Implementing Vision Zero: Cities for Kids

Abstract

With cities across North America taking the Vision Zero pledge, fresh attention and energy is being focused on improving road safety. While the goal of reducing the number of traffic fatalities and severe injuries to zero is an admirable aim, the way in which cities are attempting to reach that goal is inadequate. To fulfill Vision Zero, we need to accommodate cities' most vulnerable users; we need to design cities for kids.

The tool introduced in this paper provides a method for doing just that. By proactively identifying traffic safety issues, our method allows for the identification of perceived pedestrian and bicycle safety issues before they occur. We first identify roadway characteristics that most suppress children's walking and biking trips. We then use GIS network analyses to determine which barriers are causing the most suppression, and therefore deserve the most attention. This approach allows us to not only reduce fatalities and injuries where children are currently walking and biking, but to also enable safe and comfortable mobility where children are most likely to want to walk or bike, thereby helping ensure safety for all.

INTRODUCTION

So your city has finally come to realize that safety on our streets is not as much about reducing the number of fender benders as it is about eliminating fatalities and severe injuries. Now, city officials are even working on a Vision Zero plan that will propose some protected bike lanes, increasing police enforcement of all modes, and an education program about distracted driving and walking. If and when those things come to fruition, your city may become a little bit safer. Will you be any closer to eliminating fatalities and severe injuries? Probably not significantly.

In a perfect world, your city would set about making each and every street and intersection safer. Moreover, to make a significant dent in the problem, they'd also need to entirely change their mindset about what transportation is for. This, regretfully, is far too high of a hurdle – both economically and politically – for almost every US city at this point.

While we acknowledge the need for a comprehensive overhaul of the way that cities conduct the business of transportation, this paper gives them a more definitive place to start. We do so by changing the client. Instead of conventional design that attempts to account for a wide variety of road users, we focus on one type of road user: kids.

Children under 18 represent almost 23% of the US population, but rarely do we engineer our streets for them other than to put up a sign that attempts to limit speeds around schools at certain times of the day and certain times of the year. Even then, cities such as Denver only lower school zone speed limits to 35 mph when the adjacent street is considered important (see Figure 1). This is the antithesis of the Vision Zero philosophy.

Figure 1 – 35 mph School Zone in Denver, CO

If we want to make our cities safer – and healthier and more vibrant – let's stop focusing on traffic demand 30 years down the road and start trying to make our cities safe for kids to walk, bike, scooter, hop, roller skate, and however else they might want to get around right now. To realize this goal, the traditional approach has been to begin with trying to figure out where kids walk and bike and then trying to make those places safer. This paper proposes a subtle, but critical, change to that line of thinking. We intend to first figure out where kids *should* be out walking and biking. Then, we look to see how many of those kid active transportation trips are being *suppressed* by the existing transportation system.

Past research suggests that young children tend to have poor gap and speed assessment and often overestimate their abilities (*Connelly et al. 1998; Plumert, Kearney & Cremer 2004*). Children also have limited peripheral vision and trouble locating sounds (*David et al. 1986*). These traits are not that different from our older populations, which are expected to increase from 15% of the population to more than 23% over the next few decades. If we design our streets for kids – and include ADA accessibility – then we are designing them for just about everyone. The paper presents a new, data-driven, spatial approach to prioritizing Vision Zero transportation investments towards the creation of a kid-friendly city.

Background

The state of transportation planning has long been described as 'predict and provide' (*Owens 1995; Goulden, Ryley, Dingwall 2014*). Foremost in transportation planners and engineers' minds is providing enough capacity to reach a satisfactory level of service (LOS) after traffic growth has been extrapolated to some future date. Accommodating future traffic that will not exist for another 30 years often comes at the cost of not accommodating bicyclists and pedestrians with safe and comfortable facilities today. Even when we try to account for bicyclist and pedestrian safety, we end up with narrow sidewalks next to fast, high-traffic roads or shared-use markings on those same roads. The prioritization of safety interventions commonly resembles a triage, with only the most critical intersections receiving attention after crashes have precipitated.

