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GAUGING THE EFFECTIVENESS OF SAFE ROUTES TO SCHOOL PROJECTS

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Walking to school, which was once a commonplace rite of passage, now makes up only a small minority of school trips. Multiple studies have shown that concerns are strongly linked to the physical environment that exists between home and school. Over the past decade, hundreds of projects have been funded through the Utah Safe Routes to School and Safe Sidewalk programs, however, there is currently no mechanism in place to determine how effective these projects have been at promoting safety because once a project is funded and constructed no follow-up evaluation is conducted. This research evaluated past projects to determine which project types are the most effective at promoting safety by reviewing infrastructure projects funded under the programs and evaluating non-motorized crashes within a one-mile buffer of the project site before and after the infrastructure was put in place. The analysis found no statistical change in the number of non-motorized crashes before and after construction. The probability of minor injury non-motorized crashes increased after construction, likely due to increased volumes and exposure. Crashes occurring in wet or snowy weather were less severe, and a majority of severe injury crashes occurred during the day. Bicycle crashes resulted in less severe injuries than pedestrian crashes and were less common after construction. Future research should include volumes for both non-motorist and vehicle traffic.</td></tr>
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LIST OF ACRONYMS

CDC	Centers for Disease Control and Prevention
DPS	Department of Public Safety
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
GIS	Geographic Information System
NASDPTS	National Association of State Directors of Pupil Transportation Services
NHTSA	National Highway Traffic Safety Administration
NOAA	National Oceanic and Atmospheric Administration
PBIC	Pedestrian and Bicycle Information Center
SNAP	Safe Neighborhood Access Plan
SRTS	Safe Routes to School
TAC	Technical Advisory Committee
TRB	Transportation Research Board
UDOT	Utah Department of Transportation
USDOT	United States Department of Transportation

EXECUTIVE SUMMARY

Walking to school, which was once a commonplace rite of passage, now makes up only a small minority of school trips. Multiple studies have shown that concerns are strongly linked to the physical environment that exists between home and school, including the speed and volume of traffic students would encounter; the potential for encountering crime; and even the impact of weather.

The Utah Department of Transportation is responsible for administering the Safe Routes to School Funding Program. Local agencies are encouraged to develop proposals and submit applications for infrastructure projects that they believe will help more school children walk and bike safely to school. Over the past decade, hundreds of projects have been funded through these programs, however, there is currently no mechanism in place to determine how effective these projects have been at promoting safety because once a project is funded and constructed no follow-up evaluation is conducted. Therefore, little is known about the efficacy of these projects, or which projects have the highest return on investment for safety.

Fifty-two infrastructure projects funded through the UDOT Safe Routes to School program from 2007-2016 (project years 2007-2015) were identified. The infrastructure projects included improvements such as sidewalk extensions, crosswalks, roadway reconstruction, bike path, asphalt path, signage, pedestrian facilities, and other pedestrian improvements, and were located across the state.

Using GIS, a one-mile geographic buffer was placed around each of the sample project sites, and crashes were filtered to include only those that occurred within that buffer area. Within this buffer 2,288 total non-motorized crashes were evaluated. These crashes were then further coded based on whether they occurred before or after the construction of the infrastructure project. No data was available to identify crashes that occurred during construction.

Using a combination of Multinomial Logistic (MNL) regression, least squares regression, and independent and paired sample t-test statistical models, crash data was correlated to crash severity before and after project construction. Additionally, fixed effects models drilled down to identify specific changes at each individual site. Lastly a breakdown by mode (pedestrian versus cyclist crashes) was conducted to identify potential changes after construction.

A chi-square analysis found that within the sample, there was significant variation in crash severity. A subsequent MNL regression analysis determined that the probability of non-motorized crashes resulting in an injury (minor or serious) increased after construction. It is notable, however, that the probability of fatal crashes did not significantly change. A deeper look at the environmental conditions at the time of the crash using an MNL regression methodology determined that non-motorized crashes occurring in the snow or those occurring on wet roads were less likely to result in an injury and were less severe overall. Additionally, serious non-motorized crashes in this sample were significantly more likely to occur in daylight conditions. Lastly, the analysis examined crash severity from before and after the construction of the SRTS project infrastructure. An MNL regression mode determined that non-motorist crashes occurring in the sample area after construction resulted in significantly more severe injuries than crashes before construction.

In comparing bicycle and pedestrian crashes occurring within the study area, the analysis found that bike crashes were significantly less severe than pedestrian crashes. A second model identified that collectively, after project construction there was a significant increase in pedestrian crashes and a concomitant decrease in bicycle crashes. However, bicycle crashes occurring after construction were significantly more severe than those occurring before construction.

Based on the findings of this analysis the Technical Advisory Committee recommends creating a comprehensive online database of Safe Routes to School resources. This would include local Health Department and School District contacts, a GIS database of all SRTS plans, guidance on preparing and submitting new SRTS plans, links to the SRTS funding application and other funding sources, links to other resources, such as the Bike Utah Youth BEST program. Additionally, the TAC recommends initiating a program of micro-grants to assist smaller communities in preparing their application for the SRTS funding program. This could include a one-time grant of $3,000-$5,000. Lastly, the TAC recommends investigating a process where local law enforcement and crossing guards could be involved in collecting student travel data for each school.

1.0 INTRODUCTION

1.1 Problem Statement

Walking to school, which was once a commonplace rite of passage, now makes up only a small minority of school trips. By 2004 less than 13% of school trips were made using active modes of transportation, compared to over 50% in 1969 (Mohai, Kweon, Lee and Ard, 2011). According to Kerr, et al., the main reason students no longer walk and bike to school is parental concerns about safety (Kerr, et al., 2006). Multiple studies have shown that concerns are strongly linked to the physical environment that exists between home and school, including the speed and volume of traffic students would encounter; the potential for encountering crime; and even the impact of weather.

The Utah Department of Transportation is responsible for administering the Safe Routes to School Funding Program. Local agencies are encouraged to develop proposals and submit applications for infrastructure projects that they believe will help more school children walk and bike safely to school. Eligible infrastructure projects include bike parking facilities, sign installments, on-street bike facilities, off-street bike/pedestrian facilities, crossing improvements, street striping, signals, signage, traffic calming devices, and sidewalk. The proposed improvements should fill in gaps currently identified as necessary updates on the school's Student Neighborhood Access Plan (SNAP) map, and project budgets typically range between $50,000 and $200,000. A second program that provides funding for much-needed pedestrian infrastructure projects is the Safe Sidewalk Program. The Safe Sidewalks Program provides a legislative funding source for construction of new sidewalks adjacent to state routes where sidewalks do not currently exist and where major construction or reconstruction of the route, at that location, is not planned for ten or more years.

Over the past decade, hundreds of projects have been funded through these programs, however, there is currently no mechanism in place to determine how effective these projects have been at promoting safety, because once a project is funded and constructed no follow-up evaluation is conducted. For a location to be eligible, it must be: 1) located adjacent to a state highway, 2) be in an urban area or an area where the immediate environment of the project is urban in nature, 3) must have significant pedestrian traffic, and 4) have a guaranteed 25% local government match.

In 2019, the application process for scoring projects and allocating funding was updated to better identify projects that would provide a higher return on investment relative to safety and health for the traveling public. To date, no comprehensive evaluation has examined the effectiveness of the projects that have been funded over the past 13 years of the program.

1.2 Objectives

This project will evaluate past projects to determine which project types are the most effective at promoting safety, by:

- Reviewing infrastructure projects funded under the Safe Routes to School program from 2005-2018, and
- Conducting a quantitative evaluation of non-motorized crashes within a one-mile buffer of the project site, before and after the infrastructure was put in place.

This process will determine how effective past projects have been at promoting student safety and safe school transportation. The analysis will allow UDOT to identify which project types provide the highest safety return on investment and could inform future decision making regarding which types of projects to fund.

1.3 Scope

To understand which projects most effectively address safety concerns for students walking and biking to school, several avenues were pursued. First, a comprehensive literature review was performed to summarize existing studies conducted by professional researchers, academics, and practitioners. This included a review of journal articles, governmental reports, and other professional publications examining student travel to and from school (further described in Chapter 2). Second, a review of projects funded through the Safe Routes to School and Safe Sidewalk programs was conducted to identify infrastructure projects for the sample. Third, the research team evaluated historic crash data within a one-mile buffer of all project sites both before and after the infrastructure was put in place. Lastly, the research team sought to examine additional external sources including interviews with school staff and administrators and local law enforcement to identify the impact that each infrastructure project had on real and perceived safety among the local community.

1.4 Outline of Report

This research report is organized according to the following sections. Chapter 2 provides a brief literature review examining school travel considerations and the state SRTS program. Chapter 2 includes a description of the study methods and justifications. Chapter 3 presents the study data collected and provides summary characteristics for the sample. Chapter 4 presents a quantitative analysis of safety characteristics and non-motorized crashes within one-mile of each sample site. Chapter 5 provides conclusions based upon the data analysis, and Chapter 6 outlines recommendations from the author and Technical Advisory Committee for implementation.

2.0 RESEARCH METHODS

2.1 Overview

This chapter provides an overview of the existing research literature regarding the efficacy of the Safe Routes to School program. First, we provide a description of the Safe Routes to School Program and funding mechanisms. Second, this chapter provides a summary of evidence on the effectiveness of safe routes to school-funded projects across the country.

2.2 Safe Routes to School Programs

According to the 2017 National Household Travel Survey (FHWA, 2019), only 10.4% of students ages 5-12 currently walk or bike to school, compared to 13.7% in 2001. This is down from 48% in 1975 (Tudor-Locke, Ainsworth, and Popkin; 2001). This same dataset also showed that 80.9% of children who live “very close” to school (1/4 mile or less) walk on a usual school day (FHWA, 2019). As a result of this decline in active transportation and to improve safety for children wanting to walk or bike to school, several Safe Routes to School (SRTS) programs have been developed.

2.2.1 Federal SRTS Program

The original concept of Safe Routes to School has been credited to the city of Odense, Denmark around 1970. The initial programs quickly spread throughout Europe due to concerns about children’s safety when traveling to school (European Union Target, 2005). The first SRTS program in the United States was initiated in the Bronx (New York) in 1997. The National Highway Traffic Safety Administration (NHTSA) funded several pilot projects in the year 2000 as other SRTS programs were beginning to be established throughout the country. The United States Congress approved the first federally funded SRTS Program in 2005, which was augmented and enhanced by legislation in following years (National SRTS, 2018).

