EXPLORING NEGLECTED SAFETY EQUITY ISSUES: A REFOCUS OF NEW URBANIST PRINCIPLES

ABSTRACT

While walkability and bikability are central tenets of New Urbanism, road safety issues often act as a primary barrier to such activities. Therefore, in order to create healthy and happy New Urbanist places through walking and bicycling, it is necessary to better alleviate safety issues. However, by examining crashes, injuries, and fatalities after they occur, traditional pedestrian and bicycle safety analyses take a reactive approach to safety by only investigating the places where people are currently walking and bicycling and the people who are currently pursuing those activities. What about the places that people have deemed too unsafe to use at all? Where would these areas be located, and who would bear the brunt of those neglected safety issues?

In order to answer these questions, we examine child pedestrian and bicycle trips to and from schools in Denver, Colorado that are suppressed specifically due to safety concerns. Through the development and utilization of a tool that identifies roadways with high numbers of suppressed trips, we detect built environment characteristics – such as network configurations, barrier connections, and destination siting – linked with high levels of suppressed trips. We also examine the socioeconomics of those impacted by these neglected safety issues, finding that the weight is borne primarily by low income, Hispanic, and non-white neighborhoods. By incorporating this tool into traditional traffic safety analyses, we hope to better define the places and people that could most benefit from New Urbanism.

INTRODUCTION

In pursuit of sustainable human-scaled places, one of the guiding principles of New Urbanism is to ensure walkability and bikability. However, a primary barrier to such walking and bicycling is the threat of unsafe traffic conditions (Dellinger 2002). While our traditional approach to safety identifies locations of crashes, injuries, or fatalities, such a method only accounts for the places where people are actually walking and bicycling. Are there areas in our cities that are perceived to be so unsafe, pedestrian and bicycling activity has been suppressed, and therefore there are few or no crashes occurring? What would these neglected places look like, and who would be impacted?

In this paper, we develop and utilize a new tool for identifying such neglected areas through the quantification of walking and bicycling trips that have been suppressed because of safety concerns (Ferenchak and Marshall 2018). Based on the results of this tool, we explore which residents are impacted by these overlooked problems to see if there are equity concerns at play. These are the places and people that may be in most need of New Urbanist interventions.

In order to accomplish these goals, we explore child pedestrian and bicycle trips to and from school in Denver, Colorado. Parental surveys provided us with trip suppression rates based on street design characteristics. We applied these trip suppression rates to the optimal number of trips expected per closest facility network analysis in GIS. Median household income and racial compositions on the Census tract level provided us with data for an equity analysis. When results are combined with traditional safety methods, we acquire a more holistic view of pedestrian and bicyclist safety, thereby breaking safety barriers and better allowing for the appropriate application of New Urbanist principles.

THEORY

Crashes, injuries, and fatalities – normalized to levels of user exposure – are typically employed to analyze transportation safety of both motorized and non-motorized users (TRB 2001; Waldheim, Wempe, and Fish 2015; FHWA 2006; Zegeer et al. 2010). However, this reactive approach only accounts for individuals that are using the facility and neglects those individuals that have deemed the roadway too unsafe to use in the first place. Accounting for suppressed trips is especially prescient for pedestrian and bicycle safety analyses, where many possible users could be expected to be dissuaded because of safety concerns (Schneider, Ryznar, and Khattak 2003). Some proactive safety approaches account for such suppressed trips, with high levels of suppressed trips signaling safety issues, regardless of the presence of objective outcomes (Schneider, Ryznar, and Khattak 2003; Nevelsteen et al. 2012; Bellemans et al. 2009). However, such proactive safety analyses have thus far only examined specific areas – an approach that is not generalizable to other roadways – while only accounting for a limited number of roadway characteristics. Thus, we developed a more holistic method of measuring pedestrian and bicycle trips that have been suppressed due to safety concerns that can be applied more widely. Our method focuses on roadway characteristics such as vehicle speeds, vehicle volumes, roadway width, and the presence of non-motorized facilities (Ferenchak and Marshall 2018).

Because this tool is capable of identifying areas with high numbers of suppressed pedestrian and bicycle trips (which may indicate neglected safety issues), it begs the question: where are these neglected safety issues located, and who is most impacted? While such an analysis of neglected safety issues has not been performed as of yet, past studies have explored which populations are most impacted by traffic crashes, injuries, and fatalities. A nationwide analysis of 970,000 motor vehicle fatalities across the United States between 1989 and 2012 illuminated the fact that Black and Hispanic neighborhoods carry an unequitable share of the traffic fatality burden (Marshall and Ferenchak 2017). McAndrews et al. (2013) found similar trends for injuries, concluding that Blacks and Native Americans were more likely to experience motor vehicle injuries after controlling for travel mode and sex. In Colorado, Harper et al. (2000) found that Hispanic communities had higher rates of traffic fatalities. Finally, Braver (2003) added to the race and ethnicity conversation by finding that Blacks and Hispanics were at higher risk for traffic fatalities but also found that populations with lower socioeconomic status (SES) were at higher risk as well. However, all of these past studies have examined crashes, injuries, or fatalities in a reactive manner. What areas and people would be most impacted if we proactively examine neglected safety issues?