A new approach to traffic safety has recently gained momentum in the US. Since 2014, approximately thirty-five cities, two states, and the District of Columbia have made commitments to pursue the goals of Vision Zero. According to the Vision Zero Network, the goals of Vision Zero are to "eliminate all traffic fatalities and severe injuries, while increasing safe, healthy, equitable mobility for all" (*Vision Zero Network 2018*). Instead of treating them as accidents, Vision Zero posits that traffic crashes are preventable and accounts for human failing by endeavoring to reduce speeding, distraction, and aggressive driving behavior. New York City – which was the first major US city to commit to Vision Zero – has pursued interventions that include bus and taxi driver training, leading pedestrian intervals, speeding enforcement, protected bike lanes, truck sideguards, speed humps, and left-turn calming treatments, among others (*New York City Mayor's Office of Operations 2018*). While preliminary results are somewhat promising, New York City still has a long way to go (Figure 2). Fatalities have dropped since implementation, but it is too early to distinguish whether this was part of a wider trend or a result of Vision Zero (*New York City Mayor's Office of Operations 2018*).

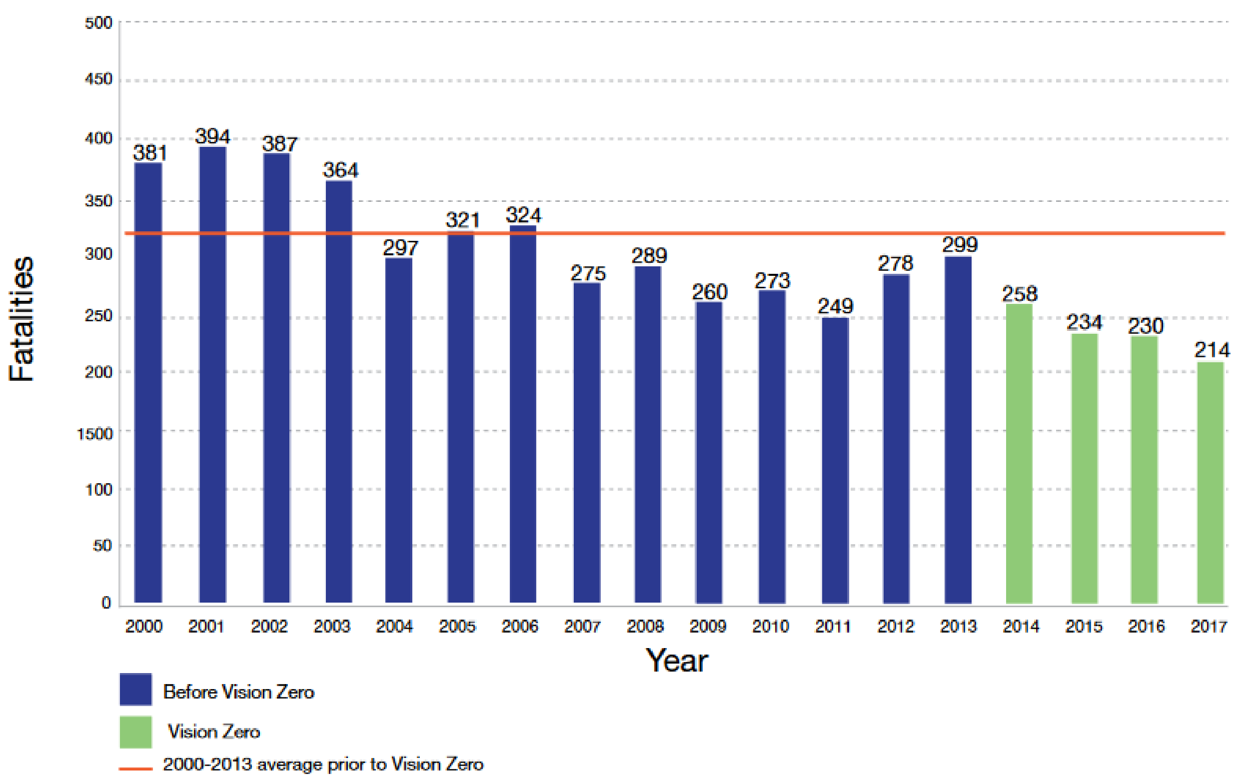

Figure 2 – New York City Traffic Fatalities, 2000-2017 (data source: NYC DOT & NYPD)

