

AN EVALUATION OF THE SAFETY IMPACTS OF SAFE ROUTES TO SCHOOL
BICYCLE EDUCATION PROGRAMS

by

KATHRYN RUSH

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Department of Landscape Architecture/Regional and Community Planning
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Approved by:

Major Professor
Huston Gibson

Abstract

Studies have shown that, since the early 1980s, the prevalence of overweight children and youth in the U.S. has tripled from approximately five to 16 percent of the population. Simultaneously, fewer and fewer children have been walking and cycling to school. Children—especially those aged 10 to 15 years—have some of the highest per capita traffic-related bicycle fatality and injury rates. While bicycle organizations, states and communities across the country have developed a variety of education programs independently and cooperatively with the National Safe Routes to School program, there is a lack of evaluation of the impact on bicycle safety, of different programs in different contexts, and of whether educational interventions reduce the risk of crashes and injuries. This study evaluated the effectiveness of Safe Routes to School programs with in-school bicycle education at reducing the crash rate and improving the safety of children and youth cyclists. The causal-comparative research design utilized bicycle mode share data collected from the National Center for Safe Routes to School for five existing programs—Boulder Valley School District Safe Routes to School, Eugene-Springfield Safe Routes to School, Safe Routes Philly, Portland Safe Routes to School, and Marin County Safe Routes to School—and crash data before and after program implementation for those respective communities. The crash assessment revealed a decreasing trend in crashes involving children and youth cyclists around treatment schools in the Eugene, OR and Philadelphia, PA program study areas, and at the aggregate level across program areas; but, this trend was not statistically significant when compared to the change in crashes around control schools in a quasi-experimental analysis. Nevertheless, the increase in students cycling to and from school reported by all but one of the programs, and the increase in exposure to crash risk as a result, indicated that the Safe Routes to School programs did not cause a decrease in the safety of student cyclists. Additional rigorous evaluations are needed utilizing randomized controlled design to maximize the reliability of reported findings and to aid decisions about where to invest resources in community-based approaches to injury prevention for cyclists.

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Chapter 1 - Introduction

Over the past decade there has been a boom in cycling interest among cities and city planners. For example, the first bike share program in the U.S. was adopted in Tulsa, OK in 2007. Since then, nearly every major city in America has rolled out its own fleet of bike share bicycles. In the most recent (May 2014) transportation issue of *Planning* magazine—the official magazine of the American Planning Association—three of the six articles were dedicated almost exclusively to cycling-related topics. Across the country, more than 600 communities have adopted local complete streets policies.

The common target of local bicycle transportation policies—novice teenage and adult cyclists who are less confident of their ability to operate in traffic without special provisions for bicycles (defined by the Bicycle Federation of America as “Group B” cyclists)—frequently make major errors such as riding against traffic and turning left improperly. Even with a larger number of designated bicycle facilities, Group B cyclists will need to use the current street network to get to many destinations since bike lanes will only exist on a minority of streets in the near future. Like dividing a road in half with paint striping, the presence of bike lanes does not substitute for knowing how to operate a bicycle safely in traffic. The importance of education is also about the one thing that all cycling advocates agree on. The National Safe Routes to School (SRTS) program, created in 2005, caused a surge in the creation of bicycle education programs in the U.S., but has been accompanied by relatively little evaluation of the effectiveness of these programs. This chapter first provides a background on the National SRTS program: the impetus for its creation, the major characteristics of the program, and its connection to bicycle education. This is followed in succeeding sections by a brief overview of previous studies of SRTS programs and bicycle education programs, and the gaps in the literature. The chapter concludes with a statement of the research questions and hypotheses, an overview of the research design, and the organization of the thesis.

Forces behind the Creation of the National SRTS Program

Over the past 30 years the rate of obesity¹ found among children and adults in the U.S. has reached epidemic proportions. From 1980 to 2012, the rate of obesity has more than doubled for children aged 6 to 11 years (7% to 18%) and quadrupled for adolescents aged 12 to 19 years (5% to 21%) (Centers for Disease Control and Prevention, 2014). Among adults, only four states had obesity rates above 20% in 1991; but, by 2007 the national obesity rate for adults had reached 34%, and Colorado was the only state to have a rate under 20% (National Safe Routes to School Task Force, 2008). Obesity, a major public health concern, plays a central role in the development of diabetes and confers an increased risk for high blood pressure, osteoarthritis, various cancers, and all-cause mortality (U.S. Department of Health and Human Services, 1996). Corresponding to the increasing rate of obesity, the number of cases of type 2 diabetes,² once almost never found in children, has skyrocketed. The presence of obesity in the U.S. is so great that, due to compounding health effects, today's generation of children may be the first in over 200 years to have a shorter lifespan than their parents (National Safe Routes, 2008). Because overweight children are likely to remain overweight as adolescents and adults, and substantial weight loss in adults is difficult to achieve and maintain, childhood obesity and its prevention have received the greatest attention. However, most of the recommended interventions for children also apply to adults, such as eating more healthfully and participating in regular physical activity (U.S. Department of Health, 1996).

Among children, the increasing rate of obesity likely corresponds with the simultaneous decrease in the number of children walking and cycling to school. In 1969, when the government began collecting data on travel mode and trip purpose, 87% of children aged 5 to 18 years living within one mile of school, and 42% of students overall, walked or biked to school. By 2009, the

¹ According to the National Heart, Lung, and Blood Institute (2012) the terms “overweight” and “obesity” refer to body weight that is greater than what is considered healthy for a certain height, putting a person at a greater risk for many health problems. “Overweight” is defined as having excess body weight to a particular height from fat, muscle, bone, water, or a combination of these factors. “Obesity” is defined as having excess body fat (Centers for Disease Control, 2014).

² Type 2 diabetes mellitus (T2DM) is diabetes resulting from insulin resistance. Obesity and T2DM are sometimes referred to as the “twin epidemics,” due to the impact the pattern of excess fat storage can have on the sensitivity of insulin target organs (such as muscle and liver) to insulin. T2DM is strongly associated with increased risk of cardiovascular morbidity and mortality (Weiss & Caprio, 2008).

total number of students walking and cycling had dropped to less than 13%. These numbers are nearly the reverse for students being driven: in 1969 12% of K-8 students were driven to school, but in 2009 the number being driven to school had skyrocketed to 45% (McDonald, Brown, Marchetti, & Pedroso, 2011). Recommendations from experts agree that for better health, physical activity should be performed regularly. The 2005 Dietary Guidelines for Americans recommend that adults engage in 30 minutes, and children and adolescents engage in at least 60 minutes, of physical activity on most days of the week. A long-term study of children aged 9 to 15 years by Nader, Bradley, Houts, McRitchie, and O'Brien (2008) found that, at ages 9 and 11, more than 90% met the recommended 60 minutes each day; but by age 15, as fewer and fewer children are required to engage in physical activity in school, only 31% met the recommended level on weekdays, and 17% on weekends. Active forms of transportation such as walking and cycling utilized during the school trip provide an opportune way to incorporate physical activity into daily life.

Factors that have led to Low Levels of Walking and Cycling to School

Researchers and advocates seeking to decrease the level of childhood obesity and reverse the trends in walking and cycling to school have identified the primary factors that have led to the low levels of active transportation on the school trip over the past 50 years. These factors include the increasing distance from home to school as a result of the low-density character of land uses in the U.S. and school siting trends, changing family dynamics, and safety concerns regarding traffic and crime.

1. Increasing Distance from Home to School

Due to the increase in time and effort, an increase in trip distance has been shown to result in cycling having a much lower share in mode choice (Moritz, 1998; Zacharias, 2005; Pucher & Buehler, 2006). Over the past half-century two phenomena in particular have contributed to increasing trip distances between students' home and school: the low-density character of land uses in the U.S., and school siting trends.

The Low-Density Character of Land Uses in the U.S.

The option to bicycle is dependent on two elements of the built environment: the spatial distribution of homes, schools, and other destinations, and the connections between those

destinations (Mapes, 2009; McDonald, 2012). The affordability of single-family homes, abundance of cheap gasoline, and the popularity of Euclidean (segregated-use) zoning, among other factors, in the post-war era supported development patterns that were low-density and auto-oriented. Traffic and land use patterns have caused communities to become increasingly isolated and major destinations to be located on busy arterials surrounded by expanses of parking, with the increasing distance removing walking and cycling as viable modes of transportation. There is no easy fix for this problem, except through new development built featuring attributes such as higher residential density, greater mixing of land uses, and improved connections to better link destinations through treatments such as multi-use trails and signalized crosswalks.

School Siting Trends

While neighborhood schools offer the best opportunity for students to walk and bicycle to school, there are many school district policies that result in schools where the majority of students do not have that opportunity. Historic neighborhood schools have increasingly been replaced by large campuses often built on the edge of cities. According to the National Center for Educational Statistics (2014), the number of public schools declined from over 226,000 in 1940 to roughly 99,000 in 2010, during which time the population more than doubled. In times of severely restricted budgets, large campuses allow school districts to accommodate the increasing number of students at a lower cost by increasing the student-to-teacher ratio, reducing the number of facilities that need to be maintained and the number of administrative staff needed to run them. Locations at the edge of cities and metro areas are chosen because the land is less expensive when compared to land closer to students' homes, and there is generally more undeveloped land available to accommodate larger athletic fields. However, these school siting decisions often do not account for personal transportation expenses, infrastructure, and bus transportation costs. Costs would be further increased if schools had to pay for the additional demand they put on the road system.

There has been some success in getting states to drop laws requiring that new schools meet a minimum size requirement. At the urging of the Environmental Protection Agency, the Council of Educational Facility Planners International has changed its guidelines to encourage school leaders to be flexible in deciding how much acreage is needed for a school. What is more difficult is getting school districts to consider the traffic impacts (and by extension the safety

impacts) as well as the impacts on physical activity levels of school siting decisions (Beaumont & Pianca, 2002). Further studies of school district policies that detract from students' ability to walk and bicycle to school, and the role that municipal planners and politicians play in encouraging the relocation and development of these large schools as a catalyst for new development are certainly needed. However, this issue is not related to the objectives of this study.

2. Changing Family Dynamics

With the rise of women in the workforce and two-income families, dropping kids off at school during the morning commute has been cited by parents as the more convenient option (McDonald & Aalborg, 2009). Greater education for parents regarding the importance of walking and cycling to school and increasing the viability of active transportation on the work trip (as seen in countries like the Netherlands) would be needed to overcome this obstacle.

3. Safety Concerns for Traffic and Crime

At any age, a crucial factor influencing the decision whether to bicycle is safety, both real and perceived (Pucher & Buehler, 2012a). A 1999 survey of parents by the Centers for Disease Control and Prevention (CDC) found that, after distance to school, traffic danger and fear of crime were the greatest barriers preventing their children from walking or cycling to school (National Safe Routes, 2008; Mapes, 2009). While parents' concerns related to crime and "stranger-danger"—the danger to children presented by strangers—are certainly important issues that should be addressed, they not the focus of this thesis.

What is relevant is the concern for the danger imposed by traffic, and much of this fear is not unfounded. In the U.S., motor vehicle crashes are the leading cause of death among children aged 3 to 14 years. As much as 21% of morning traffic is generated by parents driving their children to school, (National Safe Routes to School Task Force, 2008), and 50% of children hit by cars while walking to school are hit by parents who are driving their kids to school. Driving to school has so thoroughly penetrated the primary school consciousness that school "arrival" and "dismissal" times have been linguistically recast as "drop-off" and "pickup" hours (Graff, 2009). While there has been a decrease in the percentage of injured cyclists that are children, this likely reflects a decrease in bicycle use by children rather than safer conditions for child cyclists

(Jacobsen, Racioppi, & Rutter, 2009). Despite the risk, virtually all scientific studies show that the health benefits of cycling far offset the traffic dangers (Jacobsen & Rutter, 2012).

The Safe Routes to School Solution

The National Safe Routes to School (SRTS) program created in 2005 was the first federal transportation program addressing concerns about childhood obesity and inactivity, bicycle and pedestrian safety of children traveling to and from school, and traffic and environmental problems around schools. In other countries, programs to promote safer walking and cycling to school, and the SRTS movement in general, were initiated more than 30 years ago. Most of these early efforts focused on addressing dangerous situations for children walking and cycling to school. In the mid-1970s, Denmark had the highest rate of child traffic fatalities in Western Europe. To counter the problem, the City of Odense launched one of the first official programs related to walking and cycling to school in which all 45 of its schools participated. Specific roadway changes were identified and corrected through a variety of measures, such as new pedestrian and bicycle paths, traffic islands, and narrowed roads. Over a 10-year period, child pedestrian and bicycle casualties fell by more than eighty percent. Soon after that, Denmark established what is considered to be the first national SRTS program.

The SRTS concept soon caught on and spread to other countries. Programs in Great Britain in the 1980s and 1990s also focused on reducing hazardous situations for children traveling to school through facilities and design, such as bike lanes, traffic calming and raised crossings. Around that same time, programs in Australia, New Zealand, and Canada were expanding the SRTS model. Their programs addressed the traffic dangers of walking and cycling, but also incorporated more education, encouragement and enforcement elements to increase the number of children that walked and biked to school. In the U.S., programs in New York and Florida were launched in the late 1990s, again focused primarily on the safety of children walking and cycling to school. As additional programs formed, however, the primary focus of SRTS programs shifted to encouraging more students to walk and bicycle on the school trip as a way to improve health. In 1997, Chicago launched the first Walk to School Day in the U.S., marking one of the first large-scale efforts to raise awareness and promote behavior change in school travel patterns (Hubsmith, 2006). In 2000, the National Highway Traffic Safety Association (NHTSA) funded two pilot SRTS programs in Marin County, California and

Arlington, Massachusetts aimed at increasing the number of children walking and cycling to school. These programs were the first in the U.S. to formally incorporate a fifth “E” – evaluation – and acknowledge and promote the fact that they were based on the “5 E’s.” The 5 E’s are, in no specific order:

- Engineering: creating safer environments for walking and cycling to school through improvements to the infrastructure surrounding schools. A major component of this is the addition or repair of sidewalks. Other engineering activities might include the installation of traffic calming measures, traffic signs and signals, roadway crossing improvements, and the development of pedestrian and bicycle facilities. In the broader field of traffic safety literature, this E is sometimes referred to as “Environment.”
- Education: teaching children, parents and caregivers how to walk and bicycle safely and informing motor vehicle drivers how to drive more safely around pedestrians and cyclists. Education programs may also incorporate health and environmental messages.
- Enforcement: changing unsafe behaviors of drivers, pedestrians and cyclists as a way to increase the safety of children walking and cycling to school. Enforcement activities include the control of speeding and traffic volumes in areas where students must cross streets and in school loading zones.
- Encouragement: encouraging children to walk and bicycle to school through activities such as Walk or Bike to School Day, the Walking School Bus, contests, and other special events. This E is the focus of a majority of SRTS programs, with the goal is of improving the health of students by increasing levels of walking and cycling to school.
- Evaluation: collecting information before and after program activities or projects are implemented to allow communities to track progress and outcomes, and provide information to guide program development. Types of information most often collected include student travel mode to and from school, and what the greatest barrier are to walking and cycling to school—both collected through student or parent surveys.

The Marin County program revealed a 64% increase in the number of children walking, a 114% increase in the number of students cycling, and a decrease in the number of students being driven alone of thirty-nine percent. These positive results led to the establishment of a national SRTS model program and toolkit (Staunton, Hubsmith, & Kallins, 2003).

As knowledge of the pilot programs spread, so did awareness of SRTS in general, and many large and small programs were started throughout the United States. Documents were prepared that described the many existing programs and provided guidance on how to start and run a SRTS program (Transportation Alternatives, 2002). Before the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) (P.L. 109-59), however, there were no widely promulgated standards or guidelines regarding what constituted a SRTS program. As a result, some programs covered a single school or a single event in a school, while others covered multiple schools and multiple events. Programs calling themselves SRTS could have any number of the 5 E's and varied in tenure from being funded for a single event to being institutionalized within a community. There were also no standard sources of funding. Some states such as California set up funds specifically for SRTS programs—often for infrastructure improvements—and provided guidelines for their use. In other instances program managers needed to search for funds to cover program expenses, meaning that they could come from federal, state and local governments, as well as private sources. Thus, the SRTS programs established before SAFETEA-LU were very heterogeneous in composition. Their size and primary focus varied significantly, as did their individual longevity (Blomberg, Cleven, Thomas, & Peck, 2008).

In 2005, the U.S. Congress passed SAFETEA-LU. Section 1404 of the transportation legislation designated \$612 million in federal transportation funds for the National Safe Routes to School program from 2005 to 2009, with each state receiving a minimum of \$1 million in funding each year. Under SAFETEA-LU, each state was required to have a SRTS coordinator, and the funds were distributed through each state's Department of Transportation. Every SRTS program was encouraged to encompass all 5 E's. The federal program required that 70% to 90% of funds be directed to infrastructure improvements, and 10% to 30% to non-infrastructure activities such as encouragement activities and education programs that occurred within two miles of schools. Additional requirements and the encouraged reporting methods resulted in greater standardization of new SRTS efforts and an increase in the availability of student travel mode data (National Safe Routes, 2008; Blomberg et al., 2008).

While the creation of the National Safe Routes to School program was the most important initiative for walking and cycling the U.S. for decades, it reached less than 7% of the 98,706 primary and secondary schools in the country (Pucher, Buehler, & Seinen, 2011). The primary

obstacle to more widespread implementation was funding. Of the three E's that directly impact safety—Engineering, Education, and Enforcement—Education has the potential to impact the safety of a greater number of children than infrastructure interventions at a lower cost, and have a more lasting impact than enforcement efforts. For example, constructing one mile of a completely separate (Class I) bike path can cost up to \$1.3 million, more than many states received in SAFETEA-LU funding for an entire year. Even one mile of simple bike lane signing and striping can cost up to \$60,000 (City of Roseville, 2008), and only a limited number of the schools' students would receive the benefits. At \$40 per student for 8 to 9 hours of on-road bike classes taught by a League of American Bicyclists-certified instructor, the funding for a mile-long bike lane could teach 1,500 students how to bicycle safety (Haake, 2009). While there is no denying that bike-specific infrastructure is critical, the short distances that children travel restrict most of the trips to local streets rather than separated infrastructure. In a review of the literature associated with enforcement by Dumbaugh and Frank (2006), it was concluded that enforcement efforts tend to be effective when police are present, but have no long-term effect in changing behavior. Conversely, evaluations of bicycle education programs in the U.S. have indeed found long-term knowledge retention (Kirsch & Pullen, 2003; Thomas, Masten, & Stutts, 2005).

The National SRTS program was the first time that federal transportation dollars were made available for the purpose of educating students on how to bicycle safety. As a result, bicycle education programs sprung up across the country, adding to the existing materials and program types that had been in existence prior to the passage of SAFETEA-LU. Unlike engineering and enforcement interventions, very little is known about the impact of these education programs on the safety of children and adolescent cyclists. With little funding to promote safe, active transportation, providing conclusive evidence that specific improvements such as education make cycling safer is critical.

Previous Evaluations of SRTS Programs and Bicycle Education Programs, and Gaps in the Literature

Of the limited evaluations of SRTS programs, the majority focus on changes in trip mode to active transportation (e.g., walking and cycling). The two that have examined the impact on crash and injury rates focused on pedestrians (DiMaggio & Li, 2013; Oreinstein et al., 2007). The one crash-based assessment of multiple programs evaluated the impact of “legacy” SRTS

programs—programs in existence prior to the passage of SAFETEA-LU in 2005. There is a lack of studies evaluating individual components of SRTS programs. The evaluation efforts of bicycle education in the U.S. have primarily focused on short-term behavioral outcomes of individual programs, such as reported or observed helmet use, or other intermediate measures like observed riding skills and knowledge tests. These studies have generally had positive outcomes; however, these intermediate measures do not indicate whether improved knowledge translates to reduced risk of crashes and injuries. Those few studies that have evaluated safety in terms of crash and injury rates have not shown statistically significant results.