DATA

Through this work, we utilize a trip-suppression model based on parental perceptions of roadway characteristics. To do so, data regarding both safety perceptions and optimal trips are necessary. We garner perceptions through a survey and base optimal trips on a closest facility GIS analysis utilizing child populations (origins) and school locations (destinations). Socioeconomic data takes the form of race, ethnicity, and median household income on the Census tract level.

We utilized the City and County of Denver to build our safety perception-based mode choice model. Denver is the heart of Colorado's Front Range region with a 2015 population of 649,654 residents (118,886 under 15 years of age) spread out over the city's 155 square miles. The dense downtown is surrounded by medium-density neighborhoods laid out in predominantly gridded street networks. According to Denver Public Schools (DPS), there are 92,331 children enrolled in DPS's 207 schools throughout the city.

Parental Perceptions Data

In order to garner parental perceptions of traffic safety, we targeted a survey at parents of children in grades pre-kindergarten through 8th grade. Children were the focus of this study because they allowed for a smaller set of destinations, which makes deriving suppressed trips more achievable. We provided both promotional materials and the survey in English and Spanish. Respondents first provided the grade level and gender of each child that was included in the survey response. A more expansive discussion of the survey methodology can be found in Ferenchak and Marshall (2018).

The Leuven Travel Behavior of Children to Primary School Survey (Nevelsteen et al. 2012) served as a prototype for the travel behavior questions on the survey. Parents answered whether they would allow their child to either walk or bike along eight different picture-based roadway scenarios on the child's trip to school (four scenarios for pedestrian questions and four for bicycle questions). Each roadway scenario in our survey had four different characteristics that were identified for the parent: the speed limit of the roadway, the number of lanes, the presence of active transportation facilities (a sidewalk for walking questions and a bike lane for bicycling questions), and the vehicular volume of the roadway. Each scenario had a picture of a roadway and asked if the parent would let their child/children walk or bike to school along the roadway (Figure 1). The available responses were "No", "Yes, with trusted adult supervision", and "Yes, without adult supervision".

Two of the factors had three levels (speed limit: 25 mph, 35 mph, or 45 mph; number of lanes: 2 lanes, 3 lanes, or 4 lanes) while two of the factors had two levels (presence of facility: yes or no; volume of the roadway: low or high). This resulted in a total of 36 different scenarios for walking and 36 different scenarios for bicycling. We utilized vehicle volumes provided by DRCOG, with any roadway having more than 1,000 vehicles per day being designated as high volume (Cornell Local Roads Program 2014).

Of the 1,298 survey respondents, 924 provided complete responses. These 924 complete parent responses accounted for 1,331 children. There was a strong distribution of responses across grade levels and gender, while the majority of surveys were completed for one or two children (Table 1 and Figure 2).

8. Would you allow your child to use this roadway **on foot** to get to school?

25 mph Speed Limit
3 Lanes
Sidewalks
Low Vehicle Volume

34. Would you allow your child to use this roadway **on bike** to get to school?

35 mph Speed Limit
2 Lanes
Bike Lanes
Low Vehicle Volume

FIGURE 1: Picture-based roadway scenarios from the survey we administered to parents.

TABLE 1: Survey Response Descriptive Statistics

Gender	
Male	667
Female	658
Other	4
Number of Children for each Survey	
1	431
2	330
3	54
4	10

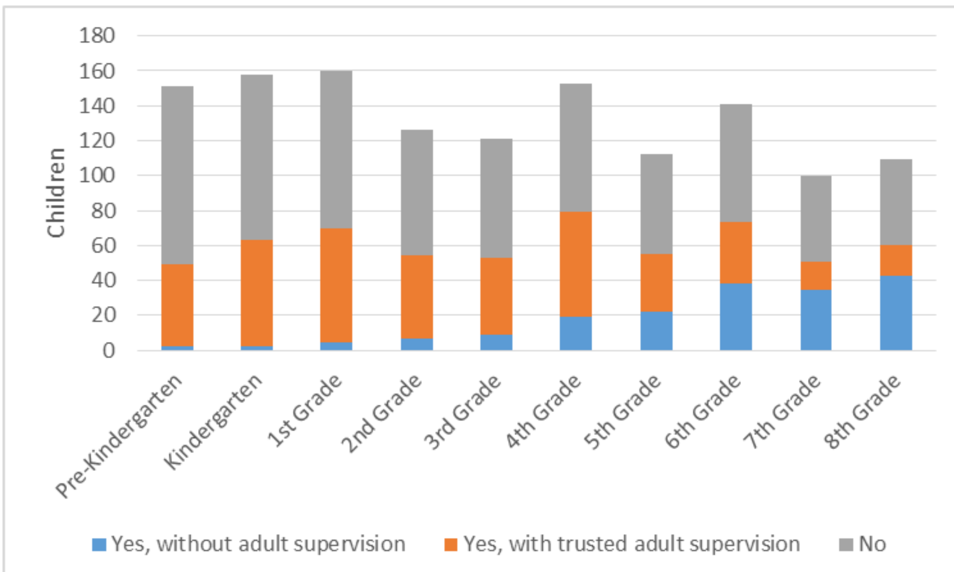

FIGURE 2: Number of parental allowance responses from survey for all roadway scenarios by grade level.

