The Role of Kinetic Energy in Bicyclist's Injury Severity at Intersections

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Abstract

Kinetic energy management has considerable potential to achieve the objectives of the Safe System. A literature review of bicycle crash studies revealed that there is a big gap in knowledge in understanding the relationship of bicycle crash severity and kinetic energy of these crashes. This study investigated the trends of bicycle crash severity for the kinetic energy related factors. Based on an analysis of police-reported bicycle crashes in Victoria, the results revealed that, in general, similar trends between vehicle to bicycle and vehicle-to-vehicle crashes were identified; however, a number of significant differences were also highlighted.

Background:

The Safe System approach has been adopted in Australia and New Zealand to manage vehicles, road and roadside infrastructure and speeds to strive to eliminate death and serious injury as a consequence of road crashes (Office of Road Safety 2009). The approach recognizes that humans, as road users, will continue to make mistakes. Additionally, humans are physically vulnerable and are only able to tolerate limited kinetic energy exchange in a crash. Crash kinetic energy management is one of the main strategies to achieve the objectives of the Safe System approach. Therefore, in order to develop an effective strategy, it is necessary to understand the relationship between crash severity and crash kinetic energy.

Bahrololoom et al. (2018) investigated the factors influencing bicycle crash severity in Victoria, Australia. They examined the effect of factors, which belonged to pillars of the Safe System approach, on fatal and serious injury bicycle crashes. They concluded that more in depth analysis of the effect of crash kinetic energy would help to achieve a better understanding of the factors influencing bicycle crash severity. This study also concluded that it is important to investigate the dynamics of bicycle crashes.

Studies conducted on vehicle-to-vehicle crashes highlighted the importance of speed, crash angle and vehicle mass as the variables influencing delta-v (crash severity) of a crash, crash kinetic energy and occupant injury severity (Sobhani et al. 2011; Tolouei et al. 2011; Jurewicz and Sobhani 2016). Very few studies have been conducted to understand the dynamics of bicycle crashes and its effect on bicycle injury severity (Short et al. 2007); however, there is a big gap in knowledge about the effect of kinetic energy on bicyclist's injury severity. The aim of this study is to investigate the role of kinetic energy in bicycle crash severity at intersections. It examines whether similar trends can be found for the effect of impact speed, vehicle mass and angle of the crash on bicycle crash severity.

Method:

The Victorian Road Crash Information System (RCIS) database was used in this study. This database comprises police-reported data collected at crash scenes in Victoria, Australia. RCIS data includes minor injury, major injury and fatality crashes.

The final dataset extracted included all reported two-vehicle casualty crashes, in which at least one bicyclist was involved, that took place on the Victorian road network between 2004 and 2013. The total number of crashes for the ten years was 11336, 7180 of these crashes occurring at intersections. Fatal and serious injury (FSI) crashes accounted for 30.7% (3483) of the total number of crashes.

Impact speed, impact angle and vehicle mass were the significant variables in estimation of delta-v and kinetic energy of a vehicle-to-vehicle crash (Sobhani et al. 2011; Tolouei et al. 2011; Jurewicz and Sobhani 2016). The RCIS database includes vehicle mass data; however, impact speed and impact angle is not available from mass crash datasets such as this one. Previous studies on vehicle to vehicle crashes used speed limit of the approach and crash type as surrogate measures for impact speed and angle respectively. They confirmed that similar trends were found for the effect of these variables on crash delta-v, crash kinetic energy and occupant injury severity. In this study, these two variables were also considered for analysis assuming the similar relationships between surrogate measures (i.e. speed limit and crash type) and main variables (i.e. impact speed and impact angle) are acceptable for vehicle to bicycle crashes.

A binary logistic regression model was calibrated to explore how combination of speed limit, vehicle type and crash type affect bicycle crash severity.

Results:

Results of this study illustrated that higher speed zone was associated with higher possibility of being involved in a bicycle fatal or serious injury crash. This result is consistent with the results achieved for vehicle-to-vehicle crashes (Sobhani et al. 2011; Tolouei et al. 2011).

The results also confirmed the effect of vehicle mass on severity of bicycle to vehicle crashes was similar to the effect of mass on vehicle-to-vehicle crash severity. Heavier vehicles contributed to higher bicycle crash severity (Sobhani et al. 2013; Jurewicz and Sobhani 2016).

In terms of the crash type, it can be concluded that ‘right angle’, ‘right near/right far’, ‘from footway’ and ‘rear end’ crashes were the most dangerous crashes for bicyclists. Results of vehicle-to-vehicle studies showed that ‘rear end’ crashes were associated with lower crash severity (Jurewicz and Sobhani 2016). Dynamics of bicycle crashes plays an important role and should be investigated to achieve better understanding of contributing factors to this result. Lack of enough protection for bicyclist can be the other reason for achieving this result as higher amount of kinetic energy is transferred to bicyclist’s body (Corben et al. 2010).

Results further showed that ‘right turn side swipe’ and ‘lane change right’ crashes were associated with higher crash severity than the ‘left turn side swipe’ and ‘lane change left’ crash.

Results further showed that:

- Bicyclists aged 46 years and older are associated with higher possibility of being involved in bicycle FSI crashes (i.e. in comparison with other age groups).
- Wearing a helmet reduced the risk of being involved in FSI crashes for bicyclists.
- The risk of FSI crashes for bicyclists was highest in ‘other’ intersection layout types. This was followed by T intersections (i.e. in comparison with cross intersections).
- The risk of being involved in FSI crashes reduced when the traffic control for bicyclists was ‘roundabout’ (i.e. in comparison with no control).

Conclusions:

Results of the binary logistic regression model illustrated that, in general higher speed limit and heavier vehicles were associated with higher bicycle crash severity. This results are consistent with the results of vehicle to vehicle crashes. Results further showed that same direction crash types (such as real end crash) were also considered as dangerous crash types; while, the results for vehicle to vehicle crashes confirmed this type of crashes were associated with lower crash severity.

The following parameters can justify the few conflicts found between the results of vehicle to vehicle and vehicle to bicycle crashes.

- Bicyclists are vulnerable road users, so rear-end, left turn and sideswipe crashes are also more dangerous for them as they have no protection, unlike vehicle occupants.
- Bicycle crash dynamics are likely to be quite different from vehicle to vehicle crash dynamics.

The effect of these parameters will be investigated in future studies.

References

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