It is evident that there are still large gaps in the literature regarding the effectiveness of SRTS and bicycle education interventions at improving bicycle safety. More specifically, the following gaps in the literature have been identified:

- I. In regards to SRTS programs:
 - A. The impact of SRTS interventions on the safety of children cycling to and from school of SRTS interventions
 - B. Evaluation of different SRTS programs in different contexts
 - C. Evaluation of specific SRTS program components
- II. In regards to bicycle education:
 - A. The impact of bicycle education programs on safety, in terms of crash and injury rates
 - B. Evaluation of different education programs in different contexts

Objectives, Research Questions, Hypotheses, and Significance

To build on the existing body of literature, the objectives of this study are to, first, determine the impact on bicycle safety of implementing a bicycle education program as part of a larger SRTS program; and second, to examine the relative effectiveness of different SRTS bicycle education programs at impacting bicycle safety in order to determine the most effective program type. To address these objectives, the research questions for this study ask:

1. *Does the implementation of a bicycle education program in schools as part of a Safe Routes to School program effect the safety of children and youth cycling?*
2. *What is the effectiveness at improving safety of various types of programs and materials relative to other program and material types?*

The corresponding hypotheses tested for the research questions are, in corresponding order:

1. *The implementation of an in-school bicycle education program as part of a Safe Routes to School program positively impacts the safety of children and youth cycling.*
2. *Those education programs taught by bicycle coalition-trained instructors will be more effective at improving safety than those programs taught by physical education (PE) teachers using the train-the-trainer model.*

For the purpose of this study, “safety,” as employed in the research questions and hypotheses, is defined as the number of motor vehicle collisions involving children and youth cyclists, relative to the number of children and youth cycling for transportation.

With limited funding to promote active transportation to school and active transportation in general, it is important to document the types of programs that have the most proven potential to achieve their intended results. This study also has the potential to impact community program packages aimed at increasing cycling levels while maintaining or improving safety levels.

Research Design

The research design of this thesis is comprised of two parts. The first and most substantial research method is a quasi-experimental crash assessment with a before-after comparison of bicycle crash rates around SRTS treatment schools and control schools. The sample is five SRTS programs that include a school-based bicycle education component³: Boulder Valley School District SRTS, Eugene-Springfield SRTS, Safe Routes Philly, Portland SRTS, and Marin County SRTS. The two units of analysis for the quasi-experimental assessment are the primary jurisdiction or school district in which the SRTS program is located, and the immediate area around elementary or K-8 schools in those jurisdictions or school districts. The unit of measurement is the number of motor collisions involving a cyclist between the ages of 7 and 15 years, in the pre-implementation (2005 and 2006) and post-implementation (2011 and 2012) periods. It was not possible within the present study to associate each bicycle crash victim with a particular school in order to determine if the victim was exposed to a SRTS bicycle education

³ The characteristics of a bicycle education program that is likely to be effective at changing behavior and reducing crash rates were determined through a literature review of previous studies, which is detailed in the following chapter. These characteristics were used in the selection of SRTS programs of study, the process of which is detailed in Chapter 3.

program. Therefore, a proximity analysis using one-quarter mile and one mile buffers around schools was used to associate a particular crash with a SRTS treatment school or a control school. Elementary or K-8 schools were identified as treatment or control using a proxy variable—the presence of data available from the SRTS Data Collection System reported during the years of 2007 to 2012.

The second research method is a trend analysis of bicycle mode share data collected by SRTS programs and reported to the SRTS Data Collection System—is intended enhance the overall assessment of safety if indeed a significant change in crashes is shown around treatment schools when compared to control schools. This data will give insight as to whether a change in the rate of exposure to crash risk caused by a change in the number of students cycling to school as a result of the SRTS programming could have been a factor on the change in crash rate around SRTS treatment schools.

Limitations and Delimitations

It is important to briefly discuss the limitations of this study in order to acknowledge the potential impact on the application and interpretation of the results of this study. This thesis utilizes data made available by the creation of the National SRTS program and from state Departments of Transportation to conduct a safety analysis of local SRTS programs that include a bicycle education component. Through the reliance on secondary data not collected by this researcher, internal validity becomes a concern. The inclusion of a control group is an attempt at overcoming this limitation. A second major threat to internal validity is the use of a proximity analysis to associate a crash with a treatment or control school. This limitation is addressed by evaluating the change in crash rate across the entire calendar year, as well as in the hours around school arrival and dismissal times during the school year. Although this creates a more limited sample size, by limited the evaluation timeframe to estimated school arrival and dismissal times, the distance a child cyclist is likely to have traveled from school in that time is more limited, thereby enhancing the plausibility of a child's association with a particular school and the SRTS treatment.

Organization of the Thesis

The following chapter provides a literature review of the theoretical foundation of bicycle education, previous evaluations of bicycle education programs, and gaps in the literature.

Chapter 3 includes a detailed description of the methodology used in this thesis and the five sample programs, as well as a more detailed discussion of the limitations of the research design.

This is followed by a discussion of the findings from the quasi-experimental crash assessment and bicycle mode share trend analysis, and a reflection on the research questions and hypotheses in Chapter 4. The final chapter, Chapter 5, includes a summary of key findings and discussion of how the findings of this thesis relate to existing literature, the implications of the research, and the opportunities for future study.

Chapter 2 - Literature Review

A broad scan literature review on bicycle education was carried out for three purposes: firstly, to understand the theoretical basis of bicycle education as an injury prevention method; secondly, to assess what is known about bicycle education from previous evaluations and where there are gaps in the literature; and thirdly, to guide the research design for this study and the selection of SRTS bicycle education programs of study. The search process for this review consisted of a comprehensive program of internet searches, journal articles reviews, and an analysis of sources used in prior studies.

Theoretical Framework

To provide a context in which prior evaluations of bicycle education have occurred, a theoretical framework is first established. These theoretical assumptions and generalizations serve to guide research in bicycle education, and are a basis for predicting what might occur.

It is first important to note that cycling in and of itself is not an intrinsically dangerous activity, but it takes place in a dangerous environment where the risk of severe injury or death is imposed by drivers of motor vehicles. This risk is related to the kinetic energy involved, which is proportional to the mass of the moving object multiplied by the square of its velocity (Jacobsen & Rutter, 2012). Several measures can be undertaken to protect cyclists in this environment: developing a protective infrastructure system for cyclists that is separated from motor vehicles (Engineering), traffic calming of residential neighborhoods and traffic regulations and enforcement that give greater protections to cyclists (Enforcement), and traffic education (Education) (Pucher & Dijkstra, 2000).

Similar to driver education, “bicycle safety training programs are based on the premise that behavior by cyclists contributes to risk of crashes and injuries, and that this behavior can be changed through training programs” (Rivara & Metrik, 1998, p. 3). This theory is not unfounded. A 1996 study by the University of North Carolina Highway Safety Research Center found that as many as a third of all bicycle collisions occurred while riding against the flow of traffic—a known dangerous behavior (Mapes, 2009). A 1995 Federal Highway Administration (FHWA) report found that, nationally, police reported one or more cyclist errors that may have contributed to 65% of bicycle-motor vehicle fatalities in 1991. The most common errors were cyclist failure

to yield (21.8%), improper crossing of roadway or intersection (12.6%), and failure to obey traffic signs, signals, or a police officer (8.6%). When taken at face value, however, this data may also mask the failure of motorists to search for and yield to bicycle traffic, as well as the low level of police training in investigating bicycle-motor vehicle crashes. Regardless, these common and avoidable errors are the general focus of education interventions.

Much of the foundation for the development of bicycle education programs and materials developed in the U.S. over the past several decades can be traced to the Cross Study. The Cross Study is the short-hand name given to the NHTSA-sponsored research in the mid-1970s that identified the specific collision situations involving cyclists (Cross & Fisher, 1977). Thirty-six problem types⁴ were identified, along with their frequency and the age groups most often affected. This allowed program developers to determine the specific needs of their target audience and structure the program accordingly. For instance, materials developed for children would be more likely to address cyclists who ride out into the roadway from a residential driveway without yielding to cross traffic, compared to those programs developed for adults, which might address crash types such as motorist left from a parallel, but facing direction.⁵

The Cross Study found that a large proportion of the crash cases were accounted for by a relatively small number of problem types: the 25 most frequently occurring problem types accounted for 87% of the fatal cases (from a sample of 166 fatal collisions) and 93% of the non-fatal cases (out of 753 non-fatal collisions). Seven frequently occurring problem types accounted for nearly 50% of the fatal and non-fatal cases. These seven included:

- Cyclist riding straight out of a driveway or alley without yielding to motor vehicle approaching from the left or right
- Cyclist failing to slow or stop at an intersection controlled by a stop sign
- Motorist attempting to enter a roadway from a commercial driveway

⁴ “Problem types” refers to a group of accidents that exhibited commonality in the traffic context, the operators’ function failures, and the combination of factors causally related to function failures (i.e., weather or lighting) (Cross & Fisher, 1977).

⁵ Due to the differing problem types between child cyclists—who most often ride on sidewalks and quiet residential streets—and adult cyclists—who more often navigate busier collector and arterial roads—many education programs such as

- Without searching or signaling, a cyclist riding along the right-hand edge of the roadway initiates a left-hand turn and collides with an overtaking motor vehicle

A major conclusion of the Cross Study was that the causes of the vast majority of bicycle-motor vehicle collisions are behavioral-related. In well over 60% of the cases, the cyclist's pre-crash course was suboptimal, indicating that a precipitating error was made before the other vehicle could have been observed. The motorist's pre-crash course was suboptimal in about one-fifth of the cases. The implication of this finding was that countermeasures, such as education, must focus on the operator's pre-crash course and behavior, rather than on his response at the time the other vehicle first becomes visible, in order to avoid a substantial number of bicycle-motor vehicle collisions.

Evaluating Traffic Safety Education

The main goal of traffic safety education—vehicular, bicycle, and pedestrian—is preventing casualties. The logical measurement for evaluations would therefore be crash and injury rates. However, the Institute for Road Safety Research has recommended against using crash involvement or the numbers of casualties for measuring the effect of education. Reasons for this are that education programs need an assessment criterion that is directly related to the behavior that is being taught; and because crashes rarely happen and are caused by a concurrence of, often random, circumstances. The Institute recommends using intermediate variables such as self-reported behavior as well as actual behavior (SWOV, 2013). However, the Cross Study's identification of 36 specific problem types caused by a similar combination of factors and events, and the fact that these problem types have continued to be relevant since they were first identified nearly 40 years ago, challenges the assertion that—at least in the case of cyclists—collisions are caused by a concurrence of random circumstances. This theory that a large number of collisions are not random and unavoidable, and that education could reduce the occurrence of these common collision types, is reflective of the call from other researchers for further crash- or injury-based evaluations of bicycle education programs (Clarke & Tracy, 1995; Thomas et al., 2005).

Previous Evaluations

Echoing the recommendations of the Institute for Road Safety Research, most available evaluations of bicycle education programs have focused on limited outcomes such as reported helmet use or other intermediate measures like observed riding skills, knowledge tests, or reported behaviors. A summary of the authors, year, country, research design, and the key results of these studies is shown in Table 1.

In 1998, Rivara and Metrik carried out an extensive critical review of available programs and materials in the U.S. to determine which were the most effective, or potentially effective, for various target audiences. The review identified few well-documented evaluations of specific bicycle safety programs. Where evaluations had occurred, most were based on before-after questionnaires, and some were based on demonstration of riding skills in controlled settings such as playgrounds. The authors noted that other studies of injury programs have shown that there is little known correlation between changes in knowledge and reported behavior on the one hand, and actual changes in observed behavior and risk of injuries on the other. Two common themes emerged, however, from the review:

1. Bicycle safety education curriculum for youth should be institutionalized in a school environment to reach more children consistently.
2. Bicycle education curriculum should be presented as a continuum of traffic safety education extending throughout a child's school years.

There have been several evaluations of brief bicycle safety interventions implemented in school settings. In Canada, an evaluation of a skills training session—the Kids CAN-BIKE Festival—failed to demonstrate any improvement in safe cycling behavior, knowledge or attitudes (Macarthur et al., 1998). In contrast, three evaluations of brief classroom interventions in U.S. schools did show increases in children's knowledge of safe riding practices (Kirsch & Pullen, 2003; Nagel et al., 2003; McLaughlin & Glang, 2010).

Table 1. Bicycle Safety Education Studies that Measured Behavior, Knowledge, and Attitude

Author(s), Year, and Country	Study Design ^a	Study Population	Intervention	Primary Outcome Measure	Key Study Results
Macarthur et al. 1998 Canada	RCT	<p>Target group:</p> <ul style="list-style-type: none"> 4th grade students at 3 schools <p>Control group:</p> <ul style="list-style-type: none"> 4th grade students at 3 schools in the same city 	Kids CAN-BIKE Festival: 90 min. playground-based course taught by trained and certified instructors.	Safe cycling behavior, knowledge, and attitudes.	This brief skills training course was not effective in improving safe cycling behavior, knowledge or attitudes.
Rivara & Metrik 1998 United States	Qual. case study	Available bicycle safety education programs and materials.	N/A	Which programs were the most effective or potentially effective.	Two common themes emerged: <ol style="list-style-type: none"> 1. Bicycle safety education curriculum for youth should be institutionalized in a school environment to reach more children consistently. 2. Bicycle education curriculum should be presented as a continuum of traffic safety education extending throughout a child's school years.
Kirsch & Pullen 2003 United States	NRCT	<p>Target group:</p> <ul style="list-style-type: none"> Children grades 5-6 that had participated in program while in 4th grade at one of the participating schools <p>Control group:</p> <ul style="list-style-type: none"> Same-grade children that did not attend 4th grade at one of the participating schools 	<p>Safe Central Program:</p> <ul style="list-style-type: none"> • Video • Letter sent home with bicycle-related crash facts • Custom-fit bicycle helmet for each student 	Student-reported knowledge of safety related behaviors, and reports of current safety-related practices.	A statistically significant association was found between participation in the program and retention of knowledge and enactment of safety messages after a 1- and 2-year period.

Nagel et al. 2003 United States	NRCT	Students in grades 1-3 at 4 suburban elementary schools.	<i>Bicycle Safety Camp</i> video, accompanied by a structured discussion of bicycle safety rules	Knowledge of safe riding behaviors and the proper way to wear a bicycle helmet.	Increased cognitive knowledge of basic bicycle safety rules, which was retained over a 1-month period of time.
McLaughlin & Glang 2010 United States	RCT	Target group: • Children grades K-3 that received Bike Smart program Control group: • Same-grade children that received a video on childhood safety	Bike Smart: an eHealth software program	<ul style="list-style-type: none"> • Knowledge of safety rules, helmet placement, and hazard discrimination • Behavioral measure of helmet placement 	Regardless of gender, cohort, and grade the participants in the target group showed greater gains than control participants in both the computer-presented knowledge items and the observational helmet measure.
Lachapelle et al. 2013 United States	NRCT	Children that participated in the New Jersey Bike School program in 3 New Jersey schools and 9 summer camps.	Two bicycle education programs, both part of New Jersey Bike School program: 1. More structured program delivered in a school setting with no on-road component 2. Less structured program delivered in a summer camp setting that included an on-road component	Knowledge of helmet use and other equipment, bicycle safety, and the ability to discriminate hazards and understand rules of the road.	<ul style="list-style-type: none"> • Both summer camp and school-based programs recorded similar improvements in test results. • Children who cycled with their parents scored higher on the pre-test but did not improve as much in the post-training test.

^a RCT=randomized controlled trial; NRCT=nonrandomized study using a pre/post design and/or a comparison group.

These studies do not make it known whether children apply learned knowledge and skills, and whether improved riding behavior actually translates into a reduced risk of crashes and injuries.

Very few studies have evaluated safety in terms of crash rates. Those studies that have are outlined in Table 2. Of the five available U.S. studies, the source of injury data in all but one study were self-reports by students (Kimmel & Nagel, 1990; Preston, 1980; Stutts & Hunter, 1990; Thomas et al., 2005). In the fifth study, an evaluation of the Harlem Injury Prevention program in northern Manhattan, NY, severe injury rates were based on hospital discharge and death certificate data (Durkin et al., 1999). While a decrease in crash rates among children that had received bicycle education or were proficient in safe cycling rules was shown in all of the U.S. studies, the results were not statistically significant. Findings of crash analyses differed outside of the United States. Two self-report studies in the United Kingdom, one of Road Safety Units and the other of students at two schools, evaluating a widely-used comprehensive educational intervention program found no evidence that training produced safer attitudes or obedience to safe rules, and no evidence of a reduction in the risk of crashes (James, 1993; Colwell & Culverwell, 2002). Similarly, a case controlled study of a widely implemented comprehensive program in Australia found no evidence of a decreased risk of injury requiring a hospital visit among children, and even evidence of an increase in bicycle-related injury among some sub-groups (Carlin et al., 1998).

Table 2. Bicycle Safety Education Studies that Included Analysis of Injury Frequency or Severity

Author(s), Year, and Country	Study Design ^a	Study Population	Intervention	Primary Outcome Measure	Key Study Results
Preston 1980 United States	NRCT	School children	N/A	<ul style="list-style-type: none"> • Cycling proficiency • Previous bicycle training • Crash rate 	<ul style="list-style-type: none"> • Children who failed the cycling proficiency test had much higher accident rates than other children. • Boys who had been trained and passed the cycling proficiency test had slightly lower accident rates than other boys, but this did not apply to girls.
Kimmel & Nagel 1990 United States	NRCT	<p>Target group:</p> <ul style="list-style-type: none"> • Children grades 4-8 that reported prior bicycle instruction <p>Control group:</p> <ul style="list-style-type: none"> • Same-grade children that reported no prior bicycle instruction 	N/A	<ul style="list-style-type: none"> • Knowledge of 3 basics bicycling rules of the road • Use of bicycle helmets • Occurrence and severity of previous bicycle accidents 	<ul style="list-style-type: none"> • The target group was more likely to be knowledgeable than those receiving no instruction regarding rules 2 and 3: always stop at a stop sign/red light, and always stop and look when approaching a street from a driveway or alley. • Children who lacked knowledge of basic bicycling rules were more likely to have had a significant bicycling accident.
Stutts & Hunter 1990 United States	NRCT	<p>Target group:</p> <ul style="list-style-type: none"> • Children grades 4-5 attending two schools in Mebane, NC. <p>Control group:</p> <ul style="list-style-type: none"> • Same-grade children attending two schools in Graham, NC. 	Basics of Bicycling: 7 40-minute lessons, 2 in the classroom and 5 “on-bike” (simulated traffic environment)	<ul style="list-style-type: none"> • Knowledge of bicycle safety issues • Safe riding skills and practice • Helmet use • Injury experience, prior to the implementation and in summer following 	<ul style="list-style-type: none"> • While the target group was less likely to be involved in a bike crash and less likely to be injured than the control group, the sample size was too small for this finding to be reliable. • Target group outperformed the control group in knowledge tests and performance on a simulated road environment course.

James 1993 United Kingdom	NRCT	Road Safety Units of County Councils and London Borough Councils	N/A	<ul style="list-style-type: none"> • Method of bicycle training: off-road or on-road • Number of instructors required for training • Accident rate of county or borough 	Training had little effect on child accident casualty statistics.
Carlin et al. 1998 Australia	NRCT	Target group: <ul style="list-style-type: none"> • Children ages 9 to 14 admitted to the emergency room with injuries received while cycling Control group: <ul style="list-style-type: none"> • Same-age children from the same city. 	Bike Ed: 3 curriculum stages: (1) basic traffic rules covered in classroom, (2) practice riding in school yard, and (3) supervised ride on local streets	Risk of bicycle injury.	<p>Analysis showed no evidence of a protective effect and suggested a possible negative effect of exposure to the bicycle safety course. This association was not substantially altered by adjustment for sex, age, socioeconomic status, and exposure.</p> <ul style="list-style-type: none"> • Previous study of program (Trotter & Kearns, 1983) showed successful improvement in bicycle riding knowledge and riding performance when compared with control group. This did not appear to translate to reductions in the risk of injury.
Durkin et al. 1999 United States	NRCT	Target group: <ul style="list-style-type: none"> • Persons age <17 years in northern Manhattan, NY Control group: <ul style="list-style-type: none"> • Persons age <17 years in the rest of Manhattan, NY 	Harlem Hospital Injury Prevention Program: <ul style="list-style-type: none"> • Safety City – traffic safety ed. in classroom simulated traffic environment • Bike safety clinics and helmet dist. 	Severe traffic injury rates, based on hospital discharge and death certificate data.	<p>Target group:</p> <ul style="list-style-type: none"> • 36% decrease in traffic injuries. • Peak incidence of ped. and bicycle injuries occurred during summer months and afternoon hours. • Peak incidence of bicyclist injuries among 9-15 year olds. <p>Control group:</p> <ul style="list-style-type: none"> • Similar decrease in traffic injuries was not shown.

