MPC-515
August 2, 2016

Project Title:
Redefining the Child Pedestrian Safety Paradigm

University:
University of Colorado Denver

Principal Investigator:
Wesley Marshall, PhD, PE
Associate Professor
University of Colorado Denver
Department of Civil Engineering
303-352-3741
wesley.marshall@ucdenver.edu

Co-Principal Investigator:
Bruce Janson, PhD, PE
Professor
University of Colorado Denver
Department of Civil Engineering
bruce.janson@ucdenver.edu

Research Needs:
Child pedestrian deaths have dropped significantly since averaging over 1,000 per year in the early 1980s to now fewer than 400 each year (Percer 2009). Much of our focus has been on school zone safety, and past research suggests that when resources are focused on the areas around schools, effective gains in child safety can be made (Clifton and Kreamer-Fults 2007). Given such promising statistics, it seems like we have made great strides towards solving this problem.

However, it is important to note that kids seem to be walking and bicycling much less now than they used to. For instance, the percent of children walking to school dropped from almost 50% in 1969 to 13% forty years later (PBIC 2012). While parental perceptions of risks such as kidnappings have played into this monumental shift, traffic safety issues remain a primary impediment to children's independently walking and biking (Kerr et al. 2006, Veitch et al. 2006, Valentine 1997). It is also important to realize that while we may not be killing as many child pedestrians or bicyclists, childhood fatalities in the transportation system remain a major problem. In fact, motor vehicle crashes are the leading cause of death for individuals from the age of 4 through the age of 24 in the U.S. (CDC 2002). Moreover, we have not been able to solve the walking and bicycling safety problem equitably (Loukaitou-Sideris and Sideris 2009). Children that walk to school in low income areas are at a much higher risk of severe injury or death than children that walk to school in higher income areas (Clifton and Kreamer-Fults 2007). This may be due to several reasons such as: lower levels of access to motor vehicles and a higher need to walk or bike; lower levels of supervision and parental involvement; or differences in the walkability and safety of the built environment.

Nevertheless, childhood walking and bicycling seems to have many benefits. In terms of health beyond road safety, there is a strong relationship between low physical activity levels and outcomes such as obesity and diabetes (Sallis and Glanz 2006, Marshall, Piatkowski, and Garrick 2015, Rahman, Cushing, and Jackson 2011, Fox 2004). Other studies suggest that kids that walk or bicycle to school perform better, both academically and behaviorally, are more independent, and have higher levels of overall happiness (Louv 2005, UK Department of Transport 2006). For all these reasons, there is a renewed interest in promoting childhood walking and bicycling, and active transportation rates are finally starting to reverse their long downward trend (SRTS 2013). Portland, Oregon is an example of this success; driving to school rates are lower than ever while busing rates are also in decline (Anderson 2016). The problem, however, in most parts of the country is the manner in which we have built our transportation and land use systems. Barriers in the environment – such as big roads with high traffic volumes and high traffic speeds, poor street connectivity, and dispersed land uses – severely inhibit a child's ability to walk or bike (EPA 2003, Larsen, Buliung, and Faulkner 2013, CDC 2002). By encouraging walking and bicycling in such places, are we actually putting more kids at risk? These issues deserve a more thorough investigation.

Currently, we expend most of our resources dedicated to promoting child active transportation on the Safe Routes to Schools program. Related to this, the first question addressed through this work is: did we really solve the child pedestrian safety problem around schools or did we solve this problem by removing the majority of child pedestrians and bicyclists from the equation? Answering this question will require a rethinking of how we measure and account for child pedestrian and bicyclist exposure. As it currently stands, it is far too easy for ostensibly dangerous streets to be deemed safe due to the fact that they have scared away all the child pedestrians. While reducing the number of children walking might reduce the number of child pedestrian deaths, we miss out on the multitude of benefits provided by having kids walk, while also likely increasing vehicle occupant fatalities. In other words, we have failed to get to the root of the problem, which has left us with a suboptimal solution. Once we devise a method for better understanding child pedestrian and bicyclist exposure, we will then seek to answer our second research question: are there other destinations with large concentrations of child pedestrian fatalities that we should be focusing resources on in addition to our traditional focus of schools? Other land uses that would deem important to children – such as playgrounds, parks, trails, and recreation centers – have not received anywhere near the same level of investment, nor scrutiny, as compared to schools. Our intent for this portion of the project is to better understand whether our current approach is justified or if there are other destinations demanding additional investment.

With the benefits of having children independently walk and bike, and the tremendously poor safety records currently, we need to improve the situation. A comprehensive approach to this problem must include education efforts for child pedestrians and bicyclists. However, we also require a better understanding of the problem itself and the role of the built environment in supporting or inhibiting safe active transportation for children. This work aims to be a piece in the puzzle of the Vision Zero effort to help increase the safety and proclivity of childhood walking and bicycling.

