TRAFFIC SAFETY ISSUES IN BUILDING LIVABLE COMMUNITIES

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GENERAL DESCRIPTION OF THE SPECIAL SESSION

In retrospect, poorly balanced transportation systems in the United States have led to auto-dependent communities. Over the past several decades our communities have become less walkable, less bikeable and less accessible to public transit. As consequences, rates of obesity have increased and our communities become unhealthy. Recently there have been ample efforts to reverse the trend by building better walkable and bikeable transportation environment. However, there are still concerns on safety. This special session intends to discuss safety concerns in developing livable communities, especially for pedestrian, bicyclists, senior population, and people with disabilities.

1. IDENTIFICATION OF FACTORS ASSOCIATED WITH PEDESTRIAN HOT CRASH SPOTS—SPATIAL AND STATISTICAL ANALYSIS APPROACH

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Pedestrian and bicycle safety challenges are becoming more apparent as those modes increase in popularity. Policy-relevant safety analysis methods for these modes are rare, particularly related to exposure. This paper presents a pedestrian safety hotspot analysis to identify and prioritize specific road segments and intersections with high crash locations using Geographic Information System (GIS), coupled with background demographic analysis to inform policy development. The identification process was done in a GIS environment using Getis-Ord Gi-star hotspot analysis tool. The Gi-star index was used to locate crash hot spot street segments and intersections and discern cluster structures of high or low-value concentration among local observations. The goal was to examine the existence of a spatial pattern for pedestrian crashes associated with roadway geometry, socioeconomic, population distribution and other related factors. This study focuses on Tennessee's pedestrian crashes and identified and ranked high crash locations based on: crash frequency; weighted crash frequency by injury severities (EPDO); crash rates calculated per VMT, area, total population, mean household income, population of Whites, Blacks and Hispanics as well as the average of all rankings. The identified high crash locations and the rankings will enable state and local agencies to properly invest and prioritize funds to improve and maximize the reduction in statewide pedestrian crashes. It will also assist in identifying suitable locations for road safety audits. The hot spot identification and ranking approaches presented here represents current best practices that can be mimicked in other states.

2. AN AUTOMATED EVALUATION METHOD FOR BICYCLING ENVIRONMENTS

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Traffic surveillance and monitoring systems are the backbone of advanced traffic management and information systems. To date, these systems have focused on vehicular traffic. As a result, transportation systems have been advanced significantly for automobiles. However, less effort has been devoted to monitoring bicycle traffic in a more intelligent way, even though the bicycle is an important human-powered transport mode used to increase the sustainability of transportation systems due to its environmentally-friendly and emission-free characteristics. To increase the use of bicycles, it is fundamental to assess bicyclist's perception of roadway environment, safety and comfort This study developed a novel methodology for evaluating bicycling environments based on the analysis of bicycle maneuvering data obtained from instrumented probe bicycles. In addition, how to integrate the proposed methodology in public bicycle-sharing systems is discussed to fully exploit the benefits of the proposed methodology in practice.

3. USING CROWD SOURCING TO LOCATE AND CHARACTERIZE CONFLICTS FOR VULNERABLE MODES

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Most agencies and decision-makers rely on crash and crash severity (property damage only, injury or fatality) data to assess transportation safety; however, in the context of public health where perceptions of safety may influence the willingness to adopt active transportation modes (e.g. bicycling and walking), pedestrian-vehicle and other similar conflicts may represent a better performance measure for safety assessment. This study develops and tests a smartphone app to better understand the continuum of conflicts (bicycle/pedestrian, bicycle/vehicle, and pedestrian/vehicle) experienced by pedestrians and cyclists. The research seeks to determine if the app can be used to locate conflicts experienced or observed by users while characterizing their severity. The study uses user feedback and hot spot analysis to determine user comfort in using the app and evaluate the potential relationship with bike and pedestrian crashes.

In response to the comments received from the field test participants, the team finalized the app with only two user groups. The regular or standard user group includes all app users who will be recording conflict scenarios. These users will receive a reminder once a day for recording a conflict, and they will also receive prompt notification of any conflict recorded in their current zip code. The second user group represents those that will work with the data and be able to share the database. The database can be shared as a *.CSV file or as a *.KML file, which can be opened in an Excel file or in a Google map file respectively. The initial field test of the app shows promise with support from many users in continuing to use the app and the app's effectiveness in mapping conflicts to previously recorded fatalities. Most of the field test users find the app easy to use and the survey questions easy to complete.