The goal of SRTS Programs is to make it safer for students to walk and bike to school and encourage more walking and biking. Many different organizations, including transportation, public health and planning professionals, school communities, law enforcement officers, community groups and families can all effectively promote SRTS through education, encouragement, engineering changes and enforcement, being flexible and reactive to each community's needs.

As the shared goals of safety and health have been recognized, SRTS programs have begun to work with traffic and safety initiatives such as Vision Zero. The National Safe Routes to School Center recently launched the Vision Zero for Youth initiative, which "builds on how cities and communities across the USA are taking a bold lead in setting ambitious goals to eliminate traffic fatalities and serious injuries" (National SRTS, 2018). Many traffic safety policies and goals focus on improving safe walking and bicycling in school zones and other places where youth are present.

2.2.2 Utah SRTS Program

Since its inception, The Utah Department of Transportation's (UDOT) SRTS program has provided Utah schools with walking and biking safety resources through the Student Neighborhood Access Program (SNAP), and Utah's Safe Routes to School Program. Recently the program was overhauled to be more comprehensive and inclusive. It is now known simply as Safe Routes Utah. The main goal of the Program is to assist and encourage students living within 1.5-2 miles to safely walk or bike to school (UDOT, 2018). The program includes both encouragement and educational programs, as well as a funding program which provides funds for construction and implementation projects. In recent years UDOT has seen great value in incorporating SRTS with other existing programs. Recently the SRTS program has begun working cooperatively with the Zero Fatalities Program and Move Utah.

Through the Utah SRTS funding program, municipalities or other agencies may apply for funding of non-infrastructure (education and encouragement programs), and infrastructure (physical improvements - primarily new sidewalks, etc.) projects, based on an allotment of both state and federal funds. Funding applications are screened by a review panel to determine which projects will provide the best return on investment for improving school safety. Projects are selected and funded on a three-year rolling funding cycle through a project reimbursement program, which means that the city pays initial construction costs and is reimbursed by UDOT when the project is completed to standard.

2.3 Efficacy of Safe Routes to School Projects

While SRTS projects aim to improve safety and accessibility for students to walk and bike to school, how effective are these projects? The premise of the SRTS program is the net benefit to communities relative to safety, health, and quality of life. For example, an examination of New York's SRTS program found that the program was associated with a net social benefit of $230 million and 2055 quality-adjusted life years gained in New York City" (Muennig, Epstein, Li and DiMaggio; 2014).

Research has also shown that students typically walk and bike more after an SRTS project has been completed in the area. A study by Boarnet, et al. (2005), examined ten sites in California where SRTS funding had been used for construction projects. The research team surveyed 1,244 parents 1-18 months after the completion of project construction and asked them to identify whether their children walked and biked more or less frequently after the project's completion. Their analysis determined that approximately 10.6% of students walked or biked more after construction, and that the proportion of children who walked or biked more after construction was "significantly greater among children for whom the project location was along their usual route". Additionally, 15.4% of children who passed the project site on the way to school walked more following construction, compared to 4.3% of children who did not pass the project site. A separate study of projects completed in Eugene, Oregon determined that SRTS infrastructure improvements were associated with increases in walking and biking of 5-20% (McDonald, Yang, Abbott, and Bullock: 2013).

While an entire program can be seen for a net benefit, it can be more difficult to determine the efficacy and outcomes of construction projects relative to improved safety. Since the main goal of the SRTS program is improved safety, it is important to quantify the actual impacts these projects have on student safety, and not just identify changes in student walking and biking behavior (although this can often serve as a surrogate for improved perceptions of safety). Dangerous environments such as road barriers and busy highways or arterial roads often prevent parents from allowing their children to walk or bike to school (Timperio, et al.: 2006). Therefore, can projects that remove such barriers improve safety and encourage safe walking and biking? Boarnet, et al. (2005) found that replacing four-way stop signs with traffic signals increased the number of children walking. However, there is a lack of evidence regarding the effectiveness and safety improvements of SRTS infrastructure projects. Dumbaugh and Frank (2006) claim that "substantive discussions of traffic safety are largely absent from the Safe Routes to School literature". Their review of SRTS literature determined that the safety benefits of SRTS projects are largely presumed, and only raised medians and sidewalks were found to reduce pedestrian-vehicle crashes. This research seeks to fill a gap in the empirical knowledge by evaluating non-motorized safety before and after the construction of SRTS-funded infrastructure projects.

2.4 Study Methods

This research employed several statistical analysis methods, including summary statistics and regression models, to describe trends in the data as well as make predictions regarding correlation and causality between variables. Each method is described in detail below and was selected based on its appropriateness for use with study-specific data and the research questions and hypotheses.

2.4.1 Summary Statistics

Summary statistics are used to provide a quick and simple description of the data without any predictive component or significance testing. They may include mean (average), median (center point of data), mode (most frequently occurring value), minimum value, maximum value, value range, standard deviation, and frequency percentages. Summary statistics were used in this analysis to provide context for the crash data and demographics.

2.4.2 Pearson's Chi-Square Test

A Chi-Square test is used on categorical data to compare an observed distribution to a theoretical one (measuring goodness of fit) for one or more categories. The events included must be mutually exclusive (e.g. weather cannot be clear and raining at the same time) and have a total probability of 1 (Greene, 2015).

Model:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

where

χ^2 is the chi-square value

Σ is the summation sign

O is the observed frequency

E is the expected frequency

2.4.3 Maximum Likelihood Regression

Maximum Likelihood Regression is used to predict a nominal dependent variable given one or more independent variables. It is sometimes considered an extension of binomial logistic regression to allow for a dependent variable with more than two categories. As with other types of regression, multinomial logistic regression can have nominal and/or continuous independent variables and can have interactions between independent variables to predict the dependent variable (Greene, 2015). Dependent variables with M categories require the calculation of M-1 equations, one for each category relative to the reference category, to describe the relationship between the dependent and independent variables.

Model:

If the first category is the reference, then for M=2,…,M,

$$\ln \frac{P(Yi = m)}{P(Yi = 1)} = \alpha_m + \sum_{k=1}^{K} \beta_{mk} X_{ik} = Z_{mi}$$

Hence, for each case, there will be M-1 predicted log odds, one for each category relative to the reference category. When there are more than 2 groups, for m=2,…,M,

$$P(Y_i = m) = \frac{exp(Z_{mi})}{1 + \sum_{h=2}^{M} exp(Z_{hi})}$$

For the reference category,

$$P(Y_i = 1) = \frac{1}{1 + \sum_{h=2}^{M} exp(Z_{hi})}$$

Assumptions:

- The dependent variable is measured at the nominal level
- There are one or more independent variables that are continuous, ordinal, or nominal (including dichotomous variables)
- Observations are independent and have mutually exclusive and exhaustive categories
- There is no multicollinearity
- There is a linear relationship between any continuous independent variable and the logit transformation of the dependent variable
- There are no outliers, high leverage values, or highly influential points

When interpreting a maximum likelihood regression model, one of the response categories is used as a baseline or reference cell, log-odds are then calculated for all other categories relative to this baseline, and then the log-odds become a linear function of the predictors.

2.4.4 Poisson Loglinear Regression

Poisson regression is similar to maximum likelihood regression analysis except that the dependent (Y) variable is a count that is assumed to follow the Poisson distribution. For this research it is used to examine the number of crashes correlating to other crash characteristics. Both numeric and categorical independent variables may be specified in a similar manner to that of the Multiple Regression procedure described above. The Poisson Regression procedure provides an analysis of deviance table, log likelihood analysis, as well as the necessary coefficient estimates and Wald tests. The Poisson distribution models the probability of y events (i.e. failure, death, or existence) with the formula:

$$Pr(Y = y|\mu) = \frac{e^{-\mu}\mu^{y}}{y!}(y = 0,1,2, \dots)$$

The Poisson distribution is specified with a single parameter μ. This is the mean incidence rate of a rare event per unit of exposure. Exposure may be time, space, distance, area, volume, or population size. For this research, it includes exposure to a specific treatment (e.g. audible signal, pedestrian barriers, etc.). Because exposure is often a period of time, we use the symbol *t* to represent the exposure. When no exposure value is given, it is assumed to be one.

The parameter μ may be interpreted as the risk of a new occurrence of the event during a specified exposure period, *t*. The probability of *y* events is then given by

$$Pr(Y = y|\mu, t) = \frac{e^{-\mu t}(\mu t)^y}{y!} (y = 0,1,2, \dots)$$

The Poisson distribution has the property that its mean and variance are equal.

In Poisson regression, we suppose that the Poisson incidence rate μ is determined by a set of *k* regressor variables (the *X's*). The expression relating these quantities is

$$\mu = t\exp(\beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k)$$

Note that often, $X_1 \equiv 1$ and β_1 is called the *intercept*. The regression coefficients $\beta_1, \beta_2, \Lambda, \beta_k$ are unknown parameters that are estimated from a set of data. Their estimates are labeled $b_1, b_2 \ldots b_k$. Using this notation, the fundamental Poisson regression model for an observation *i* is written as

$$Pr(Y_i = y_i|\mu_i, t_i) = \frac{e^{-u_i t_i}(u_i t_i)^{y_i}}{y_i!}$$

Where

$$\mu_i = t_i \mu(x_i' \beta)$$

$$= t_i exp(\beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_k X_{ki})$$

That is, for a given set of values of the regressor variables, the outcome follows the Poisson distribution (NCSS, 2018).

2.5 Summary

The number of children walking and biking to school has dramatically declined over the past 40 years. To promote safe walking and biking, federal and state Safe Routes to School programs have been established. These programs provide funding and support to local agencies and organizations for construction and encouragement projects. While existing research has shown a net benefit for Safe Routes to School-funded projects in terms of return on investment economically and regarding the number of children walking and biking to school, it can be more that little research has examined the efficacy and outcomes of construction projects relative to improved safety.

This research employs several statistical analysis methods to describe trends in the data as well as make predictions regarding correlation and causality between variables. Each method was selected based on its appropriateness for study-specific data and the research questions and hypotheses. Methods used in this research include descriptive statistics, chi-square analysis, Maximum-likelihood linear regression, and Poisson loglinear regression models.

3.0 DATA COLLECTION

3.1 Overview

This chapter discusses the data collected for the research and presents an overview of descriptive characteristics for the study area and a discussion of data quality. The overview includes a description of the geographic scale of the data collection, a summary of the demographics data used, and a description of the crash data and covariates from that dataset included in the subsequent analysis.