Population and Built Environment Data

We collected age-based population data on the block group level from the 2015 American Community Survey via the National Historical Geographic Information System (NHGIS) (Manson et al. 2017). The Denver Open Data Catalog provided the sidewalk network, roadway network, and off-road trail network in polyline shapefile format, from which we utilized the available data regarding speed limits and number of lanes. The Denver Regional Council of Governments' (DRCOG) Regional Data Catalog provided traffic volumes and school locations in point shapefile format. We created the bike lane network in polyline shapefile format based on the location of bike lanes per Google Maps, satellite imagery, and Google Streetview. Data regarding median household income, ethnicity, and race on the Census tract level were provided by NHGIS.

METHODS

The goal of this work is to integrate a trip-suppression mode choice model with built environment and socioeconomic characteristics to determine neglected places and people that may benefit from New Urbanist principles. In order to accomplish these goals, we use trip-suppression rates derived from a survey and optimal trip frequencies – the number of expected trips under ideal conditions as derived from a GIS network analysis – to determine the number of active transport trips to school that are suppressed because of safety concerns. We then determine which neighborhoods – and their built environment characteristics – and which people face these neglected safety issues.

Network Analysis

We utilized an origin/destination approach to measuring suppressed trips, with child homes being origins and their closest school being the destination. All public elementary and middle schools in Denver were used for analysis. DPS does not provide busing for elementary students that live less than a mile from their school. In order to capture these populations that would be more apt to pursue active modes of transportation, we created a Euclidian distance one-mile buffer (i.e. not a network buffer) around each of the elementary and middle schools and designated this as the study area. The study area included the vast majority of Denver, except for the far northeast portion of the city comprised of the airport.

We then ran a closest facility network analysis using GIS. This takes the origin (child) and finds the shortest route to their respective destination (school). While pedestrians and bicyclists often do not use the shortest available path because of safety and comfort concerns, we wanted to start with a baseline of how many trips would occur under ideal conditions and then derive the number of suppressed trips based on that value (Krizek, El-Geneidy, Thompson 2007). Alternatively, if we derived the number of trips being suppressed because of safety concerns from a trip count weighted on traffic safety concerns, this would result in multicollinearity issues.

We integrated the impact of roadway network connectivity on active transportation levels into the analysis by accounting for intersection density (Schlossberg et al. 2006). We did not account for crime because of mixed findings in terms of the relationship between objective crime and walking levels, mainly due to more walkable environments attracting different types of crimes (Foster et al. 2014).

Suppressed Trips

Next, the parental perceptions survey was used to determine how many of the ideal trips would be suppressed due to safety concerns. All twenty roadway scenarios were coded based on their four predictor variables, while the outcome variable took the form of the percentage of parents that would not allow their children to use the roadway. While we used survey results for roadway scenarios that were featured on the survey, roadway scenarios that were not on the survey (e.g. one-lane roads, six-lane roads, 55 mph roads, etc.) needed to be interpolated or extrapolated. In order to do this, we created a linear regression with the four roadway characteristic predictor variables and the percentage of disallowance as the outcome variable (Table 2). We did not find evidence of non-linearity, thereby justifying this technique. The presence of sidewalks was the most important factor in terms of suppressing walking trips, while vehicle volumes was the most important factor in terms of suppressing biking trips. Each roadway segment now had a set of roadway characteristics, a corresponding percentage of parents that would not allow their child to walk or bike, and the total number of trips under ideal conditions. We then multiplied the number of ideal trips by the percentage of disallowance to derive the number of trips that were being suppressed because of traffic safety concerns for each roadway segment.

TABLE 2: Linear Regression Coefficients for Trip Disallowance Derived from Survey Results

	Walk (R^2 = 0.9654)	Bike (R^2 = 0.9227)
Intercept	0.037	-0.076
Speed (mph)	0.015***	0.010***
Lanes	0.046*	0.105***
Facilities	-0.248***	-0.086***
Volume	0.131***	0.230***

* *p<0.10*
** *p<0.05*
*** *p<0.01*

RESULTS

We first determined the extent of the neglected safety issues by quantifying how many children encounter roadways with high trip suppression. We then quantified how those children's routes are altered when they encounter such a roadway. Finally, we identified associated network characteristics and socioeconomics in order to determine the places and people that – although they may currently be neglected – may also be in the most need of New Urbanist interventions.

Extent of Encounters

We began our exploration by identifying to what extent and where children are encountering roads with high levels of disallowance. More children in Denver encounter roads that parents have deemed unsafe for bicycling than encounter roads that parents have deemed unsafe for walking. Approximately 2.3% of children in Denver would encounter a road with 75% disallowance or greater for walking (a road perceived as particularly unsafe), assuming that they take the shortest route to school (Table 3). However, 31.8% of children in Denver would encounter a road with 75% disallowance or greater for bicycling. High numbers of encounters with roadways having 50% disallowance or greater signals that these problems are widespread in Denver.

TABLE 3: Percentage of Children Encountering Roads with Varying Disallowance Rates

	25% Disallowance	50% Disallowance	75% Disallowance
Walk	40.5	12.2	2.3
Bike	64.9	61.4	31.8

Children that encounter these roads perceived to be unsafe for walking – specifically those roads which more than half of parents would not allow their child to walk on – are primarily found in two different areas: an area with sidewalk gaps near the border of the Montclair and East Colfax neighborhoods of Denver (the top-right concentration) and an area near the border of the Mar Lee and Ruby Hill neighborhoods (the bottom-left concentration) (Figure 3). This first neighborhood has high numbers of children that encounter roadways perceived as unsafe because of gaps in the existing sidewalk network while the second neighborhood has high concentrations of children near Federal Boulevard and Florida Avenue, both high-suppression roads. Children that encounter roads perceived as unsafe for bicycling are similarly found near Federal Boulevard but also in Montbello, which contains high concentrations of children, a curvilinear roadway network, and a lack of bicycle facilities. It is also apparent that, in general, there are more children that encounter roads that parents would not allow them to bicycle on than children that encounter roads that parents would not allow them to walk on across the city. These are the areas to focus on that need New Urbanism, even if they are not experiencing high numbers of crashes, injuries, or fatalities.