![Road Safety on Five Continents — Jeju Island, South Korea, May 16 – 18, 2018](rs5c-banner)

4. EVALUATION OF BICYCLE SAFETY ENVIRONMENT AND RISK FACTORS

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Cycling is not regarded as a dominant mode of transportation, especially in North America, primarily due to concerns for its safety and comfort. Understanding the perception of bicycle riders on safety and comfort is thus important for cycling friendly infrastructure and policies, yet there is lack of knowledge that can effectively assist project planning to promote the safe and comfort environment for cycling. An instrumented probe bicycle is designed and constructed to collect necessary motion critical data of a human-bicycle dynamic system, and a mobile app also is developed to collect risk factors. The research 1) investigates risk factors perceived by bicyclists; 2) analyzes how the motion dynamics data relates the rider's level of cycling skills and bicycle safety; 3) determines the bike-ability in terms of safety and comfort on given bicycle environment by the level of cycling skills.

5. EFFECT OF DIVERGING DIAMOND INTERCHANGE (DDI) ON SAFETY PERFORMANCE: APPLICATION OF EMPIRICAL BAYES METHOD

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Urban population and travel demand have been increasing rapidly. It presents a challenge to transport planners and engineers for alleviating traffic congestion and reducing accident risk. Diverging Diamond Interchange (DDI) is an innovative interchange design, which was first introduced in the United States in 2009, aiming to improve the operation and safety performances of freeway interchanges. DDI can accommodate high and unbalanced traffic volume on the arterial, by reducing the number of traffic signal phases and allowing unobstructed left turns for all traffic directions. DDI has been recognized as a cost-effective solution to congested freeway interchanges. However, few studies have investigated the safety effects of DDI. This paper aims to evaluate the change in crash risk of freeway interchanges after the introduction of DDI, using Empirical Bayes (EB) before and after comparison approach. In this study, the crash data of selected DDIs and traditional diamond interchanges (comparison group) in Utah was collected. The safety performance functions (SPF) were calibrated using the negative binomial model, based on the crash data of 26 comparison sites. Then, the crash modification factors for fatal and injury crash, property damage only (PDO) crash, and overall crash were estimated respectively. Moreover, effects of DDI on pedestrian and bicycle safety were also examined. Results indicated that there were significant crash reductions, regardless of crash severity level, at most of the DDIs under investigation, at the 5% level. For instances, reduction in fatal and injury crash was more remarkable.

6.   SAFETY OF OLDER DRIVERS - WHAT IS UNIQUE ABOUT OLDER ADULTS?

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Aging may have an impact on psychological and physical abilities, which are important for driving. As a result, the aging population (age 65 and above) require special considerations in designing transportation infrastructure. Many transportation agencies have implemented engineering improvements designed to improve safety of drivers, especially those who are 65 years and above. In many cases, such improvements have benefited drivers of all ages. A recent study completed in Michigan have identified roadway features which pose difficulty to older drivers more than drivers of other ages. Another study has evaluated the effectiveness of specific engineering improvements on reducing older adult crashes. The results from these two studies will be discussed to emphasize unique characteristics of older adults related to driving safety.

7. EFFECTIVENESS USING RANDOM EFFECTS GENERALIZED MODELS WITH NONLINEARIZING LINK FUNCTIONS

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Generally, a crash modification factor (CMF) estimates the expected changes in crash frequency after a specific treatment is implemented on a roadway. This study assessed the safety effectiveness of implementation of bicycle lanes with different widths in reducing crashes on roadway segments through estimation of CMFs using the cross-sectional method. The cross-sectional method requires the development of safety performance functions (SPFs) for development of CMFs. The most common type of SPFs has been a generalized linear model (GLM) with negative binomial (NB) distribution. On the other hand, the CMFs developed from GLM cannot account for nonlinear effects of the treatments and the unobserved heterogeneity issue. For this reason, this study applied a random effects generalized nonlinear model (REGNM) to evaluate the effects of bicycle lanes. In order to apply the GNM, estimation of nonlinearizing link function is required. The RE models can overcome the unobserved heterogeneity issue by introducing random variations for specific effects.

The results of this paper indicated that bicycle lanes are safety effective to reduce all types and bicycle-related crashes in general. In particular, implementation of bicycle lanes with 5ft to 6ft is the most safety effective in reducing all types of crashes and bicycle lanes with 6ft to 7ft were found to be more appropriate to be installed to reduce bicycle-related crashes. It was found that the REGNMs show the most reliable estimates due to its strength to account for both nonlinearity and unobserved heterogeneity issues. From the results from this paper, it can be recommended to have more specific guidance on the minimum bicycle lane widths based on the empirical evidence on traffic safety considering various roadway characteristics, traffic flows, and roadway types. Also, an application of REGNMs in developing SPF and CMF can be suggested for more reliable predictions.

