Research Need Literature Review

**Topic:** NS #568 – Pedestrian engineering and enforcement at signalized intersections  
**Date:** 26 June 2019  
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**Resources searched:** TRID, RiP, Internet, Library Catalog

**Summary:** Several localities internationally, including multiple states, have recently published results or impact surveys from information campaign targeted at pedestrian safety. These have covered a broad range of environments, including signalized intersections in urban areas, but none appears to have been devoted specifically to the signalized intersection case. This is notable insofar as pedestrian safety at signaled crossings appears to have grown in significance within the broader pedestrian safety literature over the past couple of years. This suggests that, while a MnDOT study on application of lessons from the prior “Stop for Me” campaigns to signalized contexts would not be breaking entirely new ground, it could be a meaningful contribution on a topic in which there is considerable current interest.

Following is a review of literature surveying impacts from pedestrian safety information campaigns over the last ten years. This, in turn, is followed from p. 5 on by highlighted current literature on pedestrian safety at signalized crossings.

### Results
**(in order of relevance)**

| Title | Evaluation of a pedestrian safety outreach campaign in New Jersey using surrogate safety measures  

**Source** TRB 96th Annual Meeting Compendium of Papers  
**URL** [http://amonline.trb.org/](http://amonline.trb.org/)  
**Abstract** This paper presents a study to compare the rates of risky pedestrian and driver behaviors before and after two phases the North Jersey Transportation Planning Authority’s (NJTPA) state-wide pedestrian safety education and enforcement campaign called Street Smart NJ. The first phase was a four-week pilot program in four Northern New Jersey communities (Newark, Jersey City, Woodbridge, and Hackettstown) during November 2013. The second phase was an additional four-week program in eight Northern New Jersey communities (Elizabeth, Jersey City, Metuchen, Newark, Passaic, Red Bank, Toms River, and Woodbridge). Since crashes rarely occur, the program’s effectiveness has been evaluated by observing pedestrian and driver behaviors as surrogate measures of safety. Three types of unsafe behaviors (which by regulation are citable violations) were identified for observation: 1) pedestrians jaywalking and crossing against the signal, 2) failure of turning motorists to yield to pedestrians crossing parallel to...
their vehicles approach, and 3) failure of motorists turning right on red or passing stop signs to properly yield to pedestrians. The results show that in most cases, statistically significant reductions in safety proxy measures were observed following the Street Smart NJ campaign, which represents an improvement in safety behavior. Statistically significant improvements in behavior were more consistently observed in more urban communities and at more conventional crossing intersections. This paper presents the data collection and statistical analysis methods, and provides an interpretation of the results.

Date 2017

Title Advancing pedestrian safety using education and enforcement efforts in pedestrian focus cities and states: North Carolina
Source University of North Carolina, Chapel Hill
Abstract The goal of this effort was to assist selected communities in North Carolina in implementing and evaluating education and enforcement activities. The team worked with communities in the Triangle area of NC to develop a comprehensive, community-wide pedestrian safety program. The program was influenced by an understanding of health behavior theories and best practices and informed by several data sources, including an analysis of pedestrian crash data, site visits, stakeholder input, and pedestrian safety action plans. The intervention used several strategies including radio ads, printed material, paid advertising, community engagement, earned media, and training of law enforcement officers to build their level of effectiveness in the project. Program evaluation included multiple measures, including tracking program implementation records, self-reporting by law enforcement regarding their knowledge, attitudes, and capacity, and driver yielding behaviors. Results identified significant use of paid media to spread pedestrian safety messages and large amounts of positive earned media coverage. The officer training course resulted in significant improvements in knowledge, self-reported behaviors, and capacity to perform enforcement operations to support the campaign. While first-year enforcement operations were noteworthy, more effort is needed to maximize the visibility of the enforcement and plan more routine, sustained efforts throughout the region. Driver yielding behaviors varied by location but significant changes from the pre-enforcement period to the post-enforcement period were not observed in the first-year time frame. The exception was at sites where law enforcement was at its highest intensity. Yielding rates were associated with site characteristics such as crossing placement and speed limits, and may be affected by seasonal trends. Lessons learned on program development and deliveries are provided.

