Impact area and speed effects on powered two-wheeler crash fatality and injury risk

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Introduction
Understanding crash configurations in powered two-wheeler (PTW) crashes can provide insights into the fundamental vehicle dynamics during crashes and suggest potential safety countermeasures (e.g., intersection redesign, vehicle design improvements). Limited research has analyzed fatality risk as a function of impact areas between vehicles, which could support the development of novel injury risk models to link injury severity and crash factors. These models can be crucial in estimating the effectiveness of Advanced Driver Assistance Systems.

Objective
Primary objective of this investigation was to assess, using US data, the fatality odds in PTW crashes by area of impact. The study also aims to estimate an injury risk curve for crash scenarios with the highest fatality odds.

Methodology
PTW crashes from 2017 to 2020 were extracted and weighted to reflect the overall crash population. PTW fatal crash probability was estimated for different crash-occupant vehicle (OV) types. "Initial Contact Point" was used to assess fatality odds ratios of the crash configurations: events (fatal) were obtained from FARS and exposure (non-fatal crashes) from CRSS. Injury data, originally coded using KABCO scale, was converted to AIS using the probabilistic conversion matrix in. Binary logistic regression was used to model the relative speed-injury severity relationship for the configuration with the highest fatality odds. Relative speed for head-on crashes was calculated by summing the speeds of both vehicles involved.

Results and Conclusion
Calculations used the NHTSA Crash Reporting Sampling System (CRSS) and the Fatality Analysis Reporting System (FARS). The highest predicted probabilities of fatal crashes vs. OV types, given a crash occurred, were observed in collision involving Medium/Heavy Trucks, Buses, and Light Trucks. Future research could examine specific contributing factors (e.g., height, mass, shape) that may be leading to this observation. The analysis of the top ten impact configurations reveals that eight of the ten most common configurations are associated with collisions in which the front of the PTW collided with the OV. Additionally, cases where the front of the PTW collided with the front or right side of the OV ("Front / Front" and "Right / Front") obtained significantly higher odds—5.17 and 4.83 respectively—than crashes where the PTW collided with the rear of the OV ("Rear / Front"). This result highlights the potential benefit of forward-scanning protection systems (e.g., motorcycle autonomous emergency braking) in PTW fleets.

A 50% probability of AIS3+ injury was observed for PTW riders in head-on crashes at 150 Km/h of relative speed. Considering this configuration, with an expected speed reduction of 10-15.8 Km/h, the PTW autonomous emergency braking may reduce the risk of AIS3+ injuries for US PTW riders by about 12.5%. Although future studies will require more precise speed data, this result provides an initial speed-injury severity prediction model for PTWs in the US. Practical applications could include discussions about US speed limits or effectiveness assessment of crash speed reduction countermeasures.