Colwell & Culverwell 2002 United Kingdom	NRCT	<p>Target group:</p> <ul style="list-style-type: none"> Students from 2 schools that reported prior bicycle training <p>Control group:</p> <ul style="list-style-type: none"> Students from same schools that reported no prior bicycle training 	N/A	Accidents, attitudes, and behavior.	No relationship between training and accidents was found.
Thomas et al. 2005 United States	NRCT	<p>Target group:</p> <ul style="list-style-type: none"> Children grades 4-5 in programs that included an on-bicycle training component and that involved more than one encounter with students <p>Control group:</p> <ul style="list-style-type: none"> Same-grade children who had never received an in-school, on-bicycle safety course 	<p>Bicycle safety programs that used on-road training:</p> <ul style="list-style-type: none"> Bicycle Safety Program (Oregon) BikeEd (Oahu County, Hawaii) <p>Bicycle safety programs that used closed-course training on school grounds:</p> <ul style="list-style-type: none"> Basics of Bicycling (NC) Elementary Traffic Safety Education Program (Carson City, NV) 	<p>Short-term:</p> <ul style="list-style-type: none"> Student knowledge tests Student surveys on bicycle access, safety behaviors, and riding practices Parent survey on child's riding practices <p>Long-term:</p> <ul style="list-style-type: none"> Student knowledge tests Student surveys on bicycle access, riding practices, safety behaviors, and crashes 	<ul style="list-style-type: none"> All programs resulted in increase in knowledge and improvements in reported frequency of safe riding behaviors and amount and enjoyment of bicycling. Sustained improvement in knowledge among those who had had a course compared with those who hadn't. The courses taught on-road showed greater improvement in more areas and better overall outcomes than those taught on a closed course. However, many confounding factors outside the programs could also affect the outcomes. <p>Factors associated with the most successful course outcomes:</p> <ul style="list-style-type: none"> On-road training Lower student to instructor ratios More sessions/time on bike, and providing bikes and helmets for all students More consistent program delivery

^a RCT stands for randomized controlled trial; NRCT stands for nonrandomized study using a pre/post design and/or a comparison group.

Summary of the Literature

Due to the contradictory and inconclusive results of previous studies, there is a need to further document whether educational interventions reduce the risk of crashes and injuries by improving children's actual safe riding behaviors. Regardless of these inconclusive results, several commonalities can be drawn from these safety evaluations, in terms of the characteristics of education programs considered suitable for this level of evaluation. In all of the studies that were evaluating a specific educational intervention—as well as the two United Kingdom studies that were generally, though not specifically, evaluating the National Cycling Proficiency Test (and after 2000, what became the national Bikeability program)—several common program characteristics appear. Firstly, all of the bicycle education programs were implemented in school settings; secondly, the evaluations all measured children over the age of 8 and under the age of 15, and between grades 4 through 8; thirdly, the programs of study all had an “on-bike” component (riding in a simulated traffic environment or riding on local roads); and finally, all of the programs involved more than one element (e.g., education in a classroom setting and riding in a simulated traffic environment). The presence of these common characteristics in existing evaluations supports their use as a guide for selecting programs that have previously been considered worthy of evaluation.

The literature reviewed in this chapter is necessary to identify the existing gaps in the literature of bicycle education that have prevented the realization of its effectiveness as an injury prevention method, and to guide the research design detailed in Chapter 3.

Chapter 3 - Methodology

The objective of this thesis is to evaluate the effectiveness of various SRTS programs with a comprehensive bicycle education component at improving the safety of children and youth cycling. From the definition of “safety” first described in Chapter 1, a mixed method approach is necessary. The mixed method approach in this study consists of two primary methods. First, a quasi-experimental crash assessment with a before-after comparison of schools receiving the SRTS treatment and control schools provides the ideal assessment of crash rates before and after the SRTS educational intervention. The independent variable is the presence of a SRTS program with a comprehensive bicycle education program. As such, the treatment group is comprised of those elementary and K-8 schools within the program area that have received the SRTS program, and the control group consists of those elementary or K-8 schools that have not received the SRTS program. The unit of measurement is the number of motor vehicle collisions involving a cyclist between the ages of 7 and 15 years, before and after program implementation. There are two units of analysis in this study:

1. One quarter mile and one mile around elementary and K-8 schools in the jurisdiction or school district of study; and
2. The jurisdiction or school district of study.

The analytical strategy consists of two stages: matching collision incidences obtained from state Departments of Transportation with treatment or control schools using a proximity analysis in a GIS in order to derive the collision sample data, and using inferential statistics to determine the significance of this data.

The second method applied in this thesis is a trend analysis of bicycle mode share data—the percent of students cycling to and from school—collected by SRTS programs and retrieved from the National Center Data Collection System. This method is intended to indicate whether a change in the number of students cycling, which causes a change in the rate of exposure to crash risk, is reflective of a significant change in crash rate that may be found from the crash assessment, and may be a potential cause for the change in crash rate.

Since the schools were not randomly assigned as treatment or control schools, and collisions were assigned to a treatment or control school using distance as a proxy variable for the person’s actual school of attendance, internal validity is a potential concern. Nevertheless, the

inferences from this study can add to the dialogue on the effectiveness of SRTS bicycle education programs as an injury prevention method and its potential value as part of local policies to promote cycling. The rest of this chapter goes into detail about the search process for the SRTS programs of study, the characteristics of those programs, the quasi-experimental crash assessment, the trend analysis of bicycle mode share, and the issues of validity.

Safe Routes to School Study Programs

Selection of Study Programs

In order to conduct a safety analysis of SRTS bicycle education programs and determine their presence at a school, it is first necessary to identify those programs. In Chapter 2 several common characteristics of education programs previously evaluated for their impact on crash and injury risk were identified. These commonalities serve as the program selection criteria for this study. These characteristics, which a SRTS program with bicycle education had to possess in order to qualify for inclusion in this study, are as follows:

1. The bicycle education component is implemented in a school setting;
2. The education targets children between the ages of 8 and 14, or 4th to 8th grade;
3. It incorporates an on-bike riding element, such as riding in a simulated traffic environment on the playground or riding on local roads; and
4. It involves more than one activity or activity occurrence (i.e., education of traffic rules in a classroom setting and riding in a simulated traffic environment).

In order to meet the goals of this study and the research design, the SRTS programs also had to possess the following characteristics:

5. Instruction is provided to at least half of all elementary or K-8 schools within the jurisdiction or school district study area.

During the initial identification of education programs throughout the U.S., it was revealed that many programs were only implemented in a very limited number of schools relative to the number of schools in the area. This criterion was considered necessary in order to have a large enough sample of treatment and control schools to help reduce internal validity issues.

6. The program has provided bicycle education instruction for at least two years.

After the program search revealed that many programs only conducted the educational intervention one time, this criterion was intended to allow for the inclusion of a greater number of SRTS programs than any longer length of time, but still be a long enough time that safety levels could have feasibly been impacted.

7. The SRTS program regularly collects data on student travel mode to and from school using the National SRTS Student Travel Tally Sheet, and reports these findings to the National SRTS Data Center.

This information is necessary not only to evaluate any change in ridership and level of exposure to risk as a result of the program, but also proved necessary for efficiently determining whether enough schools were receiving the program (to satisfy criterion 5), and how long the program had been in place (to satisfy criterion 6).

Furthermore, the presence or lack of travel mode data for each school in the program area was used to determine whether the school had received the treatment program and whether it would be classified as a treatment or control school.

To identify the programs, a wide-ranging search for SRTS programs that incorporated bicycle education was conducted. Internet searches, published literature, and funding data reported on the National Center for SRTS website (www.saferoutesinfo.org) were reviewed to identify candidate programs. The results of the search are summarized in Appendix B. The five SRTS programs that were identified through this search as meeting the criteria listed above, and the jurisdiction(s) in which they are located are:

- Boulder Valley School District (Boulder Valley) Safe Routes to School (Boulder County, Colorado)
- Eugene-Springfield Safe Routes to School (Eugene and Springfield, Oregon)
- Safe Routes Philly (Philadelphia, Pennsylvania)
- Portland Safe Routes to School (Portland, Oregon)
- Marin County Safe Routes to School (Marin County, California)

Description of Study Programs

In order to conduct a study of the safety impacts of the subject SRTS programs, I collected in-depth information on each program included. I decided that any evaluation of the impact of SRTS programs on crashes must first classify the programs on the basis of their goals,

the extent of their implementation, the sources and extent of program funding and evaluation efforts, and the characteristics of their education component. The following summaries of each program were modeled off of the program summaries developed by Rivara and Metrik (1998) and the taxonomy developed by Blomberg et al. (2008).

Boulder Valley School District Safe Routes to School

Administration: In general, the City of Boulder applies for funds to construct school access improvements, while BVSD takes the lead on education and encouragement programs (City of Boulder, 2011).

Goal Statement: “Through fun encouragement events and educational activities, the program aims at raising the appeal, convenience, and safety of walking and cycling to school for the development of active, healthful children” (Boulder Valley School District, 2014b, Program Goal, para. 1).

Start Date: 2005 (City of Boulder, 2011).

Number of Public Elementary/K-8 Schools in Program Area: 34, not including charter schools (Boulder Valley School District, 2014a).

Number of Public Elementary/K-8 Schools Participating in Program: 21 (Bike to School Day Proclamation, 2013).

Source of Funding: 100 percent federally funded and managed by the Colorado Department of Transportation. As of 2011, the City of Boulder’s Transportation Division has been awarded over \$1 million in SRTS funding. BVSD has received over \$200,000 for education and outreach projects (City of Boulder, 2011).

Evaluation Efforts:

- Regular student tally surveys and parent surveys at schools that have participated in Safe Routes activities.
- The 2011 SRTS Program Update prepared by City of Boulder staff provided an overview of the projects completed since 2005 and the new applications.

Bicycle Education Program: Bicycle Lesson and Safety Training (BLAST). “The [BLAST] program covers a curriculum designed to teach and develop the skills and knowledge required for safe and effective cycling” (Adams et al., 2012, p. 3).

- Target Age: 5th and 6th grades (City of Boulder, 2011).

- Length of Program: 180 minutes, or 3 hours of Physical Education (PE) class time.
- Instructors: Taught by trained BLAST instructors with the assistance of the PE teacher (Adams et al., 2012).
- Curriculum Components:
 - Helmet Fitting
 - Basic Bike Check
 - Hazards
 - Starting and Stopping
 - Bike Parking/ Locking
 - 3 Rules: (1) Ride in the same direction as traffic, (2) obey all traffic signs, and (3) signal your turns.
 - Riding on a Path
 - Controlling, Scanning, Signaling
 - Riding with Traffic/Laws
- Meets State Education Requirements: Yes.

Eugene-Springfield Safe Routes to School

Administration: Regional coordinators—4J School District, Bethel School District, and Springfield Public Schools (Eugene Springfield, 2013b).

Goal Statement: “The Eugene Springfield Safe Routes to School mission is to serve a diverse community of parents, students and organizations: advocating for and promoting the practice of safe bicycling and walking to and from schools throughout the Eugene Springfield area” (Eugene Springfield, 2014, Getting up to Speed, para. 1). Four major goals and activities make up the program’s approach to encourage more people to walk and bike to school safely: (Eugene Springfield, 2013a)

1. Develop a SRTS Support Team for Individual Schools’ SRTS Programs.
2. Implement Developmentally Appropriate Bicycle and Pedestrian Safety Education Curriculum into the 4J/Bethel School Districts (K-8).
3. Develop Safe Routes to Schools Media/Event Network.
4. Establish policies that support the development of safer walking and cycling to K-8 schools.

Start Date: 2007 (McDonald et al., 2013).

Number of Public Elementary/K-8 Schools in Program Area: (Point2Point, 2012)

- Eugene 4J School District (SD): 30 schools (including charter) serving grades K-8.
- Bethel SD: 9 schools serving K-8.

Number of Public Elementary/K-8 Schools Participating in Program:

- Eugene 4J SD: All 30 schools participate to some extent in SRTS programming. Eighteen elementary schools and six middle schools receive bicycle education.
- Bethel SD: All nine schools participate to some extent in SRTS programming. Five elementary schools and two K-8 schools receive bicycle education.

Source of Funding: Oregon Safe Routes to School, the Central Lane MPO STP-U, and the Jane Higdon Foundation. From 2007 to 2011, Eugene-Springfield SRTS received over \$1.5 million in Oregon SRTS grants, nearly \$300,000 of which was for non-infrastructure purposes (Point2Point, 2012).

Evaluation Efforts:

- A study of the Eugene SRTS program by researchers at the University of North Carolina at Chapel Hill and the University of Oregon found that between 2007 and 2011 education and encouragement programs were associated with a five percentage point increase in cycling. Augmenting education programs with additional SRTS improvements such as sidewalks, crosswalks, covered bike parking, and Boltage was associated with increases in walking and cycling of five to 20 percentage points. Data on school trip mode share for the quasi-experimental study design was collected through three survey instruments: the National Center for SRTS's Student Travel Tally sheet, the National Center for SRTS's Parent Survey form, and a specialized survey on school travel developed by the University of Oregon that asked about usual travel mode to school (McDonald et al., 2013).

Bicycle Education Program: Bicycle Transportation Alliance (BTA) "Safe Routes for Kids - Bicycle Safety Program Curriculum" (2003).

- Target Age: 4th to 7th grades.
- Length of Program: 10 lessons, 55 to 60 minutes each, of hands-on instruction time.
- Instructors: BTA-trained instructor.
- Curriculum Components:

- Benefits of cycling
 - Helmet fitting
 - Checking a bicycle for safety/basic mechanisms
 - Navigating intersections
 - Rules of the road—traffic laws
 - Addressing riding hazards and repairing flat tires
 - Identifying and avoiding cycling hazards/ most common causes for crashes
 - Scanning for traffic
 - Proper cycling techniques for riding in traffic
 - How to yield and properly turn through intersections and driveways
 - Neighborhood bike ride/ bike rodeo
 - Neighborhood ride and written test: students either go on the road for the final practice ride or go through a series of cycling activities for post-testing.
- Meets State Education Requirements: Yes.

Safe Routes Philly

Administration: Safe Routes Philly is a program of the Bicycle Coalition of Greater Philadelphia (BCGP); however, it is also a partnership among the BCGP, the School District of Philadelphia (SDP), and the Philadelphia Department of Public Health (Safe Routes Philly, 2014; Get Healthy Philly, 2013).

Goal Statement: “Safe Routes Philly promotes biking and walking as fun, healthy forms of transportation in Philadelphia Elementary Schools. We provide pedestrian and bicycle safety programming and support for elementary schools in Philadelphia” (Safe Routes Philly, 2014, About, para. 1).

Start Date: 2010 (Safe Routes Philly, 2011).

Number of Public Elementary/K-8 Schools in Program Area: 174.

Number of Public Elementary/K-8 Schools Participating in Program: 132 (Get Healthy Philly, 2013).

Source of Funding: Safe Routes Philly’s teacher training program from 2010 to 2012 was made possible by the Communities Putting Prevention to Work funding from the Department of Health

and Human Services and Philadelphia Department of Public Health’s Get Health Philly Initiative (Get Health Philly, 2014; Get Healthy Philly, 2013).

Evaluation Efforts: Documented in the report “Safe Routes Philly Final Report: Summary of the Findings from Two Years of Intervention (2010-2012),” the following methods were used to evaluate training and curriculum adoption (Steif, 2012):

- Post-Training Survey: delivered after teacher trainings to measure teacher satisfaction, knowledge acquisition, institutional support, and confidence in ability to implement the curriculum.
- Teacher Completion Form: completed by teachers after lesson implementation to track which lessons were being taught, when they were being taught, how many students, and at which grade levels.
- Student Travel Talley: the survey developed by the National Center for SRTS, and used by teachers during the fall and spring semesters to track students’ primary method of commuting to school.
- 5th Grade Evaluation Surveys: two short, post-lesson surveys—one to measure knowledge and one to measure attitude, behaviors, and perceptions about cycling—conducted at six elementary schools. A baseline survey was administered immediately following the training in fall of 2011 and a follow-up in the spring of 2012.
- Parent Focus Groups: the Bicycle Coalition convened a series of five focus groups to learn how parents of Philadelphia public elementary school students feel about cycling. While these five sessions took place in distinct geographical regions of Philadelphia, the Coalition heard common concerns for safety, and these concerns made the parents reluctant to let their elementary school student bicycle more than a few blocks from home unaccompanied. These concerns were caused by a lack of trust in motorists, a lack of trust in their child to be careful, fear of bullies and criminal activity, and a lack of safe bicycle storage.

Bicycle Education Program: Safe Routes Philly Curriculum

- Target Age: 5th grade.
- Length of Program: three classroom lessons (10, 15, and 20 minutes), and one 45-minute PE lesson (Traffic Simulation).

- Instructors: Using a train-the-trainer model, Safe Routes Philly staff trained 211 educators in Philadelphia public elementary schools to implement the bicycle safety lessons. Trainings occurred during eight in-service professional development days, on-site workshops after school, and during 30 one-on-one technical assistance workshops. Providing (state-adopted) Act 48 credit was cited as an important incentive to encourage teachers to attend trainings (Get Healthy Philly, 2013).
- Curriculum Components: (Safe Routes Philly, 2010)
 - Fitting a helmet
 - Check a bike for safety (Bike ABC's)
 - Correct signals for left turn, right turn, and stop
 - Being predictable
 - Being visible
 - Identifying hazards (optional)
 - Understanding traffic signals and laws (e.g., at what age cyclists must start riding on the road)
- Meets State Education Requirements: Yes (Safe Routes Philly, 2011).

Portland Safe Routes to School

Administration: The program is managed by the City of Portland, with services provided by Alta Planning + Design, Bicycle Transportation Alliance, Trauma Nurses Talk Tough, and Oregon Acts (Portland Bureau of Transportation, 2007; Portland Bureau of Transportation, 2012b).

Goal Statement: “Portland Safe Routes to School is a partnership of the City of Portland, schools, neighborhoods, community organizations and agencies that advocates for and implements programs that make walking and biking around our neighborhoods and schools fun, easy, safe and healthy for all students and families while reducing our reliance on cars” (Portland Bureau of Transportation, 2014b, “Safe Routes to School,” para. 1).

Start Date: 2000 (in 2005 Portland SRTS initiated the 5-E pilot project) (City of Portland, 2012).

Number of Public Elementary/K-8 Schools in Program Area: 63 (Oregon Spatial Data Library, 2011).

Number of Public Elementary/K-8 Schools Participating in Program: 9 (National Center, 2014b).

Source of Funding: The majority of funding comes from traffic-fine revenue, with the rest from state and federal grants (City of Portland, 2012).

Evaluation Efforts: Surveys are mailed to the parent/caregiver of student households twice a year, once in October and once in May. There were slight alternations to the survey after spring 2009, but the survey has remained essentially the same since fall 2009. The survey consists primarily of a week-long trip log of student travel to and from school. In addition, there are several questions that allow parents to share their thoughts and concerns regarding walking and cycling, how the student's school encourages active transportation, and the impact of the SRTS program on student travel habits (Portland Bureau of Transportation, 2013a).

- “Safe Routes to School Parent Survey Results fall 2006 – fall 2012” is a series of charts, graphs, and tables summarizing that walking and cycling continues to rise while transport in family vehicles is trending down. These graphics indicate a sharp increase in bicycle mode share since spring 2012 (Portland Bureau of Transportation, 2013b).
- “City of Portland Safe Routes to School Fall 2013 Student Travel Survey Report.” The summary of the fall 2013 survey reviews the progress thus far of Portland's SRTS program. Results of the survey revealed that students living closest to school (under one-half mile) walked or biked 74% of trips to and from school. The highest bicycle mode share across distances from school was shown by students living between one-half mile and one mile of school, who biked 14% of trips to and from school (Portland Bureau of Transportation, 2013a).

