

Vehicle speed and pedestrian fatalities: Evidence to support road safety messaging

A short report for the Road Safety Authority of Ireland

Educating drivers and pedestrians about the association between speed selection and fatality risk in a Road Traffic Collision (RTC) can enhance road safety. In building awareness, both drivers and pedestrians can be empowered to modify their behaviour to reduce the risk of adverse outcomes. This report presents a snap-shot synthesis of the risk of fatalities for pedestrians during RTCs involving vehicles at different vehicle speeds. It is intended that the synthesis will inform road safety messaging directed at drivers and pedestrians in Ireland.

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Introduction

The public is increasingly being encouraged to use low-carbon alternatives (such as walking and cycling) when travelling in their daily lives. Yet any time members of the public share the road environment with vehicular traffic they are at risk of negative health outcomes – they are vulnerable road users. When struck by a moving vehicle, designed to protect its occupants in a collision with a second vehicle, pedestrians are at high risk of serious or fatal injury.

This risk is, in part at least, a function of the speed at which the vehicle in the conflict is travelling. Educating drivers, and to a lesser extent pedestrians, about the relationship between speed and pedestrian fatalities builds awareness of the consequences of different speed selections. It also empowers drivers and pedestrians to make more informed decisions about their behaviour and take steps to mitigate this risk. For drivers, this may involve reducing speeds in areas where pedestrian density is high (e.g., around schools during pick-up and drop-off). For pedestrians, such information can encourage them to maintain high situational awareness in areas with high vehicular speed, and to cross roads where speeds are lower.

Critical to building awareness of the relationship between vehicle speed and pedestrian fatalities is access to reliable and valid data on that association. The Road Safety Authority (RSA) has commissioned this report to present an up-to-date synthesis of the best evidence available on this association. The review focuses on studies published since 2015. It is intended that findings will support the design and content of road safety messaging.

Method

We (MD) developed a series of search terms (a ‘search syntax’) in consultation with the RSA. 13 search terms were combined using Boolean operands (e.g., fatalities OR fatality OR lethal* AND car* or vehicle* AND Pedestrians etc.). We searched JSTOR, PubMed and Scopus, with these platforms covering the social sciences, health sciences and engineering respectively. Searches focused on the titles of articles (i.e. a “title search”). Studies had to have been published since 2015 to be included in the review, though where a study was a systematic review or meta-analysis, and presented a synthesis of studies earlier than 2015, the review was included. Moreover, studies were only included where there was a likely accurate estimate of the vehicles’ speed at the time of the conflict, with studies using posted speed limits as proxy measures of speed excluded.

In total, we identified 396 studies from search, 351 of which were excluded based on a review of the titles and abstracts (i.e., they were clearly not about the link between vehicle speed and pedestrian fatalities) or as duplicates. 40 were subsequently excluded at full-title review, leaving 5 studies that met our inclusion criteria. Of these studies, 1 was a systematic review and meta-analysis containing 15 studies, 12 of which were published prior to 2015. The remaining three studies were published since 2015 and were also ‘captured’ as individual studies in our search. As systematic reviews and meta-analyses provide better estimates of risk than individual studies, we review below the systematic review in its entirety (15 studies, including 3 published since 2015) and a separate study published in 2021.

Results

Hussain and colleagues (2019) presented their meta-analysis of 15 studies with a pooled sample size of 36,138 pedestrian-vehicle collisions. All collisions involved pedestrians struck by the front of a vehicle. 5 of these studies utilised data compiled from medical and police reports, while 10 used data from on-scene investigations. Studies were from six countries (China, Germany, Japan, South Korea, UK and US) across 38 years (1980-2017).

The authors analysed this data using a multivariate meta-regression model to develop a statistical understanding of the relationship between estimated impact speed and fatality risk for pedestrians. The results are summarised in the table below, and synthesised in Figure 1. In concluding their review, the authors report that

our results suggest an impact speed of 30 km/h has on average a risk of a fatality of around 5%. The risk increases to 13% for an impact speed of 40km/h and 29% at 50 km/h. Speed limits should be set lower in areas of poor visibility and thus slower reaction times. Furthermore, such speed limits could be supported by appropriate speed calming approaches such as physical measures (e.g., roadway design, pedestrian islands, and speed humps), surface treatments (e.g., road markings, rumble strips, and perceptual countermeasures), and traffic enforcement (e.g., speed cameras) to motivate drivers lowering their traveling speeds. Such speed limits and speed calming approaches are already commonly used by best practice countries that have the lowest road fatality rates and that practice a Safe System Approach to road safety.