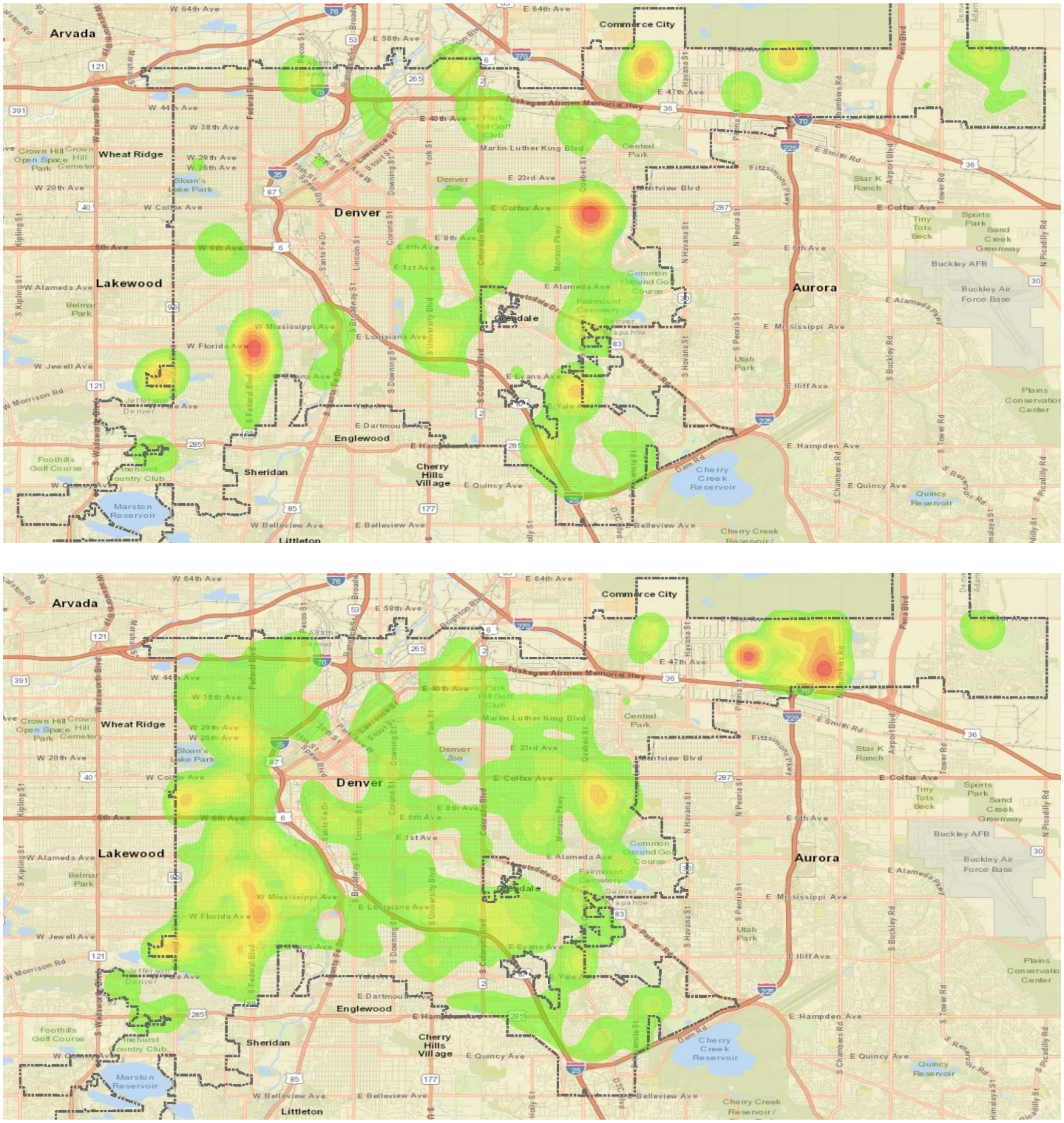

FIGURE 3: Densities of children with negatively impacted routes for walking (top) and bicycling (below).

However, if an efficient grid network is in place that presents pedestrians and bicyclists with different route options, children may be able to simply avoid these roadway segments that are perceived as unsafe by using parallel streets. How much further would children's trips be extended if these roadways that are perceived as unsafe were not utilized? In order to answer this inquiry, we reran the network analysis after the roads with high trip suppression – particularly those with greater than 50% disallowance – were weighted so that they would be discouraged according to parental safety concerns. We then compared the trip lengths under ideal conditions to those when high-suppression roads were accordingly discouraged.

