009) listed 13 studies of the risk of accident associated with darkness. The studies differed with respect to country of origin, types of accidents included, accident severity, type of traffic environment and technique used to control for other risk factors that may be correlated with darkness, such as slippery roads. The studies were judged to be too different to apply meta-analysis to summarise their findings. Besides, not all studies reported the information needed to be included in a meta-analysis.

Little is known about changes over time in the association between risk factors and accident occurrence. While, for example, darkness is a risk factor found all over the world, its relationship to accidents may vary both between countries and over time. It is known that the risk of pedestrian accidents increases more in darkness than the risk of accidents involving motor vehicles only. Hence, if there are fewer pedestrians at night, risk may change. Likewise, the standard of road lighting and of vehicle headlights may change over time and influence the risk associated with darkness. It is by no means certain that the risk associated with darkness remains the same over time. Similar points of view can be put forward with regard to many risk factors.

The objective of this paper is to explore whether the association between some risk factors and accident occurrence is stable over time. The study is exploratory and only intended to give examples that may motivate others to do more research regarding the stability over time of the associations between risk factors and accident occurrence.

2. Literature review

The idea that the association between risk factors and accident occurrence may change over time is not new. Minter (1987) described the improvement of road safety in some highly motorised countries as a process of learning and fitted learning curves developed in psychology to time-series data on the number of traffic fatalities per registered car. These curves described the overall decline over time in the number of accidents per registered car, but did not identify the factors contributing to the decline.

Qiu and Nixon (2008) reviewed studies of the effect of adverse weather on traffic crashes. They reported that the increase in accident rate associated with snow appears to have been reduced over

* Correspondence author.
E-mail address: re@toi.no

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time. The mean increase in accident rate associated with snow was 113% in studies reported between 1950 and 1979, 71% in studies reported between 1980 and 1989 and 47% in studies reported between 1990 and 2005. The increase in accident rate associated with rain also changed in the same decades, but did not decline consistently. Rain was associated with an 80% increase in accident rate between 1950 and 1979, a 29% between 1980 and 1989 and a 71% increase between 1990 and 2005. Qiu and Nixon also reported that both rain and snow were associated with a smaller increase in the risk of injury accidents and fatal accidents than the overall increase in the risk of accidents of all levels of severity.

In recent years, improvement in both the active and passive safety of cars has made an important contribution to reducing accident rates. Broughton (2012) shows how new cars registered recently in Great Britain are safer than cars registered 20–30 years ago. It is likely, as will be discussed later in the paper, that some new safety features on cars have contributed to reducing the risk associated with some environmental risk factors, such as rain or snow.

A factor that probably has been contributing to reducing accident rates for a long time, is the increasing collective experience of the population of drivers. A 60 year old driver today is likely to have had a longer driving career than a 60 year old driver 40–50 years ago. Cicchino (2015) reports that fatality rates among older drivers in the United States have declined, which is consistent with the fact that these drivers have had a longer driving career than any other group of drivers and thus more opportunities to learn safer driving.

Christophersen et al. (2016), giving detailed statistics for five countries, show that drinking and driving has been reduced in all these countries. In discussing why this trend is found, the authors note that decades of enforcement, information campaigns and fairly strict penalties for drinking and driving may have caused a change in social norms, making drinking and driving an unacceptable behaviour for most people. Whatever the underlying mechanisms, it seems clear that the contribution of drinking and driving to accidents has declined over time.

3. Identification of studies

Given the exploratory nature of this study, it is limited to a few risk factors for which the author knows that at least two studies, performed at least ten years apart, have been made. Studies that fulfilled the following criteria were identified:

1. Successive studies of the same risk factor should have been made in the same country.
2. The studies should employ the same method, or at least highly similar methods.
3. The studies should refer to the same level of accident or injury severity.

Studies fulfilling these criteria were identified for the following risk factors:

1. The length of daylight, as determined by the times of sunrise and sunset.
2. The radius of horizontal curves on rural two-lane roads.
3. The number of legs in junctions located in rural or urban areas.
4. Road surface conditions in winter (dry road, wet road, snow- or ice-covered road).
5. Precipitation in the form of rain or snow in millimetres during 24 h.
6. The frequency of drinking and driving.
7. The relative accident rate of older drivers compared to all drivers.

Studies of these risk factors have been made in Norway, Denmark, Sweden and the United States. Furthermore, a factor which has been found to be protective against injury accidents (i.e. it does not prevent accidents, but makes them less severe), snow depth, was included. Studies of this factor have been reported in Norway and Sweden.

4. Examples of changes in estimates of risk

4.1. Daylight

Two Norwegian studies made eleven years apart (Fridstrøm 2000; Elvik and Kaminska, 2011) to evaluate the effects on accidents of changes in the use of studded tyres in major cities in Norway included a variable measuring the length of daylight. This varies enormously in Norway; north of the Arctic Circle there is midnight sun in summer and no sun at all in winter. In the city of Oslo, the share of the day with sunlight varies between 0.246 and 0.785.

Negative binomial regression models were developed in both studies, including more than 20 variables (Elvik et al., 2013). The dependent variable was the number of accidents per day per city. The first study covered the period 1991–2000 (median year 1996). The second study covered the period 2002–2009 (median year 2006). Fig. 1 shows the relative number of accidents on the day with the shortest period of daylight compared to the day with the longest period of daylight in 1996 and 2006 for the four cities that were included in both studies.

The day with the shortest period of daylight has more accidents than the day with the longest period of daylight. This was found in both studies. However, in three of the four cities, the difference in the number of accidents between the day with the shortest duration of daylight and the day with the longest duration of daylight became smaller from 1996 to 2006. Moreover, the differences between the cities with respect to the variation in the number of accidents were smaller in the second study than in the first. The results thus indicate that the risk associated with darkness has become smaller and more uniform over time. The reasons for this tendency are not known. Road lighting may have been upgraded to a higher and more uniform standard in all the cities and car headlights may have been improved.

4.2. Horizontal curves

Accident prediction models for horizontal curves have been developed more than once in the United States. In general, these models describe the relationship between characteristics of a curve, like radius, length, and the presence of transition curves and the expected number of accidents. The Highway Safety Manual (AASHTO, 2010) presents a model developed by Zegeer et al. (1992), based on data for two-lane rural roads in the state of Washington. These data were, however, quite old (1976–1982). An updated accident prediction model, also based on data for two-lane rural roads in the state of Washington, was developed by Bauer and Harwood (2013). This model did not have exactly the same mathematical form as the model developed by Zegeer et al. (1992), but served the same function and included the same variables. Estimates based on the two models are therefore regarded as comparable. Fig. 2 shows how the relative accident rate (i.e. number of accidents for a given traffic volume) depends on curve radius (metres) according to the two models.

The estimated relationships are very close until curve radius is less than about 200 m. For curves with radius less than 200 m, the oldest function predicts a considerably larger increase in accident rate than the most recent function. It would thus seem that sharp