Table 1

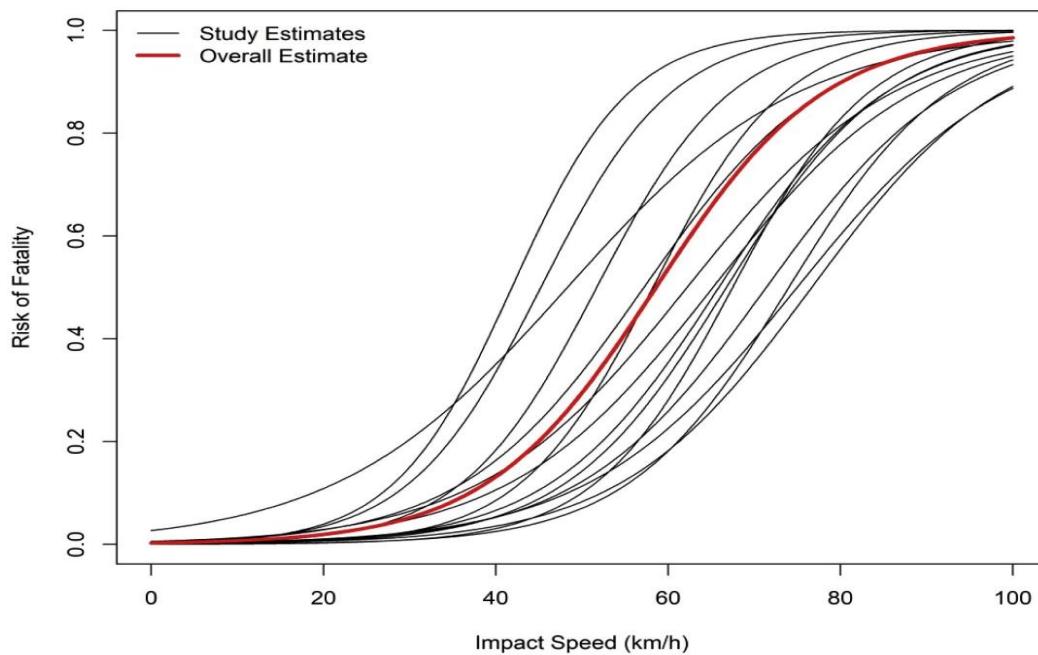
Vehicle speed and percentage of pedestrians killed at that speed. ¹

Fatality risk (Pedestrian)	Estimated impact speed
5%	30 km/h
10%	37 km/h
50%	59 km/h
75%	69 km/h
90%	80 km/h

Figure 1

S-Shaped curve showing the relationship between pedestrian fatality and impact speed.

¹Table 1 and Figure 1 from “Hussain, Q., Feng, H., Grzebieta, R., Brijs, T., & Olivier, J. (2019). The relationship between impact speed and the probability of pedestrian fatality during a vehicle-pedestrian crash: A systematic review and meta-analysis. *Accident Analysis & Prevention*, 129, 241–249.”



As illustrated in Figure 1, there is a marked increase in fatality rates with increasing vehicle speeds. Estimates of survival rates are very low (10%) at the upper end of the speed range (>80km/h).

We acknowledge that there are limitations to the review. These include the following:

1. Seven studies were excluded due to insufficient information in the source papers, and authors did not provide this data when contacted.
2. In some instances, the same data (i.e., for a collision or collisions) may have been present in different datasets, and which can lead to 'double counting' in the meta-analysis. The review authors addressed this where there was clear evidence of shared (i.e., non-independent) data but acknowledged that 'it is still possible that in a few instances double counting may inadvertently have occurred' (p. 247).
3. The study did not explore, or account for, variables other than speed in the analyses. This, the authors argue, reflects the quality of the research conducted which typically does not include factors such as age, the time taken for first responders to arrive on the scene, vehicle type or the design of roadways.

