INVESTIGATION OF CRASHES INVOLVING VULNERABLE ROADWAY USERS UTILIZING GEOGRAPHICAL INFORMATION SYSTEMS-DRIVEN SPATIO-TEMPORAL STATISTICAL TECHNIQUES

ABSTRACT

Over the last three decades, traffic crashes have been one of the leading causes of fatalities and economic losses in the world. Since vulnerable road users have specific characteristics, they are perceived to have a higher risk of being involved in fatal road crashes. Therefore, it is essential to focus on mitigating the vulnerabilities of roadway users as well as investigating the key causes of crashes in order to achieve the desired level of roadway safety. It is imperative that we understand the specific needs of vulnerable roadway users and their involvement in crashes in order to address their unique challenges, determine the underlying factors contributing to their vulnerability, and develop targeted interventions and policies that can contribute to improving their safety. The level of vulnerability among roadway users depends on a variety of factors, including their age, level of protection, surrounding characteristics, situational conditions, and the presence of extreme events such as disasters. The majority of vulnerabilities cannot be attributed to the negligence of roadway users, since they are primarily determined by an individual's intrinsic physical characteristics and the conditions imposed by particular circumstances. Therefore, this dissertation provided comprehensive insights into helping vulnerable roadway users by examining them from four distinct perspectives: (a) exploring young-driver-involved crashes to understand vulnerability based on age, (b) investigating pedestrian vulnerability due to their lack of protection, (c) examining the challenges faced by drivers experiencing daytime sun glare-induced temporary visual impairment to assess vulnerability in relation to surrounding circumstances, and (d) analyzing the impact of the COVID-19 pandemic on the entire society to comprehend vulnerability in the context of a disaster situation.

The purpose of the dissertation is to examine the spatial patterns of vulnerable-involved crashes in order to identify those locations that pose high risk to them. Furthermore, we develop several robust statistical models according to the type of dependent variables for each group of vulnerable road users. Based on an in-depth regression analysis, we are able to predict crash likelihood and provide clear guidelines for the development of plans, policies, and effective safety countermeasures. In order to accomplish the objective of the study, we introduce a Geographic Information System (GIS)-based methodology to analyze the spatial crash patterns associated with each crash type in terms of focused vulnerability. This is followed by a more detailed examination of selected counties of Florida using both planar Euclidean Distance (ED) and Roadway Network Distance (RND)-based Kernel Density Estimation (KDE). According to the GIS maps developed in this dissertation, there are differences in spatial patterns between vulnerable roadway users involved in crashes.

In conclusion, this dissertation proposes a number of novel methodological approaches in order to address the following objectives:

- An investigation of contributing factors influencing crashes caused by vulnerable youth drivers (aged 16-24) and assessment of the correlation between intersection presence near university campuses and likelihood of these crashes,

- An assessment of the spatial correlation and impact of the network-based distance between locations of vulnerable pedestrian-involved crashes and the centroid of associated land use of various types,
- An assessment of the adverse effects of daytime sun glare on driving performance and evaluation of the potential actions taken by vulnerable drivers under the direct influence of temporary blindness caused by sun glare,
- A spatial-temporal investigation of the crash density pattern during the COVID-19 pandemic, assuming all individuals to be vulnerable roadway users, in accordance with the specific socio-demographic features of the study area.

Findings clearly show that intersections near university areas pose a significant problem for youth drivers. Moreover, the part of this study focusing on pedestrians as another vulnerable roadway user reveal that pedestrian-involved crashes were more likely to occur near retail stores and nightclubs. Additionally, daylight has an effect regardless of the type of surrounding land use on the severity of pedestrian-related crashes. This dissertation also investigates the temporary visual impairment caused by sun glare during the daytime as well as the likelihood of potential actions performed by drivers experiencing this adverse circumstance. Furthermore, the results obtained from the investigation of crashes caused by vulnerable drivers exposed to daytime sun glare indicate that the majority of observed actions, particularly on local roadways, involve in the violation of stop signs and red lights. In addition, drivers tend to follow too closely in high-traffic areas when their vision is impaired by sun glare. Moreover, a non-parametric method (Kruskal-Wallis) confirms that there is a significant difference in crash densities during the COVID-19 pandemic compared to the pre-pandemic period in different counties irrespective of their sociodemographic differences. Finally, the findings indicate that the presence of young populations (e.g., college students) in Leon County is highly correlated with the decline in the number of crashes during COVID-19.

In summary, the results of this dissertation can be utilized by transportation agencies to pinpoint high-risk locations, which have a higher likelihood of vulnerable population-involved crashes, and to develop more reliable plans targeting the vulnerable population and their special needs. The implementation of safety countermeasures is essential to improving the safety of vulnerable road users. Education campaigns emphasizing defensive driving skills and risk awareness, for example, may be effective in preventing young drivers from engaging in risky driving. Additionally, implementing cutting-edge Intelligent Transportation System (ITS) technologies and offering alternative routes to avoid sun glare may improve driving performance and reduce the number of crashes caused by drivers experiencing daytime sun glare. A pedestrian-friendly environment, which includes crosswalks, adequate lighting, clear signage, and well-maintained sidewalks, also contributes to pedestrian safety. Lastly, promoting alternative remote options for E-learning, e-shopping, teleconsultations, and teleconferencing can reduce the number of trips generated during the COVID-19 pandemic and reduce the risk associated with increased vulnerability while maintaining road safety for all users in the region affected by the pandemic.