3.2 Study Site Identification

UDOT’s Traffic and Safety Division provided project data on all Safe Routes to School projects funded between 2005 and 2017. This included the complete project applications provided by municipalities, schools, districts and other applicant agencies. After sorting the project data and determining which projects were partially or completely funded, we identified 52 infrastructure projects funded through the UDOT Safe Routes to School program from 2007-2016 (project years 2007-2015). Projects were funded statewide (See Figure 1). The infrastructure projects included improvements such as sidewalk extensions, crosswalks, roadway reconstruction, bike path, asphalt path, signage, pedestrian facilities, and other pedestrian improvements. Project site details are shown in Table 1 below.

Table 1. Sample of Infrastructure Project Sites

Applicant	School District	Project Type	Infrastructure Amount	Year Completed
Lindon Elementary	Alpine	Portion of a City Trail	$150,000	2008
Shelley Elementary	Alpine	Sidewalks	$150,000	2009
Discovery Elementary	Box Elder	Sidewalk	$65,306	2009
Cottonwood Elementary	Granite	Sidewalk	$150,000	2009
Crestview Elementary	Granite	Sidewalk	$150,000	2009
Bonneville Elementary*	Ogden	Sidewalk	$150,000	2011
Ecker Hill Middle School	Park City	Trail Segment	$43,000	2011
Plain City Elementary	Weber	Sidewalk	$150,000	2009
Pioneer Elementary	Weber	Sidewalk	$150,000	2009
Washington Terrace Elem.*	Weber	Sidewalk	$150,000	2009
Hunter Elementary	Granite	Sidewalk	$150,000	2010
Foothills Elementary	Nebo	Bike Pad	$8,907	2008

Plain City Elementary	Weber	Sidewalk	$150,000	2009
Herriman Elementary	Jordan	Sidewalk and Signage	$90,000	2009
William Penn Elementary*	Granite	Sidewalk	$150,000	2010
Hurricane Elementary	Washington	Sidewalk and Crossing	$150,000	2009
Springdale Elementary	Washington	Bike Path	$150,000	2010
South Clearfield Elementary	Davis	Sidewalk	$81,477	2010
EG King Elementary	Davis	Sidewalk	$150,000	2010
Bunderson Elementary	Box Elder	Sidewalk	$62,050	2009
Grovecrest Elementary	Alpine	Sidewalk and Signage	$53,709	2009
Manila Elementary	Alpine	Sidewalk and Flashers	$59,100	2009
Arcadia Elementary	Granite	Sidewalk	$150,000	2011
Manila Elementary	Alpine	Sidewalk and Signage	$250,000	2010
Snow Horse Elementary	Davis	Sidewalk	$200,000	2011
Huntington Elementary	Emery	Sidewalk	$250,000	2010
Mountainside Elementary	Cache	Sidewalk	$250,000	2011
Evergreen Junior High*	Granite	Sidewalk and Redesign	$250,000	2010
Plymouth Elementary	Granite	Sidewalk	$100,000	2011
Alpine Elementary	Alpine	Sidewalk	$50,000	2011
Springdale Elementary	Washington	Sidewalk and Trail Ext.	$250,000	2010
Ephraim Elementary	South Sanpete	Sidewalk	$204,212	2010
Lava Ridge Intermediate	Washington	Sidewalk	$250,000	2010
Millville Elementary	Cache	Sidewalk	$40,000	2011
Grovecrest Elementary	Alpine	Sidewalk	$257,000	2012
West Elementary	Tooele	Sidewalk	$145,000	2012
Sego Lily Elementary	Alpine	Sidewalk	$166,000	2013
Fox Hollow Elementary	Alpine	Sidewalk	$194,000	2012
Monte Vista Elementary	Jordan	Sidewalk	$145,000	2013
Greenwood Elementary	Alpine	Sidewalk	$95,000	2013
Alpine Elementary	Alpine	Sidewalk and Crosswalk	$32,000	2012
Traverse Mountain Elem.	Alpine	Asphalt Path	$93,000	2012
Pahvant Elementary*	Sevier	Sidewalk and Signage	$228,000	2012
Ridgecrest Elementary	Canyons	Sidewalk	$260,000	2010
Fairview Elementary	North Sanpete	Sidewalk	$156,000	2012
Mona Elementary	Juab	Ped Facilities	$282,000	2017
Grantsville Junior High	Tooele	Ped Facilities	$205,000	2017
Discovery Elementary	Uintah	Ped Facilities	$208,000	2017
Spring City Elementary	North Sanpete	Ped Improvements	$208,000	2015
Crestview Elementary	Granite	Ped Improvements	$150,000	2017
Majestic Elementary	Weber	Ped Facilities	$369,000**	2016
Santaquin Elementary	Nebo	Ped Facilities	$588,000**	2016

*Denotes primary applicant in cases where more than one school was listed on application
**Amount requested - Amount granted was not reported

Data was further cleaned to only include infrastructure projects. After initial screening, all non-infrastructure projects were eliminated from the study sample. This was done because of the difficulty in determining their effectiveness relative to student safety and crash risk. Without comprehensive behavioral and attitudinal data collection prior to the non-infrastructure interventions, it would be difficult to identify any significant changes after the implementation of the funded programs.

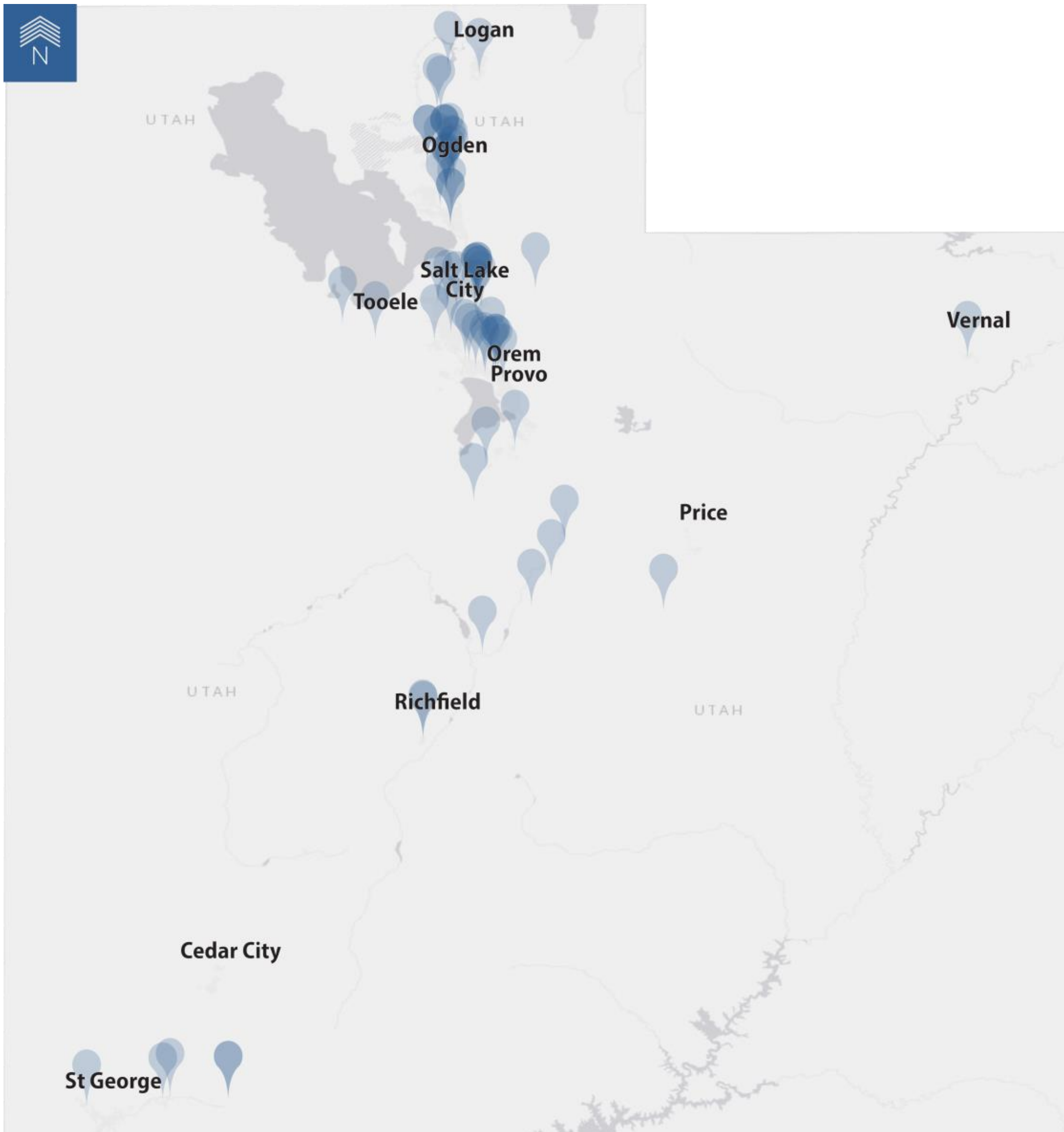

Figure 1. Statewide Map of SRTS Sample Projects

As shown above, SRTS projects have been funded along the urban corridor of the Wasatch Front and in the more rural communities of northern and central Utah. Figures 2-7 below show a more detailed representation of the locations of funded projects. While there is representation across the state for these projects, several areas with a high concentration of schools were notably void of funded projects. For example, Logan City, south Davis County, north Salt Lake County, and south Utah County had no funded projects despite their high concentration of school-aged children. There were also no funded projects in the St. George area or in Tooele County.