Date 2016

Title Watch for Me NC: bicycle and pedestrian safety, education, and enforcement campaign: 2014 program summary
Source University of North Carolina, Chapel Hill
Recognizing the importance of preventing pedestrian and bicyclist injuries among adults and children, the North Carolina Department of Transportation (NCDOT) has been taking measurable steps to address these issues. In August 2012, after a year-long effort with a range of partners to plan and coordinate, NCDOT launched the Watch for Me NC campaign in the Triangle area, which included a comprehensive set of safety messages for pedestrians and drivers disseminated using diverse formats as well as law enforcement. In 2013, the campaign was expanded by adding bicycle safety to its messaging and the Safe Routes to School program. The overall goal of this project was to assist partner communities across North Carolina in successfully implementing the Watch for Me NC program, and to monitor program delivery to develop recommendations for future program expansion. To accomplish this goal, the project team from the University of North Carolina (UNC) Highway Safety Research Center (HSRC) sought to: (1) Recruit local partners with interest and ability to participate in the Watch for Me NC program; (2) Provide technical assistance and training to support local and statewide program implementation; (3) Coordinate with local agencies and NCDOT to collect, manage, and analyze data related to the program delivery; and (4) Evaluate the program delivery and present findings and lessons learned. This report documents methods and results related to the above activities.

Do as I say, not as I do: observed compliance versus stated understanding of pedestrian crossing laws

Florida has consistently had one of the highest pedestrian fatality rates in the country. NHTSA data indicate that Florida has had one of the four highest pedestrian fatality rates since 1994. In response, the Florida Department of Transportation launched the Bicycle–Pedestrian Focused Initiative to increase awareness of and decrease fatalities among bicyclists and pedestrians in Florida. A study conducted by the Center for Urban Transportation Research at the University of South Florida tracked the crossing behavior of individuals at high crash locations and then asked them about their understanding of pedestrian traffic laws. The results showed that most of the people surveyed about the traffic laws knew the correct answer and followed the law. The study found that 82% of the people interviewed crossed at the crosswalk and correctly answered the question about whether it was illegal to cross midblock; 57% said that they pressed the pedestrian push button when it was available and also were observed to press it; 64% of people were observed to start to cross on green pedestrian time and also said they did so when asked. Further, the study compared the behavior of people exposed to the safety campaign before the survey and also how their behavior changed when they were first asked the questions and then were observed during their crossing. The data showed that people exhibited safer behavior when they were asked the questions first and observed to cross afterward. The study showed results for several attributes, including crossing
location, pedestrian signal indication while crossing, pedestrian push button use, and distraction.

Date 2015

Title Educational campaign for improving pedestrian safety: a university campus study

Source 13th COTA International Conference of Transportation Professionals, Shenzhen, China

URL http://dx.doi.org/10.1016/j.sbspro.2013.08.309

Abstract Florida is the state with the highest pedestrian fatality rate per unit population in the U.S. In addition to engineering countermeasures, educational efforts directed to pedestrians and other road users are equally important for improving pedestrian safety. To explore educational formats and identify effective educational methods, the Florida Department of Transportation (FDOT) sponsored a pilot program called “Bulls Walk and Bike Week Campaign” on the Tampa campus of the University of South Florida (USF). A before-and-after comparison study was designed to evaluate the effectiveness of this campaign. In the study, observational surveys and a questionnaire survey were conducted to compare the surrogate measures of safety performance of the campus before and after the campaign. Observational survey outcomes show that roadway safety on campus improved after the campaign. The improvement is most significant for the site closest to the location where the majority of campaign activities took place. This suggests the necessity of seeking a spatial balance between concentrated and distributed campaign structures for optimal exposure to the campaign, especially when the budget of the campaign is limited and time is constrained. The analysis results of the questionnaire survey show that respondents as pedestrians, bicyclists, and drivers have different perceptions on driver yielding behaviors towards pedestrians and bicyclists. Contrasting points of view of different types of road users warrant careful and distinct designs of educational measures intended for different users. More respondents perceived that USF is a pedestrian/bicyclist-friendly campus after the campaign. It is suggested that a longitudinal survey should be conducted to follow up the effectiveness evaluation, and a cost-effective method should be further explored to continue the campaign efforts.

