Impact of the Safe Routes to School Program on Walking and Bicycling

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Problem, research strategy, and findings: Increasing walking and bicycling to school has been a national policy goal since Congress created the Safe Routes to School (SRTS) program. While previous research has suggested positive program impacts, there have been no large-scale studies with strong research designs. Here we study 801 schools in the District of Columbia, Florida, Oregon, and Texas to assess how the proportion of students walking and bicycling to school changed after the introduction of SRTS programs. By including schools with and without SRTS programs and analyzing data collected over time (2007–2012), we are able to distinguish SRTS impacts from secular trends. We find increases in walking and bicycling after schools implemented SRTS programs. Engineering improvements are associated with an 18% relative increase in walking and bicycling, and the effects of education and encouragement programs are cumulative. Over the course of five years, these education and encouragement programs could lead to a 25% relative increase in walking and bicycling.

Takeaway for practice: Planners should work to prioritize capital improvements that improve non-motorized access to school and revise comprehensive plans and subdivision regulations to ensure that new development supports access to school.

Keywords: walk, bicycle, children, Safe Routes to School

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Increasing active transportation to school has been a national policy goal since Congress included the Safe Routes to School (SRTS) program in the 2005 federal transportation bill. Policy attention to this topic reflects the health benefits associated with regular physical activity, environmental benefits from decreased driving, and safety benefits from decreasing injuries and fatalities related to school travel (Davison, Werder, & Lawson, 2008; DiMaggio & Li, 2013; Janssen & LeBlanc, 2010; Woodcock et al., 2009; Younger, Morrow-Almeida, Vindigni, & Dannenberg, 2008). The role that planners have in infrastructure investment and the skills planners have in coordinating initiatives with developers, schools, and local law enforcement place them at the center of efforts to encourage walking and bicycling to school.

Between 2005 and 2012, Congress appropriated $1.2 billion for the SRTS program to provide education, encouragement, and enforcement programs as well as engineering improvements at almost 14,000 elementary and middle schools (McDonald, Barth, & Steiner, 2013; National Center for Safe Routes to School, 2013a). Existing evaluations of the SRTS program find increases in walking and bicycling to school (Boarnet, Day, Anderson, McMillan, & Alfonzo, 2005; Mendoza et al., 2011; Stewart, Moudon, & Claybrooke, 2014) and decreases in injuries near SRTS improvements (DiMaggio & Li, 2013; Ragland, Pande, Bigham, & Cooper, 2014). However, many of the studies focus on small geographic areas, such as an individual school or school district, limiting the generalizability of findings (Buckley, Lowry, Brown, & Barton, 2013; McDonald, Yang, Abbott, & Bullock, 2013; Mendoza et al., 2011). Larger-scale studies are characterized by research designs that make it difficult

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to discern SRTS impacts from secular trends (Staunton, Hubsmith, & Kallins, 2003).

This study addresses both of these concerns by evaluating the SRTS program in the District of Columbia (DC) and three states—Florida, Oregon, and Texas—using a strong research design with case and control schools, which allows identification of the independent impacts of the SRTS program. Using data from 801 schools, we find a positive impact of the SRTS program on walking and bicycling. Engineering improvements are associated with an 18% relative increase in walking and bicycling. The effects of education and encouragement programs are cumulative, with each additional year of program participation associated with an absolute increase of 1% in the proportion of students walking and bicycling to school. Over the course of five years, these education and encouragement programs could lead to a 25% relative increase in walking and bicycling. These results provide planners with the evidence required to make provision of safe walk and bicycle routes to school a standard part of planning practice using tools such as the comprehensive plan, subdivision regulations, and capital budgeting and planning.

Background

SRTS Program Overview

The 2005 federal transportation bill, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), authorized SRTS as a new program that would provide full federal funding to enable and encourage children, including those with disabilities, to walk and bicycle to school; to make walking and bicycling to school safe and more appealing; and to facilitate the planning, development, and implementation of projects that improve safety and reduce traffic, fuel consumption, and air pollution in the vicinity of schools (Federal Highway Administration, 2007).

The SRTS program provided grants to assist communities across the country in creating safer and more supportive environments for children to walk or bicycle to school. The program contributed to multiple policy objectives, including the U.S. Department of Transportation's livability goals and the Department of Health and Human Services' efforts to increase physical activity and reduce obesity in children and adolescents. These efforts sought to reverse sharp declines in walking and bicycling to school from about 48% in 1969 to less than 13% in 2009 (McDonald, Brown, Marchetti, & Pedroso, 2011).