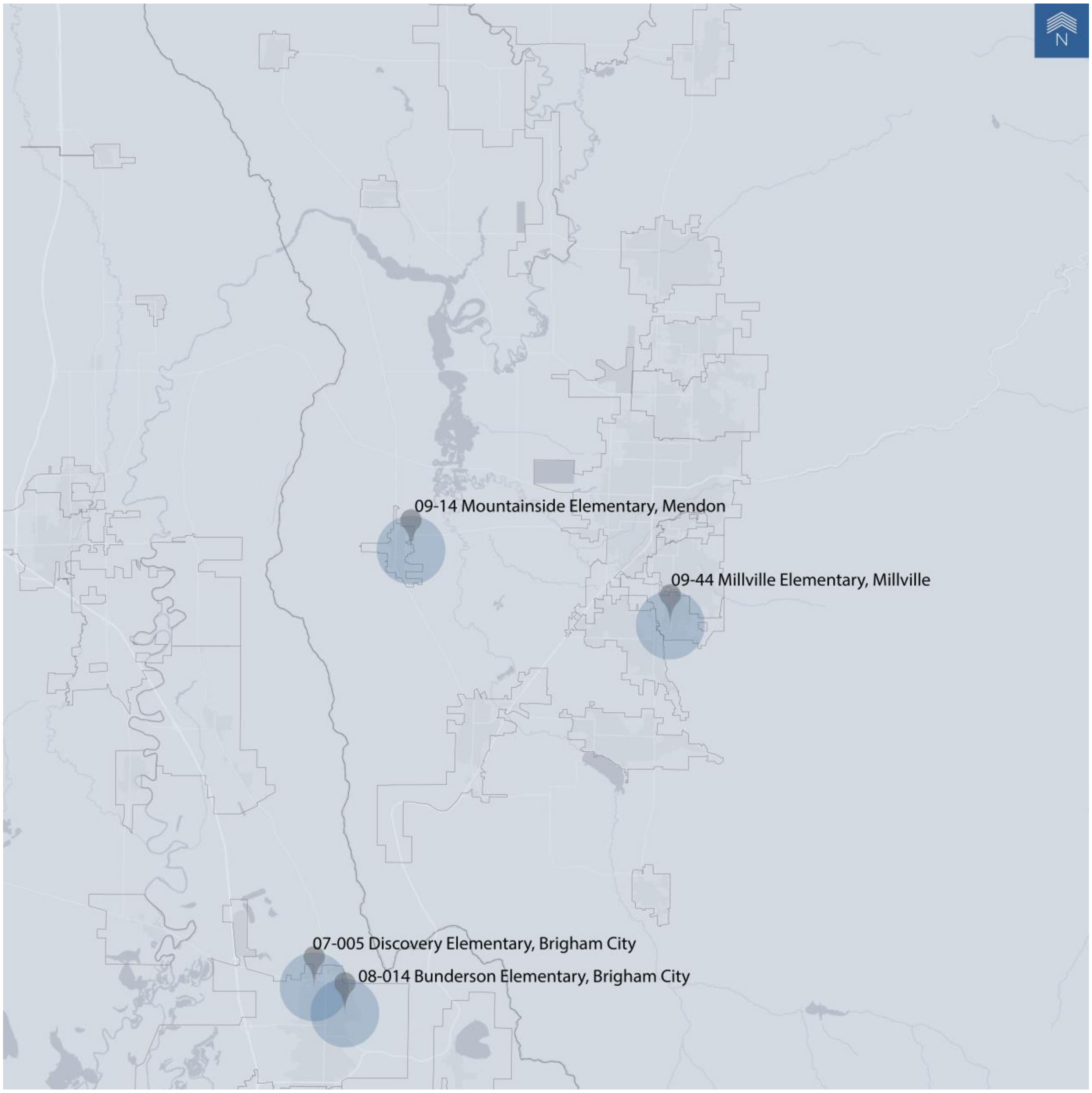

Figure 2. Northern Utah Funded Projects

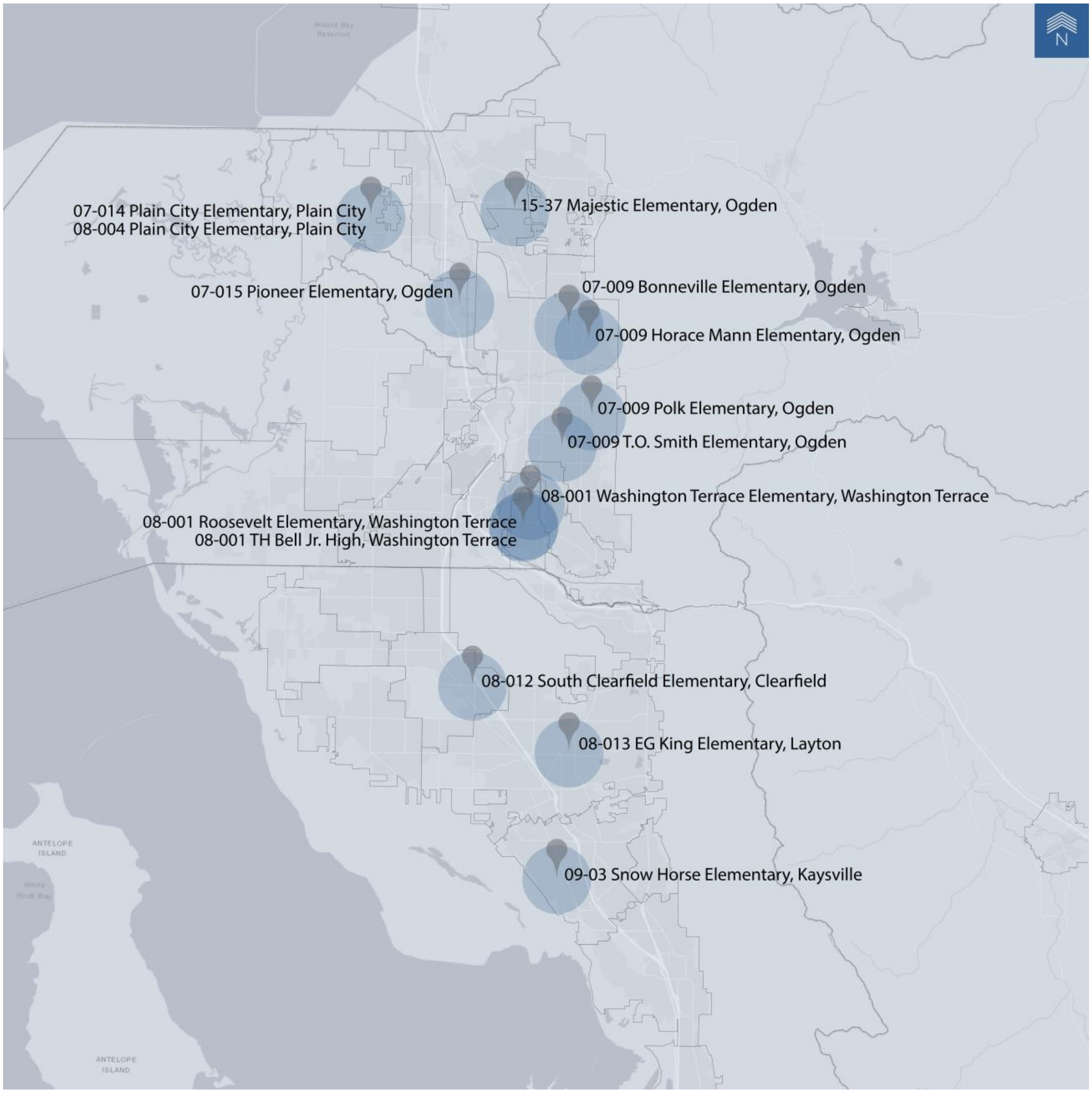

Figure 3. Weber-Davis Funded Projects

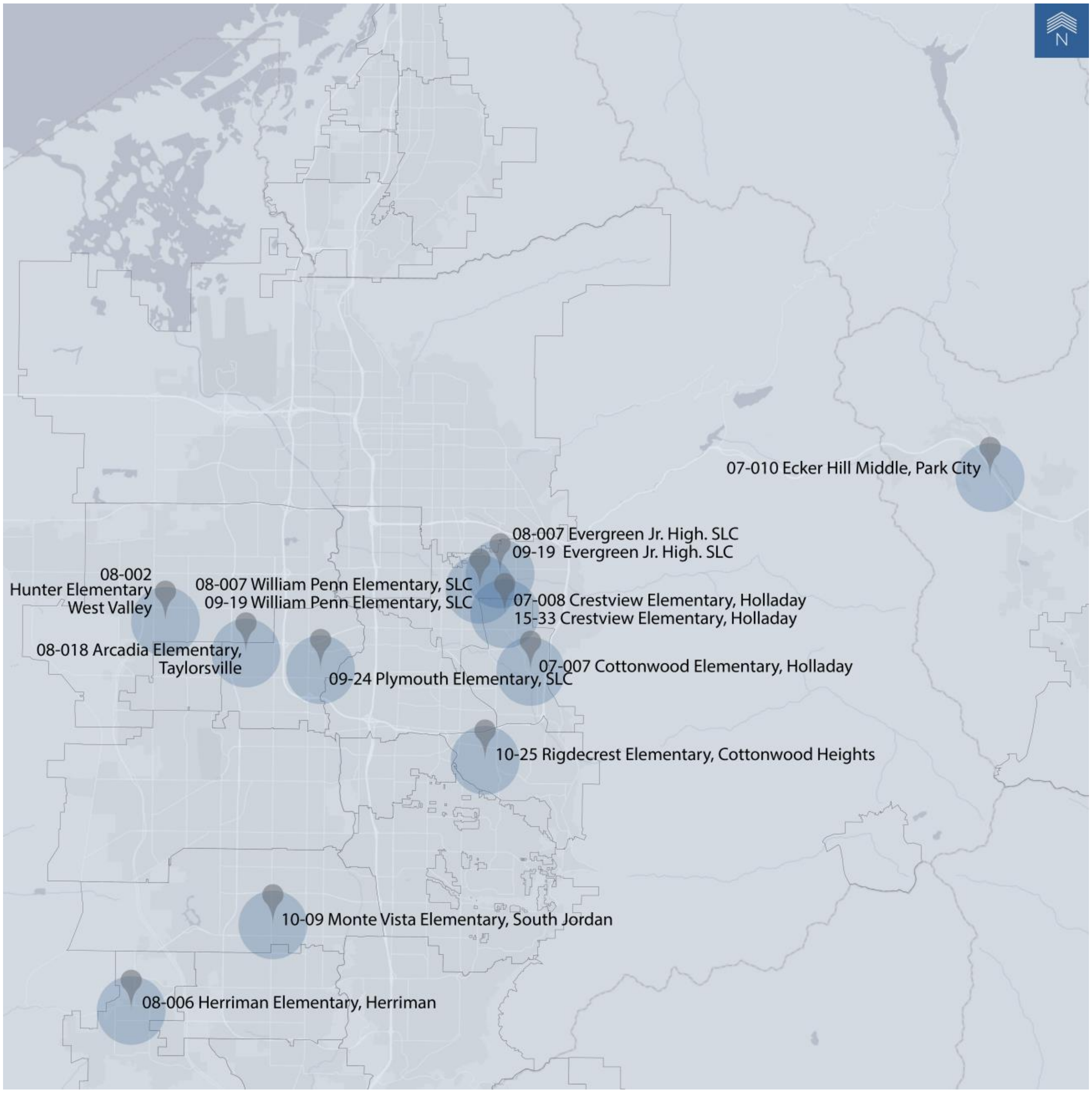

Figure 4. Salt Lake-Summit Funded Projects

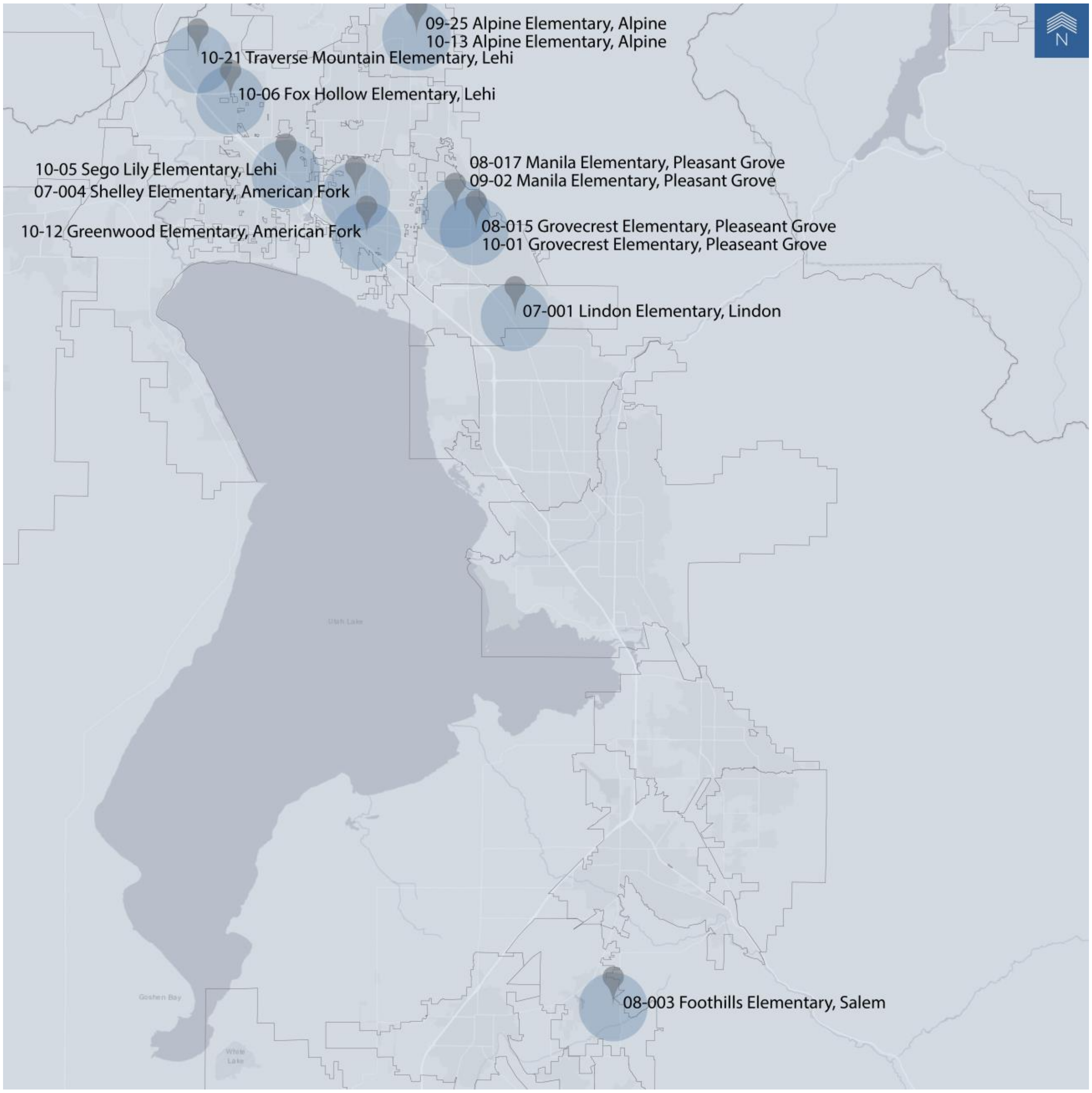

Figure 5. Utah County Funded Projects

Figure 6. Central Utah Funded Projects

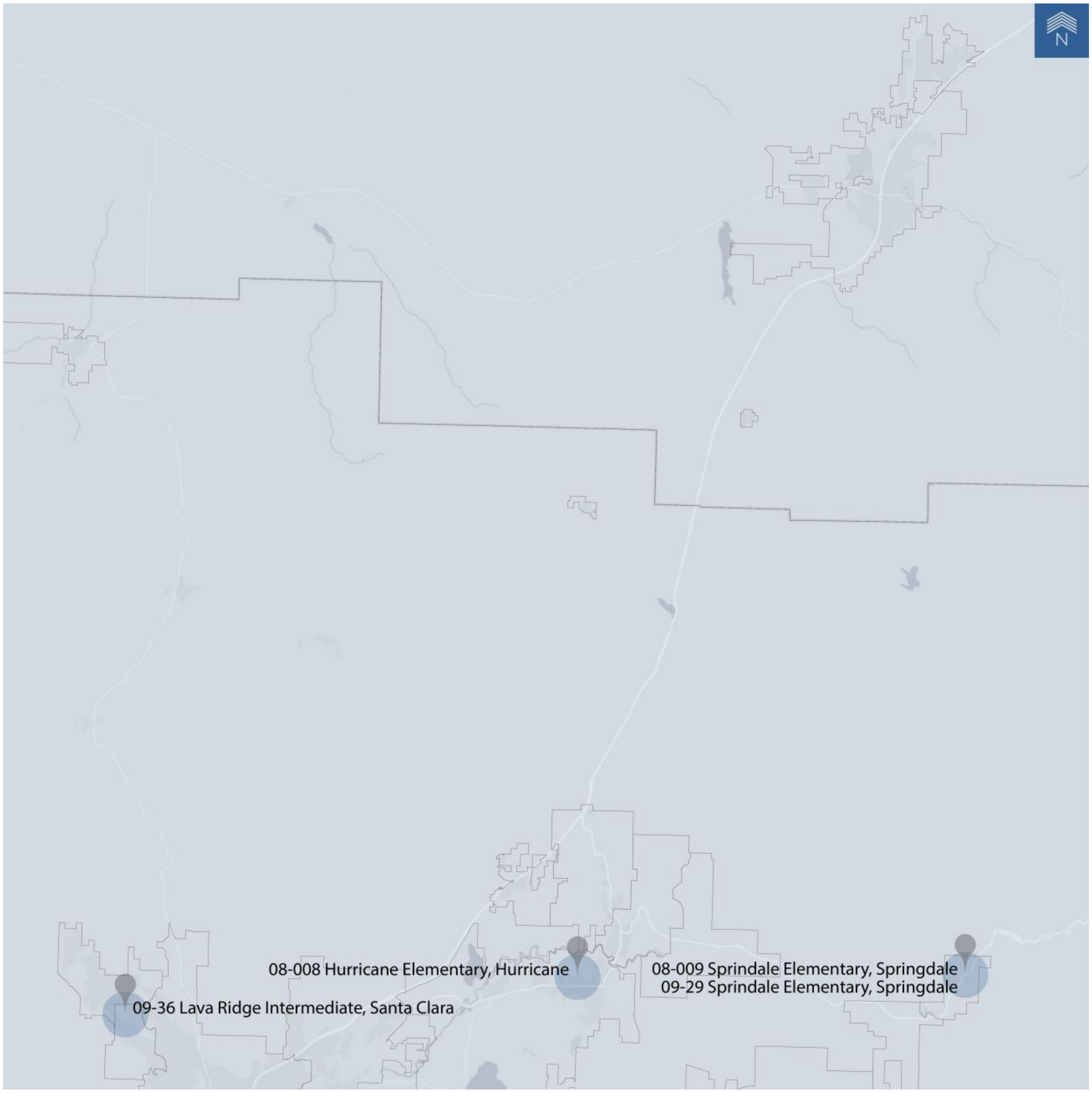

Figure 7. Southern Utah Funded Projects

In 2019, UDOT undertook a research-based approach to reconfigure their SRTS Funding Application. One goal of that effort was to ensure an equitable spatial distribution of project funding. Additionally, UDOT hopes to increase recognition of the funding program and encourage a larger number of communities to submit applications. Moving forward this may incentivize the areas described above to participate in the funding program.

3.3 Crash Data