Date 2013

Title Visibility – to be seen or not being seen – that is the difference

Source Road Safety on Four Continents: 16th International Conference, Beijing, China


Abstract In Sweden the risk of being hit and killed by a car in darkness is 3 times bigger than in daylight. Between October and March, the days are short and the nights are long. 40% of all crashes where pedestrians are involved happen at night or dusk. Most accidents at night where pedestrians are injured and killed happen in urban areas where street lights are lit. And why? Because people believe that if
they can see, they can also be seen. But street lights help you to see in the dark but it doesn’t make you visible. The human eye has difficulties to discern contrasts even in lighted streets. With the visibility campaign: IF YOU ARE VISIBLE YOU EXIST the City of Malmö wants the cyclists and pedestrians to pay attention to that they are not to be seen if they don’t use reflectors and/or lamps in the dark. One week in early November for the last three years, the campaign has been conducted in terms of activities in the central parts of Malmö, in various cycle routes as well as newspaper advertisements, billboards and cinema advertising. Evaluation shows that more than 70% of citizens felt that it was a good and credible campaign and it brought up an important topic. 40% said that they were affected by the campaign to use reflectors more often. More than 90% said that it’s a good thing that the city of Malmo conducts campaigns concerning road safety and traffic rules. One thing that shows that the campaign is appreciated is the popularity of the reflector vests that are handed out to cyclists. With the message on the back: IF YOU ARE VISIBLE YOU EXIST, you see cyclists wear these vests a lot in Malmö. The campaign has influenced other cities in Sweden to use the same message in similar campaigns. The presentation will show how the campaign was conducted but will also try to inspire other countries to raise awareness of the importance of visibility.

Date 2013

Title York region pedestrian safety campaign
Source 2013 Conference and Exhibition of the Transportation Association of Canada – Transportation: Better – Faster – Safer
Abstract York Region covers approximately 1,800 square kilometers and is located in the heart of the Greater Toronto Area (GTA) in Southern Ontario. Since the creation of York Region in 1971, the population has increased dramatically from 169,000 persons to approximately 1.1 million in 2012. York Region is anticipated to grow to a population of 1.5 million by 2031. With this increase in population comes increased exposure between pedestrians and motorists. Understanding and changing social behaviour of pedestrians and motorists through education, enforcement and engineering will change how they interact and increase public safety Region wide. A review of York Region’s 2001 to 2010 collision statistics shows that the number of roadway fatalities has remained relatively constant over the past 10 years. However in 2010, a spike in pedestrian fatalities across the Greater Toronto Area is noted. While such a cluster of incidents at first seems alarming, a review of past occurrences indicates that such sudden spikes are likely random events. No particular factors that led to the spike in pedestrian fatalities in 2010 within the Greater Toronto Area could be identified. However, an analysis of our own data does show the percentage of fatalities involving pedestrians have been on the rise in York Region over the last decade. This project was nominated for the TAC 2013 Road Safety Engineering Award. For the covering abstract of this conference see ITRD record number 201310RT334E.

Date 2013
Title: Analysis of pedestrian conflict with right-turning vehicles at signalized intersections in India

Source: American Society of Civil Engineers

URL: https://doi.org/10.1061/JTEPBS.0000239

Abstract: The interaction between pedestrians and right-turning vehicles at a signalized intersection is a usual scenario in urban locations in which both have to share a common space on the road. Due to the rapid growth of vehicular traffic in developing countries such as India, pedestrian–vehicle conflicts are increasing tremendously. This study evaluated pedestrian safety by examining the interaction between pedestrians and right-turning traffic (left-hand driving) at signalized intersections using the traffic conflict technique. Five time-based conflict indicators, namely postencroachment time (PET), time to vehicle (TTV), deceleration to safety time of pedestrians (DSTped), time to accident (TTA), and deceleration to safety time of vehicles (DSTveh) were used to analyze the conflict situation. Four signalized intersections were selected in two cities (Kolkata and New Delhi) of India. For every possible conflict situation, PET, TTV, DSTped, TTA, and DSTveh were estimated and the severity of conflicts was identified based on pedestrian demography and their crossing behavior. The k-means clustering technique was used to classify the conflict indicators into four levels of severity. Silhouette plots were developed to validate the clusters. A binary logistic regression model was developed to identify significant contributing factors to the risk-taking behavior of pedestrians. The model’s results showed that pedestrians’ age, gender, waiting time, and speed; type of crossing; pedestrian with company; the occurrence of conflicts in different quarters of the green interval; and right-turning vehicle volume have a significant effect on the risk-taking behavior of pedestrians. The findings of this study may help to identify various factors that affect pedestrian-vehicle conflicts at signalized intersections.