Another burgeoning traffic safety movement that is currently developing asserts that to design cities that are safe for everyone, we must design them so that they are safe for kids. This movement evolved from the Safe Routes to School (SRTS) program that began in the 1990's and taught us several important lessons. First, we recognized that kids need special accommodations in the transportation system. Second, we confirmed that when we focus resources on known traffic safety issues, we can get more kids walking and biking while improving safety outcomes (*Dumbaugh & Frank 2007; DiMaggio & Li 2013; Orenstein et al. 2007*). While some progress was made, efforts were narrowly focused around schools.

Recent efforts have built off this SRTS momentum by calling for entire cities that are designed to accommodate kids. The National Association of City Transportation Officials (NACTO) recently announced Streets for Kids, a program that will develop design guidance for public spaces that allow kids of all ages to learn, play, and move around a city (*NACTO 2018*). Arup, a large multinational engineering firm, recently released a report that details how to design cities for urban childhoods (*Arup 2017*). Their findings show that – not only do we need more playgrounds and parks – we need to provide child-friendly infrastructure for children's independent, safe, and comfortable mobility. The World Health Organization recently released a report that focuses on designing age-friendly cities (*WHO 2007*). While their primary focus is on the elderly, they assert that true age-friendly designs often serve both older populations and children. Finally, 8 80 Cities is a non-profit organization founded by Gil Penalosa and aimed at enhancing mobility for people of all ages, from 8-year-olds to 80-year-olds. They've worked with 250 communities on six continents to further child-friendly designs. These organizations all believe that if we can make our cities safe for kids – some of the most vulnerable users of our streets – we can surely make them safe for all.

Those serious about Vision Zero should take note of these recent movements and begin looking into how they can better design our cities for kids. Consider New York City's Vision Zero treatments we mentioned before: taxi driver training, leading pedestrian intervals, and truck sideguards. These are all good things but are probably most appreciated by the strong and fearless pedestrians and bicyclists that are on the road today. They are not nearly enough to ensure that New York City's streets are safe for their most vulnerable users. Now consider the second half of the Vision Zero credo: "…while increasing safe, healthy, equitable mobility for all" (*Vision Zero Network 2018*). Right now, because of the "Zero" in the name and the visceral relationship we have with injuries and fatalities, the first part of the ideology gets most of the attention. However, the final part is just as important and – by interpreting it as designing for kids – can define a framework for how to accomplish the first.

Vision Zero efforts in North America have largely used conventional, reactive approaches to improving road safety by focusing on where pedestrians or bicyclists are involved in crashes. Unfortunately, these data only tell us about the users that are currently out there walking or biking. To unfortunately become a crash statistic, the street needs to be perceived as safe enough to walk or bike in the first place. As is, we completely ignore users who deem the road too unsafe to use in the first place and the places where they might want to walk or bike. Instead of waiting for crashes to happen, we need a proactive approach focused on kids that embraces the second half of the Vision Zero credo: "…while increasing safe, healthy, equitable mobility for all" (*Vision Zero Network 2018*). This paper presents a more comprehensive approach to Vision Zero efforts via a method that proactively accounts for the latent demand of childhood active transportation trips and identifies locations where these trips are being suppressed by perceived safety issues.

Data & Methods

To develop our proactive method of analyzing kids' road safety, we need to understand where children's walking and biking trips are being suppressed (our indicator of safety). Trips become suppressed when two factors combine: 1) possible trips; and 2) roadway characteristics perceived as unsafe. We estimate these factors through: 1) a GIS shortest-path network analysis; and 2) a survey of parent perceptions. This paper provides a methodology for estimating these factors using Denver, Colorado, as a case study and provides suggestions for creating a model in your own city. We also provide instructions so that you can simply download our GIS Toolbox and – with minimal data input on your end – run an analysis of your own city.