Vehicle crash data was identified using UDOT's Numetric Crash Query tool – a comprehensive data analytics system that stores and allows queries of statewide crash data. The crash data is protected under 23 USC 409. All pedestrian and bicycle crashes with a vehicle between January 1, 2010 and December 31, 2019 were flagged and tallied. Using GIS, a one-mile geographic buffer was placed around each of the sample project sites and crashes were filtered to include only those that occurred within that buffer area (See Figure 8).

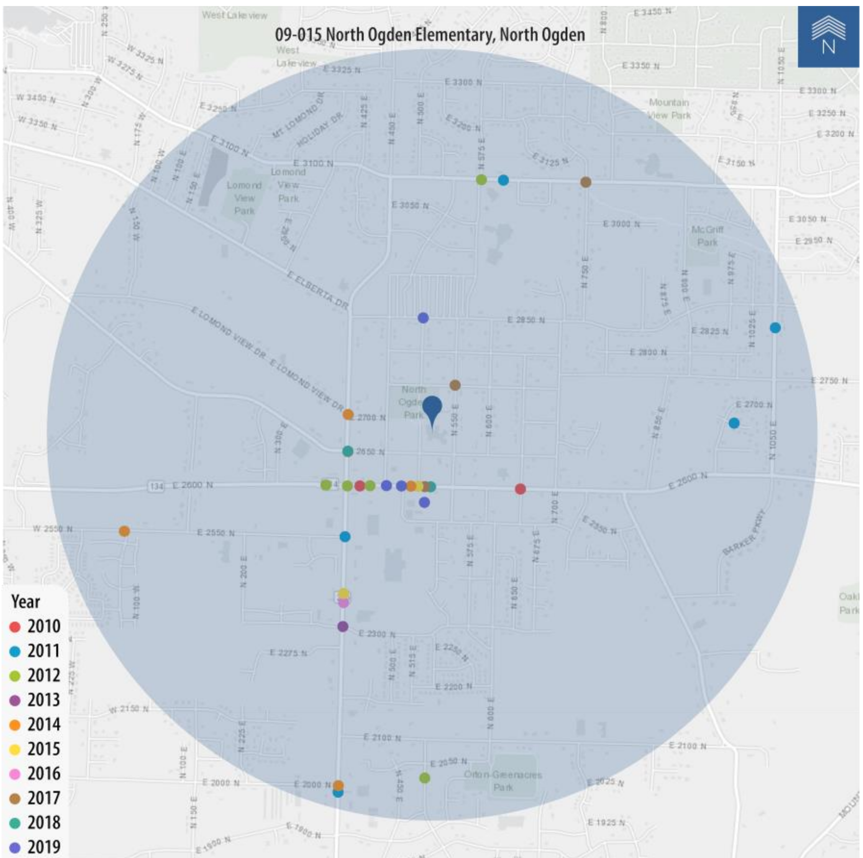

Figure 8. Example of Non-Motorized Crashes Within Buffer

Source: UDOT, Jan. 1, 2010 through Dec. 31, 2019
*All crash data is protected under 23 USC 409

Within this buffer 2,288 non-motorized crashes were evaluated. These crashes were then further coded based on if they occurred before or after the construction of the funded infrastructure project.