Bicycle Education Program: Bicycle Transportation Alliance (BTA) “Safe Routes for Kids - Bicycle Safety Program Curriculum (2003).”

- Target Age: 4th to 7th grades.
- Length of Program: 10 lessons, 55 to 60 minutes each, of hands-on instruction time.
- Instructors: BTA-trained instructor.
- Curriculum Components:
 - Benefits of cycling
 - Helmet fitting
 - Checking a bicycle for safety/basic mechanisms
 - Navigating intersections
 - Rules of the road/traffic laws

- Addressing riding hazards and repairing flat tires
 - Identifying and avoiding cycling hazards/most common causes for crashes
 - Scanning for traffic
 - Proper cycling techniques for riding in traffic
 - How to yield and properly turn through intersections and driveways
 - Neighborhood bike ride/bike rodeo
 - Neighborhood ride and written test: students either go on the road for the final practice ride or go through a series of cycling activities for post-testing.
- Meets State Education Requirements: Yes.

Marin County Safe Routes to School

Administration: Transportation Authority of Marin (TAM), with the help of Parisi Associates, Marin County Bicycle Coalition, and Alta Planning + Design (Marin County, 2011).

Goal Statement: “Safe Routes to Schools programs are designed to decrease traffic and pollution, and increase the health of children and the community. Safe Routes to Schools promotes walking and biking to school, using education and incentives to show how much fun it can be! The program addresses parents’ safety concerns by educating children and the public, partnering with traffic law enforcement, and developing plans to create safer streets” (Safe Routes to Schools Marin County, 2012a, “Safe Communities, Green Communities,” para. 1).

Start Date: 2000 (Marin County, 2011).

Number of Public Elementary/K-8 Schools in Program Area: 42, not including charter schools (Marin County Office of Education, 2013).

Number of Public Elementary/K-8 Schools Participating in Program: 70% of the county’s public elementary schools, not including charter schools (Marin County, 2011).

Source of Funding: Marin County Safe Routes to School is funded through Marin County Measure A and Measure B, which are supplemented by outside grants. Current core funding for the program (Measure A and Measure B) is approximately \$700,000 per year, but the current operating budget with outside grants is \$1,000,000 per year. Measure A, a 20-year half-cent transportation-related sales tax, was passed by Marin voters in 2004, making Marin County the first county in the country to provide long-term funding for its SRTS programs. Of the \$36.5 million 20-year projected revenue allocated to school access programs, \$11 million is dedicated

to education and encouragement programs and the rest is split between the Crossing Guard program and a capital funding program. Measure B, passed in 2010, authorized a ten dollar increase in motor vehicle registration fees for the exclusive purpose of funding local transportation projects and programs. A portion of the funds is directed to School Safety and Congestion Management, which includes the Crossing Guard program and providing matching funds for the SRTS programs. Additionally, outside grants received since 2000 total over \$13 million. Over \$350,000 of the outside grant funds were awarded through the SAFETEA-LU SRTS funds in 2007, one of the 16 grants sources used to fund the program. Across all funding sources, education and encouragement activities account for 47% of the program's current operating expenditures (Safe Routes to School Draft Work Scope, 2013).

Evaluation Efforts: Evaluation of Marin County's program involves documenting trends through student surveys conducted in the fall and spring of each school year, as well as periodic parent surveys. For student surveys, the "before" survey is generally administered at the beginning of the semester in which Safe Routes education is offered and the "after" survey is taken at the conclusion of the school year. This information is then sent to the National Center for SRTS. Student surveys have been conducted since the fall of 2003. Parent questionnaires have been administered three times, in 2006, 2007, and 2011. The survey was distributed at the schools and could be mailed back or completed online (Marin County, 2011).

Bicycle Education Program: Marin County Safe Routes to School Curriculum: Bicycle Safety, Traffic Safety, and Bicycle Rodeo (Safe Routes to School Marin County, 2012b).

- Target Age: 4th grade.
- Length of Program:
 - Bike Safety: 30 to 45 minutes, or 60 minute extension (Lesson 1 of 3).
 - Traffic Safety: 30 to 45 minutes, or 60 minute extension (Lesson 2 of 3).
 - Bicycle Rodeo: 45 to 60 minutes (Lesson 3 of 3).
- Instructors: Marin County Bicycle Coalition instructors.
- Curriculum Components:
 - Bicycle Safety: Benefits of cycling, ABC bike check, bicycle fit, helmet fit, and key phrases for safe riding—pay attention, leave space.

- Traffic Safety: Using a small-scale road and models, proper cycling technique is demonstrated. Topics covered include traffic laws, recognizing that bikes and cars share the same road and rules, and navigating a stop sign intersection.
- Bicycle Rodeo: Correctly stopping and starting, riding over obstacles, traffic awareness, and obeying traffic laws.
- Meets State Education Requirements: Yes.

Summary of Programs

To complete the narrative of the SRTS programs included for study in the thesis, the frequencies of the various descriptive parameters that were collected are summarized. These include the SRTS programs' administrators, goals, sources of funding and the extent of program evaluation, and the SRTS bicycle education programs' length, instructors, and curriculum components.

- Administration. All of the programs involve a partnership of organizations. Four (out of the five) partnerships include a public authority such as a city or county, three include a school district or districts, and three are comprised of a bicycle coalition as one of the organizations. While not all of the programs are administered by the local school district, it should be noted that due to the in-school nature of these programs, all include a minimum level of cooperation on behalf of the local school or school district.
- Goal Statement. In terms of the goals of the program, as generally stated in a goal statement, four programs' goals included improving health, three programs' goals addressed safety, two programs mentioned reducing traffic and pollution, and three cited a desire to increase the appeal of walking and cycling (presumably as a means of addressing one of the previous three goals).
- Sources of Funding. One program relied solely on the SRTS funds created through SAFETEA-LU—Boulder Valley SRTS. In contrast, the Safe Routes Philly organization, even though it is modeled after the National SRTS program's 5 E's philosophy and reports data to the National Center for SRTS, has not received any SRTS funds from SAFETEA-LU—with any federal SRTS funds going directly to individual schools. Marin County SRTS and Portland SRTS both have institutionalized sources of funding that comprise the majority of their operating budget: a dedicated half-cent sales tax and

percentage of vehicle registration fees for Marin County, and traffic-fine revenue for Portland.

- Evaluation Efforts. While, all of the SRTS programs included for study in this thesis collect data on student travel mode for the National SRTS Data Collection Center, Boulder Valley SRTS is the only program that does not actually analyze this data to track progress. Eugene-Springfield SRTS is the only program that has had a higher-level evaluation of the impact of the SRTS program on mode share, beyond a basic trend analysis of the data. Noting the weak research design employed in previous evaluations (specifically citing the 2003 Marin County evaluation as an example), researchers at two higher education institutions used control schools as part of a quasi-experimental research design to assess the impact on mode share of the Eugene SRTS program as a whole, and of various combinations of the 4 E's implemented at schools, using the Student Travel Tally. Portland SRTS also assessed which of the 4 E's had the greatest impact on changing students' travel mode to active transportation, but this was evaluated using parental perceptions as reported in parent surveys. Safe Routes Philly, Portland SRTS, and Marin County SRTS have all taken parental thoughts and concerns into consideration when evaluating program effectiveness.
- Bicycle Education Programs.
 - Length of the Education Program. Of the four different bicycle education curriculums represented in this study, the Safe Routes Philly curriculum is the shortest, with a maximum program time of one and a half hours covering four lessons. The Marin County SRTS curriculum and Boulder's BLAST program are of slightly longer duration, requiring one and a half to three hours. BTA's Safe Routes for Kids program, implemented in Portland and Eugene schools is by far the longest program, with ten lessons that require 55 to 60 minutes each.
 - Instructors. Four of the five programs are taught by instructors trained specifically for that bicycle education program, such as volunteers or paid instructors from the administering bicycle coalition. The Safe Routes Philly curriculum is taught by PE teachers who generally receive a one-time training in the program.
 - Curriculum Components. There are four education components that appear in all four curriculums: fitting a helmet; bicycle checks; understanding and obeying

traffic laws and signs; and scanning, signaling, and general traffic awareness. Additional components, and the number of curriculums in which they appear, are as follows:

Hazards – identifying and avoiding: 3

Starting and stopping: 2

Navigating intersections: 2

Riding in traffic: 2

Benefits of cycling: 2

Additional components only covered by one of the programs: bike parking and locking (BLAST), riding on a path (BLAST), being predictable and visible (Safe Routes Philly), bike fit and leaving space (Marin County SRTS).

Geographic Boundary of Program Evaluation

Once the programs had been identified, it was considered necessary for any comparison of the programs to make the areas of study consistent across the programs, as they previously varied in the number of jurisdictions and school districts covered. Since crash data is often reported at the jurisdiction-level, the programs were limited in area of study to one jurisdiction where possible. The political and administrative boundaries of study assigned to each program are as follows:

- Boulder Valley School District (Boulder Valley) SRTS: Boulder, Colorado
- Eugene-Springfield SRTS: Eugene, Oregon
- Safe Routes Philly: Philadelphia, Pennsylvania
- Portland SRTS: Portland, Oregon
- Marin County SRTS: San Rafael Elementary School District, San Rafael, California

Safe Routes Philly and Portland SRTS were the only programs to not have their reach restricted, as the programs were already geographically bounded by the political boundaries of the City of Philadelphia and the City of Portland, respectively. Boulder Valley SRTS and Marin County SRTS were limited to the largest city in the county. However, Marin County SRTS had to be further defined because, as illustrated by Figure 9 in Chapter 4, mountainous terrain nearly divides the City of San Rafael in half, with San Rafael Elementary School District and the majority of the city's elementary schools to the south and only two elementary schools in the

Dixie School District to the north. The land use mix and street density—two factors that have been shown to directly affect cycling frequency and safety (Cervero & Duncan, 2003; Ladrón de Guevara, Washington, & Oh, 2004)—differ greatly between these two halves, with southern San Rafael comprising the county’s governmental and commercial center and a diversity of other land uses, and the northern half of the city dominated by lower density residential land uses. Due to these factors and the greater number of elementary schools participating in the SRTS program located in southern San Rafael, San Rafael Elementary School District was selected as the geographic boundary of study for the Marin County SRTS program.

Eugene, OR was selected as the study area for Eugene-Springfield SRTS because the city was the original boundary for the program before it expanded a few years after creation to include schools in Springfield, OR. The differing number of years that the program had been in place between the two cities was considered a threat to internal validity. Therefore, Eugene, OR was selected as the program area of study.

The rest of the chapter discusses the methods employed in this thesis for evaluating these programs.

Measurement Technique

Quasi-Experimental Crash Assessment

The principal methodological challenge of this study was how to conduct a crash-based assessment of SRTS bicycle education programs when SRTS programs are typically school-based while crash data is generally aggregated at the jurisdiction level. The use of jurisdiction-wide crash data in an evaluation of various SRTS bicycle education programs would have been possible if more than one jurisdiction could be found in which the program was implemented in almost all schools. The program search described earlier in this chapter revealed that this was not the case (although the programs in Boulder, CO and Portland, OR came the closest). Therefore, to associate a specific crash with a particular school and the SRTS treatment, all crash reports for the jurisdiction or school district of interest would have to be accessed, geocoded, and the victim’s school enrollment traced—a process that would be impossible for a civilian researcher because of the identity confidentiality of crash data, and extremely time consuming regardless.

To overcome this obstacle, a proximity analysis was used to associate a crash and the cyclist involved with a particular elementary school and the presence of the treatment program.

Under this approach, crashes that occurred within one mile of an elementary or K-8 school were assigned to either the treatment group or the control group, depending on that school's involvement in the SRTS program. One mile was selected as the maximum distance because existing research indicates that most crashes occur within one mile of the cyclist's house, and within just a few short blocks from home for individuals under the age of 18 (Clarke & Tracy, 1995). If a crash was within one mile of two or more schools, then the measurement tool in a GIS was used to determine which school it was nearest to, and it was assigned to the treatment or control group accordingly.

To help account for any external forces that might have occurred in a given year, aggregated crash data for two years prior to program implementation, and two years after program implementation were used for the pre/post comparison. 2005 and 2006 (period A) were used as the base years across all programs because SAFETEA-LU SRTS funding was initiated in 2005 but the first local SRTS data did not reach the national clearinghouse until 2007 (National Center, 2012). The years 2011 and 2012 (period B) were selected as the post-implementation comparison because 2012 was the most recent data available from state Departments of Transportation.

Analytic Strategy

Once the crashes were appropriately assigned to treatment or control schools, the collision locations were broken out further for evaluation: to all those collisions within one mile of schools, and to only those collisions occurring in the immediate vicinity of schools (one-quarter mile). Collisions were also evaluated based on the time of year in which they occurred. As SRTS programs generally focus on the trip to and from school, it was of interest whether any change in riding behavior and the associated impact on crash risk was limited to the school trip, or whether it also translated to the rest of the calendar year. Classifying a collision as occurring on the school trip was based on estimated school calendar and bell time information, and the dates of weekends and school holidays. A crash was included in the school year series if it occurred between the dates of August 10th and May 30th (with the exception of December 24th to January 2nd in which most children are on Christmas/New Year's break; and the Labor Day,

Thanksgiving, Martin Luther King Jr. Day and Memorial Day holidays⁶); on a week day (Monday through Friday); and between the hours of 6:30 a.m. and 5:00 p.m.

In Chapter 4, seven tables, one for each of the five program areas and two that aggregate the data across all program areas, summarize the findings of the raw crash data for the treatment and control schools during the pre- and post-implementation periods, over the entire calendar and just during the school year, and at the two distances of one-quarter mile and one mile from schools. These tables indicate a general positive or negative trend in the crash data between the two periods for the different subgroups of analysis.

Independent samples t-tests were conducted in SPSS to determine whether the observed differences between the treatment and control groups are, in fact, statistically significant. The *Significance (p)* values indicate whether the association revealed by the time series model is greater than can be expected based on chance alone. If this value is less than 0.05, it indicates that there was a statistically significant increase or decrease in crashes over time for the treatment series. For each program area and the aggregated data, a table summarizing the findings of the t-tests follows the table and accompanying analysis of the raw crash data. Based on the time series and distance subgroups of analysis, there are four possible t-tests that can be conducted for each program area's data and the aggregated data: one, each, at the two buffer distances (one-quarter mile and one mile) around schools, over the calendar year and during the school year.

Crash Data

The bicycle crash data used in this study was retrieved from the Colorado, Oregon, and Pennsylvania Departments of Transportation, and the Statewide Integrated Traffic Records System (SWITRS) interactive GIS map maintained by the University of California, Berkeley for the California crash data. Collision characteristics of interest included a cyclist as one of the parties involved; the age of the cyclist; the year, date, and time of the collision; and the location of the collision. Collision data was extracted from state crash data if it: (1) involved a cyclist between the ages of 7 and 15 years; (2) occurred in the years 2005, 2006, 2011, and 2012; and

⁶ In the U.S., Labor Day is celebrated on the first Monday in September, Thanksgiving on the final Thursday in November, Martin Luther King Jr. Day on the third Monday of January, and Memorial Day on the last Monday in May.

(3) occurred in one of the SRTS program areas of study. While a criterion for program selection was that the program targeted individuals between the ages of 8 and 15 years, 7 years was selected as the minimum age to allow for any slight deviation of program implementation that may occur in schools.

Mode Share Trend Analysis

The second part of the safety analysis is a secondary data trend analysis used to determine whether the implementation of the SRTS programs had any impact on the number of students cycling to and from school. This is an essential part of evaluating safety, because any increase in cycling corresponds to an increased exposure of cyclists to the risk of collisions, and a decrease in cycling to a decrease in exposure to risk. Under this assessment, there could be several potential outcomes:

- A decrease in the number of crashes while cycling rates remain constant or increase would translate into an increase in safety
- An increase or decrease in crashes proportional to the increase or decrease in ridership would indicate that there was no effect on safety
- An increase in crashes and a decrease in ridership, a decrease in safety

To promote consistency in data collection methods, the National SRTS Evaluation Plan (National Center, 2011) recommends student travel to and from school be measured using the Student Talley Sheet developed by the National Center for SRTS. Data collection under the 2005 SAFETEA-LU legislation is voluntary by states and communities, though it is recommended in the Guidance. To encourage participation in evaluation efforts, the National Center developed an online data entry and reporting system in 2007. It is from this platform that the bicycle travel mode data was gathered for use in this study.

Limitations of Study

Safe Routes to School Data

The crash analysis and the mod share trend analysis are both dependent on the information provided to the National SRTS Data Center. The schools that were shown to have submitted data to the National Center in a general search of schools on the National Center's website were classified as treatment schools, and all other public elementary or K-8 schools

within the program area were then classified as control schools. This classification, in turn, impacts whether a crash site is reported as being within the vicinity of a treatment or control treatment school, for the purpose of this study.

The general narrative of transportation mode shift is also dependent on the information provided to the National SRTS Data Center. Therefore, any inconsistency in the number of schools or the presence of particularly influential schools reporting data across the study timeframe has the potential to skew results and reveal an inaccurate portrayal of bicycle mode share trends.

Use of Proximity Analysis to Associate Crashes

It was not possible within the present study to associate each bicycle crash victim with a particular school in order to determine if the victims were exposed to a SRTS program. A proximity analysis was instead used to associate each crash with a treatment or control school. Crashes were associated with a school if they occurred within a buffer distance of one mile of that school. The use of proximity opens up the possibility that a bicycle crash, and the cyclist involved, can be incorrectly associated with the presence of a SRTS program, or lack thereof.

State Crash Data

The primary limitation of using crash data provided by state Departments of Transportation is the lack of uniformity among state data sets. When using crash datasets, regardless of the source, there are some systematic issues that are not easily addressed. For example, a state or police agency may change its crash reporting form, which in turn affects how the data is reported. To illustrate this dilemma, the Portland Police Bureau changed its policy regarding mandatory crash investigations for bicycle-related crashes in January of 2008. Prior to 2008, a cyclist would have to sustain a trauma-level injury to warrant a crash investigation by Portland police. Since 2008, a cyclist just has to be transported by ambulance to a hospital to warrant a crash investigation. This change in policy has resulted in an increased number of investigations of bicycle collisions since 2008 (Portland Bureau of Transportation, 2012a). Also, some states may report crashes that other states do not report. An example relevant to this study would be whether or not a state reports bicycle crashes that occur on private property. This can vary among states as well as among police agencies within a state (Blomberg et al., 2008). In California a reported collision can occur on private property (California Highway Partol, 2008),

but in Oregon and Pennsylvania it must occur on a public roadway to be reported (Oregon Department of Transportation, 2012; Pennsylvania Department of Transportation, 2010).

Number of Crashes

As addressed in previous studies (Blomberg et al., 2008; National Center, 2011), the number of crashes for any particular school would likely be too small to allow for any valid statistical analysis. To help account for this limitation and increase the sample size, crash data is aggregated among treatment and non-treatment schools, and across multiple years. Even so, the lower crash rates in small municipalities such as Boulder, CO and San Rafael, CA could make drawing reasonable conclusions difficult. It is also important to note that the crash data used here are only based on police reported crashes between motor vehicles and bicyclists. In particular, no data on incidents involving bicyclists alone (e.g., fall) or pedestrian and bicyclist interaction is included because there are no standardized reports for these events. National data from FHA indicates that 70% of bike injuries resulting in a visit to the emergency room do not involve a motor vehicle, and 31% occurred on non-roadway locations (e.g., off-street paths) (Stutts & Hunter, 1990). Any future in-depth analysis of the safety effects of SRTS programs might profitably include an examination of these non-motor vehicle related events from data such as emergency room records or self-reports (Blomberg et al., 2008).

External Impacts

With any analysis similar to the one conducted here, it is nearly impossible to account for the effects of other ongoing safety programs or policies in the focus communities or for other changes in the environment that may be affecting crashes. The use of comparative series from control schools and an examination of bicycle crash trends for other ages is helpful for determining if any observed effect in the focus series are the result of a general trend. Nevertheless, no causal inferences are made here; rather, the data are described in terms of crash patterns and the differences among the patterns for the various crash series that were examined (Blomberg et al., 2008).