To perform your own analysis, you will need a few pieces of data that are likely to be free and relatively easily accessible for your city (Table 1). The data you will need to compile yourself are noted in the 'Compile Yourself' column and the name you should give those files is in the 'Name' column.

Table 1 – Necessary data (*optional data in italics*)

		Format	**Compile Yourself**	**Name**
Suppression Rates		%		
Study Area		GIS Polygon	X	'StudyArea'
Origins	Kid Populations	GIS point		
Destinations	Schools	GIS point	X	'School'
	Parks, playgrounds, recreation centers, etc.	*GIS point*	*X*	*'Park', 'Playground', 'RecCenter'*
Transport Network	Roads	GIS line	X	'Roads'
	Speed Limits	In road layer	X	
	Number of Lanes	In road layer	X	
	Vehicle Volumes	GIS point	X	
	Sidewalks	GIS line	X	
	Bike Lanes	GIS line	X	
	Trails	GIS line	X	'Trails'

Survey Data

For your city, it will be easiest to use the suppression rates from our survey. These can be found in the Methods section below and will be automatically joined to your road layer from the GIS Toolbox. You may also want to use your own survey, as perceptions may differ, but that will involve administering a survey to hundreds of parents and a statistical analysis of the results. For more information on survey methods, see the Methods section below.

Network Data

To understand where child pedestrian and bicycle trips could possibly be occurring (the first step in figuring out how many are suppressed), the Toolbox will run a GIS closest-facility network analysis connecting children with their closest schools via the transport network. The Toolbox will first create random points representing child populations within the defined study area (defined by your GIS 'study area' polygon layer) using a block group GIS polygon layer, thereby approximating child home locations. The National Historical Geographic Information System (NHGIS) provided us with child populations from the 2016 American Community Survey (*Manson et al. 2017*). The analysis includes children between the ages of four and fourteen years to match our survey responses. To avoid edge issues, the Toolbox will include children living in the block groups just outside of your city and account for them in the analysis if their closest school is in your city.

An optional step you may wish to perform is to cluster origin points according to residential building footprints or residential land uses so that trip origins are in residential areas. To do so, you will need to provide those layers.

You should provide a GIS point layer of elementary and middle schools. You can also provide data (in GIS point format) for other child destinations such as parks, playgrounds, community centers, etc. for your analysis.

You will need road network GIS data that accounts for the roadway factors used in the survey. Vehicle volumes should be considered high for any roadway with more than 1,000 vehicles per day and the rest should be considered low volume (*Cornell Local Roads Program 2014*). Local roads that are not provided with traffic volumes should be considered to be low volume.

Combine your road and off-road trail segments into one layer and make sure that every segment has all attributes identified. Add connections to schools (Figure 3). If connections aren't added, all trips will end at a single point. Then, create a new field in your layer and code each segment 'AABBCD' (AA=speed limit [25, 35, 45, etc.]; BB=total number of lanes on road [01, 02, 03, 10, 11, etc.]; C=sidewalk or bike lane facilities [0, 1, or 2 sides of the street]; D=vehicle volumes [0=low; 1=high]). Code off-road trails as '000000'. This coding will be used to join your suppression rates later. Provide this layer and the Toolbox will split your layer at each intersection using the Feature to Line (Data Management) tool and convert the road layer to a network dataset.