The program allocated funding to state departments of transportation (DOTs) based on the number of school-aged children. Each state was required to set aside 10% to 30% of the funds for non-infrastructure-related activities such as public awareness campaigns and outreach to the community, traffic education, bicycle and pedestrian safety programs for children, and training for SRTS volunteers and managers. The infrastructure investments could include the planning, design, and construction of sidewalk improvements; traffic calming and speed reduction improvements; pedestrian and bicycle crossing improvements; on-street bicycle facilities; off-street bicycle and pedestrian facilities; secure bicycle parking; and traffic diversion improvements in the vicinity of schools (within 2 miles) that would substantially improve the ability of students to walk and bicycle to school. Each state was also required to fund a full-time coordinator for the state's SRTS program. In 2012, the SRTS program was merged with other non-motorized funding programs into the Transportation Alternatives Program (Federal Highway Administration, 2013a).

SRTS Evaluation Studies

Many studies evaluate aspects of the SRTS program. Several of those studies are primarily descriptive, aimed at explaining the program history, trends, or funding mechanism and expenditures (Cradock, Fields, Barrett, & Melly, 2012; McDonald, Barth, et al., 2013; National Center for Safe Routes to School, 2013b). The remainder focuses on the impacts of SRTS programs on active transportation and injuries. Most attention has been given to the program's impacts on the modes of travel children use to go to and from school; the results generally show increased walking and bicycling. The study designs of these evaluations have been a major challenge. Studies with strong research designs tend to have a limited geographic scope and range of SRTS interventions, and therefore limited generalizability. For example, Mendoza et al. (2011) test the impacts of researcher-led walking school bus programs using a randomized controlled trial in eight low-income Houston schools, finding these programs led to more walking to school. However, it is unclear what the impact of the intervention would be in other areas or with "walking school buses" organized by volunteers or school staff.

Another set of recent studies investigates a wider range of environments using comparisons of active travel before and after SRTS interventions or between areas with and without SRTS interventions. For example, Stewart et al. (2014) use data from 53 schools in four states and find walking and bicycling increased from

12.8% to 19.8% after completion of SRTS projects. Ragland et al. (2014) study eight California schools, and find students living near SRTS improvements were more likely to walk to school than students living equally close to school but not near a SRTS improvement. The limitation of these studies is that, due to the research designs, it is unclear whether the observed increases in active travel are due to the SRTS program or alternate explanations such as preexisting conditions or an exogenous, time-dependent shift such as a change in gas prices or employment levels.

A small number of studies that include control schools in their research design also find that SRTS programs have positive impacts. Buckley et al. (2013) study encouragement events at two Moscow (ID) elementary schools and find sustained increases in walking and bicycling after the program compared with a nearby school that did not participate in the program. McDonald, Yang, et al. (2013) find absolute increases of 5 to 20 percentage points in walking and bicycling due to the SRTS programs at Eugene (OR) schools, using data from nine schools with SRTS projects and five schools without such projects. While these studies use an improved research design, they represent a very small number of schools, and are therefore unlikely to be generalizable to a wider range of environments.

Two recent, high-quality studies find reductions in pedestrian injuries and crashes around SRTS interventions. DiMaggio and Li (2013) find that the rate of pedestrian injury decreased by 44% for youth aged 5 to 19 years in New York City census tracts with SRTS treatments, while rates were unchanged for census tracts without SRTS projects. Ragland et al. (2014) analyze the impacts of SRTS infrastructure at 47 schools in California and find significant decreases in total collisions within 250 feet of SRTS infrastructure interventions; a decrease in child-involved collisions is also observed, but the effect is not statistically significant.

Approach and Methods

Our analysis focuses on DC and three states—Florida, Oregon, and Texas. These areas were selected because they include a wide range of environments and the research team had access to extensive data on their SRTS programs. As Table 1 shows, Florida and Texas are large states where active SRTS programs funded interventions at nearly 1,000 schools in each state. Oregon is a mid-sized state with cities that have received national attention for their SRTS programs, such as Portland and Eugene. DC represents a highly urbanized region with schools serving students from diverse socioeconomic backgrounds. As Table 1 shows, available SRTS funding on a per-student basis was much higher in DC due to the structure of the program, which set a funding floor irrespective of student population. The remainder of this section describes the data and analytic methods used to identify the impacts of the SRTS program on walking and bicycling to or from school.