For walking trips, the average trip length across the city increased from 2,728 feet under optimal conditions to 2,937 feet once high-suppression roads were discouraged. For bicycling trips, the average trip length increased from 2,728 feet under optimal conditions to 3,763 feet once high-suppression roads were discouraged. Citywide, about 4,274 children were pushed out of a ½ mile walkshed when safety perceptions were accounted for, while 23,429 children were pushed out of a ½ mile bikeshed. The greatest increases in distance were concentrated near Interstate 25, the South Platte River, and Sheridan Boulevard. These neighborhoods have curvilinear roadway networks or limited route options because of barriers, resulting in large increases in trip distance (upwards of an additional 5,228 feet to avoid high-suppression roads in the curvilinear neighborhood). Areas with grid networks that saw large percentages of roads perceived as unsafe did not have similarly large increases in trip distance because of the ability for pedestrians and bicyclists to select alternate routes with little additional distance.

Suppressed Trips

We then integrated the results from the mode choice model with the number of total possible trips to derive the number of trips that are suppressed due to safety concerns for roadways in Denver and identified which roadways are doing the most suppressing. We focused on roads with greater than 25% disallowance because these roads are perceived as unsafe and most likely in need of amendment. While some roads with less than 25% disallowance (those perceived as safe by parents) had high numbers of suppressed trips, it was only because of high levels of ideal exposure, not because of a lack of perceived safety. Therefore, these roads were not considered. The high number of low-speed local roads in Denver's grid networks resulted in a relatively low mean of suppressed trip per road segment (1.60 trips for walking, 7.11 trips for biking), although some segments had up to 272 suppressed trips for walking and 528 suppressed trips for biking.

So which neighborhoods might benefit the most from a New Urbanist focus? Walking trip suppression and bicycling trip suppression displayed similar patterns. We found high levels of trip suppression primarily near either a connection through a barrier in the roadway network or in close proximity to a school. The barrier connections were at impediments that have limited pathways over or under them (e.g. limited access highways or bodies of water), for which high rates of trips would optimally funnel through the few available connections. Because these barrier connections primarily serve vehicles, they are usually wide, high-speed roadways. Therefore, while such connections are vital to both motorists and non-motorists, the connections are built to accommodate vehicles and present non-motorists with few options. Examples of these barrier connection issues are identified in the model are near Interstate 70 and First Creek, and also near Interstate 25 as pictured below (Figure 4). While there were some examples of high levels of trip suppression, we found high numbers of suppressed trips at barrier connections to be relatively rare because children often have schools within their own neighborhoods that are closer.