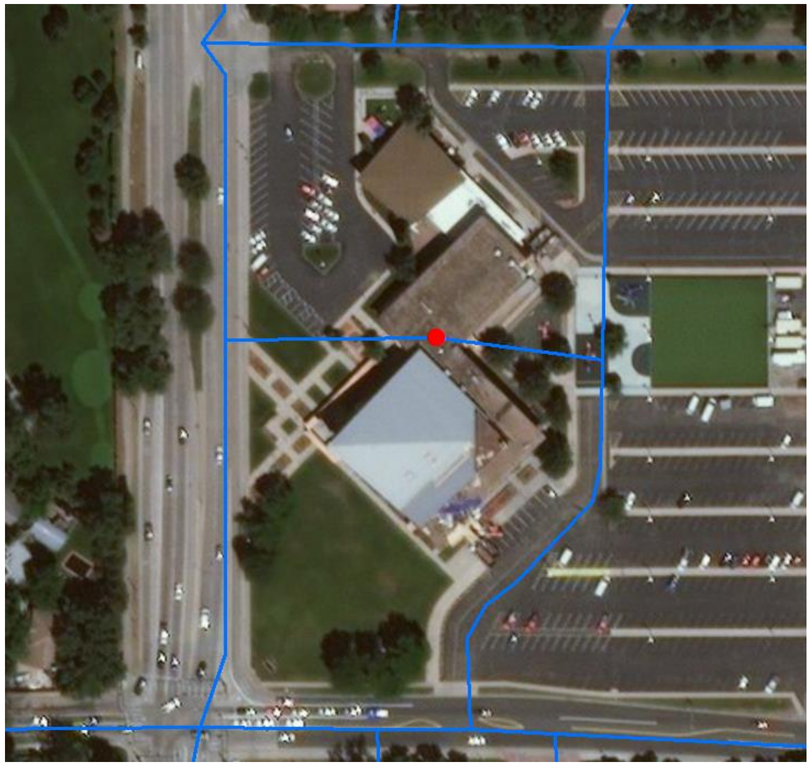

Figure 3 – Example of a school connection

Survey & Trip Suppression Methods

We first explain survey methods, although you can also simply use the model derived from our survey which is provided below. Parents of children in elementary and middle school answered whether they would allow their children to walk or bike on scenarios consisting of varying roadway characteristics. Our survey was offered exclusively online – in both English and Spanish – and was open in 2017 for the month of October. 924 complete responses from 1,298 survey respondents provided us with information on 1,331 children.

Information regarding child age and gender was provided by parents first. The survey then presented parents with scenarios consisting of varying roadway design characteristics with consistent land use and residential contexts (Figure 4). Each scenario included a corresponding picture from a road in Denver. Parents were able to answer "No", "Yes, with trusted adult supervision", or "Yes, without adult supervision" when asked whether they would allow their child to walk or bike to school on each roadway. Each survey included five randomly selected walking questions and five randomly selected bicycling questions from a pool of twenty walking questions and twenty bicycling questions. Roadway design characteristics on the survey included number of lanes (2, 3, or 4 lanes), posted speed limits (25 mph, 35 mph, or 45 mph), the presence of sidewalks and bike lanes (none or on one or both sides of the road), and vehicle volumes (low or high volumes). You can include other roadway characteristics if you are administering your own survey but might find it difficult to get enough responses for statistical significance. We converted parent responses into suppression rates for each of the forty roadway scenarios by dividing the total number of responses by the number of parents responding "No." You may also want to ask about actual travel behavior if you wish to derive your own distance decay functions (explained below).

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

25 mph Speed Limit
2 Lanes
Sidewalks
Low Vehicle Volume

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

25 mph Speed Limit
3 Lanes
Bike Lanes
High Vehicle Volume

Figure 4 – Example of survey questions

Since there will likely be more roadway scenarios in your city than can feasibly be included in a survey, you will need to interpolate and extrapolate suppression rates for these other scenarios. Because the dependent variable was in the form of a proportion (of parents not allowing their child to walk or bike), we developed a beta regression general linear model (GLM) with a logit link function using the betareg package in R. The beta regression GLM is appropriate when the dependent variable is in the form of a proportion bounded between zero and one. We formed the beta regression GLM by taking results from the twenty walking scenarios and twenty biking scenarios included in the survey and coding the four predictor variables as dummy variables. This standardized the regression results, allowing for comparison between the different variables. We removed the twenty-five mph and two-lane variables from the model to avoid multi-collinearity.

For walking, sidewalks were the most important factor (Table 2). Parents are then concerned about vehicle speeds and then vehicle volumes. For biking, vehicle volumes is the most important factor (approximately equivalent to going from two to four lanes of traffic). Facilities are the next most important factor (approximately equivalent to going from 25 mph to 45 mph).