Data: School Travel Mode

The outcome of interest in this study is the proportion of students walking and bicycling for school trips. Information on children's mode to and from school is compiled from surveys of students and parents obtained from the National Center for SRTS, the federally funded clearinghouse for information related to SRTS. The National Center developed a freely available survey instrument to collect information on school travel mode from parents and students and also provided schools with free data entry and data storage. Student reports of travel mode were collected at the classroom level, with students raising their hands to report how they traveled to and from school on the survey day. Parent reports were collected through individual surveys sent from the school to parents. An evaluation of the National Center surveys finds that they provide reliable reports of travel mode (McDonald, Dwelley, Combs, Evenson, & Winters, 2011). While there

Table 1. Characteristics of state Safe Routes to School programs.

	District of Columbia	Florida	Oregon	Texas	Total
Appropriated SRTS funding (FY 2005–2012) (thousands)[a]	\$8,140	\$58,239	\$13,017	\$90,067	\$169,463
Number of K–8 students (fall 2010) (thousands)[b]	53.5	1,858.5	392.6	3,586.6	5,891.3
SRTS funding per student	\$152	\$31	\$33	\$25	\$29
Schools with announced SRTS funding[c]	31	1,085	152	853	2,121

Notes: FY = fiscal year; SRTS = Safe Routes to School.

a. Federal Highway Administration, 2013b.

b. National Center for Education Statistics, 2012.

c. National Center for Safe Routes to School, 2013a.

Table 2. Parent and child respondents by year and state.

	2007	2008	2009	2010	2011	2012	Annual average
Student report							
District of Columbia	0	1,489	1,003	476	252	2,623	974
Florida	3,263	54,634	51,154	27,682	35,181	30,204	33,686
Oregon	19,880	22,871	24,785	25,787	32,009	26,237	25,261
Texas	445	0	18,509	6,308	2,740	4,202	5,367
Total	23,588	78,994	95,451	60,253	70,182	63,265	65,289
Parent report							
District of Columbia	0	780	135	240	588	139	314
Florida	72	10567	13486	10049	6177	6295	7,774
Oregon	67	6517	5664	12267	8338	2403	5,876
Texas	2504	3370	2252	4193	760	1176	2,376
Total	2,643	21,234	21,537	26,749	15,863	10,013	16,340

is no federal requirement that schools collect mode data, many states require applicants and recipients of SRTS funding to provide travel mode data.

The National Center's travel mode database covers the period from the program's start through the current period. We selected the years 2007–2012 for our study because there were few travel mode reports in the program's early years (2005–2006), and our study began in 2013. We supplemented the National Center data with mode data from previous research studies on school travel to increase the sample of schools included in this analysis; the supplemental surveys used phrasing consistent with the National Center surveys (see the Technical Appendix for further details). Our analysis focuses on public and public charter schools because states awarded few grants to private schools, and information on school characteristics was not available for all private schools (McDonald, Barth, et al., 2013).

School travel mode and information on SRTS programming was available for an initial sample of 810 schools in DC, Florida, Oregon, and Texas. Data cleaning, described in the Technical Appendix, reduced the sample to 801 schools. As Table 2 shows, the final sample reflects travel mode reports from approximately 65,000 students and 16,000 parents annually. As Table 3 indicates, of the 801 schools in the final sample, 378 (47%) schools had an SRTS program between 2007 and 2012, and 423 (53%) schools had no program during the study period. For many schools in the sample, travel mode was surveyed at multiple time points. For example, 110 (14%) schools reported mode data four or more times, 85 (10%) schools reported data at three time points, 193 (24%) schools reported at two time points, and 413 (52%) schools provided data for one time point.

For each school and survey date, we calculate the proportion of students that walked or bicycled to and from the school in the morning and afternoon. The Technical Appendix describes the process of calculation for the student and parent data. Mode surveys at the 801 study schools generated 4,090 observations of the proportion of students walking and bicycling to or from school. The number of observations was larger

Table 3. Number of intervention and control schools by state.

	District of Columbia	Florida	Oregon	Texas	Total
Total study schools	24	282	222	273	801
Control schools	7	123	59	234	423
Control: none or unknown SRTS application	0	35	15	41	91
Control: applied for SRTS funding	7	88	44	193	332
Schools with SRTS interventions	17	159	163	39	378

Note: SRTS = Safe Routes to School.

