The relationships between accessibility and crash risk from social equity perspectives: A case study at the Rotterdam-The Hague metropolitan region

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EXTENDED ABSTRACT

Traffic safety and accessibility have been two important subjects in transportation research. On the one hand traffic crashes bring about high societal costs and serious health risks for urban road users. The cost of traffic crashes is estimated to be 17 billion euros per year only in the Netherlands while over 600 people were killed in traffic, of whom 229 were cyclists and 195 were car users [1, 2]. Accessibility, on the other hand, is regarded as one of the indicators of the quality of the transport system serving the public. There is comprehensive literature investigating the relationship between traffic crashes and factors associated with traffic, roadway design, built environment, and human factors. Similarly, several studies assessed and evaluated accessibility levels of individuals, communities, and regions by utilizing the aforementioned factors. Nevertheless, there is a scarcity of literature investigating the relationships between accessibility and traffic safety. This is especially surprising considering that both subjects are associated with a similar set of factors, including land use and transport systems, as well as individual and temporal factors [3-7]. The relationships between accessibility and traffic safety can be an adverse one; for example, improved accessibility by increasing the travel speeds (i.e., declining travel time) intensifies the crash risks which also deteriorates equity. Furthermore, levels of both accessibility and traffic safety are not homogeneous throughout urban areas and among different population groups. Based on the literature, it is obvious that accessibility is associated with economic equity [8]. It is revealed that accessibility of lower-income groups is substantially worse than the higher-income groups as these groups have less mobility [9]. Previous studies also showed that lower-income groups usually suffer from traffic safety problems more than other socio-economic groups [10-12]. Therefore, this research aims to address the aforementioned gap in the literature in understanding the relationships between accessibility levels and traffic safety with a focus on social equity perspectives. For this purpose, a Gravity model and risk exposure evaluation approaches are utilized to analyze traffic safety and accessibility to jobs by bicycle via extending the traditional definition of accessibility based on only travel time or proximity to a location.

This study aimed to find the relationship between job accessibility and crash risk, using a case study on work travels by bikes in the Rotterdam – The Hague metropolitan region. By use of GIS software, potential job accessibility was estimated for each postcode-4 (PC-4) zone using a Gravity model that incorporates the travel time between origin and destination and the number of jobs at the destination. The crash risk estimation was done based on actual bicycle-involved crash data for the period 2015-2019. The EPDO values were calculated on the routes and the crash risks on cyclists are expressed in the monetary crash risk per origin per person per year.

This research uses a three-step analysis approach including crash risk estimation, job accessibility analysis, and statistical analysis. First, the shortest path routes for cycling trips to jobs are identified by using travel time. Then, safety risk per route for the identified shortest paths was calculated by weighting the crashes based on the costs associated with their severity levels and the exposure of cyclists through the routes (i.e., € per bicycle-kilometer-traveled). The accessibility levels are calculated by the Gravity model and safety risks are calculated by using the aggregated risks per route for analysis units in the study region. Consequently, multiple

linear regression modeling approaches are utilized to model the relationships between accessibility, safety, land use characteristics, and socio-demographic factors. The results of two multiple regression models indicate contradictory impacts of some land use and socioeconomic factors on traffic crash risk and job accessibility which are two important factors in transportation analyses.

Figure 1 shows potential job accessibility in each PC-4 area within the study region. The potential accessibility level indicates the level of opportunities, here the total number of jobs, that can be reached from a PC-4 area which is reduced as the distance between the areas increase. In this figure, a quantile classification interval is used because of the distribution of the data, resulting in ranges with unequal sizes but a better presentation of the results. Unsurprisingly, the highest job accessibility values are in the more urban areas and cities of Rotterdam and The Hague. The lowest accessibility values can be found in the southwest. Next, as it is shown in figure 2, the total crash cost per inhabitant per origin PC-4 zone per year is calculated. This figure reveals that different from the potential job accessibility levels there is no clear pattern in the monetary value of crash risk on cyclists.