Table 2 – Predictors of the proportion of parents who would not allow their child to walk or bicycle

		Walk $R^2 = 0.977$; n =20	Bike $R^2 = 0.9509$; n = 20
Intercept		-0.260*	-0.703***
Speed	35 mph	0.995***	0.644***
	45 mph	1.868***	0.901***
Lanes	3 lanes	0.495***	0.618***
	4 lanes	0.597***	1.166***
Facilities		-2.584***	-0.819***
Volume		0.770***	1.111***

*** *$p<0.001$*
** *$p<0.05$*
* *$p<0.01$*

Using these beta regression results, the Toolbox will derive the suppression rate for each segment in your road layer. Now every road segment in your city will have a corresponding rate of walking and biking trip suppression.

Network Methods

The Toolbox will then figure out how much each child's trip is suppressed because of traffic safety concerns. To do this, the Toolbox determines how much distance would be added to children's shortest-path trips if the children were to avoid roads perceived as unsafe. If a trip length does not increase very much, it is not very suppressed. If trip length increases greatly, you can deem it considerably suppressed.

The Toolbox will determine the shortest path distance from each child's estimated home to their closest school using a closest facility network analysis in GIS using your origins, destinations, and your network dataset. The Toolbox will then rerun the network analysis with each road segment weighted according to its suppression rate. In the weighted analysis, trip choices are a balance between distance and safety perceptions. In other words, does the child want a short, unsafe trip or a long, safe trip? Distance decay functions allow us to standardize these distance and safety variables. Distance decay functions are inverse power functions that use distance or time as a proxy for travel costs. Those used in our survey were specific to walking and biking to school and were developed based on data from travel surveys, joint-use facility user surveys, and a Non-Motorized Pilot Program (NMPP) survey from the Twin Cities region (*Iacono et al. 2008*). If you are administering your own survey, you could develop distance decay functions specific to your city. We have provided the distance decay function outputs in the GIS Toolbox, but we explain the methods below for the sake of transparency.

The distance decay function for walking to school had an output variable of percent of school and school-based trips made by walking and an independent variable of travel time in minutes (Equation 1). To standardize travel time into a distance so that you can perform a closest facility analysis, use an assumption of 25 minutes per mile for pedestrian speed (a rough conversion of the standard 3.5 feet per second used in the Manual on Uniform Traffic Control Devices). You can input the proportion of children allowed to walk to school (the inverse of the suppression rate) into this equation and derive an equivalent distance, which will then be used to weight your network analysis. For example, a road segment with a pedestrian disallowance rate of 25% has a weight of approximately 711 feet while a segment with a pedestrian disallowance rate of 95% has a weight of approximately 7,400 feet.

$$y = 0.523\mathrm{e}^{-0.10x} \qquad (1)$$

where:
y = percent of school or school-related trips made by walking
x = travel time (minutes)

The distance decay function for biking to school (Equation 2) has a dependent variable of percent of school and school-based trips made by biking and an independent variable of travel distance in kilometers. You should convert the function to feet to coincide with the foot-based network analysis. You should also transform both distance decay functions so that a value of 100% of trips correlates with a distance of zero. This avoids any negative distance outcomes, which would not be acceptable in the network analysis.

$$y = 0.4651\mathrm{e}^{-0.1236x} \qquad (2)$$

where:
y = percent school or school-related trips made by biking
x = distance (km)

When the Toolbox joins the spreadsheet in the GIS Toolbox to your road layer, it will also have an additional weight (in feet) for each road segment that will be an added-cost barrier that is assigned at the midpoint of each segment. Therefore, when the weighted network analysis is run, it will account for both distance and perceptions in units of feet. This weighted network analysis will run separately for walking and biking.

The Toolbox will then compare the weighted distance to the original shortest path distance. The distance decay functions allows us to convert the added distance back to a percentage of suppression. In other words, if a child's walking trip increased by 711 feet when they accounted for safety perceptions, that child's trip was considered 25% suppressed. If a child's trip increased by 7,400 feet, that child's trip was considered 95% suppressed.