Table 4. Types of Safe Routes to School interventions at study schools by state.

	District of Columbia	Florida	Oregon	Texas	Total
Schools with Safe Routes to School interventions	17	159	163	39	378
Non-infrastructure interventions	17	126	135	11	289
Education and encouragement	17	126	134	11	288
Enforcement	2	3	34	11	50
Infrastructure interventions	11	54	116	29	210
Sidewalk	9	50	38	28	125
Crosswalks	4	0	38	27	69
On-street bicycle	1	2	7	2	12
Off-street bicycle and pedestrian	0	0	14	2	16
Traffic calming	3	0	26	4	33
Bicycle parking	1	2	24	8	35
Signage	3	2	56	0	61

than the number of schools because each survey generated at least two observations of school travel mode, such as morning and afternoon, because some schools surveyed students and parents on the same survey date, and because nearly half of schools were surveyed multiple times. Despite the inclusion of multiple observations from the same school and survey date, we are not "double counting" because we used appropriate statistical methods to adjust for the presence of multiple observations from the same school and survey date. We also conducted several additional analyses that validated our strategy (described in detail in the Technical Appendix).

Data: SRTS Interventions

For all schools with available travel mode data, we attempted to identify the type and timing of SRTS interventions. State SRTS coordinators provided lists of schools with SRTS funding and, in some states, detailed information about the nature of the projects. In cases where the state DOT lacked information on when SRTS interventions were implemented or the nature of the interventions, members of the research team interviewed local SRTS program managers, school and municipal staff, and state and local health departments. In some cases, staff turnover made it impossible to obtain this information; in these cases, schools were dropped from the analysis. For schools that did not receive any SRTS interventions (i.e., control schools), we also used state DOT records and interviews with school officials, state health departments, and other providers of SRTS programs to help identify those that had applied for SRTS funding but had been unsuccessful in their application.

We categorize reported SRTS activities based upon the "4 E's": engineering, enforcement, education, and encouragement. As Table 4 indicates, education and encouragement programs are the most common non-infrastructure programs in our sample. Education programs include classroom safety instruction as well as skills workshops outside of the classroom where students practice crossing the street by foot and bicycle. Encouragement efforts focus on creating excitement around walking or bicycling by offering small rewards such as pencils and stickers, or using organized efforts, such as walking school buses, to encourage children to walk. We find that education and encouragement initiatives were undertaken at the same time; thus, we combine these categories in our analysis. Enforcement efforts ranged from collaborations with local police departments to assign officers to monitor and enforce school zone speed regulations to more passive initiatives such as placing portable speed signs in the school zone to provide drivers with real-time speed information. Almost all schools with enforcement interventions also had education and encouragement programs.

Engineering improvements were designed to improve the safety of walking and bicycling through the provision or improvement of sidewalks, crosswalks, paths, and bicycle lanes. Engineering projects also funded bicycle parking at schools, signage, and traffic calming near the school. In this sample, many schools reported sidewalk and crosswalk improvements but relatively few investments in bicycle lanes or off-street paths.

Data: Contextual School, Neighborhood, and Survey Information

Previous research has shown that walking and bicycling to school varies based on demographic and spatial characteristics (Davison, Werder, & Lawson, 2008; McDonald, Brown, et al., 2011). To control for this systematic variation, we incorporated information about school characteristics from the National Center for Education Statistics (NCES) and information about neighborhood characteristics from the American Community Survey (ACS). The NCES database contains annual information on enrollment, racial and ethnic composition, free and reduced-price lunch program eligibility, and school location for American public schools.[1] We obtained neighborhood socio-demographic information from the 2007–2011 ACS using the block group where the school was located.[2] Most neighborhood-level sociodemographic variables (e.g., racial and ethnic composition of residents) were not significant in preliminary models and are not included in the final models due to the lack of significance and the presence of school-level measures of racial and ethnic composition. We retain median household income in the final model despite a lack of statistical significance because previous research has highlighted meaningful economic differences in walking and bicycling to school and we wanted to control for neighborhood-level income variation in addition to school-level variation (McDonald, 2008).

The school's location is also used to assess the local built environment through street network and destination proximity metrics. Final models include Walk Score as a primary environmental metric, a commercially available index (0–100) that correlates with access to walkable destinations and residential population density (Carr, Dunsiger, & Marcus, 2011; Duncan, Aldstadt, Whalen, Melly, & Gortmaker, 2011).[3] We tested metrics of street connectivity, such as intersection density and average block length, in the models, but they were not statistically significant.