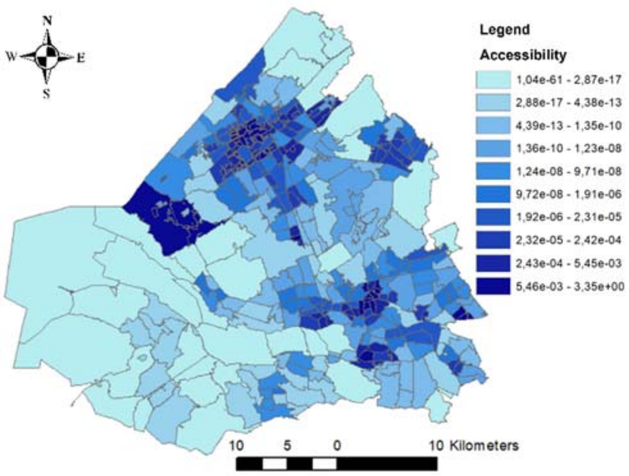

Figure 1 Potential accessibility level

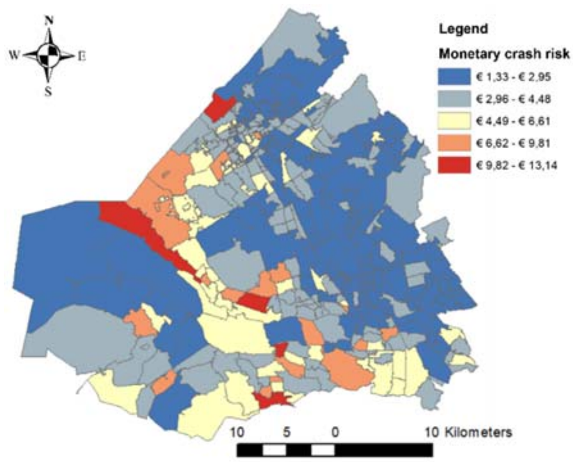

Figure 2 Monetary crash risk per inhabitant per origin

The relationships between job accessibility and crash risk were analyzed by conducting two multiple linear regression models by controlling for independent variables, including population density, income level, age-group populations, density of different types of bicycle infrastructure as well as land use features. The crash risk model showed that cyclists are at more crash risk in areas with lower income levels. Moreover, a higher population aged between 15 and 44 years old predicts a lower crash risk in the PC-4 areas.

To compare the impacts of the independent variables on both job accessibility and crash risk we compared the magnitude of the coefficients of a similar set of land use and socioeconomic variables in both models. To make the coefficients comparable they are transformed into standardized coefficients. Figure 3 shows that the impact of the different age groups is much higher on crash risk than on job accessibility level. This can be explained by known strong relation between crash risk and the age of travelers [13]. Furthermore, it stands out that for population density and income level the direction of the estimated coefficients in the crash risk model are negative, whilst they are positive in the job accessibility model. Meaning that higher population density and income levels in the areas are associated with lower crash risk and higher job accessibility. Also, a higher ratio of living, facilities, and industrial land uses is correlated with increased crash risk and reduced job accessibility in an area. Similar to the previous studies (e.g., Chen and Shen [14]) we found developing high mixed land use areas helps to enhance cyclists' safety, however, our results show a decreased job accessibility in these areas. Job accessibility and cycling safety, on the other hand, are both positively affected by increased population density. These findings suggest the decision-makers for further investigations on tradeoffs between improving safety and enhancing accessibility.

The results of this comparative analysis indicate that the low-income people are not only less advantaged in terms of job accessibility, but also exposed to a high level of crash risks. In addition, compared to other age groups, the population group aged between 45 and 64 are at higher crash risks, and also their accessibility to jobs is lower than other the other age groups. These findings become rather more beneficial for the decision-makers, considering the probable mutual impacts of land-use and transport developments and projects (i.e., improved accessibility) on safety of different population groups.

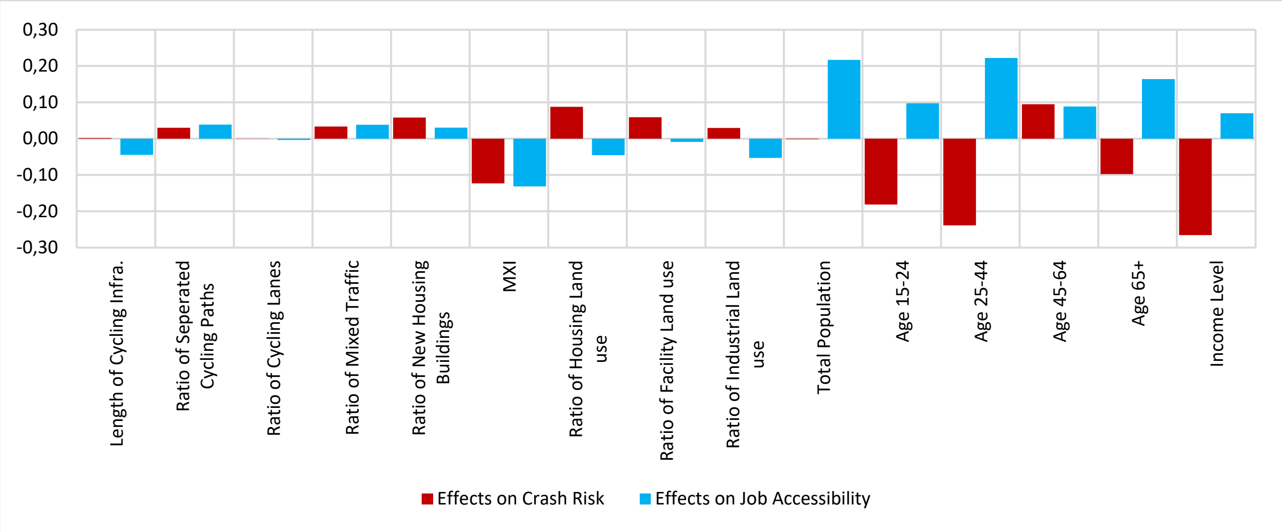

Figure 3 Standardized regression coefficients for two models

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