

Modelling Road Traffic Accidents (RTAs) as a Stochastic Process Using the Negative Binomial: A Case of Kitwe Central Business District, Zambia.

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Background

Road traffic accidents (RTAs) remain one of the most pressing public health challenges in Zambia, contributing to injuries, fatalities, and economic losses. Despite ongoing interventions, the frequency of RTAs in urban centers such as Kitwe Central Business District (CBD) continues to rise.

Aim

The study aimed at modelling the occurrence of RTAs in Kitwe CBD as a stochastic process, using negative binomial regression to predict and identify factors influencing accident frequencies and recommend data-driven solutions.

Method

This study applied stochastic modelling approaches to investigate accident patterns in Kitwe Central Business District (CBD) between 2018 and 2024. While the Poisson regression model was initially considered, diagnostic tests revealed significant over-dispersion (dispersion parameter = 2.38, AIC = 682.32), making the Negative Binomial (NB) regression model more appropriate (AIC = 675.7). Accident data obtained from the Zambia Police Traffic Department and the Road Transport and Safety Agency (RTSA) were analyzed to identify temporal, behavioral, and environmental predictors of accident frequency.

Results

Findings indicate that mid-morning hours (09:00-12:00) and early afternoon (12:00-14:30) are particularly high-risk periods, while evenings (16:00-18:00) record relatively fewer accidents. Misjudgment accounted for over 40% of accidents, underscoring behavioral lapses as a dominant factor. The Negative Binomial model successfully predicted accident frequencies for 2025, with monthly forecasts aligning closely with simulated values.

Conclusions

The results demonstrate that accident frequency is significantly shaped by time of occurrence, accident severity, and road type. Further, under the period of study, high frequency of accidents in Kitwe CBD happened on Monday in all months apart from January and the model predicted this trend to continue unless there is a change of road safety strategies and interventions.