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Risk and protection factors in fatal accidents

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ABSTRACT

This paper aims at addressing the interest and appropriateness of performing accident severity analyses that are limited to fatal accident data. Two methodological issues are specifically discussed, namely the accident-size factors (the number of vehicles in the accident and their level of occupancy) and the comparability of the baseline risk. It is argued that – although these two issues are generally at play in accident severity analyses – their effects on, e.g., the estimation of survival probability, are exacerbated if the analysis is limited to fatal accident data. As a solution, it is recommended to control for these effects by (1) including accident-size indicators in the model, (2) focusing on different sub-groups of road-users while specifying the type of opponent in the model, so as to ensure that comparable baseline risks are worked with. These recommendations are applied in order to investigate risk and protection factors of car occupants involved in fatal accidents using data from a recently set up European Fatal Accident Investigation database (Reed and Morris, 2009). The results confirm that the estimated survival probability is affected by accident-size factors and by type of opponent. The car occupants' survival chances are negatively associated with their own age and that of their vehicle. The survival chances are also lower when seatbelt is not used. Front damage, as compared to other damaged car areas, appears to be associated with increased survival probability, but mostly in the case in which the accident opponent was another car. The interest of further investigating accident-size factors and opponent effects in fatal accidents is discussed.

1. Introduction

The goal in collecting accident data is to learn from the past and gain information that can help preventing future accidents from occurring (crash prevention), or mitigating their consequences (crash protection). The ultimate objective of road-safety management is the reduction of the number of fatalities. As a consequence, road-safety targets are expressed and quantified as number of casualties (or as the desired reduction thereof). Well-maintained fatal accident databases are thus necessary to monitor the evolution of road-safety and the effects of the measures implemented. Detailed information on fatal accidents, on the other hand, is also sought after with the aim of increasing knowledge of fatal crashes and of developing fatal crash prevention measures. It is well known that fatal accident data, as compared to data recorded from less severe accidents, are the most reliable. "Not only are fatalities the most serious and permanent consequence of traffic crashes, but fatality data are vastly more reliable and readily interpretable than data for any other level of harm" (Evans, 2004, p.19). As a result, databases are developed that focus on fatal accidents exclusively. This is the case of the Fatal Accident Reporting System (FARS) in the U.S, and more recently of the Fatal Accident Investigation (or FAI) database (Reed and Morris, 2009), created under the impetus of the European commission.

Such fatal accident databases cannot be used to perform analyses aiming at fatal crash prevention, unless they are linked with data from other accident severity levels. Indeed, in order to determine which features are *specific* to fatal accidents, these have to be compared to non-fatal accidents. Yet, as Evans notes: "the majority of people involved in fatal crashes are not themselves killed" (Evans, 2004). Consequently, differentiating the survivors from the fatalities *in fatal crashes* – and thereby identifying protection factors *within* those severe crashes – is a legitimate and interesting step to take to improve existing knowledge of fatal crashes. Of course, observations that are limited to fatal accidents can only provide information that is restricted to this high-end of the accident-severity continuum. The conclusions that can be derived from such an analysis in terms of protection factors will similarly be limited to the "worst case scenarios". But identifying the properties of the road-users, vehicles, or of the accident itself that play a protective role in those extreme situations is all the more important.

Despite their potential interest, few investigations have been conducted so far on risk and protection factors in fatal accidents (Evans, 1983, 1986; Evans and Frick, 1993). It must be acknowl-

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edged that limiting a severity analysis to fatal accident data raises important methodological considerations. Although these considerations are generally at play in all accident severity analyses (i.e. analyses focusing on the consequences that an accident has for the road-users it involves, and which are not restricted to fatal accident data), they are seldom explicitly discussed, even when appropriately addressed in the models developed (e.g. Lui et al., 1988). Below, two of these issues – here labelled "the accident-size bias", and "the comparability of the baseline risk" – are discussed: their general effects on severity analyses are described, as well as the reasons to expect these effects to be exacerbated in the case of data limited to fatal accidents. Then, an analysis of the risk and protection factors of road-users involved in fatal accidents, conducted on the basis of the Fatal Accident Investigation database (Reed and Morris, 2009) is presented. The aim is both to stress the importance of accident size and of the comparability of baseline risks in this kind of investigations, as well as to propose practical solutions to control for these factors when working with fatal accident data.