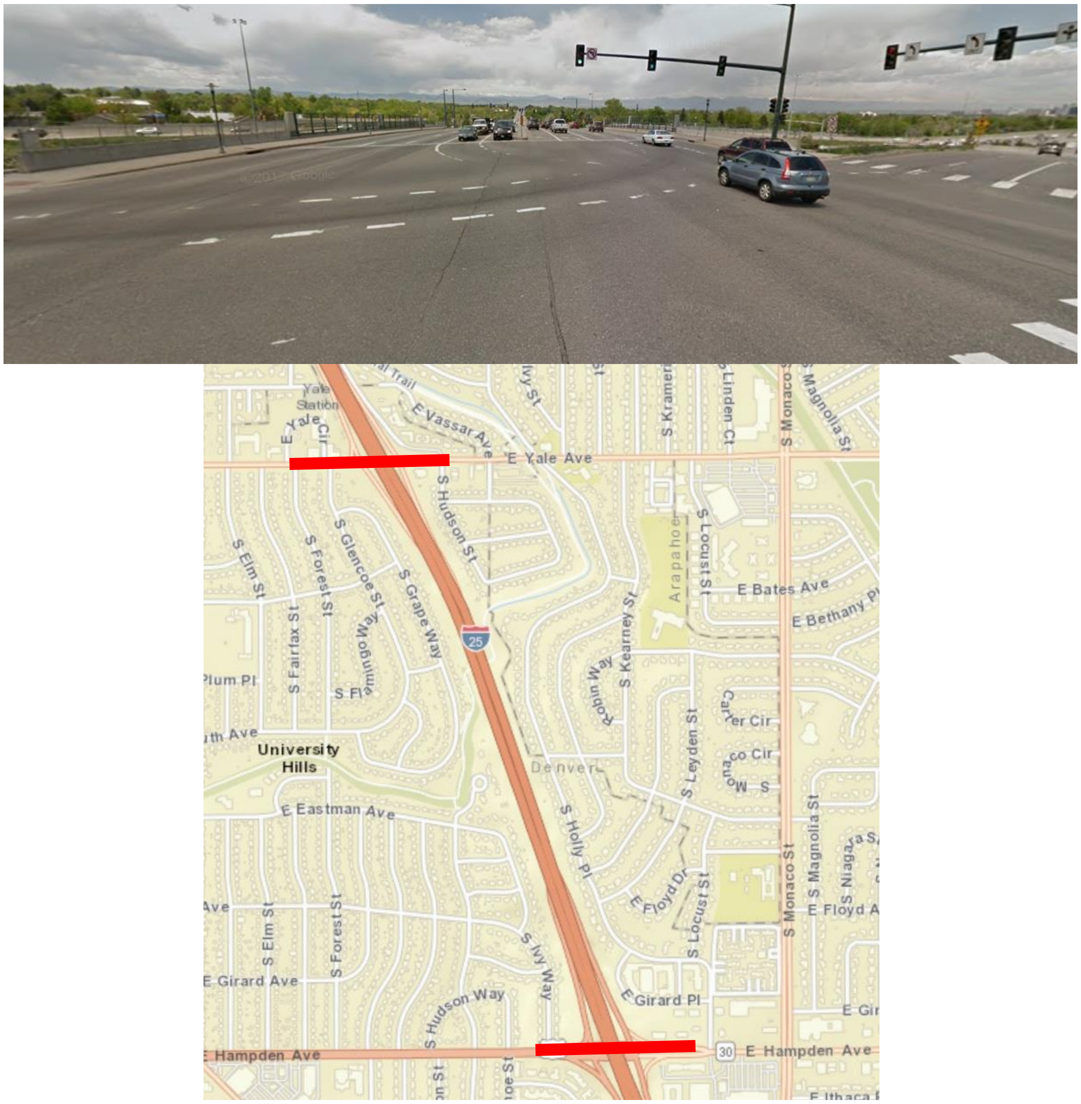

FIGURE 4: Examples of barrier connection with high trip suppression (Yale Avenue and Hampden Avenue (pictured) over Interstate 25).

There were also high numbers of suppressed trips on roadways in close proximity to schools. These roadways can be broken into two categories: those in curvilinear loop networks and those in grid networks. While the majority of Denver consists of gridded networks, three of the top six areas for walking trip suppression and two of the top six areas for biking suppression near schools are found in the Montbello neighborhood of northeast Denver (Figure 5). Montbello has a predominately curvilinear loop roadway network, as the bulk of its development occurred in the late 1960s and early 1970s. These networks consist of curved local streets that channel onto collector or arterial streets. While pedestrians and bicyclists in grid networks typically have the option to use a variety of roadways to get to their destination, non-motorized users in these curvilinear loop networks typically have to channel to a main road that has been prioritized for vehicles.

While the roads in these neighborhoods may not be perceived to be as dangerous as some in central Denver (the roadways have two sidewalks, do not have bike lanes, are signed at 25 mph or 30 mph, have four lanes, and are high volume), the high levels of trip suppression in these northeast neighborhoods are being driven by the fact that trips are concentrated on main roads because of the street network configuration.

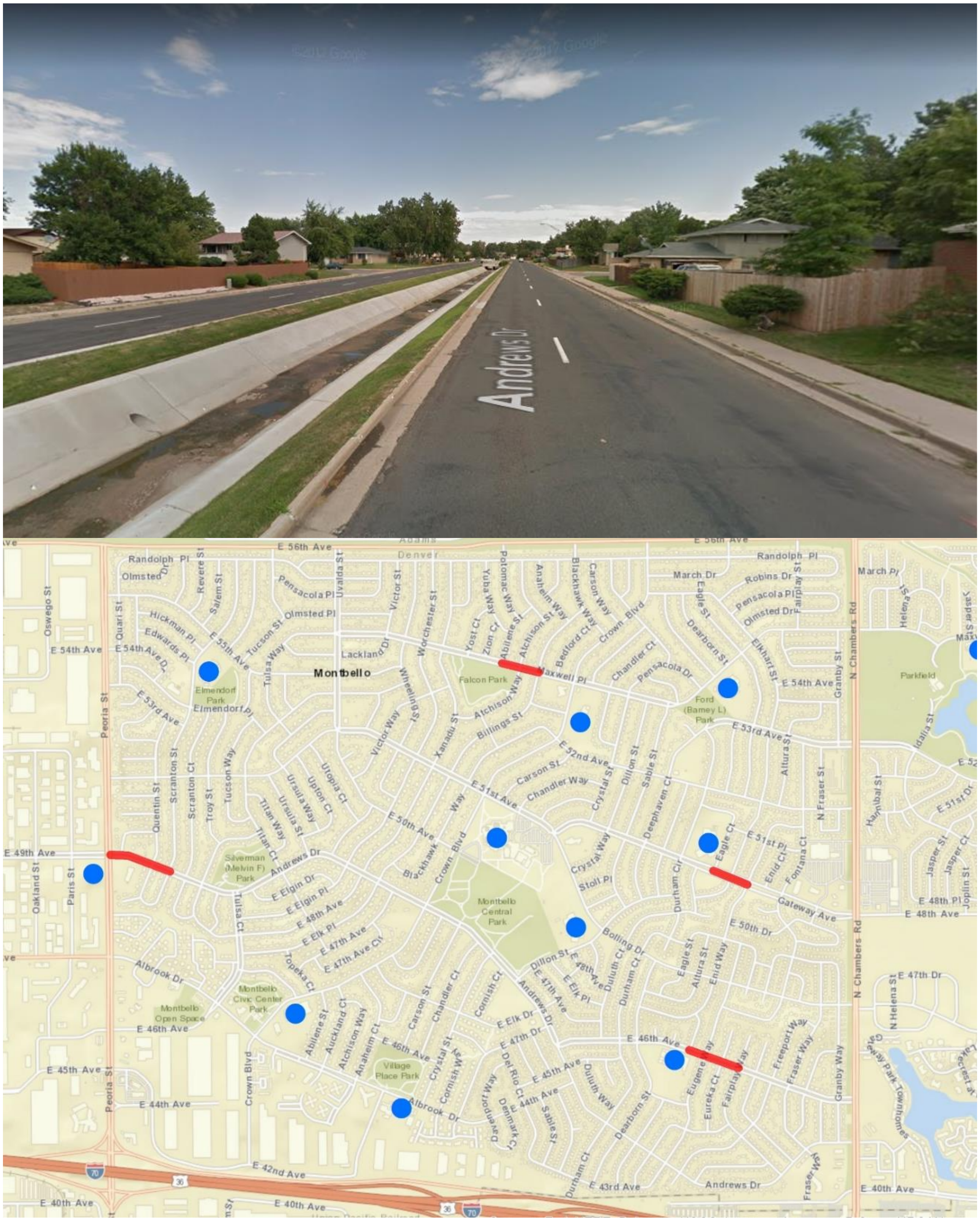

FIGURE 5: Examples of high trip suppression around a school in a curvilinear loop network (Blue dots are schools; image is of Andrews Drive).

