Joint Transportation Research Program

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SPR-4437 2021

Effective Design and Operation of Pedestrian Crossings

Introduction

Pedestrians are vulnerable road users who suffer much more severe injuries in collisions than passengers of vehicles. According to the Indiana ARIES data, the annual number of pedestrians involved in crashes had not significantly reduced in recent years, while the number of pedestrians killed increased considerably. Although the multiplicity of pedestrian-protecting solutions is encouraging, improving safety at troublesome pedestrian crossings necessitates a careful analysis of local conditions before effective countermeasures can be selected.

This research study focuses on a methodology that helps identify roads and areas in Indiana where the frequency and severity of pedestrian-vehicle collisions are heightened above the acceptable level and select effective countermeasures to mitigate or eliminate addressed safety-critical conditions. Two general methods of identifying specific pedestrian safety concerns were proposed: (1) areawide analysis and (2) road-focused analysis. The emphasis of this study is on the road-focused approach.

Findings

Probabilistic regression models were developed to estimate pedestrian activity and safety on segments around urban intersections. A multinomial logit model was used to assess the effects on a seven-level categorical pedestrian AADT using a small sample of urban intersection segments across Indiana. Results from this analysis were later used to predict the pedestrian crossing activity at other sites based on available land use, vehicle traffic, and roadway data. While pedestrian count data is scarce and its collection prohibitively expensive, the developed pedestrian activity model links land use and other spatial features with pedestrian crossing activities and has an unprecedented ability to provide a sound

Pedestrian crosswalk on the Purdue University Campus in West Lafayette, IN.

estimate of pedestrian presence at any urban intersection in Indiana. The analysis focuses on intersections located in communities with more than 2,500 residents.

A sequential binary logit framework was used to estimate the crash probabilities at four severity levels: (1) property damage only, (2) non-incapacitating, (3) incapacitating, and (4) fatal. The analysis confirmed the strong effect of speed limits on pedestrian safety combined with other local conditions. The knowledge of the pedestrian activity level allowed the research team to separate the pedestrian exposure factor from other safety factors and develop intuitive crash probability and severity models that include estimated effects of pedestrian traffic, vehicle traffic, built environment, speed limits, and traffic control. Since the available data contains observations from 2020, COVID-19 effects were estimated. This is helpful to avoid biases in future safety analyses that include the pandemic effect. In addition, a more practical and accurate estimation of crash probability was achieved by combining probability estimates with observed crash counts using the specialized EB method.

EB method is widely used in current safety management practice to adjust crash counts. An Empirical Bayes (EB) method based on the beta distribution is proposed to improve the crash probability estimates with past crash occurrence and resulting injury severity. The research report describes and tests its application to crash probabilities.

The pedestrian safety model provides a basis to identify high-risk urban intersection segments that are eligible for safety audits and improvements. The screening criterion includes the crash cost calculated with the crash risk and severity models. The safety estimate is further improved by combining it with the crash occurrence and its severity with the Empirical Bayes (EB) method adjusted to the probabilistic safety representation. A screening criterion alternative to the crash cost is the crash probability obtained for intersection segments.

Implementation

Two sets of models were developed to facilitate the road-focused analysis: (1) pedestrian Crossing Activity Level models to fill the gap in pedestrian traffic exposure data and (2) crash probability and injury severity models to estimate the risk of pedestrian crashes around urban intersections in Indiana. The resulting equations serve as the primary tool for road-focused screening. The developed models and procedures can be implemented in an existing tool, RoadHAT 4D, via an additional module specialized in analyzing pedestrian safety. A suitable tool for areawide analysis, SNAP, is under development by the research team in a separate project.

The results of this study provide a groundwork for improving pedestrian safety on road segments in close vicinity to urban intersections in Indiana where the majority of road crossing takes place. Multiple potential pedestrian safety countermeasures with specific behavioral and road conditions that justify these countermeasures are provided in this report. A computational procedure to predict the economic effects of the proposed countermeasures based on associated crash reduction factors was also facilitated.

Recommended Citation for Report

Ahmad, N. S., Pineda-Mendez, R., Alqahtani, F., Romero, M., Thomaz, J., & Tarko, A. P. (2021). *Effective design and operation of pedestrian crossings* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2021/32). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284317438

View the full text of this technical report here: https://doi.org/10.5703/1288284317438

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