Chapter 4 - Results

This chapter outlines the findings from the quasi-experimental crash assessment and the trend analysis of SRTS bicycle mode share data. The chapter is broken out into five subsections, one subsection for each program area and one for the examination of aggregated data across all program areas. The discussion of findings for each SRTS program area is supplemented by two tables and two figures. The first table summarizes the absolute and percentage change in crash frequency from the pre-implementation period A (2005 and 2006), to the post-implementation period B (2011 and 2012), for the treatment and control groups. The data in this table is presented for two timeframes—bicycle crashes involving 7- to 15-year old cyclists that occurred across the entire calendar year, and those crashes that occurred during the school year arrival and dismissal times (from here on, simply referred to as the school year). A map showing the location of these crashes in the pre-implementation and post-implementation periods is included to supplement the analysis of the raw crash data by providing a visual reference. The second table for each SRTS program area displays the results of the independent samples t-tests, indicating whether the difference between the change in crash rate for the treatment and control groups is statistically significant. The second and final figure for each SRTS program area displays the results of the second study method: the trend analysis of bicycle mode share data for the treatment schools. The mode share data retrieved from the National SRTS Data Center for each SRTS program is displayed in a scatter plot diagram with a linear trend line. The accompanying narrative relates the trend analysis of bicycle mode share to the quasi-experimental crash analysis, and provides a conclusion of the results for that program area.

The aggregate-level subsection is laid out similarly to those of the individual program areas, as described above, but does not include a supplemental crash map or mod share diagram. Two tables summarize the absolute change in crash frequency from the pre-implementation to the post-implementation periods for each program area—the first table summarizing the data for crashes that occurred across the entire calendar year and the second table those crashes that occurred only during the school year. The third table in this subsection summarizes the findings of the independent samples t-tests conducted at the aggregate level. Finally, the chapter concludes with a summary of results across all SRTS program areas and at the aggregate level, a

re-statement of the initial research questions and hypotheses, and answers the research questions based upon the observed results.

Boulder, Colorado SRTS Program Area

The raw data for crashes involving all cyclists, and cyclists aged 7- to 15-years is summarized in Table 3 and spatially displayed in Figure 1. The slight increase in bike crashes, post-implementation, involving the target age group likely reflects the slight increase in bike crashes for all age groups. There were no bike crashes around the two control schools in either the pre- or post-implementation periods. This may reflect a concerted effort by the program coordinator to target those schools with the greatest safety concerns. As a result of the absence of control data, tests of significance could not be conducted on the difference in crash data between treatment and control school areas. Around those schools that did receive the SRTS treatment, the data reveals an average increase of one bike crash within one mile of schools over the calendar year, but no change in crash rate during the school year. The mapped collision locations in Figure 1 reveal that they are relatively dispersed throughout the City of Boulder, with a slight clustering north of the University of Colorado, Boulder along Pearl Street.

Table 3. Bicycle Crashes in Boulder, CO Involving Individuals Aged 7 to 15 Years

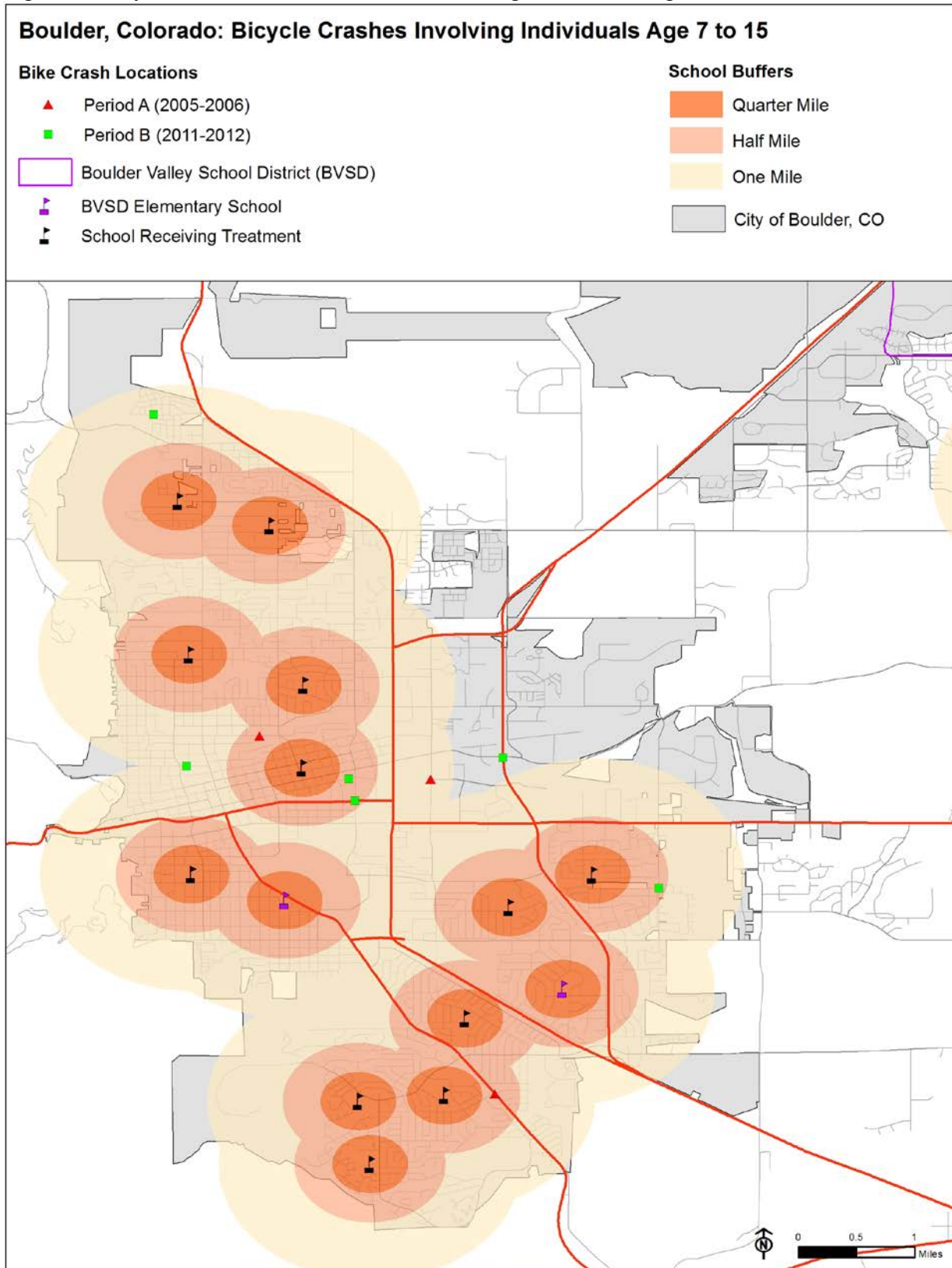
Boulder, CO	(A)	(B)	(B-A)	(B-A)/A
Total Bike Crashes	176	182	6	3.4%
Age 7-15 Bike Crashes, Calendar Year	3	5	2	66.7%
Treatment Schools ^a				
Within 1/4 mile	0	0	0	0.0%
Within 1 mile	3	5	2	66.7%
Control Schools ^b				
Within 1/4 mile	0	0	0	0.0%
Within 1 mile	0	0	0	0.0%
Age 7-15 Bike Crashes, School Year	1	2	1	100.0%
Treatment Schools				
Within 1/4 mile	0	0	0	0.0%
Within 1 mile	1	1	0	0.0%
Control Schools				
Within 1/4 mile	0	0	0	0.0%
Within 1 mile	0	0	0	0.0%

Source: Colorado Department of Transportation (2014)

^a Number of treatment schools, $N=12$

^b Number of control schools, $N=2$

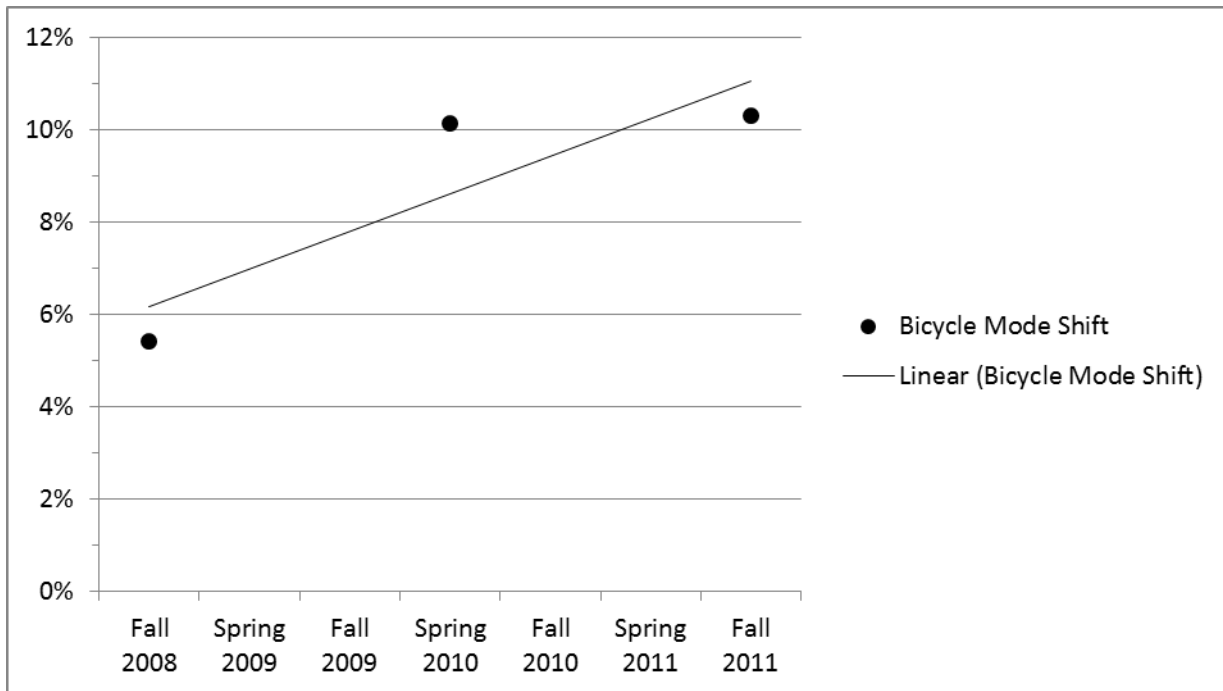
Figure 1. Bicycle Crashes in Boulder, CO Involving Individuals Aged 7 to 15 Years



Source: Colorado Department of Transportation (2014)

SRTS-documented mode shift using Travel Tally Surveys for Boulder, CO is shown in Figure 2. The seasons with the greatest number of schools reporting results—fall 2008, fall 2010, and fall 2011—had 10, 11, and 11 out of 15 possible schools, respectively, reporting SRTS data. The number of schools for each season of program reporting is shown in Table C1 of Appendix C. Of the seasons with the greatest number of schools reporting results, there was an increase in the number of students cycling to school of approximately 5% from fall 2008 to fall 2011.

Figure 2. SRTS Boulder – Change in Students Traveling by Bicycle to and From School



Source: National Center for Safe Routes to School (2013)

In summary, from the pre-implementation period to the post-implementation period there was an average increase of one crash involving 7- to 15-year old cyclists within one mile of SRTS treatment schools over the calendar year (from 3 crashes to 5 crashes), but there were no crashes within one mile of control schools reported in either period. It could not be determined whether this difference in crash rate was significant due to the absence of data for the control group. The supplemental data provided in Table 3 and Figure 2 may indicate that the increase in crashes involving 7- to 15-year old cyclists reflects the increase in crashes involving cyclists of all ages; and that the increase in crashes around SRTS treatment schools is reflective of the sharp increase in the number of students cycling reported by the SRTS program. However, the extent

to which these factors correlated with or impacted the crash rate was not examined within the scope of this study beyond this basic narrative.

Eugene, Oregon SRTS Program Area

The crash results of the quasi-experimental crash analysis for Eugene, OR are shown in Tables 4 and 5 and Figure 3. From the pre-implementation period (A) to the post-implementation period (B), the number of crashes involving cyclists of all ages decreased by 23, or fifteen percent. For those crashes involving 7- to 15-year olds, there was an average decrease of three crashes, or sixty-seven percent. This would likely suggest that the decrease in bike crashes involving the target age group is a reflection, to some extent, of the overall decrease in crashes during that time period. In the areas around public elementary and K-8 schools, there was a relatively significant decrease in crashes involving the target age group immediately surrounding (-3 crashes) and within one mile (-5 crashes) of treatment schools, but no change at a distance of one mile or less from control schools.

Table 4. Bicycle Crashes in Eugene, OR Involving Individuals Aged 7 to 15 Years

Eugene, OR	(A)	(B)	(B-A)	(B-A)/A
Total Bike Crashes	149	126	-23	-15.4%
Age 7-15 Bike Crashes, Calendar Year	9	3	-6	-66.7%
Treatment Schools ^a				
Within 1/4 mile	3	0	-3	-100.0%
Within 1 mile	7	2	-5	-71.4%
Control Schools ^b				
Within 1/4 mile	0	0	0	0.0%
Within 1 mile	1	1	0	0.0%
Age 7-15 Bike Crashes, School Year ^c	6	2	-4	-66.0%
Treatment Schools (N=13)				
Within 1/4 mile	3	0	-3	-100.0%
Within 1 mile	5	1	-4	-80.0%
Control Schools (N=10)				
Within 1/4 mile	0	0	0	0.0%
Within 1 mile	1	1	0	0.0%

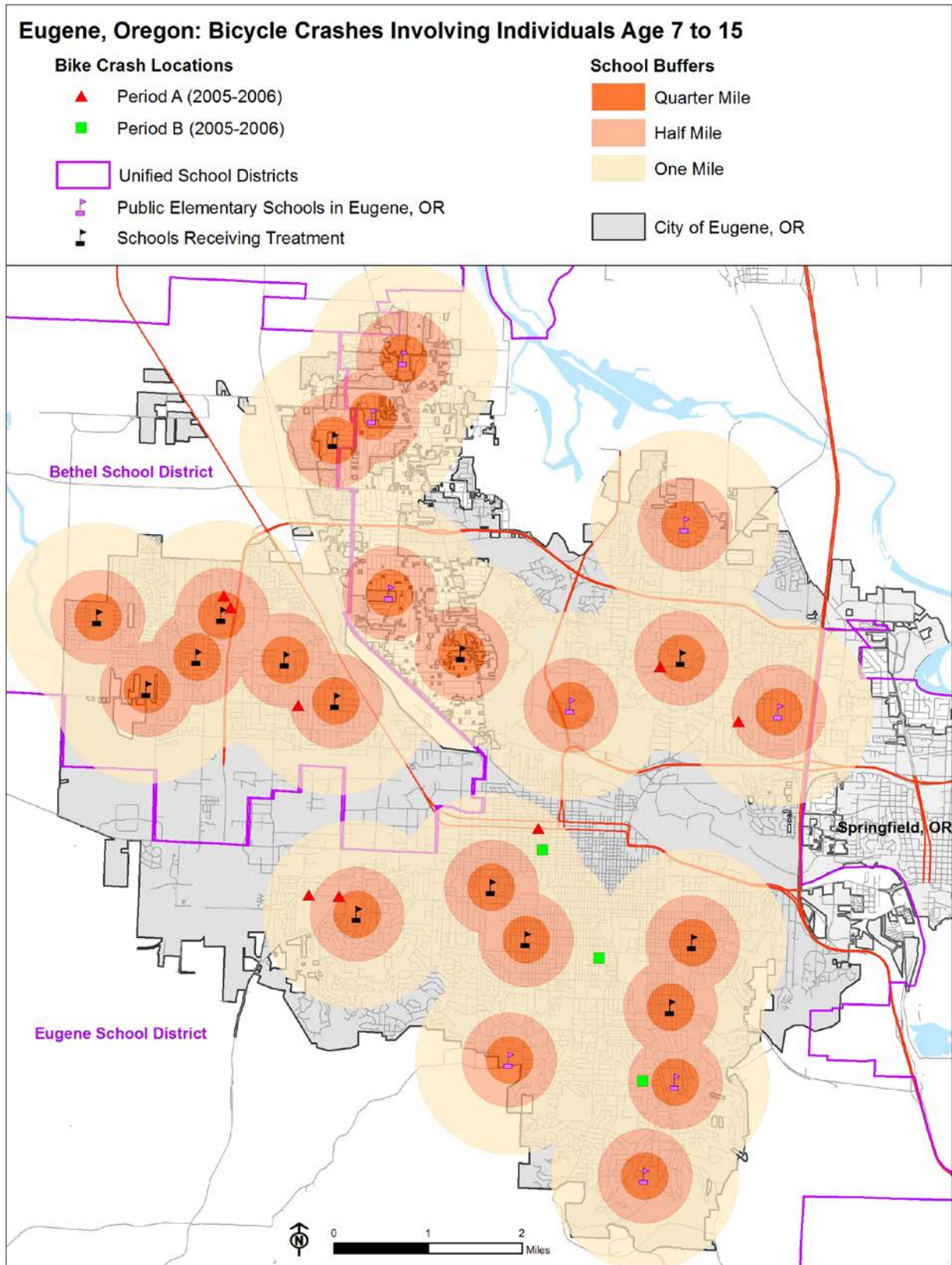
Source: Oregon Department of Transportation (2014a)

^a Number of treatment schools, N=13

^b Number of control schools, N=10

^c During Period A there was not time and date information available for all crashes, therefore the crash numbers during the school year may be slightly skewed.

Figure 3. Bicycle Crashes in Eugene, OR Involving Individuals Aged 7 to 15 Years



Source: Oregon Department of Transportation (2014a)

Independent samples t-tests were conducted to compare crash rates between treatment schools and control schools for each analytical framework. No statistically significant differences were found in the change in crash rates between treatment and control schools at either school buffer distance during the school year or over the calendar year. Table 5 summarizes the results.

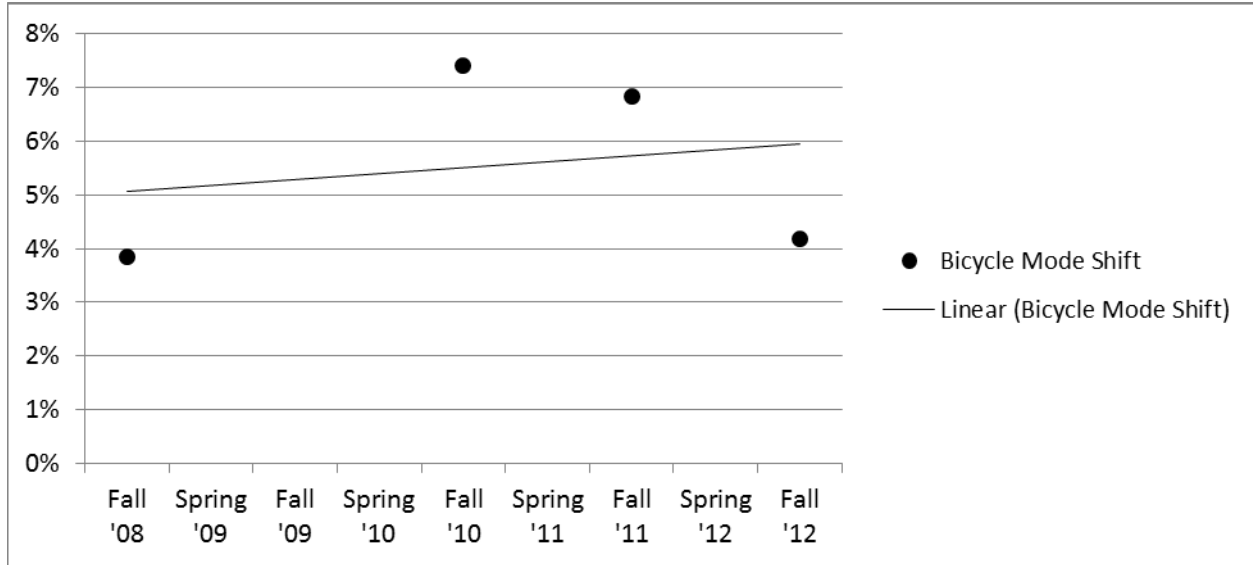
Table 5. Independent Samples t-Tests for Eugene, OR

Timeframe	School Buffer Distance	School Group	N	M	SD	t	Sig. ^a
Calendar Year	Within 1/4 mile	Treatment	13	-.23	.599	1.211	–
		Control	10	.00	.000		
	Within 1 mile	Treatment	13	-.38	.870	1.259	–
		Control	10	.00	.471		
School Year	Within 1/4 mile	Treatment	13	-.23	.599	1.211	–
		Control	10	.00	.000		
	Within 1 mile	Treatment	13	-.31	.855	1.022	–
		Control	10	.00	.471		

^a Sig: “–” = $p > 0.05$; “*” = $p < 0.05$

SRTS-documented mode shift using Student Travel Tally Surveys for Eugene, OR is shown in Figure 4, along with a linear trend line to identify a positive or negative trend in the data. The seasons of program reporting with the greatest number of schools reporting results—Fall 2008, Fall 2010, Fall 2011, and Fall 2012—had 10, 8, and 7 out of 15 possible schools, respectively, reporting SRTS data reported results. The number of schools for each season of program reporting is shown in Table C2 of Appendix C. Using the SRTS program data from these time periods, the chart reveals an overall positive trend in the number of students cycling to and from school.