Date: 2019

Title: Pedestrians’ behaviors at signalized mid-block Danish offset crosswalks using Bayesian networks

Source: Science Direct

URL: http://dx.doi.org/10.1016/j.jsr.2019.02.008

Abstract: This study presents the prediction of driver yielding compliance and pedestrian tendencies to press pushbuttons at signalized mid-block Danish offset crosswalks. It applies Bayesian Networks (BNs) analysis, which is basically a graphical non-functional form model, on observational survey data collected from five signalized crosswalks in Las Vegas, Nevada. The BNs structures were found in the data by applying several score functions. By considering prediction accuracy and the Area under the Receiver Operating Characteristic (ROC) curves, the BN found that using the Bayesian Information Criterion (BIC) score resulted in the best network structure, compared to the ones found using K2 and the Akaike Information Criterion (AIC). The BIC score-based structure was then used for parameter learning and probabilistic inference. Results show that, when considering an individual scenario, the highest predicted yielding compliance (81%) is attained when pedestrians arrive at the crosswalk while the flashes are active, whereas the lowest predicted yielding compliance (23.4%) is observed...
when the pedestrians cross between the yield line and advanced pedestrian crosswalk sign. On the other hand, crossing within marked stripes, approaching the crosswalk from the near side of the pushbutton pole, inactive flashing lights, and being the first to arrive at the crosswalk result in relatively high-predicted probabilities of pedestrians pressing pushbutton. Furthermore, with a combination of scenarios, the maximum achievable predicted yielding probability is 87.5%, while that of pressing the button was 96.3%. Traffic engineers and planners may use these findings to improve the safety of crosswalk users.

**Title**  
Modeling transitional states of drivers yielding right-of-way to pedestrians at signalized midblock crosswalks using a hazard-based multistate model

**Source**  
Transportation Research Record

**URL**  
https://doi.org/10.1177/0361198119841859

**Abstract**  
This study presents an analysis of transitional states of drivers yielding right-of-way to pedestrians at signalized midblock crosswalks. The study utilizes data from twenty signalized midblock crosswalks located in Las Vegas, Nevada, equipped with traffic control signals (TCSs), pedestrians hybrid beacons (PHBs), circular flashing beacons (CFBs), circular rapid flashing beacons (CRFBs), and rectangular rapid flashing beacons (RRFBs). It applies both descriptive analysis and multistate models to explore the variations in transition durations and factors associated with the states' transition of drivers yielding right-of-way, namely non-yield, multiple-threats, and full yield. The study found that RRFBs are the signal types that have a high frequency of multiple-threats state. The duration to reach full yield varies between 0 s and 318 s; the duration of non-yield to multiple-threats varies between 1 s and 105 s; whereas multiple-threats to full yield duration varies between 1 s and 38 s. The multistate model results show that only the signal type factor has a clear pattern. For this factor, the RRFBs showed low hazard ratios for all three transitions, when compared with CFBs and CRFBs. In various ways, the states' transition durations were also associated with the number of cross stages, number of lanes, vehicle density, incoming vehicle speeds, annual average daily traffic, and number of pedestrians crossing, as well as their crossing positions. The developed model can be used by engineers and planners to evaluate factors affecting the effectiveness of the crosswalk treatments.

**Date**  
2019

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**Title**  
A pedestrian crash prediction model for urban signalized intersections case study: the city of Isfahan, Iran

**Source**  
Transportation Research Board

**URL**  
http://amonline.trb.org/

**Abstract**  
In this paper, in order to develop and validate a model of vehicle-pedestrian prediction crashes at urban signalized intersections, data are gathered and extracted for 212 crashes at 55 signalized intersections of the city of Isfahan for
four years period (2013-2016). While the total number of crashes within 50 m of each intersection was considered as the dependent variable, road network characteristics, land use characteristics, demographic and socio-economic characteristics within 400 m of each the intersection were considered as independent variables. The correlation test was performed to diagnose a possible multi-collinearity between variables to eliminate variables which were correlated to each other. To model the frequency prediction of pedestrian crashes, a generalized linear model based on the negative binomial distribution was developed and validated. The results indicate that the number of legs, the average number of lanes of the intersection, population, and land use characteristics within 400 m of the intersection have a positive impact on the number of pedestrian crashes. Conversely, the number of pedestrian crashes decreases with an increase in the pedestrian volume, the presence of marked crosswalks, and public transport stops. In addition to prediction of the number of pedestrian crashes, this study can be useful since it provides insights for a better transportation policy-making and planning as well as engineering improvements to minimize pedestrian crashes in the city of Isfahan.