3.4 Data Quality

All crash data included in this analysis was collected outside the scope of this research. Crash data was collected by law enforcement and has been cleaned and verified for accuracy and validity. It should be noted that UDOT 2019 crash data may be incomplete and not fully validated, however, the available non-motorized crashes from 2019 are included as part of this dataset with the aim of enhancing the project team's understanding of the research problem.

The Safe Routes to School Application data was provided in its original application form. Because the format of the application was identical for all applicants, and the data fields were required for preliminary consideration and ultimately for funding to be granted, the data for all applications was consistent and complete. The only data limitations related to the project completion dates. In the data provided by the DOT for project completion a small sub-sample of projects had multiple dates listed for completion. This limitation only poses a problem in terms of classifying whether crashes within the buffer area occurred before or after the construction of the project.

3.5 Summary

We identified 52 infrastructure projects funded through the UDOT Safe Routes to School program from 2007-2016 (project years 2007-2015). The infrastructure projects included improvements such as sidewalk extensions, crosswalks, roadway reconstruction, bike path, asphalt path, signage, pedestrian facilities, and other pedestrian improvements, and were located across the state.

Using GIS, a one-mile geographic buffer was placed around each of the sample project sites, and crashes were filtered to include only those that occurred within that buffer area. Within this buffer 2,288 total non-motorized crashes were evaluated. These crashes were then further coded based on whether they occurred before or after the construction of the infrastructure project. No data was available to identify crashes that occurred during construction.

All crash data included in this analysis was collected outside the scope of this research. The data was collected by professional organizations and has been cleaned and verified for accuracy and validity. It should be noted that UDOT 2019 crash data may be incomplete and not fully validated, however, the available non-motorized crashes from 2019 are included as part of this dataset with the aim of enhancing the project team's understanding of the research problem.

4.0 DATA EVALUATION

4.1 Overview

This section includes analysis of all location characteristics and crash data. First, descriptive statistics are provided describing the crash data in the sample. Next, statistical methods are used to identify significant changes in crashes over time, particularly relative to the construction of each funded project.

4.2 Summary of Crash Data

Between 2010-2019 there were 2,288 crashes within one mile of Safe Routes to School project sites. There was an average of 229 non-motorized crashes per year with considerably higher frequencies from 2010-2012, and significantly fewer crashes in 2013 and 2017 (See Table 2 below).

Table 2. Non-Motorized Crashes per Year

Year	# NM Crashes	Percent
2010	253	11.1
2011	253	11.1
2012	283	12.4
2013	219	9.6
2014	232	10.1
2015	224	9.8
2016	241	10.5
2017	198	8.7
2018	249	10.9
2019	136	5.9
Total	2,288	100.0

A large majority of crashes resulted in no injury or only minor injuries (including possible injuries - 85.6%), while 11.5% resulted in serious injuries, and 2.8% were fatal.

Table 3. Non-Motorists Crashes by Severity (2010-2019)

Severity	# NM Crashes	Percent
No Injury	174	7.6
Possible Injury	721	31.5
Suspected Minor Injury	1065	46.6
Suspected Serous Injury	264	11.5
Fatal	64	2.8
Total	2,288	100.0

Lighting conditions, weather conditions, and condition of the roadway surface (wet or dry) can all significantly contribute to non-motorist crashes and fatalities (Burbidge, 2016). Tables 4, 5, and 6, identify the frequency of these conditions for the crashes included in the sample. A large majority of crashes occurred during daylight (70.7%) and another 6.7% occurred at dawn or dusk. These crashes would be the most representative of safety conditions for school children in the areas, as they are typically traveling to and from school under these conditions. There is some potential for school children to travel to school in dark conditions during winter months (December-February). Approximately 22.1% of crashes occurred in the dark (13.3% lighted, 8.8% not lighted).

Table 4. Non-Motorist Crashes by Light Condition (2010-2019)

Light Condition	# NM Crashes	Percent
Daylight	1617	70.7
Dawn	59	2.6
Dusk	94	4.1
Dark, Lighted	304	13.3
Dark, Not Lighted	202	8.8
Not Provided	12	0.5
Total	2288	100.0

Nearly all crashes in the study area occurred on clear or cloudy days (93.8%). Approximately 3.2% of crashes occurred in rain and 1.6% occurred in snowy conditions, with 6.3% of crashes occurring on wet roadways. The reduction in non-motorized crashes in bad weather can be attributed to the fact that non-motorized transportation typically decreases in inclement weather, particularly for school-aged children, and motorists tend to drive slower and with more caution in inclement weather. Approximately 18-24% of parents state that they would not let their children walk or bike to school in bad weather (National SRTS, 2011a).

Table 5. Non-Motorist Crashes by Weather Condition (2010-2019)

Weather	# NM Crashes	Percent
Clear	1869	81.7
Cloudy	277	12.1
Fog/Smog	6	0.3
Rain	72	3.2
Snow/Sleet	36	1.6
Unknown	28	1.2
Total	2,288	100.0

Lastly, a stratified analysis of non-motorized crashes by type determined that nearly 19.9% of non-motorized crashes involved a cyclist, while 80.1% involved one or more pedestrians.

4.3 Before-and-After Analysis

As mentioned in the prior chapter, each crash was coded based on if it occurred before or after the construction of the SRTS project. An analysis of the non-motorized crashes occurring within one mile of the project sites determined that 20% of crashes in the sample occurred before construction and 80% occurred after. The following sections describe significance testing of various characteristics of crashes from before the SRTS project's construction to after. Ideally, once a project is constructed key indicators such as number of crashes, crash severity, etc. would improve.

<u>4.3.1 Crash Change by Location</u>

The premise of the Safe Routes to School funding program is to promote safety for school children and other non-motorists and to reduce crashes. Therefore, the purpose of this research is to determine if areas granted funding to install active infrastructure see an improvement in non-motorist safety. Table 6 below shows a breakdown, by site, of the mean number of non-motorized crashes per year before the project's construction and after. Additionally, the table identifies the mean severity of non-motorized crashes within one mile of the installed infrastructure from before to after.

Table 6. Non-Motorized Crashes by Site - Before and After

Project Site	Mean Crashes per Year – Before	Mean Crashes per Year – After	Mean Crash Severity Before	Mean Crash Severity After
Lindon Elementary	n/a	3.8	n/a	1.4
Shelley Elementary	n/a	8.4	n/a	2.8
Discovery Elementary	n/a	1.3	n/a	2.9
Cottonwood Elementary	n/a	1.3	n/a	1.5
Crestview Elementary	n/a	6.1	n/a	1.7
Bonneville Elementary*	7.0	9.75	1.9	1.9
Horace Mann Elementary	4.0	4.22	1.6	1.9
Polk Elementary	8.5	8.0	1.7	1.9
T.O. Smith Elementary	14.5	16.3	2.7	2.8
Ecker Hill Middle School	n/a	0.27	n/a	1.3
Plain City Elementary	n/a	0.36	n/a	2.8
Pioneer Elementary	n/a	0.09	n/a	1.0
Washington Terrace Elem.*	n/a	5.45	n/a	1.8
Roosevelt Elementary	n/a	2.36	n/a	1.5
TH Bell Jr. High	n/a	2.27	n/a	1.5
Hunter Elementary	0.6	9.5	1.8	1.7
Foothills Elementary	n/a	0.7	n/a	1.9
Plain City Elementary	n/a	0.4	n/a	2.8
Herriman Elementary	n/a	3.0	n/a	1.7
William Penn Elementary*	9.0	9.2	0.8	1.8
Evergreen Jr. High	5.0	7.0	0.8	1.8
Hurricane Elementary	n/a	1.9	n/a	2.0
Springdale Elementary	0.0	0.0	0.0	0.0
South Clearfield Elementary	3.0	11	2.7	1.5
EG King Elementary	2.0	3.8	3.0	1.9
Bunderson Elementary	n/a	3.4	n/a	1.9
Grovecrest Elementary	n/a	3.8	n/a	1.5
Manila Elementary	n/a	2.0	n/a	1.6
Arcadia Elementary	10.33	18.7	1.4	1.6
Manila Elementary	0.5	2.14	2.0	1.6
Snow Horse Elementary	1.0	0.75	0.5	1.8
Huntington Elementary	0.66	1.11	1.5	1.7
Mountainside Elementary	0.0	0.5	0.0	1.5
Evergreen Junior High*	9.0	9.2	0.8	1.8
William Penn Elementary	5.0	7.0	0.8	1.8
Plymouth Elementary	9.0	14.25	1.3	1.6
Alpine Elementary	2.0	0.55	2.5	1.4
Springdale Elementary	0.0	0.0	0.0	0.0
Ephraim Elementary*	0.0	1.44	0.0	1.5
Gunnison Valley Elem.	0.0	0.0	0.0	0.0
Lava Ridge Intermediate	1.0	0.71	2.0	2.6
Millville Elementary	0.5	0.71	3.0	1.8
Grovecrest Elementary	n/a	3.8	n/a	1.5
West Elementary	3.33	4.57	1.8	1.6
Sego Lily Elementary	4.75	4.0	1.5	1.8
Fox Hollow Elementary	0.33	1.86	1.0	2.1
Monte Vista Elementary	2.25	2.33	1.8	1.5
Greenwood Elementary	7.5	6.33	1.7	1.9

Alpine Elementary	1.0	0.43	2.3	1.0
Traverse Mountain Elem.	0.67	1.14	2.5	2.3
Pahvant Elementary*	4.5	2.42	1.7	1.3
Ashman Elementary	5.0	2.42	1.6	1.3
Ridgecrest Elementary	9.0	5.67	1.7	1.4
Fairview Elementary	0.0	0.0	0.0	0.0
Mona Elementary	0.14	0.0	2.0	0.0
Grantsville Junior High	2.86	2.5	1.6	2.2
Discovery Elementary	0.71	0.5	2.0	1.0
Spring City Elementary	0.0	0.2	0.0	1.0
Crestview Elementary	6.85	7.0	1.7	1.6
Majestic Elementary	2.14	0.67	1.9	1.0
Santaquin Elementary	1.00	0.0	1.6	0.0
	Mean=3.52	Mean=3.75	Mean=1.5	Mean=1.6

**Lead Applicant*

A paired samples t-test was first employed to determine if there was a significant difference in the mean number of crashes per year within a mile of each SRTS project before and after construction. The analysis did not find a significant change in the number of non-motorized crashes per year after the construction of an SRTS project (t=1.994, sig=0.053).