The authors also note that some of the studies are dated, raising concerns about the validity of the pooled estimates. However, when the authors excluded studies published earlier than 2010, the reduction in fatality risk was reported to be 'small' and may possibly reflect improvements in the frontal design of newer vehicles and 'resulting from pedestrian impact consumer test ratings' (p. 247).

More recently, Goel (2021) constructed a model to estimate change in pedestrian fatal crashes resulting from changes in speed of traffic. **The study is primarily of interest to those designing road calming measures who need to estimate how an achieved reduction in average speed pre-post the introduction of such measures influences pedestrian fatalities.** The model of pedestrian-fatality risk used by Hussain and colleges was combined with a crash prediction model to form an integrated model. This integrated model was then applied to 4 data sets of speed of traffic before and after a speeding intervention. These speeding interventions included speed limit changes and road design alterations, and were conducted

in major cities in Australia, India and two in the UK. Changes in mean traffic speed (of all vehicles in the area) and pedestrian fatalities were recorded pre and post intervention in each study, and Goel's integrated model was applied to this data.

Results indicated that a 1% reduction in mean speed results in an average of 7% reduction in pedestrian fatalities. It must be noted that unlike Hussain's findings, which apply to individual vehicle speeds when colliding with a pedestrian, Goel's model relates to speed of the population of vehicles – where the author derives a mean speed for all vehicles recorded in the study. The authors note this as a general limitation of studies in the field, where 'most reported only mean and few reported mean and standard deviation' and there was a general failure to report descriptive data. The findings of this study were generated from data compiled exclusively from urban areas, and so these findings may not be applicable to rural traffic populations.

Conclusion

In our view Hussain and colleagues' review, and the data presented in Table 1 and Figure 1 above, presents the best estimates available to the RSA at this point in time. The studies captured in that review used relatively reliable measures of vehicle speed. Moreover, they ran a series of moderator analyses, examining the effects of publication year, individual studies (e.g. one study from Japan with a sample >30,000 collisions), vehicle type etc., and reported no or small changes in the pooled estimates taking these moderators into consideration.

Recommended text in public health campaigns

The speed at which you drive determines the fatality risk to the pedestrian with whom you may collide. The best evidence on pedestrian road safety suggests that:

5% of pedestrians struck by a vehicle travelling at 30km/h will be killed (reported for 30km/h, p. 244).

13% of pedestrians struck by a vehicle travelling at 40km/h will be killed (reported for 40 km/h on p. 247).

29% of pedestrians struck by a vehicle travelling at 50km/h will be killed (reported for 50 km/h on p. 247).

50% of pedestrians struck by a vehicle travelling at 60km/h will be killed (reported at 59 km/h on p. 244).

75% of pedestrians struck by a vehicle travelling at 70km/h will be killed (reported at 69km/h on p. 244).

90% of pedestrians struck by a vehicle travelling at 80km/h will be killed (reported for 80km/h on, p. 244).

References

Goel, R. (2021). A new model to estimate pedestrian deaths from speed-related interventions.

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<https://doi.org/10.1080/15389588.2021.1908544>

Hussain, Q., Feng, H., Grzebieta, R., Brijs, T., & Olivier, J. (2019). The relationship between

impact speed and the probability of pedestrian fatality during a vehicle-pedestrian

crash: A systematic review and meta-analysis. *Accident Analysis & Prevention*, 129,

241–249. <https://doi.org/10.1016/j.aap.2019.05.033>

Appendix

Studies included in Hussain et al., (2019)

Author	Year	Jurisdictions
Aston	1980	UK
Garrett & John	1981	US
Cuerde et al.	2007	UK
Oh et al.	2008	Korea
Rosen & Sander	2009	Germany
Kong & Yang	2010	China
Nie et al.	2010	China
Richards	2010	UK
Zhao et al	2010	China
Helmer et al.	2011	US
Matsui et al.	2013	Japan
Tefft	2013	US
Zhang et al.	2014	China
Li et al.	2015	China
Nie et al.	2015	China