1.1. The accident-size bias

The size of an accident (i.e., the total number of road-users involved) is a joint function of the number of participants it involves (pedestrians, passenger cars, powered 2-wheelers, ...) and of the level of occupancy of the vehicles. Using all-severity crash data, Kockelman and Kweon (2002) have shown, for example that vehicle occupancy had no effect on driver injury risk in 2-car crashes, but that higher occupancy levels were associated with a lowered driver injury risk in single-car crashes. Chang and Mannering (1999) predicted the most severe injury sustained by car occupants in all-severity crashes using vehicle occupancy as a nesting factor. The results showed that the occupancy level corresponding respectively to property damage only, injury, and fatal accidents were 1.31, 1.53, and 1.63, suggesting a positive association between the number of occupants and the worst consequence of the accident (the most severe injury). Finally, Khorashadi et al. (2005) observed a negative relation between the level of occupancy of vehicles and the probability that the driver will be left uninjured, while the relation between the number of vehicles in the accident and the probability for the driver to be uninjured was found to be positive. The severity of an accident is consequently affected by its size. The lack of consistency in the results summarized above indicates, on the one hand, that the overall relation between accident size and accident consequences is far from simple. It probably depends on a number of other factors; to begin with a likely interplay between the accident-size factors themselves, namely the number of participants and the vehicle occupancy level. On the other hand, the relation between accident size and accident severity (here generally understood as the consequences an accident has for the road-users it involves) is also likely to differ depending on the precise way in which severity is operationalised (e.g. as the most severe injury sustained by each of the car occupants, or as the probability for the driver to be injured or left uninjured).

Matters are different when the accident size–severity relation is examined within the restricted context of fatal accident data. In this case, the relationship between the size of an accident and its outcomes can be considered a bias. Indeed, it results mainly from the selection criterion applied during the data collection: each accident recorded in a fatal accident database necessarily generated at least one fatality. As a consequence, the presence of survivors in the same accident most crucially depends on whether or not more than one person was involved in this accident. The probability to survive will inevitably be estimated as 0 for single car-occupants in single-vehicle accidents, and steadily increase with the number of occupants in vehicles, as well as with the number of these vehicles.

Although they are seldom explicitly discussed in the literature, the effects of accident-size factors are usually dealt with in accident-severity models. The effects of vehicle occupancy on estimates of accident severity are often controlled for by selecting drivers as units of observation (e.g., O'Donnell and Connor, 1996; Kockelman and Kweon, 2002; Shibata and Fukuda, 1994; Martin and Lenguerrand, 2008), or by including occupancy as a predictor in the model (Kockelman and Kweon, 2002; Chang and Mannering, 1999; Khorashadi et al., 2005). The number of accident participants is, on the other hand, usually maintained constant by selecting accidents with a given number of participants and focusing, for example, on two-car crashes or single-car crashes (e.g. Savolainen and Mannering, 2007; Yau, 2004; Khorashadi et al., 2005; Martin and Lenguerrand, 2008). The main disadvantage of most of these methods, however, is that the desired level of control is attained at the costs of data losses. Some of them, such as the selection of drivers as units of observation may remain problematic when working exclusively with fatal data: it does not allow to fully control for the effects of occupancy levels on the dependent variable ("severity"), since the risk for the driver to sustain, say, a fatal injury still depends on the level of occupancy of his/her vehicle. To avoid this problem, only cars occupied solely by the driver have to be selected (e.g., Evans, 1983), which means that even less data are available for the analysis and puts further restrictions on the generalisability of the results. Finally, working on the basis of driver data often poses problems in interpreting results related to the individuals' characteristics. As an example, drivers who wear a seat-belt are known to be less often involved in severe accidents, so that it is difficult to determine with certainty whether a reduced probability for severe injury among belted drivers reflects their less frequent involvement in severe crashes, or whether unbelted drivers are indeed more at risk for severe injuries (Evans, 2004). When the results are based on all car occupants, accident risk is not confounded with injury risk anymore.

1.2. The comparability of baseline risks

Accident severity models focus on the risk ran by road-users to sustain one or several types of injuries, once involved in an accident. Whatever the particular injury risk that is focused upon (i.e. the fatality risk, or the risk to sustain fatal vs. severe vs. slight vs. no injury, and so on), the initial risk, or the "baseline risk" ran by each accident protagonist strongly depends on his/her mode of transport, but also on that of the road-user they collide with in the course of the accident: the injury risk ran by a pedestrian differs strongly from that of a car driver, and so does the risk for a car driver vary a lot depending on whether he/she collides with a motorcycle or with a light goods vehicle (LGV) or heavy goods vehicle (HGV). When the aim of the analysis is to compare the survivors and the fatalities in accidents so as to identify risk/protection factors, it is important to ensure that one and the others have comparable "baseline risks". Most often, the road-users' and their opponents' modes of transport are controlled for through the selection of well-defined accident types (e.g. Martin and Lenguerrand, 2008). Other models have been developed that include the respective transport modes of the road-users and of their opponents as predictors (e.g. Kockelman and Kweon, 2002; Khorashadi et al., 2005). Quite often, however, the road-users' transport mode is the only one that is controlled for (Yau, 2004; Yau et al., 2006; Shibata and Fukuda, 1994).

1.3. Aim of the study

The analysis presented here focuses on car occupants and integrates both the type of collision opponent and accident-size factors (number of vehicles and level of occupancy) in the model. Car–car accidents – the most frequently encountered accident type in the