Sample Summary

Schools with SRTS programs differ on some but not all characteristics. For example, as Table 5 shows, schools with SRTS programs had a lower percentage of Hispanic students and a higher proportion of African-American students than schools without a SRTS program. Schools with SRTS programs had a smaller number of enrolled students. Economic characteristics were similar across the two groups; there are no significant differences in the proportion of students receiving free or reduced-price lunch or the block group median household income. Schools receiving SRTS interventions were located in

Table 5. Comparison of schools with and without Safe Routes to School interventions.

	All schools (*n* = 801)	Schools with SRTS interventions (*n* = 378)	Control schools (*n* = 423)	Difference: intervention control	*p* value of difference
School characteristics (2010–2011)[a]					
Elementary school (%)	83	86	79	7	0.008
Enrollment	607	579	632	–53.26	0.004
Free or reduced-price lunch (%)	61	61	61	1	0.718
Black (%)	14	17	11	6	<0.001
Hispanic (%)	42	31	51	–20	<0.001
Two races (%)	3	4	2	1	<0.001
White (%)	38	43	33	10	<0.001
Neighborhood characteristics (2007–2011)[b]					
Walk Score	44	47	41	7	<0.001
Median household income ($)	51,741	53,074	50,550	2,524	0.200
Population density per square mile	4,172	4,957	3,471	1,486	<0.001
Proportion walking and bicycling					
To school (%)	18	20	13	7	<0.001
From school (%)	22	23	17	6	<0.001

Notes: SRTS = Safe Routes to School.

a. Keaton, 2012.

b. U.S. Census Bureau, 2013.

neighborhoods with a higher population density and better access to destinations as measured by Walk Score.

Active travel was more common at schools that received an SRTS intervention during the study period than at control schools. Rates of walking and bicycling to school averaged 18% to school and 22% from school, but with considerable variation across schools. For example, the bottom quarter of schools had active travel rates of less than 8%, while the top quarter of schools had rates higher than 26% in the morning. These reports are higher than recent national estimates of walking and bicycling (13%) (McDonald, Brown, et al., 2011).

Analysis

By using schools with and without SRTS programs in a wide range of contexts, we are able to identify the impacts of SRTS programs and ensure these impacts are not confounded with secular trends or demographics. We model the proportion of students that walked or bicycled to school as a function of two factors: SRTS interventions and contextual variables related to school, neighborhood, and survey characteristics. The focus of our interest is the SRTS interventions in place at the school at the time of the survey. For each observation of school travel mode, we use our database of SRTS interventions to determine if the SRTS program was in place at the school and, if so, the number of years the program had been in place. This structure allows researchers to test how the presence and length of participation in the SRTS program affected walking and bicycling.

We developed two models to test the impacts of the SRTS program. The first focuses on the presence or absence of any SRTS program elements without regard to the exact nature of the efforts. This model provides the broadest test of whether the SRTS program has affected children's travel behavior. The second model assesses the impacts of different categories of SRTS interventions, such as education and encouragement, engineering, and enforcement, and is included to provide practitioners with a better understanding of the impacts of each type of SRTS intervention. We did not develop models to analyze the impacts of specific SRTS projects, such as crosswalk improvements, because we believe the choice of specific intervention is controlled by idiosyncratic local conditions that are difficult to model.

Models include contextual variables related to school, neighborhood, and survey characteristics to control for systematic variation in rates of walking and bicycling to school unrelated to the SRTS interventions. For example, the prevalence of walking and bicycling is higher in denser areas. We systematically controlled for the time of day because previous research shows that walking is higher in the afternoon. We also controlled for who reported the travel mode because we know that parents tend to report higher walking and bicycling rates than do students themselves (McDonald, Brown, et al., 2011).

We use a fractional logit model, as described in the Technical Appendix, because it best fits our needs and the data. To account for dependence across observations from the same school, we use robust standard errors that adjust for potential correlation across schools in the final models. We also conducted several tests (described in the Technical Appendix) to ensure that potential correlation across observations from the same school and survey date did not unduly influence the final results. All these additional tests confirm the model results presented in this study.