Kernel density analysis in GIS then enables the Toolbox to simultaneously account for levels suppression and the number of possible users by estimating a magnitude-per-unit area for cells in a raster layer. In other words, one neighborhood might have high levels of trip suppression but only one possible user while another neighborhood might have slightly less trip suppression but many possible users. Child points are the base layer and trip suppression rates (as proportions) are the population variable. The Toolbox employs a planar method as the analysis took place on a relatively localized area.

TOOL OUTPUT

Outputs from your city should mirror the outputs from the case study in Denver detailed below. Results from the tool show us that there are road safety issues that have been neglected in Denver. On a large scale, we can see that there are issues found throughout Denver and specifically localized hotspots within neighborhoods (Figure 5). The hotspots show where two factors have combined: 1) large concentrations of kids; and 2) roads perceived as unsafe. These hotspots differ from where crashes are occurring and show that we need to supplement our reactive analyses with proactive approaches.

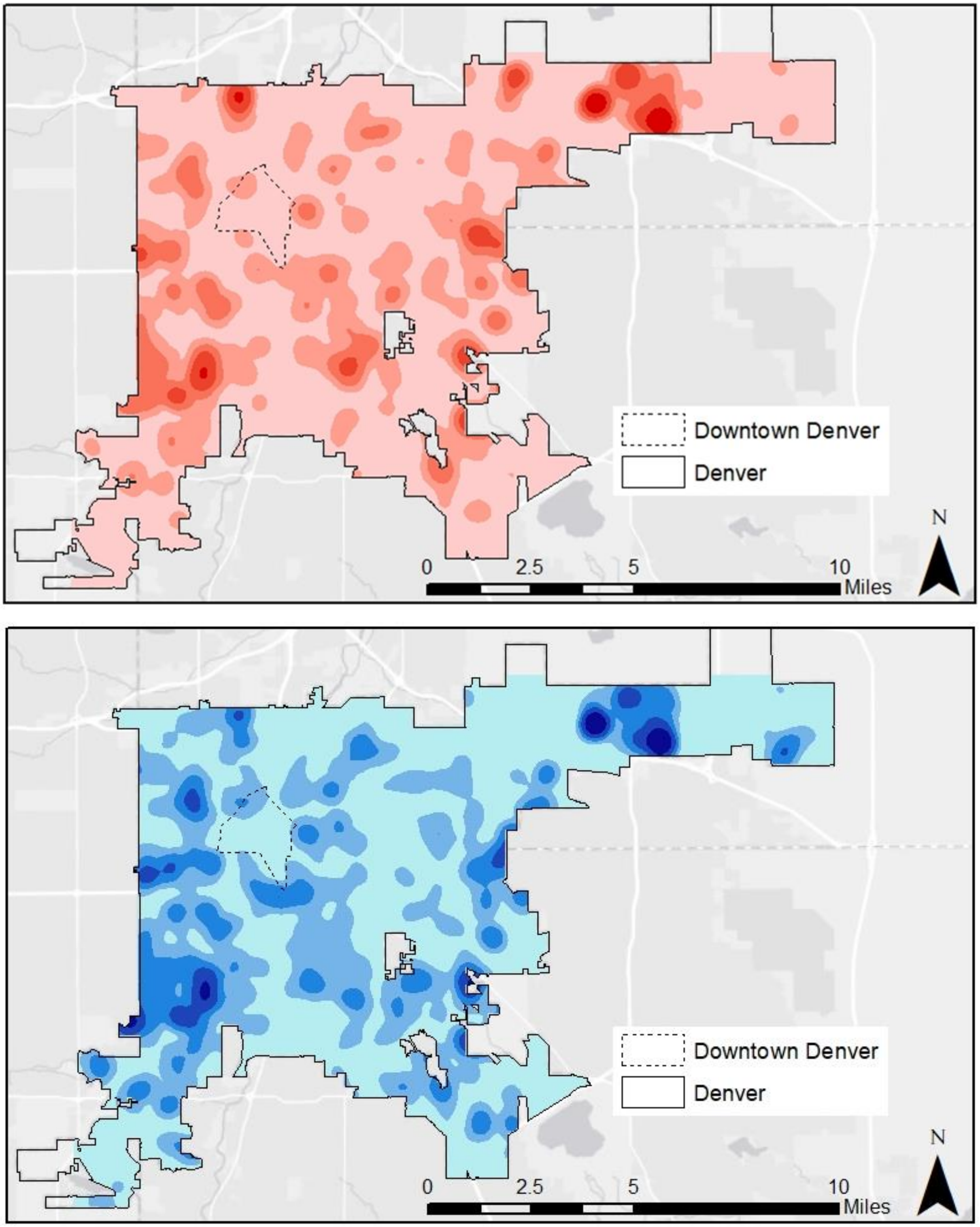

Figure 5 – Suppressed trips throughout Denver

The most important benefit of the tool becomes apparent when we take a finer-grained look at the output (Figure 6). Although we would ideally design every street for kids, that is a lofty goal. Using the tool, we can see which ones should be prioritized. There are specific issues (whether they are sidewalk gaps, high vehicle volumes, or a lack of bike lanes) that are holding large clusters of children back. Even though there may not be any crashes occurring, we can now see where there are hidden issues that should be addressed. This gives us a place to start and a way to prioritize.

The tool will also tell you how much each child's trip is suppressed. Some trips may not be suppressed at all, but some trips may be suppressed fully. This allows us to see specific issues that would have been hidden otherwise. These hotspots represent clusters of possible trips and safety issues; in other words, potentially some of the most pressing road safety issues. For example, at the bottom of Figure 6, we can see how one sidewalk gap is causing considerable trip suppression for a high number of children. This would not have been detected with a traditional reactive analysis.

Figure 6 – Example of survey questions

CONCLUSIONS