Research Objectives:
This study will seek to:

1. Collect and geocode crash data;
2. Gather built environment data;
3. Investigate novel approaches for modeling child pedestrian walking and bicycling rates and develop a methodology for estimating this exposure;
4. Identify where child pedestrian crashes are occurring and which built environment factors are correlated with unfavorable frequencies and severities;
5. Advance knowledge by carrying out analyses to answer our research questions;
6. Advance policy and practice with respect to building safer cities;
7. Advance education through the training of students; and
8. Build an evidence base by disseminating findings through publications and presentations.

Research Methods:
This research will initiate with a thorough literature review of research related to child pedestrian safety. The next step will involve site selection, which will be based, in part, on the presence of secondary data for child walking and bicycling rates. In our preliminary investigation, we acquired potentially useful exposure data from Washington, D.C., and Portland, OR. We intend to study six cities. Road safety exposure – particularly as it relates children – is a tricky proposition. First off, children do not have homogenous street safety knowledge nor abilities. While as young as 7½ years old is approximately the age when children can cross a street independently, this is not necessarily consistent (MacGregor, Smiley, and Dunk 1999). Moreover, there are likely to be discrepancies in terms of parental supervision, which would further confound the comparison. The existing research has measured exposure is a variety of ways, including: mode choice (Rao, Hawkins, and Guyer 1997, Bly, Jones, and Christie 2005, Roberts and Norton 1994); total distance traveled (Jonah and Engel 1983); time spent near streets (Bly, Jones, and Christie 2005, Posner et al. 2002); and the number of roads crossed (Rao, Hawkins, and Guyer 1997, Posner et al. 2002, Percer 2009). Other potentially fruitful methods worth exploring include space syntax, which has been utilized by a plethora of past researchers as a pedestrian volume modeling tool (Raford, Chiaradia, and Gil 2007, Raford and Ragland 2004). Using baseline pedestrian counts at select locations, space syntax then factors in built environment variables such as land use and street network characteristics as well as demographic variables such as population and employment density to estimate pedestrian volumes and exposure. No matter the exposure metric, assessing improvements to child street safety via conventional methods can too easily be achieved by eliminating childhood active transportation. Our goal, however, is multi-objective in that we want to eliminate children dying in the transportation system (as pedestrians/bicyclists in addition to vehicle occupants) as well as increase active transportation rates for children. This process will involve devising a strategy that accounts for multi-objective criteria in a manner that is also fair and comparable from place to place.

This project will also include a large crash geocoding effort. We will begin by collecting and geocoding approximately 30 years of fatal crashes from the national FARS database for our selected cities. We will then collect and geocode as many years of injury crash data as possible from the local municipalities and government agencies. In our experience, this availability and consistency of such data varies significantly from place to place. Accordingly, we may have to revisit site selection or focus in on fatal crashes depending upon the outcomes of this step.

The other major data need for this project is extensive built environment data. Thus, we will collect land use data, street network measures, street-design variables, and intersection characteristics for our selected cities. Our main source for this data will be publically available GIS data. This database will be supplemented through a combination of historical aerial images and background research related to when specific infrastructure elements were added or changed over the study time period. All elements will be geocoded in GIS and coded for our statistical analyses. The overall goal is to create a longitudinal database suitable for statistical analysis.

One possible statistical approach for such a longitudinal study between crashes and explanatory variables (Cotti and Tefft 2011), where we are also interested in cross-locational issues, is a panel data model (Ahangari et al. 2014). For instance, the following equation would examine the fatality rate:

$$\log(FatalityRate_{it}) = \alpha \log(X_{it}) + \beta \log(Y_{it}) + \gamma \log(Z_{it}) + (AX = F) + \sum \theta_t + \varepsilon_{it}$$

with:

FatalityRate = road fatality rate;
X = set of transportation behavior variables;
Y = endogenous built environment variables;
Z = socio-economic / socio-demographic variables;
α, β, γ = coefficients of X, Y, and Z;
(AX =F) represents the fixed effect for each city;
θ_t = time dummy variable; and
ε_{it} = error term for city i at time t.

We may also employ a multilevel negative binomial model with crash and/or fatality counts as the outcome variable. For spatial area-level research, our data is considered multilevel since it consists of records on the neighborhood level that can be clustered into a second level of geography at the city level. The concept behind a multilevel hierarchical model is linking a pair of statistical models in order to simultaneously allow a focus on both micro- and macro-level relationships and the interaction between the two (Healy 2001). This type of structure helps account for spatial autocorrelation and the fact that people living in the same location tend to share the characteristics of that location, which would violate the independence assumption of an ordinary least squares regression (Ewing et al. 2003). If we did not take this into account, the standard errors of regression coefficients that we are seeking to associate with our characteristics would likely be underestimated (Ewing et al. 2003).