Title Mixed logit analysis of pedestrian red-light violations and injury severity in pedestrian crashes at signalized crossings
Source Transportation Research Board
URL http://amonline.trb.org/
Abstract Pedestrian red-light violations at signalized crossings are an important traffic safety concern. The authors aimed to quantitatively investigate factors associated with pedestrian red-light violations and injury severity resulting from pedestrian–motor vehicle crashes at signalized crossings. Mixed logit models are used to account for individual-specific heterogeneity that arises from a set of unmeasured factors related to traffic conditions and the pedestrians’ physical and mental status. Data for the analysis are based on the historical crash record maintained by the Hong Kong Transport Department. Children younger than 11 years are not only associated with a higher likelihood of pedestrian red-light violations but also tend to have a higher probability of fatal or serious injuries. Factors including summer, dual carriageways with a central traffic island, and pedestrian age of 12 to 25 years are solely related to a higher likelihood of pedestrian red-light violations; meanwhile, variables solely associated with a higher probability of fatal or serious injuries include crashes that occur between 22:00 and 06:59, crashes occurring in rainy weather, crashes involving pedestrians older than 46 years, and bus crashes. Based on identified statistically significant factors, appropriate countermeasures are recommended to curb pedestrian red-light violations and to reduce the severity of pedestrian crashes.

Title Bayesian approach to model pedestrian crashes at signalized intersections with measurement errors in exposure
This study intended to identify the potential factors contributing to the occurrence of pedestrian crashes at signalized intersections in a densely populated city, based on a comprehensive dataset of 898 pedestrian crashes at 262 signalized intersections during 2010–2012 in Hong Kong. The detailed geometric design, traffic characteristics, signal control, built environment, along with the vehicle and pedestrian volumes were elaborately collected. A Bayesian measurement errors model was introduced as an alternative method to explicitly account for the uncertainties in volume data. To highlight the role played by exposure, models with and without pedestrian volume were estimated and compared. The results indicated that the omission of pedestrian volume in pedestrian crash frequency models would lead to reduced goodness-of-fit, biased parameter estimates, and incorrect inferences. The authors' empirical analysis demonstrated the existence of moderate uncertainties in pedestrian and vehicle volumes. Six variables were found to have a significant association with the number of pedestrian crashes at signalized intersections. The number of crossing pedestrians, the number of passing vehicles, the presence of curb parking, and the presence of ground-floor shops were positively related with pedestrian crash frequency, whereas the presence of playgrounds near intersections had a negative effect on pedestrian crash occurrences. Specifically, the presence of exclusive pedestrian signals for all crosswalks was found to significantly reduce the risk of pedestrian crashes by 43%. The present study is expected to shed more light on a deeper understanding of the environmental determinants of pedestrian crashes.

The movement of pedestrians in the urban environment is a key factor in sustaining the social and economic relationships which are essential to the quality of life and maintaining a healthy life. To enhance pedestrian safety, there is a need to improve the pedestrian facilities at signalized intersections. The study objective is to develop pedestrian safety index model in crosswalks at signalized intersections under mixed traffic conditions. The data were collected from selected eight signalized intersections in Mumbai, India by performing video graphic and questionnaire surveys. The Pearson correlation test was performed to identify significant factors with respect to pedestrian perceived safety index score. Stepwise linear regression method was applied to develop a safety index model at 95% confidence interval and k-means clustering was used to define the threshold values for each safety index rating. The proposed model and threshold values were validated by using field data. The validation results showed that the proposed model and threshold values were estimated accurate safety levels of a pedestrian at a signalized intersection. Finally, the sensitivity of each model variable was analyzed by using Tornado diagram and improvement measures on
pedestrian safety were applied and analyzed theoretically at selected signalized intersection. This study is helpful to improve the existing conditions of intersections and recommends guidelines for providing adequate pedestrian facilities to cross the crosswalk safely and comfortably at signalized intersections.

Date          2018