Relatively few areas with high numbers of suppressed trips were found in the grid network, which is the predominant network type in Denver. High trip suppression roadways that were found in the grid network typically occurred when a school was placed near a major road. There were also instances of high trip suppression when a school was sited next to a major roadway outside of the grid. Examples include Southmoor Elementary School near S. Monaco Parkway and Goldrick Elementary School near Mississippi Avenue (Figure 6). While pedestrians and bicyclists in a grid network typically have options in regards to which roads they utilize, siting a school directly on an arterial can force them to use a road perceived as unsafe, thereby dissuading trips and prompting an unsafe scenario.

FIGURE 6: Example of high trip suppression near Goldrick Elementary School (blue dot) at Mississippi Avenue.

While we have identified parts of our built environment that experience neglected road safety issues, it is important to explore who bears the brunt of these problems. A cursory examination of the neighborhoods that had the most children encountering roads perceived as unsafe shows that those neighborhoods had median household incomes 6.2%, 15.1%, and 46.7% below average for Denver. In order to further explore this relationship, we counted the number of suppressed walking and bicycling trips, for each Census tract in Denver, and normalized per the number of road segments in each Census tract. NHGIS then provided median household income, race, and ethnicity data on the Census tract level. Results show that the neglected safety issues in Denver are concentrated in neighborhoods with high levels of non-white, Hispanic, and low income populations (Table 4). The relationship is strongest with Hispanic populations, while the relationship between suppressed walking trips and median household income is weakest and does not reach statistical significance. Because the SES factors had collinearity, we created separate models for each socioeconomic variable. We can see that these formerly unrecognized safety issues are inequitably impacting lower income, Hispanic, and non-white populations. These are the people that might be best helped from New Urbanism principles, although their need may not be fully recognized through more traditional approaches.

TABLE 4: Linear Regression of Census Tract Socioeconomics and Number of Suppressed Trips per Road Segment

	Median Household Income	% Non-White	% Hispanic
Walk	-0.122	0.255***	0.360***
Bike	-0.281***	0.290***	0.435***

* *p*<0.10
** *p*<0.05
*** *p*<0.01

CONCLUSION

By combining trip suppression rates derived from a perception survey with optimal trip frequencies from a GIS network analysis, we can identify areas where trips are suppressed because of safety concerns. These areas may especially benefit from New Urbanist concepts aimed at improving walkability and bikability. Although areas identified in this paper are not technically objectively unsafe – only perceived as unsafe – identifying such areas will hopefully aid in the identification of safety issues before they occur.

Areas with high numbers of suppressed trips were heavily concentrated around schools in parts of the city with curvilinear loop networks. Grid networks can help to alleviate the safety issues, provided that the school is not sited on or very near a major road. Furthermore, appropriate grid networks can minimize the distance that a child must add to their route if they do encounter a roadway that is perceived as unsafe. There are also high numbers of suppressed trips present at barrier connections. Segments of high trip suppression are typically not great in length, meaning that it may only take one or two blocks or crossings of unsafe conditions to dissuade a pedestrian or bicycle trip from occurring. Importantly, the overlooked safety issues identified in this paper are inequitably concentrated in non-white, Hispanic, and lower income neighborhoods.

Primary limitations of the work are focused on the origin and destination location of the school trips employed in the model. Because of privacy issues, we could not account for the actual trip of each student, and instead assumed that children would be most likely to attend their closest school. This is an assumption that we know to be imperfect because of Colorado's open enrollment policy. We would also like to examine pedestrian and bicycle trips of all ages and for all trip purposes in future work.

In terms of macro-scale perspectives of the work, future analysis could account for varying land uses. While we were only concerned with trips to and from school, and it was therefore appropriate to only account for this one specific institutional land use (Ewing, Schroeer, and Greene 2004), more holistic future examinations would be wise to account for the presence of other land uses and destinations.

Results from such a proactive analysis could be compared to a traditional reactive safety analysis. Outcomes from the two analyses would be expected to vary. Hopefully, we would be able to identify areas with high rates of trip suppression but low objective crashes or injuries. These would be areas with safety issues that dissuade non-motorized users enough to preclude objective outcomes, and therefore have thus far been neglected. It is recommended that planners and engineers utilize such analysis approaches and also deploy recommendations from this work, namely employing grid networks, siting schools – and other locations that children may be expected to frequent – on slower roads, and ensuring that there are pedestrian and bicycle facilities present where there are vital connections across barriers. It is also vital to account for low income, Hispanic, and non-white populations equitably, as they bear a disproportionate amount of these neglected traffic safety issues.