Please note that one limitation of the data involves the fact that SRTS is a reimbursement program. Therefore, some of the earliest SRTS projects were constructed in 2009 prior to their funding. Consequently, the data compiled in the crash database did not represent non-motorized crashes occurring before construction, as that data is not as readily available. Those cases are identified as “n/a” in the table.

4.3.2 Crash Severity

Table 7 below shows the breakdown of non-motorized crash severity before SRTS project construction and after. While a chi-square analysis of crash severity did not find significant variation in crash severity from before a project’s construction to after (p=0.086), more complex non-parametric statistical measures (shown at the bottom of Table 7) determined that there was significant variation in the distribution of crash severity.

Table 7. Crash Severity – Before and After

	No Injury	**Possible**	**Minor**	**Serious**	**Fatal**	**Total**
NM Crashes Before	47	13	194	43	11	437
NM Crashes After	127	578	871	221	53	1,850

Total	174	721	1,065	264	64	2,288
						X^2=9.629 P=0.086
Kendall's Tau-b=0.049 (p=0.013), Gamma = 0.107 (p=0.013), Spearman Correlation= 0.053 (p=0.012)						

A subsequent multinomial logistic regression (MNL) model examined the relationship between construction of all SRTS projects and injury severity for crashes occurring within one mile, while controlling for lighting and weather conditions. The probability of non-motorized crashes with an injury occurring (not fatal crashes) was significantly higher after construction of an SRTS project. Non-motorized crashes occurring in the snow were significantly less likely to result in injury, while crashes resulting in a serious injury were significantly more likely to occur in daylight or lighted nighttime conditions than in the dark. Table 8 shows the parameter estimates for the model.

Table 8. MNL Crash Severity and Crash Timing (MNL)

				95% Conf. Interval	
Crash Severity	***B***	**Sig**	**Exp(*B*)**	**Lower Bound**	**Upper Bound**
Possible Injury					
Intercept	0.080	0.937	6.462	0.395	105.778
Light Condition- Daylight	1.866	0.191	7.215	0.338	154.179
Dawn	1.976	0.206	4.372	0.241	79.209
Dusk	1.475	0.318	4.968	0.293	84.276
Dark, Lighted	1.603	0.267	4.839	0.277	84.384
Dark, Not Lighted	1.577	0.280	6.462	0.395	105.778
Weather- Clear	0.229	0.858	1.258	0.101	15.609
Cloudy	0.388	0.768	1.474	0.112	19.397
Fog/Smog	-0.499	0.776	0.607	0.019	18.916
Rain	-0.975	0.574	0.377	0.013	11.322
Snow/Sleet	-3.681	0.045	0.025	0.001	0.929
Roadway was wet	0.736	0.702	2.088	0.048	90.785
Crash occurred after construction	0.430	0.029	1.537	1.045	2.261
Minor Injury					
Intercept	0.727	0.425			
Light Condition- Daylight	1.176	0.374	3.240	0.242	43.375
Dawn	1.722	0.237	5.594	0.321	97.321
Dusk	0.740	0.591	2.096	0.141	31.049
Dark, Lighted	0.845	0.529	2.327	0.168	32.276
Dark, Not Lighted	0.935	0.490	2.548	0.179	36.305
Weather- Clear	-0.490	0.690	0.613	0.055	6.821
Cloudy	0.157	0.901	1.170	0.099	13.791
Fog/Smog	-2.500	0.186	0.082	0.002	3.344
Rain	-1.007	0.552	0.365	0.013	10.065
Snow/Sleet	-2.692	0.112	0.068	0.002	1.882
Roadway was wet	1.091	0.565	2.9878	0.073	122.262

Crash occurred after construction	0.538	0.005	1.713	1.177	2.491
Serious Injury					
Intercept	-30.67	0.990			
Light Condition- Daylight	15.486	0.000	5313771	2626361.3	10751058.3
Dawn	15.659	0.000	6321009	1296137.0	30826344.4
Dusk	15.676	0.000	6424934	2234646.7	18472618.7
Dark, Lighted	15.588	0.000	5885406	2583996.952	13404817.669
Dark, Not Lighted	15.572	0.000	5789681	5789681.892	5789681.892
Weather- Clear	-0.923	0.505	0.397	0.026	6.003
Cloudy	-1.026	0.471	0.359	0.022	5.838
Fog/Smog	-1.527	0.443	0.217	0.004	10.715
Rain	-0.761	0.681	0.467	0.012	17.624
Snow/Sleet	-3.741	0.071	0.024	0.000	1.377
Roadway was wet	16.882	0.994	21464568.7	0.000	-
Crash occurred after construction	0.722	0.003	2.059	1.279	3.315
Fatality					
Intercept	-1.151	1.410			
Light Condition- Daylight	-0.429	0.846	0.651	.009	49.527
Dawn	0.376	0.880	1.457	0.011	193.963
Dusk	-0.014	0.995	0.986	0.010	97.515
Dark, Lighted	0.988	0.658	2.685	0.034	213.217
Dark, Not Lighted	2.004	0.370	7.421	0.093	591.396
Weather- Clear	0.185	0.921	1.204	0.031	46.719
Cloudy	1.259	0.506	3.524	0.086	144.222
Fog/Smog	-17.44	0.998	2.643E-8	0.000	-
Rain	-1.205	0.623	0.300	0.002	36.437
Snow/Sleet	-0.904	0.712	0.405	0.003	49.477
Roadway was wet	-0.147	0.959	0.864	0.003	219.065
Crash occurred after construction	0.520	0.173	1.683	0.796	3.558
					N=2,288

*Reference Category is "No Injury"

Likewise, using ordinal categories, a traditional least-squares regression model was used to confirm directional correlation. This second regression model determined that across all sample crashes, non-motorized crashes occurring after the construction of an SRTS project were significantly more severe than those occurring before construction (Table 9). This could be due to several factors discussed in the following chapter.

Table 9. Crash Severity and Crash Timing (Least Squares Regression)

Variable	***B***	***t***	**Sig.**
_Constant	1.585	36.883	0.000
Crash Occurred After Construction	0.130	2.769	0.006
Light Conditions	0.004	1.348	0.178
Weather Conditions	0.002	-1.841	0.066
Roadway Surface			
R Square = 0.005			N=2,288

Additionally, crashes occurring on wet roads were significantly less severe than those occurring on dry roads, perhaps suggesting that vehicles were driving slower in wet conditions, or that far fewer people were walking and biking in wet conditions resulting in fewer severe crashes.

4.3.3 Bicycle Crashes vs Pedestrian Crashes

A secondary analysis was performed to examine non-motorized crashes by mode. Within the dataset 1,850 crashes involved a pedestrian and 438 crashes involved a cyclist. Table 10 below shows the breakdown of non-motorized crashes by severity, by mode. A chi-square analysis shows significant variation from the equal distribution that would be expected in a normal random sample. The sample distribution shows that when an injury occurred during a non-motorized crash, pedestrian crashes were more severe than bicycle crashes.

Table 10. Crash Severity by Non-Motorized Mode

Non-Motorized Mode	No Injury	Possible	Minor	Serious	Fatal	Total
Bicycle Involved	73 (7.7%)	324 (34.2%)	456 (48.2%)	82 (8.7%)	11 (1.2%)	946 (100%)
Pedestrian Involved	101 (7.5%)	397 (29.6%)	609 (45.4%)	182 (13.6%)	53 (3.9%)	1342 (100%)
	Chi-Square= 31.730 Sig=0.000					

To statistically evaluate the variation shown in Table 10, an independent samples t-test evaluated the difference in crash severity by non-motorized mode (all crashes). That analysis determined that within this sample, all bicycle crashes were significantly less severe than all pedestrian crashes (Table 11).

Table 11. Crash Severity by Non-Motorized Mode (t-test)

			95% Confidence Interval	
	t	**Sig.**	**Lower**	**Upper**
Crash Severity	4.209	0.000	0.083	0.227
$\bar{X}$ Bicycle Involved	1.61			
$\bar{X}$ Pedestrian Involved	1.77			
				N=2,288

Given this baseline, a second independent samples t-test was performed comparing bicycle and pedestrian crashes before and after SRTS project construction (Table 12) to further examine the impact of the SRTS projects. This analysis determined that there were significantly fewer bicycle-involved crashes after project construction, while there were significantly more pedestrian crashes after project construction.

Table 12. Bicycle and Pedestrian Crashes (Before/After)

			95% Confidence Interval	
Non-Motorized Mode	***t***	**Sig.**	**Lower**	**Upper**
Bicycle Involved	1.991	0.047	0.001	0.103
$\bar{X}$ Before	0.46			
$\bar{X}$ After	0.40			
Pedestrian Involved	-1.991	0.047	-0.103	-0.001
$\bar{X}$ Before	0.54			
$\bar{X}$ After	0.60			
				N=2,288

Lastly, crash severity was evaluated by non-motorized mode, based on if the crash occurred before or after SRTS project construction. As shown below (Table 13), a chi-square analysis shows significant variation from the equal distribution that would be expected in a normal random sample. There is also an unequal distribution of crashes by severity both before and after SRTS project construction.