8. INTEGRATED MULTIVARIATE APPROACH FOR PEDESTRIAN AND BICYCLE TRIPS AND CRASHES IN THE FRAMEWORK OF TRANSPORTATION SAFETY PLANNING

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In the recent years, considerable efforts have been made to incorporate safety into long-term transportation plans, which is termed transportation safety planning (TSP). Although some macro-level safety studies have attempted to adopt planning data (e.g., trip generation) for estimating traffic crash frequency, no studies have developed trip and crash models simultaneously. In this study, the authors suggested an integrated modeling approach for pedestrian and bicycle trip and crash estimations. The American Housing Survey (AHS) data were collected from the U.S. Census Bureau and used for this study. The AHS is a longitudinal housing unit survey that asks questions regarding the quality of housing including but not limited to demographic, socioeconomic, walking or cycling environments, public transportation systems, and accessibility to various facilities, in major metropolitan areas. The first part of the model is a multivariate logistic regression model, which estimates the proportion of pedestrians and bicyclists' trips among total trips in each metropolitan area. The second part is a multivariate Poisson-lognormal model, which estimates pedestrian and bicycle-involved crash counts. In the crash model, the predicted trips estimated from the first step were used as exposure variables. The modeling results revealed several contributing factors for pedestrian and bicycle trips, and crash counts. The number of pedestrian trips are positively related to median household income and whether grocery store is accessible by walking while it is negatively associated with the proportions of household whose overall opinion of present structure is poor and households not using non-motorized mode because of insufficient light. The number of pedestrian crashes is positively related to its predicted exposure, the proportions of African American and Hispanics, households below poverty level whereas whether open space, park, wood, farm, or ranch are located within a half block has a negative relationship. Furthermore, the number of bicycle trips has positive associations with whether grocery store, school, or workplace are accessible by school, whether industrial structures or factories are within a half block, and the proportions of African Americans and households without vehicle. In contrast, it has negative relationships with the proportions of households not using non-motorized mode because of no sidewalk or no time, and the proportions of Hispanics. Lastly, the number of bicycle crashes is positively associated with the predicted exposure from the trip estimation model, the proportions of manufactured or mobile homes and whether four or more lane highway, railroad, or airport is within a half block, while whether open space, park, wood, farm, or ranch are located within a half block is negatively related. It was shown that the integrated model significantly outperforms its non-integrated counterpart, in terms of Deviance Information Criterion (DIC) (186.492 vs. 262.83). It is expected that the integrated modeling approach for trips and crash counts in this study will provide great insights into the future directions of TSP.

9. ASSESSING CRASH RISKS CONSIDERING VEHICLE INTERACTIONS WITH TRUCKS USING POINT DETECTOR DATA

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Trucks have distinct driving characteristics in general traffic streams such as lower speeds and limitations in acceleration and deceleration. As a consequence, vehicles keep longer headways or frequently change lane when they follow a truck, which is expected to increase crash risk. This study introduces several traffic measures at the individual vehicle level to capture vehicle interactions between trucks and non-trucks and analyzed how the measures affect crash risk under different traffic conditions. The traffic measures were developed using headways obtained from Inductive Loop Detectors (ILDs). In addition, a truck detection algorithm using a Gaussian Mixture (GM) model was developed to identify trucks and to estimate truck exposure from ILD data. Using the identified vehicle type from the GM model, vehicle interaction metrics were categorized into three groups based on the combination of leading and following vehicle types. The effects of the proposed traffic measures on crash risk were modeled in two different cases of prior- and non-crash using a case-control approach utilizing a conditional logistic regression. Results showed that the vehicle interactions between the leading and following vehicle types were highly associated with crash risk, and further showed different impacts on crash risk by traffic conditions. Specifically, crashes were more likely to occur when a truck following a non-truck had shorter average headway but greater headway variance in heavy traffic while a non-truck following a truck had greater headway variance in light traffic. This study obtained meaningful conclusions that vehicle interactions involved with trucks were significantly related to the crash likelihood rather than the measures that estimate average traffic condition such as total volume or average headway of the traffic stream.

10. CONNECTED VEHICLE DATA FOR CRASH HOTSPOTS

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Identifying crash hotspots help traffic engineers implementing countermeasures to improve transportation system safety. However, given it typically takes 12 to 18 months to obtain crash reports, the crash hotspots based on actual crash reports might not be applicable (as the hotspot locations often change). In order to identify hotspots more timely than current practice, we have investigated the basic safety message (BSM) including equipped vehicle deceleration data at every 0.1 seconds from connected vehicles. Based on the safety pilot study data from April 2013, we proposed "extreme braking event" as a crash surrogate. The extreme braking event was defined as a longitudinal deceleration rate greater than 0.6 g (or 19.32 ft/s^2). When comparison was made between the actual crash (i.e., crash rate) and the extreme braking event (i.e., event rate based on the number of equipped vehicles) at the same freeway segments in the city of Ann Arbor, the proposed extreme braking event showed high correlation (over 0.7). In addition, top 5 actual crash hotspots (about 50% of crashes out of 38 segments) were identified

by using top 8 extreme braking event measures. Thus, our research indicates that the proposed extreme braking event measure has of great potential to identify crash hotspots in timely manner than the current practice based on delayed crash reports.