We calculate the impacts of the SRTS program on school travel mode by estimating the marginal effect of the presence and number of years of SRTS interventions on walking and bicycling. The reported marginal effects represent how the proportion of students walking and bicycling to school would change if the SRTS program were implemented or if it were in place for one additional year. Further details on the calculation of marginal effects are available in the Technical Appendix.

SRTS and Children's Travel to School

As Figure 1 shows, rates of walking and bicycling to school increased with each year of participation in the SRTS program. At schools with SRTS programs, 18% of students walked or bicycled prior to the start of the program. Schools with one year of SRTS program participation had average rates of walking and bicycling of 20%. Schools with four or more years of SRTS participation had active travel rates greater than 30%. These simple averages showed an absolute increase of 13 percentage points, or a relative change of 71%, in the proportion of students walking and bicycling after five years of participating in the SRTS program. These results suggest that SRTS programs may strongly affect walking and bicycling. Moreover, there may be a "dose-response" relationship where each additional year (or "dose") of SRTS participation leads to more walking and bicycling.

However, the simple averages are not a definitive evaluation of the SRTS program because of the possibility of selection bias. Schools with long-lived and successful SRTS program may simply be located in environments where walking is more likely or may have been surveyed in a year when exogenous factors increased walking, such as increases in gas prices. To address these issues, as described

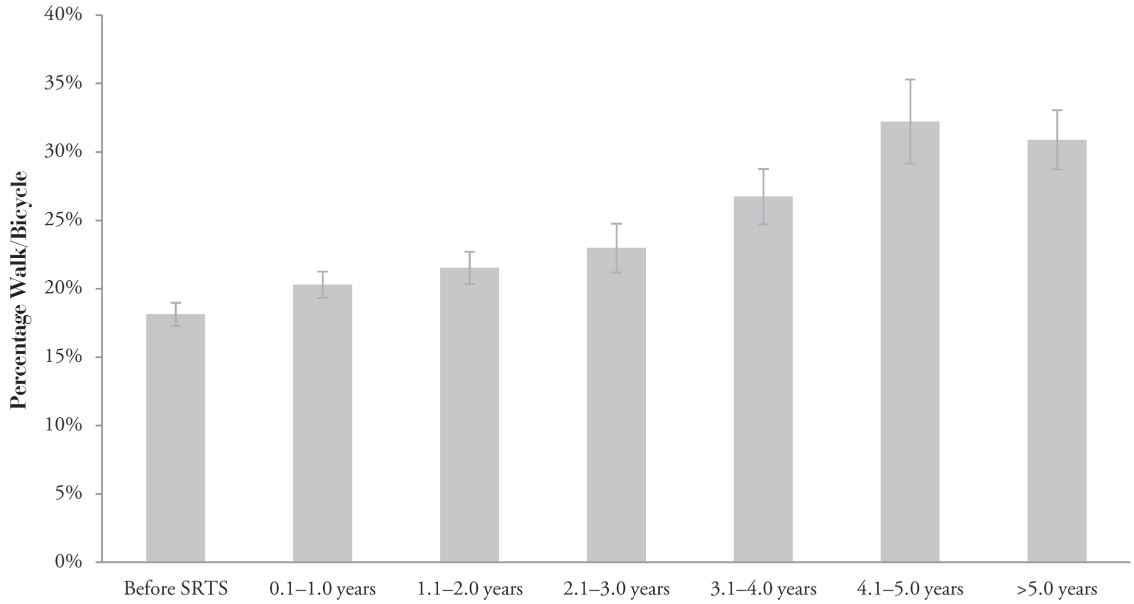

Figure 1. Average rates of walking and bicycling to school by length of participation in Safe Routes to School program.

above, we use multivariate regression models that introduce statistical controls for school and neighborhood characteristics, as well as time period, to assess active travel at schools with and without SRTS programs.

After controlling for these other factors, we continue to find that the SRTS program increased walking and bicycling to school. Specifically, walking and bicycling rose by 1.1 percentage points ($p = .002$) with each year of participation in the SRTS program. These findings suggest a linear "dose-response" relationship: Each additional year of SRTS participation led, on average, to more walking and bicycling. For example, if active travel rates were 18% prior to the start of an SRTS program, our model predicts that 23.5% of students, on average, would walk and bicycle after five years of program participation. This represents an absolute increase of 5.5 percentage points and a relative increase of 31% after five years of SRTS participation. After one year of SRTS participation, the expected absolute increase would be 1.1 percentage points or a relative change of 6%. For reference, the Technical Appendix contains the full model results.