Figure 4. Eugene-Springfield SRTS – Change in Students Traveling by Bicycle to and From School



Source: National Center for Safe Routes to School (2013)

The quasi-experimental crash assessment of 7- to 15-year old cyclists in Eugene, OR revealed a decrease in crashes within one mile of treatment schools that was not shown around control schools. While this difference in the change in crash rate between treatment and control schools was not statistically significant, the increased rate of exposure from more students cycling to and from SRTS treatment schools revealed by the trend analysis indicates that the Eugene-Springfield SRTS program did not negatively impact the safety of children and adolescent cyclists by encouraging students to bicycle.

Philadelphia, Pennsylvania SRTS Program Area

The crash results for Philadelphia, PA are detailed in Table 6 and shown in Figure 5. From the pre-implementation (A) to the post-implementation (B) periods, there was an average decrease in bike crashes involving 7- to 15-year olds of 43% (or 59 fewer crashes). For treatment schools there was either a slight increase or no change in crash rate immediately around schools for the two timeframes analyzed, but a decreased crash rate within one mile of schools for both timeframes. Control schools experienced a decreased crash rate within one mile of schools over the calendar year; but when the timeframe was limited to the school year, an increased crash rate within one mile.

Table 6. Bicycle Crashes in Philadelphia, PA Involving Individuals Aged 7 to 15 Years

Philadelphia, PA	(A)	(B)	(B-A)	(B-A)/A
Total Bike Crashes	--	--	--	--
Age 7-15 Bike Crashes, Calendar Year	271	154	-117	-43.2%
Treatment Schools ^a				
Within 1/4 mile	31	32	1	3.2%
Within 1 mile	58	48	-10	-17.2%
Control Schools ^b				
Within 1/4 mile	59	50	-9	-15.3%
Within 1 mile	131	95	-36	-27.5%
Age 7-15 Bike Crashes, School Year ^c	37	24	-13	-35.1%
Treatment Schools				
Within 1/4 mile	2	2	0	0.0%
Within 1 mile	6	4	-2	-33.3%
Control Schools				
Within 1/4 mile	5	11	6	120.0%
Within 1 mile	10	21	11	110.0%

Source: Pennsylvania Department of Transportation (2014)

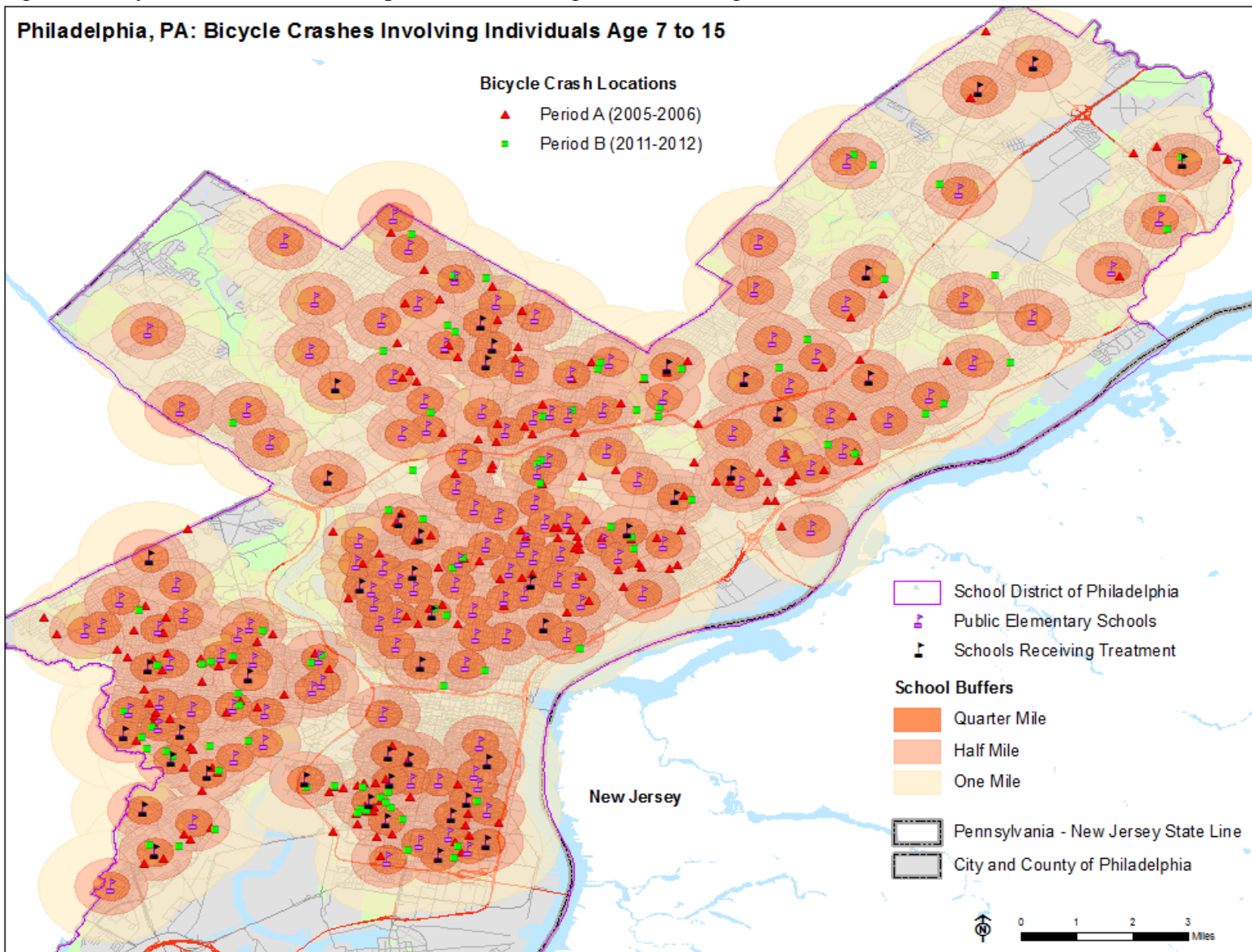
^a Number of schools, $N=47$

^b Number of schools, $N=117$

^c Time and date information was not available for all crashes.

As shown in Figure 5, there is some spatial clustering of crashes in the Philadelphia, PA program area. Those clusters of crash locations are shown in South Philadelphia, West Philadelphia, North Philadelphia, and the lower neighborhoods of Northeast Philadelphia such as Frankford. This likely reflects the higher population density in those areas, as a higher density of elementary and K-8 schools can be seen in these areas as well.

Figure 5. Bicycle Crashes in Philadelphia, PA Involving Individuals Aged 7 to 15 Years



Source: Pennsylvania Department of Transportation (2014)

The difference in the change in crash rate between treatment and control schools were examined at the two timeframes and two school buffer distances of analysis, by four independent samples t-tests. As shown in Table 7, there were no statistically significant differences in the change in crash rate between treatment and control schools at either buffer distance in the two timeframes.

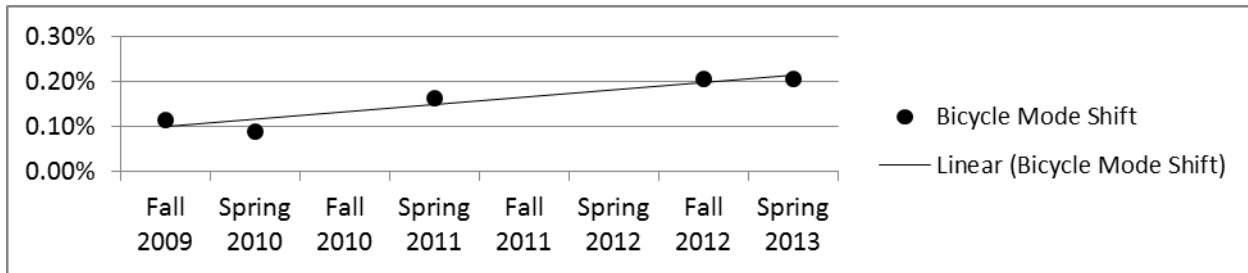
Table 7. Independent Samples t-Tests for Philadelphia, PA

Timeframe	School Buffer Distance	School Group	N	M	SD	t	Sig. ^a
Calendar Year	Within 1/4 mile	Treatment	47	.04	.932	.500	–
		Control	117	-.03	.870		
	Within 1 mile	Treatment	47	-.30	.998	.589	–
		Control	117	-.16	1.444		
School Year	Within 1/4 mile	Treatment	47	.04	.292	.324	–
		Control	117	.03	.307		
	Within 1 mile	Treatment	47	.06	.567	.052	–
		Control	117	.07	.487		

^a Sig: “–” = p>0.05; “*” = p<0.05

SRTS-documented mode shift using Student Travel Tally Surveys for Philadelphia, PA is shown in Figure 6. The seasons of program reporting with the greatest number of schools reporting results—Fall 2009, Spring 2010, Spring 2011, Fall 2012, and Spring 2013—had 17, 13, 12, 8, and 8 out of 56 possible schools, respectively reporting SRTS data, as detailed in Appendix C. Safe Routes Philly recorded the smallest percentage of students cycling to and from school, both before and after program implementation. With that in mind, for the seasons with the greatest number of schools reporting data there was a slight increase in the percentage of students cycling to and from school.

Figure 6. Safe Routes Philly – Change in Students Traveling by Bicycle to and From School



Source: National Center for Safe Routes to School (2013)

In summary, while there was a 43% decrease in crashes involving 7- to 15-year old cyclists from the pre-implementation to the post-implementation period throughout Philadelphia, around treatment and control schools no conclusive findings could be made. During the school year, treatment and control schools both experienced a slight average increase in crashes outwards to one mile; but over the entire calendar year this trend was reversed, with the data revealing a slight decrease in crashes within one mile of treatment and control schools. Any difference in the change in crash rate between the two groups was not statistically significant.

Portland, Oregon SRTS Program Area

Portland’s crash data is shown in Table 8 and Figure 7. A significant threat to the internal validity of this data was revealed during the internet search for the number of crashes involving cyclists of all ages, data which had previously not been retrieved from the Oregon Department of Transportation when crash data for 7- to 15-year old cyclists had been retrieved for mapping purposes. In 2008, the Portland Police Bureau lowered its threshold policy for mandatory crash investigations of bicycle-related crashes. Before 2008, a cyclist had to sustain trauma-level injury to warrant an investigation by the police; whereas, after 2008, a cyclist only had to be transported by ambulance to a hospital—regardless of the true injury severity—to warrant a crash investigation. As a result of this policy change there was a significant increase in the number of crashes reported. For example, from 2003 to 2007 there was an average of 70 crash investigations per year; but from 2008 to 2010, there was an average of 271 per year (Portland Bureau of Transportation, 2012a). The dissimilar nature of crashes reported in the pre-implementation period (2005 and 2006) and crashes reported in the post-implementation period (2011 and 2012) prevents conclusions being drawn from this data with any sort of surety.

Therefore, tests of significance have not been conducted for the crash data, and the crash data for the Portland SRTS program area has not been included in the aggregate-level analyses.

One general observation that can be made from the data summarized in Table 8, however, is that the change in crash investigation policy does not appear to have impacted the number of crashes reported for 7- to 15-year olds as significantly as it did for all age groups. Indeed, many of the areas around schools experienced a decreased crash rate. The geographic distribution of the crashes reported is shown in Figure 7.

Table 8. Bicycle Crashes in Portland, OR Involving Individuals Aged 7 to 15 Years

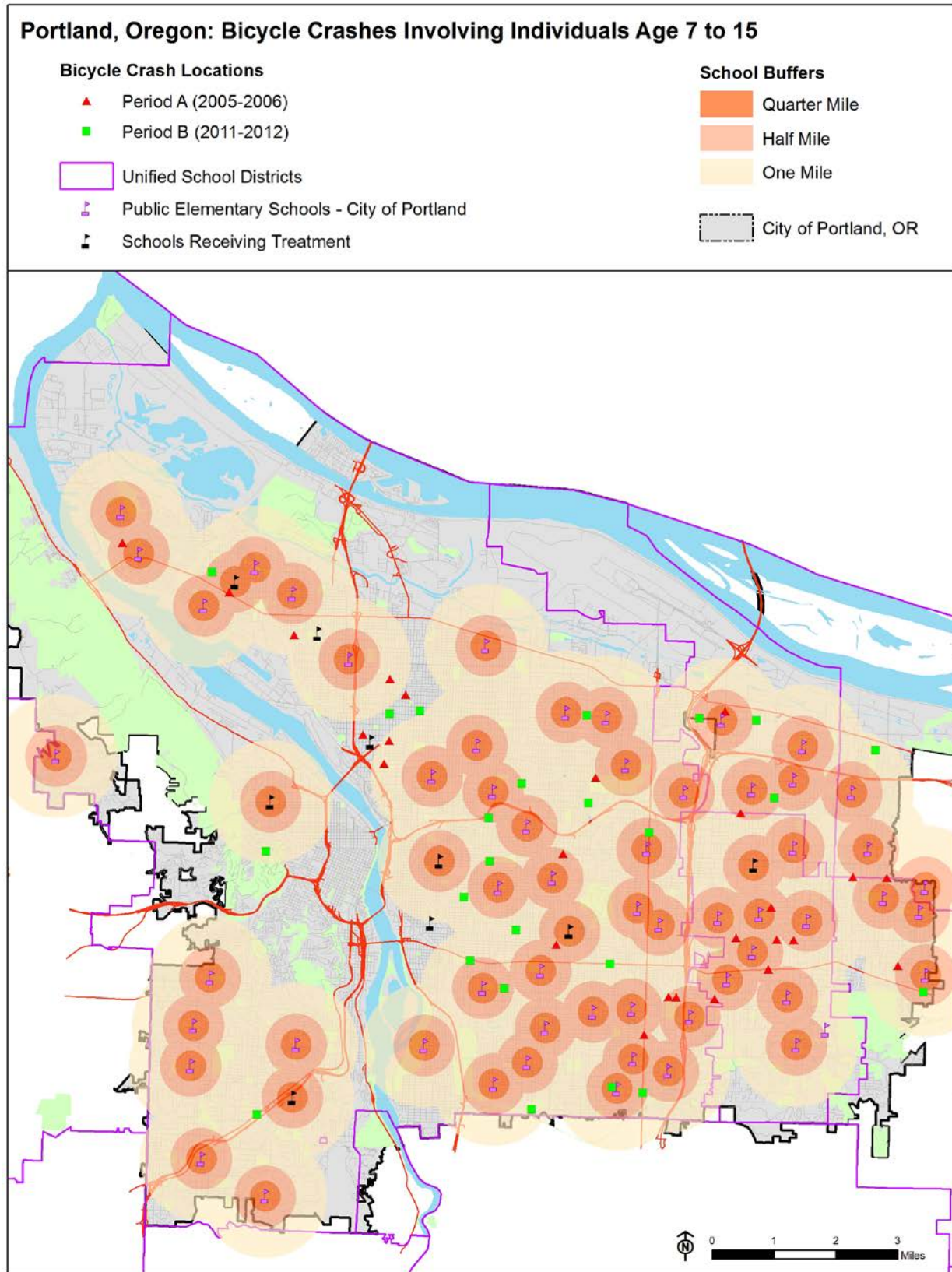
Portland, OR	(A)	(B)	(B-A)	(B-A)/A
Total Bike Crashes	391	554	163	41.7%
Age 7-15 Bike Crashes, Calendar Year	25	27	2	8.0%
Treatment Schools ^a				
Within 1/4 mile	1	0	-1	-100.0%
Within 1 mile	2	3	1	50.0%
Control Schools ^b				
Within 1/4 mile	2	1	-1	-50.0%
Within 1 mile	21	19	-2	-9.5%
Age 7-15 Bike Crashes, School Year	9	8	-1	-11.1%
Treatment Schools				
Within 1/4 mile	0	0	0	0.0%
Within 1 mile	0	1	1	50.0%
Control Schools				
Within 1/4 mile	1	0	-1	-100.0%
Within 1 mile	8	7	-1	-12.5%

Source: Oregon Department of Transportation (2014b); Portland Police Bureau (2013); and Portland Bureau of Transportation (2012a).

^a Number of schools, $N=9$

^b Number of schools, $N=64$

Figure 7. Bicycle Crashes in Portland, OR Involving Individuals Aged 7 to 15 Years

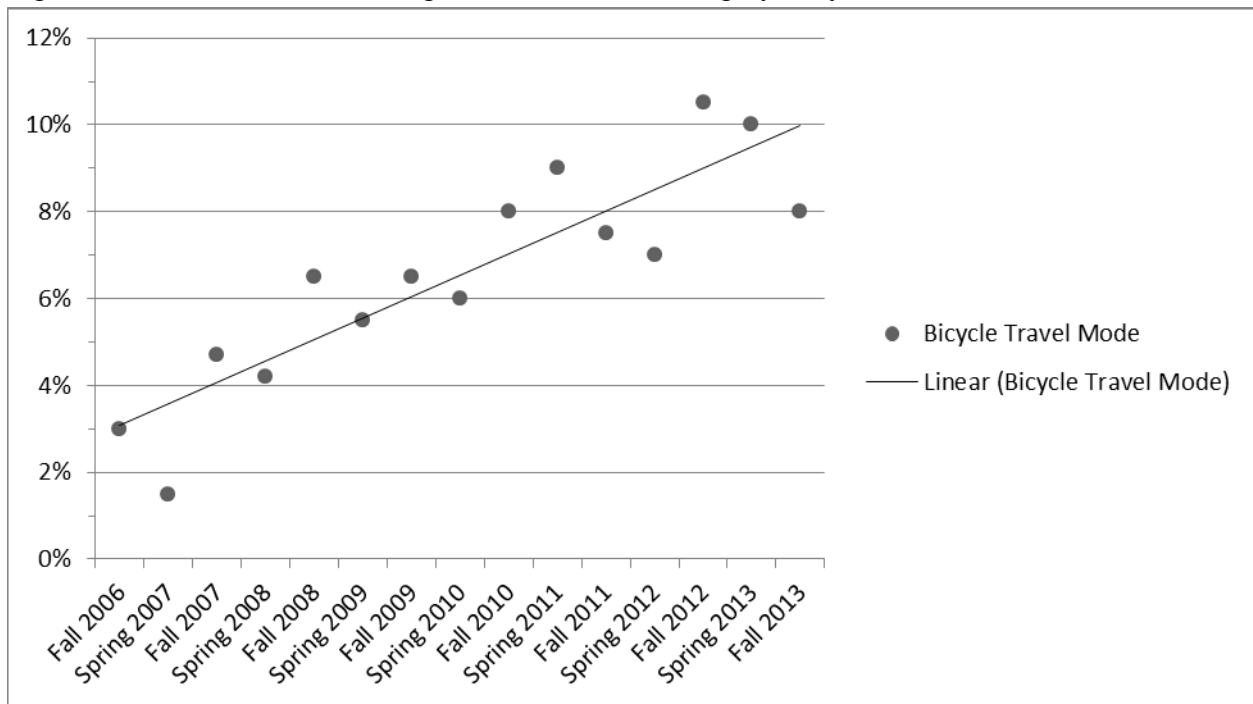


Source: Oregon Department of Transportation (2014b)

When requesting access to data located on the National SRTS Data Center website, the Portland program coordinator declined, and instead deferred to the use of the data found on the program website. A search of the program website resulted in the mode shift data presented in Figure 8. The use of this data, however, means that little is known about the number of schools included in the trend analysis and whether it was the Student Travel Tally or some other form of data collection that was used to produce the data results.

