Risk of serious injury relative to impact speed in two-vehicle crashes: deriving risk curves for crash types from impact type risk curves

Sam D. Doecke

I. INTRODUCTION

Safe speeds are considered fundamental to achieving the goals of the Safe System. Part of the equation to determine safe speeds is knowing the risk of serious injury at a given impact or travel speed, in a certain crash type. Doecke *et al.* [1] developed risk curves that showed the risk of serious injury (MAIS3+F) relative to impact speed using data from Event Data Recorders (EDRs) from NASS-CDS in front, side, rear and head-on impacts. Doecke *et al.* had hoped to produce impact speed-injury risk curves by crash type to allow the risk curves to be easily understood and applied by policy-makers. However, impact type was used in these risk curves as NASS-CDS had many cases where the injury data were only collected for one vehicle due to a vehicle age criterion. The aim of the present work is to produce impact speed-injury risk curves for crash types involving two light vehicles by combining the impact speed-injury risk curves for impact types.

II. METHODS

For the crash types where the impacts involved are consistently either a front, side, rear, or head-on impact, the method of producing a crash speed-injury risk curve is to apply Equation (1) to the risk curve equations provided in [1]. The first part of Equation (1) is the sum of the probability that each impact type will result in an occupant suffering a MAIS3+F injury, and the second part of the equation represents the probability that both vehicles will have an occupant who suffers an MAIS3+F injury:

$$P_{crash} = \left(P_{vehicle\ 1\ impact} + P_{vehicle\ 2\ impact}\right) - \left(P_{vehicle\ 1\ impact} \times P_{vehicle\ 2\ impact}\right) \quad (1)$$

where P is the probability of MAIS3+F injury at a given impact speed.

The two-vehicle crash types that consistently involve two of the impact types included in [1] are rear-end crashes (front impact + rear impact), right angle crashes (front impact + side impact), and head-on crashes (head-on impact + head-on impact). Equation (2) shows an example of a full crash type equation using the equations provided in [1] to produce an equation for the probability of MAIS3+F injury in a right angle crash. Similar equations were developed for rear-end and head-on crashes. The other common two-vehicle crash type, right turn in front crashes (when driving on the left), does not involve consistent impact types and consequently an impact speed-risk curve has not been produced for it at this stage.

$$P_{right\ angle} = \left(\frac{1}{1+e^{8.1231-0.0548(impact\ speed)}} + \frac{1}{1+e^{10.5583-0.1161(impact\ speed)}}\right) - \left(\frac{1}{1+e^{8.1231-0.0548(impact\ speed)}} \times \frac{1}{1+e^{10.5583-0.1161(impact\ speed)}}\right) \quad (2)$$

S. D. Doecke (e-mail: sam.doecke@adelaide.edu.au; tel: +61 0412 083 251) is a Research Fellow at The University of Adelaide, Centre for Automotive Safety Research, Australia.

III. INITIAL FINDINGS

The risk curves for the selected two-vehicle crash types are shown in Fig. 1. Head-on crashes have the highest serious injury risk at a given impact speed, followed by right angle crashes and rear-end crashes. It should be noted that the impact speed that is considered in each impact type is subtly different. Head-on impacts in [1] were based on average impact speed, therefore the impact speed shown in Fig. 1 also represents the average speed of both vehicles. Front, side and rear impacts in [1] used closing impact speed in the forward direction of the striking vehicle. For right angle crashes, this closing speed is equivalent to the impact speed, but in rear-end crashes this represents closing impact speed.

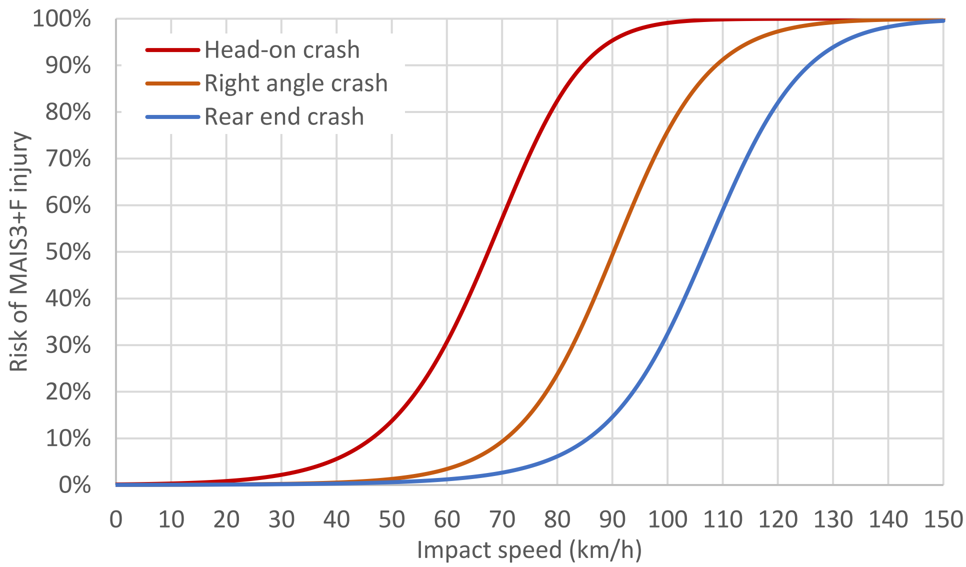

Fig. 1. The risk of serious injury (MAIS3+F) relative to impact speed in select two-vehicle crash types.

IV. DISCUSSION

The risk curves shown in Fig. 1 follow the general form of the two logistic regression functions on which they are based [1]. However, that they appear to have a very similar shape, merely shifted along the x-axis, is not a result of the modelling approach in [1] or the method of the present analysis.

The method of combining two impact or vehicle-based risk curves to create crash-based risk curves for the risk of serious injury relative to impact speed is applicable when the crash type can be well represented by two impact types. When this cannot be done, more complex methods would be required. This would most likely be achieved through estimating the proportion of different impact types within a crash type. It is also important to appreciate the nuances of the risk curves being used, in terms of what situations they represent, and to ensure that these are applicable to the crash type under consideration. Furthermore, because Doecke *et al.* [1] deliberately did not consider the many factors other than impact speed that can influence risk of serious injury caution should be taken when applying the risk curves shown in Fig. 1 to an individual crash, rather than a sample of crashes.

Development of risk curves for more impact types, or more specific impact types, such as near-side and far-side, would allow for more crash type risk curves to be developed using the method presented. The method could also be extended to the vehicle-based risk curves for travel speed presented in Doecke *et al.* [2].

V. REFERENCES

[1] Doecke, S. D., *et al., Accid Anal Prev*, 2020.

[2] Doecke, S. D., *et al.*, *Accid Anal Prev,* 2021.