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# Effects of infrastructure design, operation and volumes of bicycles and motorised vehicles on bicycle accidents at urban junctions

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With increasing bicycle use in urban areas, transport planners and policy makers are faced with a rise in bicycle accidents. Most of these accidents happen at junctions and mostly in conflicts with motorised traffic. Safe junction design (layout of the junction, type of cycling facility etc.) and operation (allowed speed, type of signalling etc.) are core success factors for achieving the goal of minimising the number of bicycle accidents. Volumes of bicycles and motorised vehicles (exposure) are further correlates of bicycle accidents that are, similar to the effects of design and operation, not well understood so far.

The aim of this study is to identify the effects of design, operation and exposure on bicycle accident numbers at urban junctions. Thanks to a unique and comprehensive data basis, the analysis can be done on a very detailed level for specific arms of the junctions and accident types. This study is part of the research project 'Estimation of the influence of traffic safety on route choice of cyclists based on a pseudo-representative sample of GPS data – SiRou' (nrvp.de/21520) which is funded by the German Federal Ministry of Transport and Digital Infrastructure within the National Cycling Plan 2020 (NRVP).

The dataset used in this study includes 543 bicycle accidents at 477 junction arms in the city of Dresden (Germany). Official accident data for the 5-year period 2015-2019 was geocoded and assigned to specific junction arms. Exposure data on volumes of bicycles and motorised vehicles per arm and direction was provided by the city administration for the years 2017-2019. A detailed GIS data base was set up including all relevant design and operational characteristics. These range from general characteristics such as traffic control (traffic lights vs. traffic signs) to signalling schemes (e.g. separate phase for right-turning motorists) and type of cycling facility (e.g. mixed traffic vs. dedicated facility) in each specific approach of the junction.

Descriptive statistics and Accident Prediction Models (APM) are used to estimate the effect of junction design, operation and exposure on bicycle accident numbers. Three models were estimated in total: all bicycle accidents, turning accidents and right hook turning accidents.

The analysis shows that the influence of bicycle volume is significant and positively degressive in all models, which supports the safety-in-numbers hypothesis. The model effects of bicycle volumes range from 0.386 to 0.645. The effect of motorised vehicle volumes is also positive and usually twice as high as the effect of bicycle volumes.

The type of traffic control system significantly influences the estimated number of accidents in all models. Traffic light control has an effect of exp(-0,533), compared to traffic sign control. This means that junction arms at signalised junctions are safer than at junctions without signalling.

The model for turning accidents (65 % right hook; 26 % left hook; 9 % others) shows a negative relation with bicycle accidents for right turn bans and type of cycling facility (mixed traffic, advisory cycle lane, detached cycle path). Each of these effects explain about 4 % of the observed accidents. The exposure of cyclists and motorists explains about 75 % of the observed accidents. The strongest effect is found for the right turn bans (exp(-0.735)) whilst the effect of cycling facilities is around exp(-0,5). For right hook turning accidents alone, a separate phase for right turning motorists has a negative relation with the number of accidents.

In summary, exposure is the most important variable in all models. Different types of exposure (volumes at the whole junction or for specific flows) are to be considered. This means that accidents between cyclists and motorists at junctions are happening especially where user volumes are high. These junctions need to be planned with much consideration in terms of road safety. The highest level of safety is given with either spatial or temporal separation of the flows. A suitable method for temporal separation are traffic lights. Where the volume of right turning motorists is high, the traffic light should operate a separate phase for right turning motorists. Spatial separation is given with turn bans, which are of course no measure for all junctions but could be feasible on a network level, if turning movement was channelled at junctions that offer a sufficient level of safety.