While the specific mode share data could not be gathered from the Data Center, it was still possible to see which schools had reported data to the Center. Like the other program areas, it was this list of schools that was used to identify the treatment group used in the quasi-experimental crash analysis. Due to the unknown sources of data used in the trend analysis shown here, it is impossible to analyze any crash findings in the context of bicycle mode share (in addition to the previously described limits of the crash data). From basic observation, however, Figure 8 would indicate that substantial gains have been made in encouraging active transportation since data was first recorded in 2006 with more than twice as many children cycling to and from school as of 2013.

Figure 8. Portland SRTS – Change in Students Traveling by Bicycle to and From School



Source: Adapted from *Evaluation and Survey Results* (Portland Bureau of Transportation, 2014a)

San Rafael Elementary School District, California Program Area

Due to the small number of bicycle crashes that are reported in San Rafael each year, any change between the pre-implementation (A) and the post-implementation (B) periods is very minimal. The raw crash data for crashes involving all cyclists and those involving cyclists aged 7 to 15 years is summarized in Table 9. From this data it can be determined that both treatment and control schools in the district experienced slight increases in crash rate over the study timeframe. The mapped crash data in Figure 9 reveals that the majority of crashes occurred along or to the west of Highway 101.

Table 9. Bicycle Crashes in San Rafael Elementary School District Involving Individuals Aged 7 to 15 Years

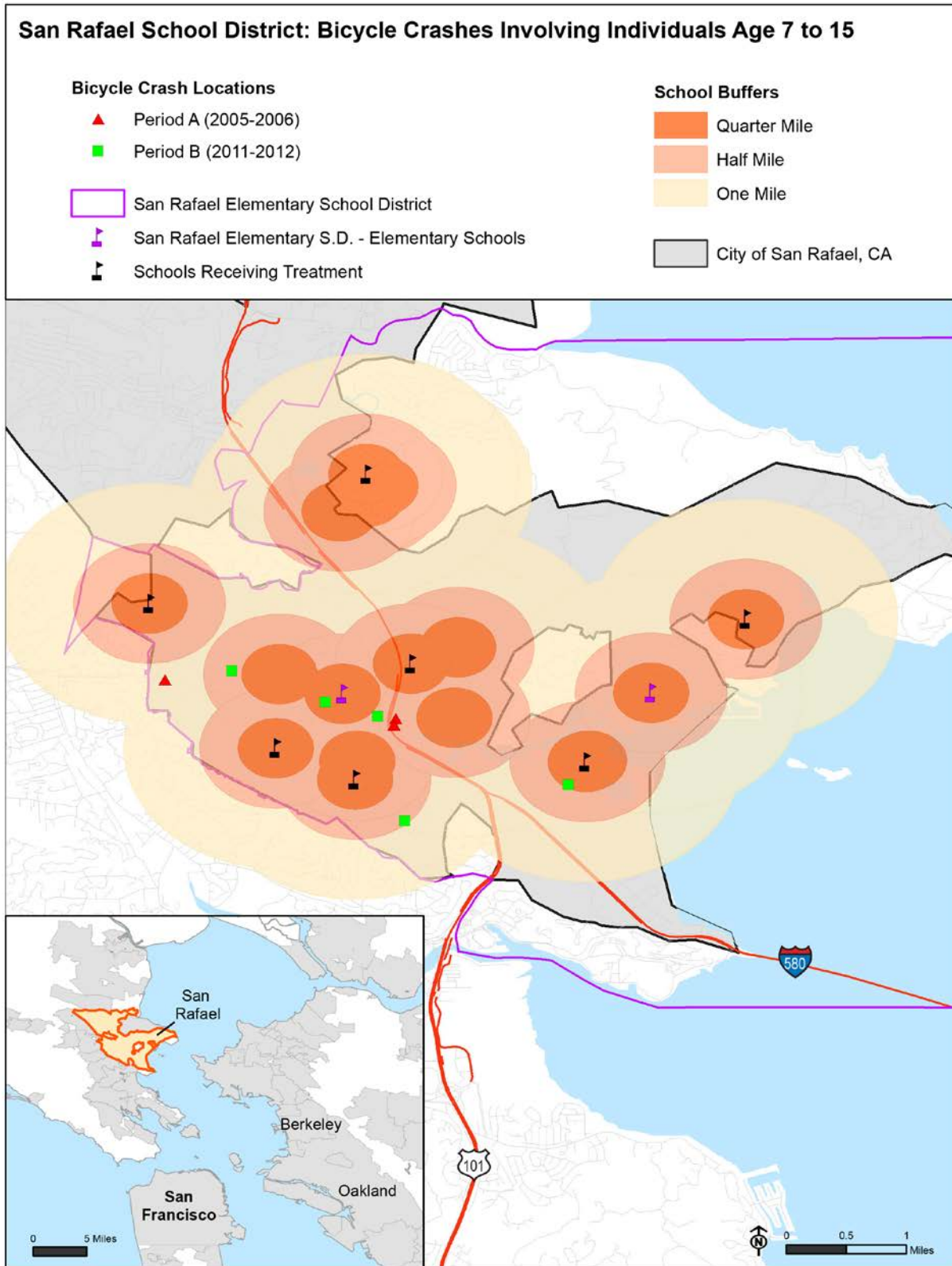
San Rafael Elem. SD, CA	(A)	(B)	(B-A)
Total Bike Crashes	37	38	1
Age 7-15 Bike Crashes, Calendar Year	3	5	2
Treatment Schools ^a			
Within 1/4 mile	0	1	1
Within 1 mile	2	5	3
Control Schools ^b			
Within 1/4 mile	0	1	1
Within 1 mile	3	3	0
Age 7-15 Bike Crashes, School Year	1	4	3
Treatment Schools			
Within 1/4 mile	0	0	0
Within 1 mile	0	1	1
Control Schools			
Within 1/4 mile	0	1	1
Within 1 mile	1	2	1

Source: Transportation Injury Mapping System (2014)

^a Number of schools, $N=6$

^b Number of schools, $N=2$

Figure 9. Bicycle Crashes in San Rafael Elementary School District Involving Individuals Aged 7 to 15 Years



Source: Transportation Injury Mapping System (2014)

The limited frequency of bicycle collisions in San Rafael resulted in only two of the four potential test scenarios—bicycle crashes that occurred over the entire calendar year at the two buffer distances—having sufficient data to perform independent samples t-tests. As shown in Table 10, the results for neither test were statistically significant.

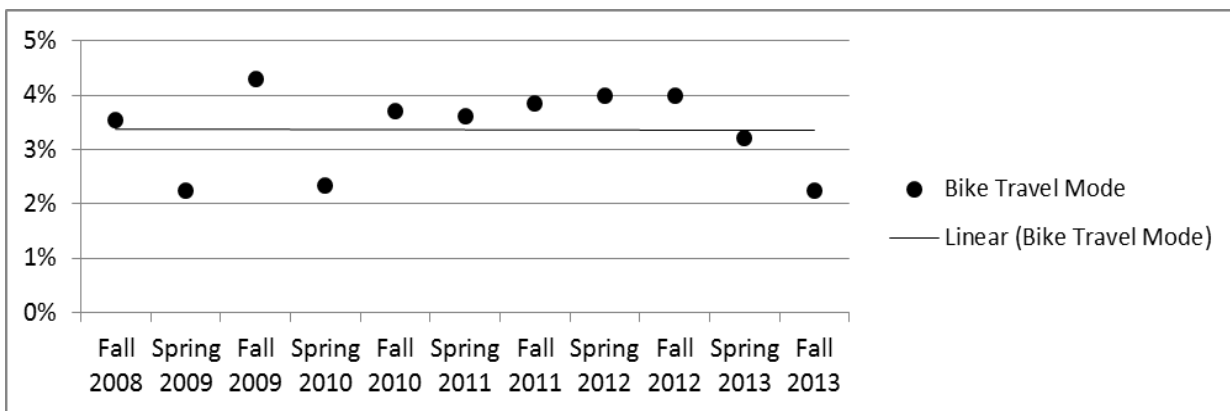
Table 10. Independent Samples t-Test for San Rafael Elementary School District

Timeframe	School Buffer Distance	School Group	N	M	SD	t	Sig. ^a
Calendar Year	With 1/4 mile	Treatment	6	.17	.408	.866	–
		Control	2	.50	.707		
	Within 1 mile	Treatment	6	.00	.632	.949	–
		Control	2	.50	.707		

^a Sig: “–” = $p > 0.05$; “*” = $p < 0.05$

The results of the trend analysis of bicycle mode share data for the treatment schools, as reported to the National SRTS data center, is shown in Figure 10. This SRTS program area was the only one in which all or most schools had data reported to the National Center for the spring and fall of every year possible. Bicycle mode share remained relatively constant over the reporting time period, however, it is still well above national cycling levels. As the change in crash rate over the study time period was not significant, this mode share data is purely supplemental.

Figure 10. Marin County SRTS, San Rafael Elementary SD – Change in Students Cycling to and From School



Source: National Center for Safe Routes to School (2013)

Aggregate Data across All Program Areas

The following two tables aggregate the raw crash data of all program areas studied, with the exception of Portland, OR due to the previously described data limitations. Table 11 details the aggregated crash data results of treatment and control schools over the entire calendar year. Tables 12 similarly details the crash data, but with the data time frame limited to the school year.

Aggregating the data of treatment and control schools for the program areas of study, the data for treatment and control schools showed similar results: a decrease in the number of crashes both within the immediate vicinity of schools and within one mile. Diverging results occur when the data series is limited to only those crashes that occurred during the school year. The treatment group experienced a decreased crash rate within one-quarter mile and one mile of schools, whereas the control group experienced an increased crash rate at both distances.

Table 11. Aggregate Crash Data over the Calendar Year

	Within 1/4 mile			Within 1 mile		
	(A)	(B)	(B-A)	(A)	(B)	(B-A)
Treatment Schools ^a	34	33	-1	78	70	-8
Boulder, CO	0	0	0	3	5	2
Eugene, OR	3	0	-3	7	2	-5
Philadelphia, PA	31	32	1	58	48	-10
San Rafael, CA	0	1	1	10	15	5
Mean	8.5	8.3	-0.3	19.5	17.5	-2.0
Control Schools ^b	59	51	-8	135	99	-36
Boulder, CO	0	0	0	0	0	0
Eugene, OR	0	0	0	1	1	0
Philadelphia, PA	59	50	-9	131	95	-36
San Rafael, CA	0	1	1	3	3	0
Mean	14.8	12.8	-2.0	33.8	24.8	-9.0

Table 12. Aggregate Crash Data over the School Year

	Within 1/4 mile			Within 1 mile		
	(A)	(B)	(B-A)	(A)	(B)	(B-A)
Treatment Schools	5	2	-3	12	9	-3
Boulder, CO	0	0	0	1	3	2
Eugene, OR	3	0	-3	5	1	-4
Philadelphia, PA	2	2	0	6	4	-2
San Rafael, CA	0	0	0	0	1	1
Mean	1.3	0.5	-0.8	3.0	2.3	-0.8
Control Schools	5	12	7	12	24	12
Boulder, CO	0	0	0	0	0	0
Eugene, OR	0	0	0	1	1	0
Philadelphia, PA	5	11	6	10	21	11
San Rafael, CA	0	1	1	1	2	1
Mean	1.3	3.0	1.8	3.0	6.0	3.0

Four independent samples t-tests were conducted using the crash data from all program areas of study to determine whether the difference in the change in crash rate summarized in Table 11 and Table 12 is significant. The results of the tests are shown in Table 13. While the results of the crash assessment were not statistically significant at any of the levels of analysis, it can be reasonably concluded from the decreased average crashes that, at the aggregate level, the SRTS programs did not accompany a decrease in the safety of student cyclists, despite the increase in the number of students cycling shown by most of the programs.

Table 13. Independent Samples t-Tests for the Aggregate Crash Data

Timeframe	School Buffer Distance	School Group	N	M	SD	t	Sig. ^a
Calendar Year	Within 1/4 mile	Treatment	78	.00	.773	.198	-
		Control	131	-.02	.827		
	Within 1 mile	Treatment	78	-.23	.896	.578	-
		Control	131	-.13	1.378		
School Year	Within 1/4 mile	Treatment	66	-.02	.372	.928	-
		Control	129	.03	.305		
	Within 1 mile	Treatment	66	-.02	.620	1.115	-
		Control	129	.08	.509		

^a Sig: “ - ” = p>0.05; “ * ” = p<0.05

Summary of the Results

This chapter provided the results for the quasi-experimental crash analysis and mod share trend analysis of five SRTS programs that included model bicycle education components, based on the findings of previous evaluations. In Boulder, CO, home of the Boulder Valley School District SRTS program, there was an increased number of crashes involving cyclists of all ages as well as crashes involving the target age group (7 to 15 years) from the pre-implementation period to the post-implementation period. Due to the lack of control group data, tests of significance could not be conducted on the difference in the change in crashes between the treatment and control school groups. Therefore, it could not be determined whether the Boulder SRTS program had any significant impact on the safety of children and adolescent cyclists.

In Eugene, OR, where 13 out of 23 elementary or K-8 schools received Eugene-Springfield SRTS programming, data revealed a decreased number of crashes involving cyclists of all ages and decreased crashes involving cyclists aged 7 to 15 years. While this decrease in crashes was experienced around SRTS treatment schools, and there was no change in crash rate around control schools, the difference was not statistically significant. Nevertheless, the decreased crash rate around treatment schools indicates that, despite the increasing number of students cycling to and from school reported by the SRTS program, the safety of students cycling on the school trip was improving over the time studied, and that there is no cause for safety concerns arising from the implementation of the Eugene-Springfield SRTS program.

In Philadelphia, home of Safe Routes Philly, there was a 43% decrease in crashes involving cyclists aged 7 to 15 years between the treatment and control groups. There was little difference in the change in crash rate: from the pre-implementation period to the post-implementation period, both groups experienced a decreased number of crashes within one mile over the calendar year, but an increased number within one mile during the school year. What difference there was between the two groups was not statistically significant.

In the San Rafael Elementary School District, CA, where Marin County SRTS provides programming, the increased number of crashes involving cyclists aged 7 to 15 years reflected the increased number of crashes involving cyclists of all ages. The difference in the change in crash rate between treatment and control school groups was not statistically significant. Finally, at the aggregate level in which crash data for treatment and control schools of the four eligible programs was combined, the area outwards to one mile around both treatment and control school

groups experienced a decreased crash rate over the study timeframe. When the data series was limited to only those crashes occurring during the school year, there was diverging, though not statistically significant, results between the two groups: there was a decrease in the number of crashes around treatment schools but an increase in crashes around control schools.

In conclusion, for three out of the four program areas in which the total crash data was available for this study—Boulder, CO; Eugene, OR; and San Rafael Elementary School District, CA—the positive or negative trend in the number of crashes involving cyclists aged 7 to 15 years, from pre-implementation to post-implementation, reflected the trend for in crashes cyclists of all ages. Any difference in the change in crashes between the treatment and control groups was not statistically significant. Therefore, the first research question, “Does the implementation of a bicycle education program in schools as part of a Safe Routes to School program effect the safety of children and youth cycling?” could not be determined, and the accompanying affirmative and positive hypothesis, not supported. Due to the lack of statistically significant crash results, the second research question, “What is the effectiveness at improving safety of various types of programs and materials relative to other program and material types?” could not be determined. Chapter 5 provides further discussion on the findings and outlines opportunities for future research.

Chapter 5 - Conclusion

Due to the health, environmental, safety, and decreased cost benefits associated with increased levels of cycling, bicycle-related programs, policies, and interventions have been on the rise in the U.S. in recent years. Yet outside of bicycle infrastructure interventions, very little evaluation has been conducted on the efficacy of these programs and policies at achieving their intended goals, or whether they result in unintended consequences. The objective of this thesis was to evaluate the extent to which bicycle education programs impact the safety of cyclists in the age group targeted for education—usually children and youth. For the purpose of measurement, “safety” was thus defined as the number of motor vehicle collisions involving children and youth cyclists, relative to the number of children and youth cycling for transportation (the transportation mode share).

Previous evaluations of bicycle education program success have most often utilized intermediate measures such as knowledge tests or observed riding behavior, which do not necessarily translate into actual safety improvements. Those few evaluations analyzing safety using self-report or hospital injury rates have had mixed, though not statistically significant, results. Nevertheless, of the research conducted on the safety impacts of bicycle education programs, there have been some common characteristics of the programs of study: the target age group (in the range of 8 to 15 years), program implementation in a school setting, and the inclusion of an on-bike component. After identifying the empirical studies of bicycle education, it was evident that many gaps in the literature remained. The most prominent gap was the lack of program evaluations since the creation of the National Safe Routes to School (SRTS) program in 2005, which created competitive funding for, and accompanied the creation of education programs across the country. Furthermore, there had been no evaluations of the impact of SRTS programs or program components on bicycle safety. An additional gap in the literature regarding education was the lack of evaluation of different programs in different contexts. As a result, the following research questions were developed to address these gaps in the knowledge base:

1. *Does the implementation of a bicycle education program as part of a Safe Routes to School program effect the safety of children and youth cycling?*
2. *What is the effectiveness at improving safety of various types of programs and materials relative to other program and material types?*

The hypothesis tested for the first research question was:

The implementation of an in-school bicycle education program as part of a Safe Routes to School program positively impacts of the safety of children and youth cycling.

The second question, regarding the relative efficacy of various program and material types, could only be addressed if the first hypothesis was not rejected. If such was the case, the hypothesis tested for the second research question was:

Those education programs taught by bicycle coalition-trained instructors will be more effective at improving safety than those taught by physical education (PE) teachers using the train-the-trainer model.

The remainder of this chapter includes a summary of the key findings and reflection upon the research questions and hypotheses, a comparison of the findings to existing literature, a discussion of the practical implications of this thesis, an overview of the study limitations and suggestions for future research, and concluding final remarks.

Summary and Discussion of Key Findings

To provide the most ideal assessment of bicycle-motor vehicle collision rates before and after the implementation of a SRTS bicycle education program, a quasi-experimental design was selected, with a before-and-after comparison of crash rates around schools that had received the SRTS treatment to the crash rate around control schools. Crash data was retrieved from state Departments of Transportation data files. To address the bicycle mode share element of the definition of safety employed in this thesis, a second method utilized was a bicycle mode share trend analysis, with mode share data collected by the individual SRTS programs and retrieved from the National SRTS Data Center. Five SRTS programs were identified as having a bicycle education component with characteristics identified in the literature review as being ideal, and several other characteristics necessary to enhance the research design, as detailed in Chapter 3.

The programs, and program areas of evaluation, are:

- Boulder Valley School District SRTS (Boulder, CO)
- Eugene-Springfield SRTS (Eugene, OR)
- Safe Routes Philly (Philadelphia, PA)
- Portland SRTS (Portland, OR)
- Marin County SRTS (San Rafael Elementary School District, CA)

The crash data for treatment and control schools was also evaluated at the aggregate-level, across the program areas. While the detailed findings from the study methods can be found in Chapter 4, this section focuses on summarizing the key findings and providing analytical interpretations.

Ultimately, only the crash data for four of the five SRTS program study areas was evaluated for statistical significance and included in the aggregate-level analysis. While the Portland SRTS program met the bicycle education criteria and the criteria developed for the research design of this thesis, it was discovered during the data collection process that a change to the local police's crash reporting policy in the middle of this study's timeframe had already been shown to significantly increase the volume of bicycle crashes reported. Facing the risk of serious internal validity issues as a result of this change, as well as the additional likelihood that school data reported to the National Center was largely incomplete, the Portland SRTS program area was not included in the safety analyses. The remainder of this section includes a summary and discussion of the results of the safety analyses for the other four program areas and at the aggregate level.