Walking and bicycling are important principles of New Urbanism and play an important role in providing happy and healthy places. However, many traffic safety issues – which act as barriers to walkability and bikability – remain neglected. The tool developed and utilized in this paper allows for the identification of roadways with high levels of suppressed trips in terms of street design characteristics. Through the application of this tool in Denver, we identified the importance of grid networks, barrier connections, and destination siting, and identified the inequitable nature of these issues. By identifying areas with high suppressed trips, we have facilitated the proactive identification of safety issues on our roadways and better enabled sustainable and people-oriented places.

REFERENCES

Bellemans, T., K. van Bladel, D. Janssens, G. Wets, and H. Timmermans. (2009). Measuring and Estimating Suppressed Travel with Enhanced Activity-Travel Diaries. *Transportation Research Record*, 2105, 57-63.

Beltz, M., and H. Huang. (1998). *Bicycle/Pedestrian Trip Generation Workshop: Summary*. Federal Highway Administration. FHWA-RD-97-141.

Braver, E. R. (2003). Race, Hispanic Origin, and Socioeconomic Status in Relation to Motor Vehicle Occupant Death Rates and Risk Factors among Adults. *Accident Analysis & Prevention*, 35(3), 295-309.

Cho, G., D. A. Rodriguez, and A. J. Khattak. (2009). The Role of the Built Environment in Explaining Relationships Between Perceived and Actual Pedestrian and Bicyclist Safety. *Accident Analysis and Prevention*, 41, 692-702.

Cornell Local Roads Program. (2014). *Basics of a Good Road*. New York Local Technical Assistance Program Center, CLRP No. 14-04.

Dellinger, A.M., and Centers for Disease Control and Prevention. (2002). Barriers to children walking and biking to school--United States, 1999. *Morbidity and Mortality Weekly Report*, 51(32), 701-704.

Federal Highway Administration. (2006). *Pedestrian and Bicyclist Safety*. FHWA-HRT-05-090.

Ferenchak, N. N., and W. E. Marshall. (2018). Quantifying Suppressed Child Pedestrian and Bicycle Trips. *Accident Analysis & Prevention*, (Working Paper).

Foster, S., M. Knuiman, K. Villanueva, L. Wood, H. Christian, and B. Giles-Corti. (2014). Does Walkable Neighbourhood Design Influence the Association Between Objective Crime and Walking? *International Journal of Behavioral Nutrition and Physical Activity*, 11(1), 100.

Harper, J. S., W. M. Marine, C. J. Garrett, D. Lezotte, and S. R. Lowenstein. (2000). Motor Vehicle Crash Fatalities: A Comparison of Hispanic and Non-Hispanic Motorists in Colorado. *Annals of Emergency Medicine*, 36(6), 589-596.

Krizek, K. J., A. El-Geneidy, and K. Thompson. (2007). A Detailed Analysis of How and Urban Trail System Affects Cyclists' Travel. *Transportation*, 34, 611-624.

Larsen, K., R. N. Buliung, and G. E. J. Faulkner. (2013). Safety and School Travel: How Does the Environment Along the Route Relate to Safety and Mode Choice? *Transportation Research Record*, 2327, 9-18.

Manson, S., J. Schroeder, D. Van Riper, and S. Ruggles. *IPUMS National Historical Geographic Information System: Version 12.0* [Database]. Minneapolis: University of Minnesota. 2017. http://doi.org/10.18128/D050.V12.0

Marshall, W. E., and N. N. Ferenchak. (2017). Assessing Equity and Urban/Rural Road Safety Disparities in the US. Journal of Urbanism, 10(4), 422-441.

McAndrews, C., K. Beyer, C. E. Guse, and P. Layde. (2013). Revisiting Exposure: Fatal and Non-Fatal Traffic Injury Risk Across Different Populations of Travelers in Wisconsin, 2001-2009. *Accident Analysis & Prevention*, 60, 103-112.

Moudon, A. V., P. M. Hess, J. M. Matlick, and N. Pergakes. (2002). Pedestrian Location Identification Tools: Identifying Suburban Areas with Potentially High Latent Demand for Pedstrian Travel. *Transportation Research Record*, 1818, 94-101.

Nevelsteen, K., T. Steenberghen, A. Van Rompaey, and L. Uyttersprot. (2012). Controlling Factors of the Parental Safety Perception on Children's Travel Mode Choice. *Accident Analysis and Prevention*, 45, 39-49.

Schlossberg M., J. Greene, P. P. Phillips, B. Johnson, and B. Parker. (2006). School Trips: Effects of Urban Form and Distance on Travel Mode. *Journal of the American Planning Association*, 72(3), 337-346.

Schneider, R. J., R. M. Ryznar, and A. J. Khattak. (2003). An Accident Waiting to Happen: A Spatial Approach to Proactive Pedestrian Planning. *Accident Analysis and Prevention*, 36, 193-211.

Transportation Research Board. (2001). *Statistical Methods in Highway Safety Analysis*. NCHRP Synthesis 295, Washington, DC.

Waldheim, N., E. Wemple, and J. Fish. (2015). *Applying Safety Data and Analysis to Performance-Based Transportation Planning*. FHWA-SA-15-089.

Zegeer, C., D. Nabors, D. Gelinne, N. Lefler, and M. Bushell. (2010). *Pedestrian Safety Strategic Plan: Recommendations for Research and Product Development*. FHWA-10-035.