Safety Contributing Factors Analysis of Elderly Vulnerable Road Users: Global and Local Perspectives

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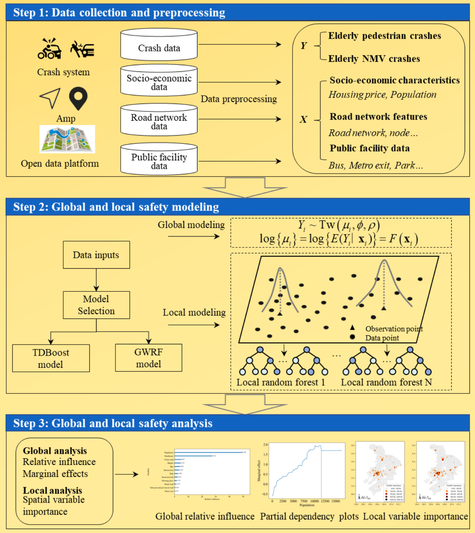
INTRODUCTION

- By the end of 2023, there are 297 million elderly people aged 60 and above in China, accounting for 21.1% of the total population, and it becomes particularly important to tackle the population aging while improving the road traffic safety of the elderly.
- Older VRU safety is becoming an increasingly pressing issue in Suzhou, China, driven by a rapid rise in the older population. The number of vehicle-VRU crashes involving persons 60 years and older accounted for 61.21% all older crashes between 2019 and 2023.
- The abundance of zero crashes in many analysis units for some specific types of crashes, makes traditional models unsuitable for accurate analysis in spatial modeling.
- Few studies have revealed the spatial heterogeneity in the effects of contributing factors on older VRU crashes. Ignoring this spatial heterogeneity can lead to inaccurate predictions.
- The GWRF model has the dual capability to capture effectively the spatial heterogeneity and nonlinear relationships. Therefore, the GWRF model is employed in this study to understand how factors contribute to older VRU crashes in different spatial areas.

OBJECTIVES

- To propose an analytic approach for contributing factors analysis of older VRU safety, which uses general and local models to analyze older VRU crashes.



Study framework

DATA PREPARATION

ANALYSIS UNITS

- Suzhou is a major city in East China's Jiangsu province, which covers an area of 8,657.32 km2, with a population of 2,515,600 aged 60 and above people accounting for 19.41% of the resident population by the end of 2023. We used a grid measuring 1 km × 1 km for the case study area..

INDEPENDENT VARIABLES

- Socioeconomic: population and housing prices.
- Roadway network: road network, nodes, and the total length of urban, rural, and national and provincial roads.
- Public facility: metro exits, bus stops, healthcare, parks, markets.

DEPENDENT VARIABLES

- Pedestrian and NMV crashes involving persons 65 years and older in Suzhou (2019-2023).

Contributing factors from three aspects

METHODOLOGY

GLOBAL SAFETY MODELING

To deal with zero-inflated crash data, the study employed gradient tree-boosted Tweedie compound Poisson models (TDboost). The TDboost model can provide the variable importance and partial dependence plots (PDPs) to interpret the general impact.

$$Y_i \sim \mathrm{Tw}(\mu_i, \phi, \rho)$$

$$\log\{\mu_i\} = \log\{E(Y_i|\mathbf{x}_i)\} = F(\mathbf{x}_i)$$

LOCAL SAFETY MODELING

To account for spatial heterogeneity of factors' effects, the GWRF model is the appropriate spatial statistical technique to capture the spatial non-stationarity by establishing a local equation at each analysis unit.

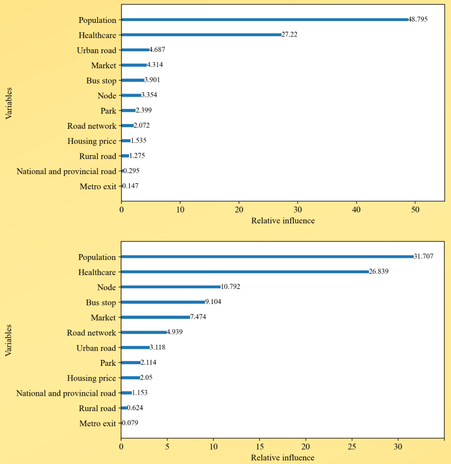
$$y_i = \beta_0(u_i, v_i) + \sum_{k=1}^{n} \beta_k(u_i, v_i)\, x_{ki} + \varepsilon_i$$

$$y_i = f_{(u_i v_i)}(x^*) + \varepsilon_i$$

GLOBAL SAFETY ANALYSIS RESULTS

VARIABLE IMPORTANCE

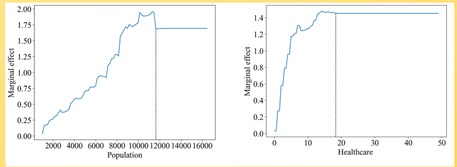
- Population stood out conspicuously in predicting elderly pedestrian crashes and NMV crashes, with a contribution of 48.795% and 31.707%, respectively, accounting for a substantial proportion of the total importance.
- Healthcare was the second most important independent variable with a contribution of 27.22% and 26.839%, respectively.



Relative contributions of independent variables of elderly crashes

MARGINAL EFFECTS

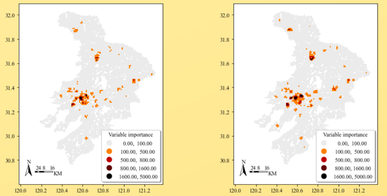
- Major four contributing factors demonstrated nonlinear effects in predicting elderly pedestrian crashes.
- First, elderly pedestrian crashes increased substantially when population was under about 11,600 persons, that is, population was positively associated with elderly pedestrian crashes. When population exceeded about 11,600 persons, it had no additional effect on crashes.
- Similarly, there was an obvious increasing trend as the number of healthcare facilities increased from 0 to about 18.



PDPs of key contributing factors on elderly pedestrian crashes

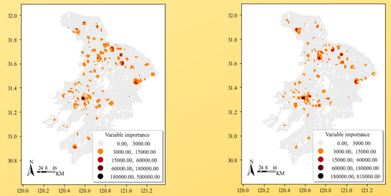
LOCAL SAFETY ANALYSIS RESULTS

- The importance of population and healthcare varied significantly across areas in the elderly pedestrian crashes model, showing a spatial clustering tendency with high importance in the downtown areas and central areas of county-level cities.
- The importance of contributing factors for elderly NMV crashes was centrally dispersed in the central and northern areas, showing a block distribution tendency.



（a）Population （b）Healthcare

Geographical distribution of variable importance of the major contributing factors in predicting elderly pedestrian crashes



（a）Population （b）Healthcare

Geographical distribution of variable importance of the major contributing factors in predicting elderly NMV crashes

SUMMARY AND CONCLUSIONS

- This study introduced a viable analytic framework to model the older VRU crashes generally and locally, exploring contributing factors' safety effects.
- General safety analysis results showed that population and healthcare played an important role in predicting older VRU crashes.
- There were slight differences in the relative importance of the independent variables with respect to older and younger pedestrian crashes and NMV crashes.
- Major influencing factors showed nonlinear effects on older VRU crashes. They had a positive correlation with both older pedestrian crashes and NMV crashes.
- GWRF model revealed the spatial heterogeneity between elderly VRU crashes and influencing variables from the local view. The variable importance of major contributing factors for VRU crashes showed a spatial clustering tendency and a block distribution tendency, respectively.
- The proposed approach highlights that countermeasures for improvement should be developed according to the spatial distribution of variable importance, emphasizing the need to "adapt to local conditions".