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Analyse og modellering af cyklisters nær-ulykker ved hjælp af storskala sensordata

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Abstract

To create safe cycling environments, it is important to reveal and gain detailed insights into potential accident-prone locations. While numerous studies have found that bicycle near accidents can be a surrogate measure to disclose risky places, few studies have explored near accidents using sufficient data sources with complete exposure levels and over extended periods of time. Using both crowdsourced near-accident data and conventional accident data (Police data), this study models and compares rates of accidents and near accidents in terms of infrastructure features in the Copenhagen area. Data covers 2019-2021, and results reveal that near accidents occur more frequently on pedestrian-oriented paths, while accidents tend to occur more frequently at intersections and roundabouts.

Præsentationen vil være på dansk.

Introduction

Cycling is gaining attention as a sustainable transport alternative, and bicycle safety is recognized as a main barrier to increasing its popularity. Most studies exploring hotspots and potential causes of bicycle accidents have used accident data recorded by police or hospitals. However, such accidents mostly involve severe insurance claims or injuries, while many minor accidents often go unreported (Laureshyn et al., 2017). To overcome the issue of underreporting, detecting bicycle near accidents, which are incidents that cause no or only slight injuries (Springer et al., 2020), can be used as a surrogate measure for analyzing accident risks (Puchades et al., 2018). With sensors embedded in bicycles becoming more universal, large amounts of near accident/accident data can be collected (e.g., Gupta et al. (2022)), making crowdsourced data a robust source to have precise and profound insights into bicycle safety studies. However, there is still a lack of understanding of the characteristics of the bicycle near accidents, and few studies have conducted a comparative analysis between bicycle accidents and near accidents (e.g., Strauss et al. (2016)). Therefore, this study aims to compare rates of accidents and near accidents and to analyze the variation across different infrastructure types to further enhance bicycle safety.

Data and Methodology

Data sources

Two datasets were used in this study. The first dataset is comprised of crowdsourced bicycle accident and near-accident data from Hövding --- a head protection airbag for cyclists worn around the neck (Hovding, 2023). The helmet is equipped with a sensor that tracks the movement and acceleration of cyclists and continuously determines the current safety state. The safety states include *normal state*, *accident* (i.e., helmet is deployed) and three levels of *near accidents* (i.e., to what extent the helmet is about to deploy). 97 accidents and 129,818 near accidents were recorded from 2019 to 2021 in the Copenhagen area. The second dataset consists of accident data from the police, which contains conventional accidents reported to the police involving cyclists. Overall, the second dataset includes 4,220 accidents recorded in the same area and period.

Statistical models of bicycle near accident and accident

To get a better understanding of the risk of (near)accidents and what infrastructure features affect the (near)accidents risk, this study calculated occurrence rates of (near)accidents on each road segment by dividing the frequency of (near)accidents by the annual bicycle traffic (i.e., exposure). For Hovding (near)accidents, the exposure was directly obtained from tracking the users (i.e., we have the full population of Hovding users), making risk assessment more precise. For police accidents, however, the exposure was approximated from cyclists' flow modelled in the COMPASS traffic model, and it was recorded in limited and certain locations (e.g., mostly on main corridors). Two models were estimated, one for near accidents and one for accidents. The models were specified as negative binomial models. The model selection is based on if the data is overdispersed (i.e., if variance are equal or larger than the mean of the occurrence of accidents/near accidents). Equation 1 shows the specification of the Negative binomial regression model used for both models, which enables the logarithm of occurrence rate to be modeled by the linear combination of explanatory variables.

$$log(Rate_i) = log(\frac{10^5 \times (Near)Accident\ frequency_i}{Annual\ bicycle\ traffic_i \times Length_i}) = \beta_0 + \boldsymbol{\beta_1} \times \mathbf{Infrastructure_i} + \mathcal{E}_i \qquad (1)$$

where $Rate$ denotes the number of accidents or near accidents occuring per 100,000 bicycle-kilometer traveled on each road segment i per year. The $\mathbf{Infrastructure}$ column vectors consist of infrastructure variables, including 15 road types, 4 surface types, and 8 point-based infrastructure types (e.g., traffic lights). β_0 denotes the intercept, and $\boldsymbol{\beta_1}$ is a row vector containing coefficients for infrastructure and $\mathcal{E}_i$ is the residual.

Results and Discussion

In this study, we modeled Hövding (near)accident rates and police accident rates. To understand which infrastructure features cause higher occurrence of near accidents and accidents, the expected annual frequency of Hövding near accidents and Police accidents is shown in Figures 1a and 1b, respectively. These were calculated by multiplying estimated (near)accident rates obtained by the model with exposures. Generally, the expected number of near accidents is far higher than the expected number of accidents, which indicates underreporting of police accidents. We also observe that, when compared to accidents, more near accidents occur on the small paths or ways that are primarily pedestrian-oriented, particularly in the southern part of the city center. This might be because cyclists have a higher chance of having near crashes with pedestrians on such paths or ways, while accidents were not severe enough to be reported to the police. Compared to near accidents, in contrast, accidents occurred more often at signalized intersections and roundabouts, indicating more cyclists-vehicle conflicts. As a result, bicycle near accidents and accidents have different patterns of occurrence, enabling us to identify unknown risky locations.