Table 13. Crash Severity by Non-Motorized Mode (Before/After)

Non-Motorized Mode	No Injury	Possible	Minor	Serious	Fatal	Total
Bicycle Involved - Before	26 (13.0%)	68 (34.0%)	89 (44.5%)	16 (8.0%)	1 (0.5%)	200 (100.0%)
Bicycle Involved – After	47 (6.3%)	256 (34.3%)	367 (49.2%)	66 (8.8%)	10 (1.3%)	746 (100.0%)
Pedestrian Involved - Before	21 (8.8%)	75 (31.5%)	105 (44.1%)	27 (11.3%)	10 (4.2%)	238 (100.0%)
Pedestrian Involved - After	80 (7.2%)	322 (29.2%)	504 (45.7%)	155 (14.0%)	43 (3.9%)	1104 (100.0%)
N=2,288	Chi-Square= 22.253 Sig=0.000					

A follow-up independent samples t-test statistically quantified the variation in severity before and after SRTS project construction. The analysis determined that bicycle crashes occurring after project construction were significantly more severe than those occurring before construction. There was no significant variation in pedestrian crash severity (Table 14.)

Table 14. Crash Severity by Non-Motorized Mode

			95% Confidence Interval	
Non-Motorized Mode	***t***	**Sig.**	**Lower**	**Upper**
Bicycle Involved	-2.466	0.014	-0.280	-0.032
$\bar{X}$ Severity Before	1.49			
$\bar{X}$ Severity After	1.65			
Pedestrian Involved	-1.160	0.246	-0.206	0.052
$\bar{X}$ Severity Before	1.71			
$\bar{X}$ Severity After	1.78			
				N=2,288

4.3.4 Crash Changes within Individual Sites

The analysis in the sections above examined all crashes in a pooled approach to maximize statistical power (comparing all crashes occurring before to all crashes occurring after). This allowed for the identification of patterns from all sites before and after construction. However, to better isolate change in individual sites, a final paired t-test examined mean crash severity by site before and after project construction. The analysis identified no significant change in crash severity after a project's construction (t=-0.001, sig=0.999). While the holistic analysis of all 2,288 crashes is more robust, the fixed effects analysis which compared each site to itself from before and after construction is likely more meaningful. Although overall data can expose trends across multiple sites, using fixed effects modeling can reveal more microscale change.

4.4 Summary

A sample of 2,288 non-motorized crashes that occurred within one-mile of an SRTS project site were compiled and evaluated. The physical conditions present during each crash were described including lighting, weather, and roadway conditions. Crashes were then evaluated in three main ways. First, the number of crashes before and after construction were evaluated to identify significant change. Next, crashes were examined based on the severity of any injuries. Lastly, crashes were analyzed by non-motorized mode (bicycle vs pedestrian) to evaluate significant differences in severity and prevalence.

5.0 CONCLUSIONS

5.1 Summary

This research examines the impact of projects constructed using funding from Utah's SRTS program. The sample included 52 infrastructure projects funded between 2005 and 2015. Additionally, crash data was compiled for all non-motorized crashes that occurred from 2010-2019 within one-mile of each SRTS project site. Using a combination of Multinomial Logistic (MNL) regression, least squares regression, and independent and paired sample t-test statistical models, crash data was correlated to crash severity before and after project construction. Additionally, fixed effects models drilled down to identify specific changes at each individual site. Lastly, a breakdown by mode (pedestrian vs cyclist crashes) was conducted to identify potential changes after construction.

5.2 Findings

Proximal non-motorized crashes were examined before and after SRTS project construction. In order to ensure that the analysis provided was robust and comprehensive, several additional variables were included in various iterations of each model to ensure that latent confounding variables did not skew the analysis and that collinearity was reduced or eliminated. For example, several physical environment conditions at the time of each crash were included in the models. These included lighting conditions, weather conditions, and roadways surface conditions.

The first goal of this research was to examine the impact that SRTS projects had on non-motorized crash incidents. The research sought to determine if there was a significant difference in non-motorist crashes (per year) before and after the construction of an SRTS-funded project. A preliminary analysis identified no significant change in the mean number of non-motorized crashes per year from before to after the construction of SRTS infrastructure projects. This initial examination prompted a more detailed and in-depth evaluation of the characteristics of crashes to better evaluate the impact of the infrastructure changes.

5.2.1 Crash Severity

Next, crash severity was examined. It was hypothesized that although there may not have been a significant reduction in total non-motorized crashes, the severity may have been reduced with the introduction of new infrastructure. Typically, a random sample of non-motorized crashes would provide an equal distribution of crash severity. A chi-square analysis found that within the sample, there was significant variation in crash severity. A subsequent MNL regression analysis determined that the probability of non-motorized crashes resulting in an injury (minor or serious) increased after construction. It is notable, however, that the probability of fatal crashes did not significantly change. There could be several reasons for this. For example, construction of a new facility may have resulted in a large increase in students walking and biking to the school. This increase would, in turn, lead to more exposure and a higher probability of non-motorized crashes occurring in the area. Although the analysis did not find a significant increase in crashes, any increase in travel by children could inherently result in an increase in injury crashes simply due to the fact that children are more likely to be injured in a crash than adults.

A deeper look at the environmental conditions at the time of the crash using an MNL regression methodology, determined that non-motorized crashes occurring in the snow or those occurring on wet roads were less likely to result in an injury and were less severe overall. Two main reasons for this could be that, 1) non-motorist volumes decrease significantly in inclement weather, particularly snow, which would result in lower exposure rates, and 2) vehicles are typically traveling at slower speeds when the roads are wet or slick. Slower speeds at the time of a crash are correlated to a lower risk of injury for non-motorists. Next, the analysis examined the relationship with lighting conditions. An MNL regression model identified that serious non-motorized crashes in this sample were significantly more likely to occur in daylight conditions. Again, near these sample sites the volume of non-motorized traffic is likely much higher during daylight, particularly for corridors where students are walking and biking to school. This would result in higher exposure.

Lastly, the analysis examined crash severity from before and after the construction of the SRTS project infrastructure. An MNL regression mode determined that non-motorist crashes occurring in the sample area after construction resulted in significantly more severe injuries than crashes before construction.

Finally, this research sought to determine the impact of project construction on crash severity on a site-by-site basis. A fixed-effects independent samples t-test examined changes in crash severity before and after implementation. Rather than examining crashes before and after collectively (all crashes before vs all crashes after), the model examined each site individually against itself (all crashes within one mile of project X before vs all crashes within one mile of project X after; repeated for all 58 sites). This more robust, drilled-down approach determined that there was no significant change in non-motorized crash severity from before to after project construction.

5.2.2 Cyclist vs Pedestrian Crashes

In comparing bicycle and pedestrian crashes occurring within the study area, the analysis found that bike crashes were significantly less severe than pedestrian crashes. This may be related to both non-motorist volumes as well as the nature of such crashes. As this analysis did not include these factors in the models, no additional detail is available on the potential impacts. A second model identified that collectively, after project construction, there was a significant increase in pedestrian crashes and a concomitant decrease in bicycle crashes. However, bicycle crashes occurring after construction were significantly more severe than those occurring before construction. Again, this could be explained by changes in volumes and crash type. A new sidewalk, for example, would likely result in an increase in pedestrian traffic. This increase would lead to an increase in exposure and an expected increase in conflicts. As these projects take place within proximity to schools, any new facility could provide more protection for young cyclists (e.g. children biking on a new sidewalk instead of on the roadway shoulder). However, moving cycling students to a sidewalk can reduce their visibility to motorists, which can cause additional conflict at crossings where bikes can seemingly come out of nowhere.

5.3 Limitations and Challenges

There were several limitations to the evaluations conducted in this scope of work. First and foremost, the models did not control for non-motorist or vehicle volumes. UDOT did not collect volume data prior to or following each facility's construction. This can be a major confounding factor in modeling. For example, if a given site had an average of 100 pedestrians and 50 cyclists per day prior to construction, and that increased to 500 pedestrians and 250 cyclists after construction, volumes increased five-fold. If during that same time period the number of crashes increased from 8 non-motorist crashes to 12 (a 50% increase) without controlling for volumes, the models would view that simply as an increase in crashes even though the rate of crashes decreased significantly (from 5 per 100 to 1.6 per 100). The new SRTS application process requires applicants to provide volume data before construction as well as follow-up counts. Applicants who fail to complete this requirement may lose their reimbursement.

The second limitation of this research relates to the fact that before-and-after data did not encompass the same number of years which can limit the breadth of data evaluated. Because validated crash data was only available for a set number of years, we were unable to compute a specific identical evaluation window for all projects. This was somewhat controlled for by using average crashes per year before and after rather than using cumulative numbers in the models, but it should be noted that some locations had fewer years include in those averages which may limit the outputs.

In addition to not having volume counts for the corridors, no travel behavior data was available for the schools associated with each project. Again, the new SRTS application requires applicants to provide data on the percentages of students using each transportation mode to and from school. This will provide an additional layer of complexity for future analysis while also allowing for comparisons between site counts near a project site and counts for the entire school.

The last limitation of this project was the inability to conduct a qualitative analysis. Initially the scope included efforts to reach out to schools and communities where these projects had been completed. The intent was to gain additional insight into the impact that the projects have had by interviewing school administrators and local law enforcement. However, due to lack of institutional memory regarding what conditions were like before the project was built, this qualitative analysis was not possible. In most cases, school administrators only stay with an institution for 3-5 years. For projects that were completed more than five years ago, there were few individuals at the school who participated in the application/project process, or who even remembered that the project had been completed. Additionally, turnover among local law enforcement and a lack of specific memory regarding a given site made identifying change nearly impossible. For example, few police departments were able to provide an officer who could provide information on what day-to-day behavior and safety looked like 6 years ago at a given location. This is where synchronous data will be beneficial moving forward.

6.0 RECOMMENDATIONS AND IMPLEMENTATION

Based on the findings of this research, the Technical Advisory Committee recommends the following:

- Create a comprehensive online database of Safe Routes to School resources. This will include local Health Department and School District contacts, a GIS database of all current SRTS plans, guidance and best practices for preparing and submitting new SRTS plans, links to the Utah SRTS funding application and other funding sources, and links to other community resources.

- Initiate a process within the Safe Routes to School Funding Program to provide micro-grants to assist smaller communities in preparing their application for the SRTS funding program. This would likely include a one-time grant of $3,000-$5,000.

- Track participation in school transportation initiatives. This will include all activities sponsored under the Utah Safe Routes to School Program (assemblies, contests, etc.), and other community programs such as the Bike Utah - Youth BEST program.

- Investigate a process where local law enforcement and crossing guards could be involved in collecting student travel data for each school.

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