The following represents a sample hierarchical structure:

Level 1: Between-Neighborhood Disparities
Level 2: Between-City Differences

The first level of the model includes the safety outcomes, socio-economic/socio-demographic data, and built environment characteristics of each neighborhood, which can be modeled as a function of the characteristics of the neighborhood plus stochastic random error (Ewing et al. 2003). This equates to each city having a specific regression equation portraying the association between the characteristics and safety outcomes of the neighborhood. For the second level, the city-specific intercept and coefficients are modeled in terms of city characteristics plus random error (Ewing et al. 2003).

The level 1 model tested safety outcomes as a function of the city mean using the following form:

$$Y_{ji} = \beta_{0j} + \beta_{1j}x_{ij} + r_{ij} \qquad\qquad r_{ij} \sim N(0, \sigma^2)$$

where Y_{ji} is the outcome for neighborhood i in city j, and x_{ij} is a fixed covariate. β_{0j} represents the mean level of the outcome in city j, and β_{1j} represents the effect of the neighborhood-level variable on the outcome in city j.

The expected random effects level 2 model allows the intercept and slope to vary across cities. The level 2 model corresponding to a level 1 random coefficients model is as follows:

$$\begin{aligned} \beta_{0j} &= \gamma_{00} + u_{0j} \\ \beta_{1j} &= \gamma_{10} + u_{1j} \end{aligned} \qquad \begin{pmatrix} u_{0j} \\ u_{1j} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \tau_{00} & \tau_{01} \\ \tau_{01} & \tau_{11} \end{pmatrix} \right)$$

where γ_{00} represents the overall average outcome level (at $x_{ij} = 0$), and γ_{10} is the average effect of neighborhood variables on the outcomes. The variables used in all of the final models will be selected in an effort to maximize model significance using the AIC value.

In terms of dissemination, the intent is to target both academic and practitioner audiences. For academic audiences, we will produce conference presentations and peer-reviewed journal papers. To share findings of this project with broader audiences in mind, we will make sure these results are disseminated via newsletter and/or popular press articles and presented at more practitioner-oriented conferences. We also will seek to coordinate with the Safe Routes to School program and other groups interested in child pedestrian and bicyclist safety.

Expected Outcomes:

Children are some of the most vulnerable users of our roadways due to the fact that they must walk or bike if they are not able to get a ride from an adult, their lack of understanding of and experience in the transportation system, and their small physical size. When planning and designing safe transportation systems, it is imperative to account for the special needs of children. Ensuring their safety (and giving them places to safely walk and bike) aids with their healthy development (both physically and mentally), improves academic achievement and behavior, and increases self-esteem. The current focus on child road safety is primarily concentrated around schools. We seek to shed light on whether this is the best place to focus our resources as well as delve into what other factors relate to child road safety injuries and fatalities so that we can remedy these issues from both a design and policy framework. The expected outcomes of this work include:

1. Findings with respect to the testable hypotheses and research questions;
2. A set of explanatory and dependent variables and constructs where we can disaggregate the factors influencing better road safety for child pedestrians;
3. Manuscripts for presentation/publication at TRB and other peer-reviewed journals;
4. Presentations to academic and policy audiences; and
5. A module about road safety, active transportation, and vulnerable road users for transportation courses at the University of Colorado Denver.

Relevance to Strategic Goals:

The work primarily falls under the strategic goal of safety, but it also highly relates to livable communities and accessibility for vulnerable road users.

Educational Benefits:
This study will be integrated into Dr. Marshall's "Transportation System Safety" graduate course and Dr. Janson's "Traffic Safety Data and Analysis" graduate courses. The data collected for this project will also be made available to students for use in term projects and/or master's reports. As a result, this project will influence students from a variety of disciplines. Students who work on the project will have the opportunity to be co-authors on publications and presentations.

Work Plan:
The proposed scope of work is scheduled for a one-year timeframe, beginning with notice to proceed from the Mountain Plains Consortium. Major project steps include the following:

Task	Timeline
Conduct literature review	Months 1-2
Collect possible exposure data	Months 1-2
Develop child pedestrian exposure models	Months 3-6
Collect and geocode safety data	Months 3-4
Select study cities	Months 3-4
Collect built environment data	Months 5-6
Analyze data	Months 7-10
Incorporate lessons into transportation classes	Months 8-10
Draft manuscripts and presentation materials	Months 10-12

Project Cost:
Total Project Cost: $135,571
MPC Funds Requested: $67,740
Matching Funds: $68,830

Source of Matching Funds: University of Colorado Denver

TRB Keywords:
Safety, pedestrians, children, schools, parks

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