Eliminating all fatalities and serious injuries is a great goal. However, to meet that goal, we need to get serious and start designing for our most vulnerable users. In addition, we need to not forget about the second part of the vision: "…while increasing safe, healthy, equitable mobility for all." This tool enables planners, engineers, and city officials to identify and prioritize safety issues that may have been neglected by past crash-based studies. It also gives us a starting point for the substantial journey of redesigning cities so they work for kids.

Some cities that have already promoted children's mobility are finding success. Vienna recently completed a pilot project that banned cars on a primary school's access road during the beginning of the school day (*Köllinger 2018*). Vienna's pedestrian officer Petra Jens reported that the program made the area safer for children, with many kids starting to walk or bike and vehicle volumes decreasing not just on the access road, but throughout the surrounding area. The pilot recently transitioned into a permanent project, and twenty other schools are requesting similar treatments. The city of Pontevedra in Spain has similarly experimented with traffic restrictions (*Velazquez 2018*). They found that – in addition to making the streets safer for children, resulting in more children walking, biking, and playing – their new streets program also attracted families from throughout the region to move to the city. The "Children's Fountain" square – an intersection that once accommodated 25,000 vehicles per day – now accommodates children independently playing. These are great examples of cities that truly value safe mobility for all.

While we provide a tool to allow cities to be designed for kids, the methodology does employ some assumptions that can be improved through future work. Excluding levels of non-motorized exposure was a limitation. While non-motorized exposure is difficult to obtain, future work would benefit from user counts or volumes to better understand where trips are occurring and are being suppressed.

Additionally, there were other factors – such as crime and socioeconomics – that may be influencing trip suppression and would be worthy to examine in future analyses. Finally, we could account for the characteristics of crossings (e.g. signalization, phasing, turning movements, crosswalks, refuge islands, etc.) as well as other levels of the current variables (e.g. vehicle speed, vehicle volume, number of lanes, and non-motorized facilities) not tested in the current iteration in future work to gain a better understanding of safety perceptions.

Vision Zero has brought needed attention and resources to the road safety arena. Preliminary results are promising. However, to truly make streets that are safe for everyone, we need to design our cities for kids. Through the tool introduced in this paper, we can finally begin to do exactly that.

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