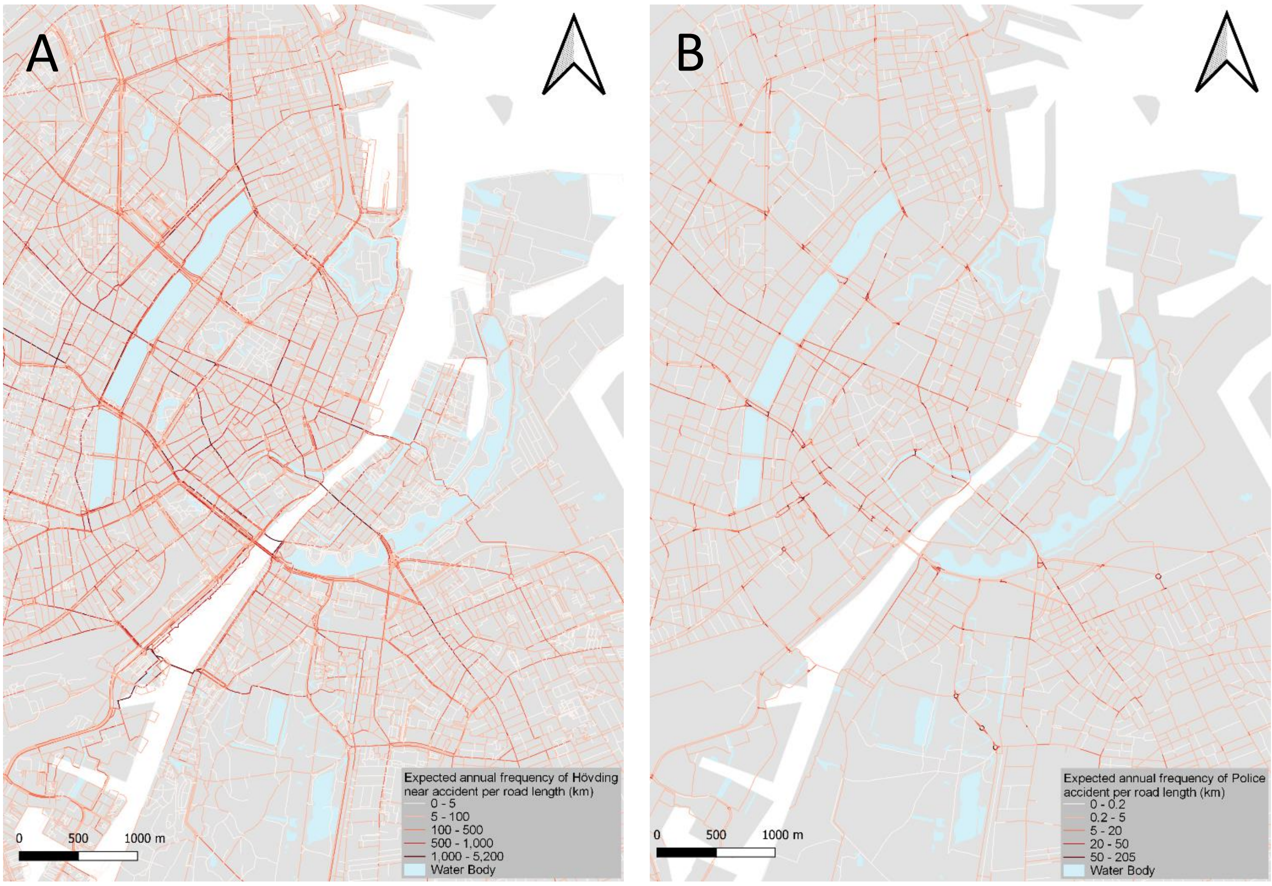

Figure 1. A: Expected Annual frequency of Hövding near accident per km road length; B: Police accident per km road length

Conclusions

We used crowdsourced and conventional accident data to investigate how different infrastructure features impact the frequency of bicycle accident and near-accidents, and to compare how effects differ between accidents and near accidents. Although accidents and near accidents from Hövding data have false-positive detections (e.g., non-risky vibration caused by uneven surfaces sometimes recorded as near accidents), this study fills a gap by focusing on modelling bicycle near accidents across different places and infrastructure types, helping to solve the issue of underreporting of bicycle (near)accidents and identify potentially unknown risky places. Finally, this study has demonstrated that bicycle accidents and near accidents from crowdsourced and conventional data can be used complimentarily to effectively disclose accident-prone hotspots remaining unrevealed.

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