Of the four remaining SRTS program study areas, at no level of analysis (within the buffer distances of one-quarter mile and one mile of schools, for all crashes and only those that occurred during school arrival and dismissal times) was the difference in the change in crashes involving the target age group between treatment and control schools statistically significant. The trends in the raw crash data did, however, have varying results.

The crash data results for the two smallest program study areas by physical size and population—Boulder, CO, the study area for the Boulder Valley SRTS program, and San Rafael Elementary School District, CA, study area of the Marin County SRTS program—showed similar results: an increase in crashes involving cyclists of all ages across the study area, an increase in crashes involving cyclists in the target age group of study (aged 7 to 15 years) across the study area, and an increase in crashes involving cyclists in the target age group within one mile of SRTS treatment schools. In San Rafael, the increase in crash rate around control schools as well indicates that the increase in crashes involving the target age group, around treatment and control schools, is likely the result of a general trend outside the control of the SRTS program. Such was also likely the case in Boulder, despite the lack of crash incidences around control schools. As indicated by the extremely small sample size of crashes that occurred during the

study timeframe, it is highly probably that the timeframe was not long enough for any crashes to have occurred around the much smaller number of control schools in Boulder.

The crash data results for the two larger program areas—Eugene, OR, the study area for Eugene-Springfield SRTS, and Philadelphia, PA, study area for Safe Routes Philly—were nearly the reverse, with a decrease in total bicycle crashes. At every level of analysis in Eugene, OR there was a decrease in bicycle crashes involving the target age group around treatment schools, but no change in crash rate around control schools. The crash data for Philadelphia, PA also revealed a decrease in bicycle crashes involving the target age group around treatment schools at all levels of analysis. However, the trend in crashes around control schools was not as consistent in Philadelphia: there was also a decrease in crashes over the calendar year, but when the timeframe of analysis was limited to the school year, there was an increase in crashes. The negative crash results for these two larger program areas appeared to negate the results of the two smaller ones, for when the data for treatment and control schools was combined across at the aggregate level, there was a decrease in crashes around treatment schools at all levels of analysis, whereas the control school data was not as consistent at the different levels of analysis.

Due to the lack of statistically significant findings, the null hypothesis for the first research question could not be rejected, and the second research question was not addressed. While the findings of this thesis were not statistically significant, it can nevertheless be concluded that at the aggregate level, despite all of the programs reporting an either level or increasing number of students cycling over time, the SRTS programs were not causing a decrease in the safety of students cycling. Indeed, in Eugene, OR and Philadelphia, PA, the safety of cyclists in the target age group had improved over the study timeframe.

Findings Compared to Existing Literature

This is the first known bicycle crash assessment of SRTS programs since the creation of the National SRTS program in 2005, making it a base comparison for future SRTS evaluations of bicycle safety. One primary finding from this thesis does, however, reflect that of previous evaluations of bicycle education programs: any change in crash or injury rate following the implementation of the program was not statistically significant.

It seems clear, however, that without some effort to educate young cyclists in proper on-street and off-street riding skills—whether at home, school, or camp—there is little chance of

them learning how to ride correctly. Previous studies have found that learning does take place and is retained over time, at least when students are exposed to fairly comprehensive education programs (Thomas et al., 2005). However, a significant impact of bicycle education interventions on crash and injuries rates has yet to be shown, indicating that while education is important, it is not likely to cause any substantial improvements in safety on its own. This evaluation of bicycle education programs as part of SRTS programs, which were often implemented along with other measures designed to improve safety, and the continued lack of significant findings, places into question the effectiveness of SRTS programs at improving the safety of children and adolescent cyclists.

Practical Implications of the Findings

The results of this thesis provide no cause for concern that these SRTS programs, which all included in-school bicycle education, negatively impacted cycling safety for the target age group. While there was no evidence that the implementation of these programs correlated with an increase in cycling safety, it is my opinion that, due to the ultimate purpose of bicycle education programs at increasing safe behavior, these programs should continue to be implemented in schools. Indeed, I believe that bicycle education should be implemented in all schools, particularly when other policies and programs designed to increase the level of cycling are being implemented such as separated bicycle infrastructure or bike share programs. More explicit justification for continued and expanded bicycle education, and education in schools, is provided below.

Education is required for successfully performing even simple activities such as tying shoe laces, and safe participation in traffic is a complex task requiring skills like rule application, speed estimation, and prediction. Even adults or experienced cyclists do not always assess dangerous behavior as such (e.g., hugging the side of the road). It is unnecessarily risky to encourage more children and adults to bicycle or construct new types of bicycle-specific facilities without first educating cyclists or potential cyclists on the safest ways to operate either in traffic or separated from traffic. Once the decision has been made to provide bicycle education, there are several reasons why it should be implemented in schools. First, children are recognized as a vulnerable group regarding road safety because of their increased likelihood to walk and bicycle for transportation, and their lack of knowledge of traffic laws and road safety.

Secondly, because all children attend school, they are an easy group to reach equitably with education. Unless education is institutionalized, only a self-selected group of adults—generally characterized by higher income and higher educational attainment—is likely to seek out bicycle education (Mapes, 2009).

Recommendations for Future Studies

The lack of SRTS program evaluations beyond a basic analysis of trends in mode share data, and the lack of statistically significant findings from this thesis, indicates a strong need for additional rigorous safety evaluations of SRTS programs and evaluations of the effectiveness of various program elements at improving the safety of cyclists. To improve the reliability and transferability of results, these evaluations should include the use of control cases and should account for any extraneous variables, such as exposure.

While the use of secondary data in this thesis was intended to improve efficiency, it also led to several significant limitations. The secondary data utilized was SRTS data retrieved from the National SRTS Data Center and crash data retrieved from state Departments of Transportation. The SRTS data was used for program identification, the classification of treatment schools, and the bicycle mode share trend analysis. The Data Center would still be useful for these purposes in future studies, so long as programs continue reporting data to the National Center and the data accuracy is verified by program coordinators. To improve the trend analysis, mode share data collected using the Student Travel Talley should be requested from control schools.

The other secondary data relied upon heavily for this thesis was crash data from state Departments of Transportation, which opened up the research design to several threats to internal validity. The first, which ultimately impacted the analysis of the Portland SRTS program crash data, is the possibility that a state or police agency may change its reporting form. It has also been found by previous studies that a large number of bicycle crashes resulting in injury do not involve a motor vehicle and are therefore not reported to the police, further limiting the crash sample size and providing what may be an inaccurate view of bicycle safety (Clarke & Tracy, 1995). Finally, public crash data does not include information on the victim's school of attendance, and as a result a proximity analysis was used to associate a crash with a treatment or control school if it occurred within one mile of a school. While it would involve significantly

more effort on the part of the researcher, these issues caused by the use of state crash data can be eliminated through the use of hospital injury reports. Data collected in these reports would need to include the victim's age, transportation mode at the time of collision, time and date of the collision, and location, as well as the victim's specific school of attendance and whether they had previously received the education program.

Conclusive findings from rigorous evaluations are important not only for designing programs that best improve safety, but also for funding purposes. The most recent federal transportation bill, MAP-21 (P.L. 112-141), established a performance- and outcome-based system for program investment. The limited evaluation of SRTS performance outcomes (such as safety), which in turn limited the ability of the Federal Highway Association (FHWA) to report on how well the SRTS program is meeting its national goals and objectives, is likely one of the reasons for the program's consolidation and decreased funding under MAP-21 (U.S. Government Accountability Office, 2008). The same can be argued for all bicycle and pedestrian programs that were consolidated and received decreased funding under MAP-21. At most, 2% of all federal transportation funding is spent on bicycle and pedestrian projects (FHWA, 2013), but 12% of trips are made via non-motorized modes of transportation (FHWA, 2010), indicating that the level of funding is out of balance with the proportion of non-motorized trips. Furthermore, pedestrians and cyclists represent roughly 14% of all traffic fatalities (NHTSA, 2014a; NHTSA, 2014b). A higher standard of data collection and evaluation of bicycle improvements, programs and policies similar to that for automobiles needs to be adopted by practitioners and researchers to ensure that these measures are objectively improving safety (versus the feeling of safety) and are worthy of their equal share of transportation funding.

Concluding Remarks

The purpose of this thesis was to fill several gaps in the body of literature regarding the safety impacts of SRTS programs and bicycle education programs. Previous evaluations of the safety impacts of SRTS programs have remarked that there was likely an increase in the level of walking and cycling as a result of the program, which increased the exposure to crash risk; but the extent to which there had been an increase in these mode shares had never been specifically examined in conjunction with bicycle crash or injury rates. This study was also the first time police-reported crash data had been used in an evaluation of bicycle education programs. The

lack of a statistically significant change in crashes resulting from the implementation of any of the four comprehensive SRTS bicycle education programs of study provides an awareness of the need for more rigorous evaluation of bicycle safety interventions.

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+		+
<p>8. Has your child asked you for permission to walk or bike to/from school in the last year? <input type="checkbox"/> Yes <input type="checkbox"/> No</p>		
<p>9. At what grade would you allow your child to walk or bike to/from school without an adult? (Select a grade between PK,K,1,2,3...) <input type="text"/> <input type="text"/> grade (or) <input type="checkbox"/> I would not feel comfortable at any grade</p>		
<p>Place a clear 'X' inside box. If you make a mistake, fill the entire box, and then mark the correct box</p>		
<p>10. What of the following issues affected your decision to allow, or not allow, your child to walk or bike to/from school? (Select ALL that apply)</p> <p><input type="checkbox"/> Distance.....</p> <p><input type="checkbox"/> Convenience of driving.....</p> <p><input type="checkbox"/> Time.....</p> <p><input type="checkbox"/> Child's before or after-school activities.....</p> <p><input type="checkbox"/> Speed of traffic along route.....</p> <p><input type="checkbox"/> Amount of traffic along route.....</p> <p><input type="checkbox"/> Adults to walk or bike with.....</p> <p><input type="checkbox"/> Sidewalks or pathways.....</p> <p><input type="checkbox"/> Safety of intersections and crossings.....</p> <p><input type="checkbox"/> Crossing guards.....</p> <p><input type="checkbox"/> Violence or crime.....</p> <p><input type="checkbox"/> Weather or climate.....</p>	<p>11. Would you probably let your child walk or bike to/from school if this problem were changed or improved? (Select one choice per line, mark box with X)</p> <p><input type="checkbox"/> My child already walks or bikes to/from school</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Not Sure</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Not Sure</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Not Sure</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Not Sure</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Not Sure</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Not Sure</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Not Sure</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Not Sure</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Not Sure</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Not Sure</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Not Sure</p>	
<p>Place a clear 'X' inside box. If you make a mistake, fill the entire box, and then mark the correct box</p>		
<p>12. In your opinion, how much does your child's school encourage or discourage walking and biking to/from school?</p> <p><input type="checkbox"/> Strongly Encourages <input type="checkbox"/> Encourages <input type="checkbox"/> Neither <input type="checkbox"/> Discourages <input type="checkbox"/> Strongly Discourages</p>		
<p>13. How much fun is walking or biking to/from school for your child?</p> <p><input type="checkbox"/> Very Fun <input type="checkbox"/> Fun <input type="checkbox"/> Neutral <input type="checkbox"/> Boring <input type="checkbox"/> Very Boring</p>		
<p>14. How healthy is walking or biking to/from school for your child?</p> <p><input type="checkbox"/> Very Healthy <input type="checkbox"/> Healthy <input type="checkbox"/> Neutral <input type="checkbox"/> Unhealthy <input type="checkbox"/> Very Unhealthy</p>		
<p>Place a clear 'X' inside box. If you make a mistake, fill the entire box, and then mark the correct box</p>		
<p>15. What is the highest grade or year of school you completed?</p> <p><input type="checkbox"/> Grades 1 through 8 (Elementary) <input type="checkbox"/> College 1 to 3 years (Some college or technical school)</p> <p><input type="checkbox"/> Grades 9 through 11 (Some high school) <input type="checkbox"/> College 4 years or more (College graduate)</p> <p><input type="checkbox"/> Grade 12 or GED (High school graduate) <input type="checkbox"/> Prefer not to answer</p>		
<p>16. Please provide any additional comments below.</p> <div style="border: 1px solid black; height: 40px; width: 100%;"></div>		

Source: National Center for Safe Routes to School (2014)

Appendix B. Review of Bicycle Education Programs

Table B1. Literature Review of Bicycle Education Programs in the United States

Program	Location	Creator	Year Started	Year Ended or Current Status
Florida Traffic and Bicycle Safety Education Program	Florida	--	1982	--
Florida Traffic and Bicycle Safety Education Program - Elementary Traffic Safety Education Guide	Florida	--	2008	--
Basics of Bicycling	North Carolina	North Carolina DOT/ Bicycle Program and the Bicycle Federation of America	1990	--
Basics of Bicycling	Washington: Seattle School District, Edmonds School District, Lake Washington, and Highline School Districts	Cascade Bicycle Club Education Foundation	2007	--
Bicycle Safety Program: Safe Routes for Kids	Oregon Safe Routes to School - Portland, Eugene, etc.	Bicycle Transportation Alliance, Oregon	2003	Cont.
BikeEd Hawaii	Hawaii	Hawaii Bicycle League	1988	--
Neighborhood Adventures in Bicycle Safety: Striving to be a SuperCyclist	--	Texas Bicycle Coalition	1997	--
Texas SafeCyclist (formerly SuperCyclist)	--	--	1999	--
Marin County Safe Routes to School	Marin County, CA	Marin County Bicycle Coalition	2001	Cont.

Maine Safe Routes to School: Bicycle and Pedestrian Safety Education Program	Maine	Bicycle Coalition of Maine	2000	Cont.
Bicycle Lesson and Safety Training (BLAST) Program	Los Angeles, CA	--	1995	--
BVSD Safe Routes to School: Bicycle Lesson and Safety Training (BLAST) Program	Boulder, CO	Boulder Safe Routes to School Program	2007	Cont.
BIPED	Deleware	White Clay Bicycle Club & 4H Cooperative Extension Services	1988	--
Maryland Pedestrian and Bicycle Safety Education Program	Rockville, MA	City of Rockville Department of Parks and Recreation	2003	--
Let's Move	Montgomery, AL	--	--	--
Curriculum Guidelines Material Resource Lists for Grades K-6 in Bicycle and Pedestrian Safety	--	Minnesota 4H, Extension Services	--	--
Smart Wheeler Ride Safely Bicycle Safety and Education Curriculum	--	Iowa Department of Transportation, Iowa Department of Public Health, and Iowa SAFEKIDS	2003	--
Bike Smart!	Santa Cruz County, CA	Ecology Action	--	--
Arkansas Safe Routes to School: Bike ED	Fayetteville, AR	Bicycle Coalition of the Ozarks	2011	--
Safe Routes Philly: Pedestrian and Bicycle Safety	Philadelphia, PA - School District of Philadelphia	Safe Routes Philly	2010	Cont.

WalkSafe and BikeSafe programs	Miami-Dade County, FL	--	2013	Cont.
Home to School Safe Travel for Children (Train the Trainer Course)	--	Colorado	1995	--
Nevada Elementary Traffic Safety Program Instructor Course and Traffic Safety Education Program	Carson City, NV	Nevada Office of Traffic Safety, Dept. of Public Safety	--	--
Bicycle Skills 123 Clinic	Austin, TX	Austin Cycling Association	--	--
North Carolina Safe Routes to School: Let's Go NC! - Pedestrian and Bicycle Safety Curriculum	North Carolina	NCSU's Institute of Transportation Research and Education	2013	--
Middle School Bicycle Safety Curriculum	Wisconsin	City of Madison Traffic Engineering Division Bicycle Program	--	--
Wisconsin Safe Routes to School: Bike For Life: Bicycle Safety Education Curriculum for Physical Education Classes	Wisconsin	Bicycle Federation of Wisconsin	--	Cont.
Pima County-Tucson Bicycle and Pedestrian Safety and Education Program	Pima County-Tucson, AZ	--	2005	2008
San Francisco Safe Routes to School	San Francisco, CA	--	2009	Cont.

Appendix C. SRTS Program Reporting

Table C1. Boulder, CO Elementary Schools Reported to the National SRTS Data Center - Travel Tally Survey

Elementary School	Spring 2008	Fall 2008	Spring 2009	Fall 2009	Spring 2010	Fall 2010	Spring 2011	Fall 2011
BCSIS								1
Bear Creek	1	1			1			1
Columbine		1			1			1
Community								1
Creekside		1			1			1
Crest View	1	1			1			
Eisenhower		1			1			
Flatirons	1		1					1
Foothill	1	1	1		1			1
Heatherwood		1		1	1			1
High Peaks								1
Lafayette		1		1	1		1	
Mesa		1			1			1
Shining Mountain Waldorf			1		1			
Whittier		1		1	1			1
Number of Schools	4	10	3	3	11	0	1	11

Table C2. Eugene, OR Elementary Schools Reported to the National SRTS Data Center - Travel Tally Survey

Elementary Schools	Spring 2008	Fall 2008	Spring 2009	Fall 2009	Spring 2010	Fall 2010	Spring 2011	Fall 2011	Spring 2012	Fall 2012
Adams								1		1
Buena Vista		1				1		1		1
Camas Ridge			1			1				
Cesar E. Chavez		1						1		1
Clearlake		1								1
Danebo		1								1
Edison			1			1		1		1
Fairfield		1								1
Irving		1				1	1		1	1
Malabon		1				1	1	1	1	1
McCornack	1									1
Meadow View		1				1	1	1	1	1
Meadow Lark		1				1				
Prairie Mountain		1				1	1	1	1	1
River Rd/El Camino del Rio ^a										
Total schools	1	10	2	0	0	8	4	7	4	12

^a Note that River Road Elementary is a reported school in the National Center Data Collection Center and is listed in Appendix C; however, based on its evaluation efforts it did not join the program until the fall of 2013, making it a control school for the purpose of this study.

Table C3. Philadelphia, PA Elementary Schools Reported to the National SRTS Data Center - Travel Tally Survey

Elementary Schools	Fall 2009	Spring 2010	Fall 2010	Spring 2011	Fall 2011	Spring 2012	Fall 2012	Spring 2013	Fall 2013
Abigail Vair				1					
Alaine Locke				1					
Anderson	1								
Anna B. Pratt				1					
Chester Arthur				1					
Benjamin Franklin							1		
Blaine				1					
Carnell School					1			1	
Catharine	1	1							
Comly				1					
Decatur								1	
Farrell School								1	
Fell	1								
Franklin	1								
Gompers	1	1							
Harrington									
Hopkinson					1				
James Alcorn	1								
John Barry								1	
John Marshall				1					
John Moffet				1					
John Welsh	1								
John Whittier	1	1							
Kinsey									
Kirkbride		1							
Lingelback		1							
Loesche	1								
Longstreth									
Mann	1								
Mayfair								1	
McDaniel		1							
Meade							1		1
Meredith							1		1
Mifflin		1							
Mitchell	1	1							
Patterson	1								
Pennell	1								
Pierce	1	1							
Prince Hall	1								
Sharswood	1	1							
Sheridan		1							
Smith	1	1							
South Southwark		1					1		1
E. M Stanton							1		1

Stephen Decatur				1					
Stephen Girard				1			1	1	1
Waring				1					
Willard				1			1	1	1
William H. Loesche							1		
William H. Ziegler								1	
Number of Schools	17	13		12	2		8	8	6

Table C4. San Rafael Elementary School District Elementary Schools Reported to the National SRTS Data Center - Travel Tally Survey

Elementary Schools	Fall 2008	Spring 2009	Fall 2009	Spring 2010	Fall 2010	Spring 2011	Fall 2011	Spring 2012	Fall 2012	Spring 2013
Bahia Vista	1			1	1	1	1	1	1	1
Coleman	1	1	1	1	1	x	1	1	1	1
Glenwood			1	1	1	1	1	1	1	1
Laurel Dell	1	1	1	1	1	1	1	1	1	1
Short								1	1	1
Sun Valley	1	1	1	1	1	1	1	1	1	1
Venetia Valley		1	1	1		1	1	1	1	x
Number of Schools	4	4	5	6	5	6	6	7	7	7