In our second model, we compare the differential impacts of engineering, education and encouragement, and enforcement programs (the full model is available in the Technical Appendix). The presence of an engineering improvement was associated with a 3.3 percentage point increase in walking and bicycling ($p = .031$); this impact did not depend on how long the improvement had been in place. For comparison, this would mean that schools with 18% of students walking and bicycling might expect to see rates rise to 21.3%, on average, after completing an engineering project. This represents a relative increase of 18%.

Education and encouragement interventions also had significant positive impacts on walking and bicycling, with each year of participation in an education and encouragement program associated with a 0.9 percentage point increase in walking and bicycling ($p = .025$). In other words, schools that started with 18% of students walking and bicycling would be expected to increase the rate of active transportation by 0.9 percentage point per year to 22.5% after five years on average, an absolute change of 4.5 percentage points and a relative change of 25%. Enforcement initiatives did not have a significant association with walking and bicycling, though in our sample many schools implemented education, encouragement, and enforcement at the same time.

Other variables beyond simply adopting an SRTS program also influence rates of walking and bicycling to school in ways consistent with previous research. For example, walking and bicycling were higher in areas with greater population density. Walk Score, a proxy for access to commercial and recreation amenities, had no significant association, perhaps because the indicator only reflects access and not the quality of the walking environment (Talen & Koschinsky, 2013). Other factors also matter. Rates of walking and bicycling were 3 percentage points higher in the afternoon, results consistent with other studies (National Center for Safe Routes to School, 2013b; Zhu & Lee, 2009). Reported walking and bicycling rates were also higher when reported by parents than by students because parents reported the students' usual travel mode as opposed to their actual travel mode (McDonald, Dwelley, et al., 2011).

School characteristics generally did not significantly affect walking and bicycling to or from school. However, a 10 percentage point increase in the proportion of students receiving free or reduced-price lunch was associated with a 0.5 percentage point increase in walking and bicycling. We did include a dummy variable indicating whether the school ever received a SRTS treatment to account for any remaining differences between schools that participated in the SRTS program and those that did not. The dummy variable was not significant in either model, suggesting that observed characteristics do an adequate job of adjusting for differences between treatment and control schools.

Impacts of the SRTS Program

Our analysis shows that SRTS interventions are associated with increased walking and bicycling in DC, Florida, Oregon, and Texas. We find that engineering improvements are associated with an absolute increase of 3 percentage points in active travel, which represents a relative increase of 18%. Education and encouragement programs exhibit a dose-response relationship with walking and bicycling, where each additional year of program participation is associated with a 1 percentage point increase in walking and bicycling. Over a five-year period, these education and encouragement programs would be expected to lead to a relative increase in active travel of 25%. These results hold when comparing funded schools only with those that applied for the SRTS program and after controlling for other factors that influence walking to school such as population density. These findings accord with the results of previous studies, which also find positive impacts of the SRTS program (Boarnet, Anderson, Day, McMillan, & Alfonzo, 2005; McDonald, Yang, et al., 2013; Mendoza et al., 2011; Staunton et al., 2003; Stewart et al., 2014). However, our study represents a substantial extension of the literature because it uses a stronger research design with a large study area, thereby increasing confidence in the generalizability of the results.

While this analysis demonstrates the effectiveness of the SRTS program in meeting the goal of increasing walking and bicycling to school, recent changes in federal transportation policy may result in less federal funds being available for such investments. The SRTS program was created in the 2005 federal transportation bill, and approximately $1.2 billion was appropriated for the program (McDonald, Barth, et al., 2013). However, the 2012 transportation bill, Moving Ahead for Progress in the 21st Century (MAP-21), dismantled the standalone SRTS program and instead made SRTS projects eligible to compete for funding with other non-motorized improvements. In addition, MAP-21 decreased the total funding available for non-motorized programs and allowed states increased flexibility to move non-motorized funds to other programs. It is not yet clear how these changes will affect state funding for the SRTS program, but it is possible that some states will decrease funding for SRTS or non-motorized programs more generally.

What do these results mean for planning practitioners? This study provides strong evidence that children will walk and bicycle to school if communities invest in supportive infrastructure and programs. Given the uncertainty and limitations of federal funding for non-motorized modes, communities should develop strategies to mainstream SRTS programs through tools available to local planners. First, planners can articulate support for providing access by foot and bicycle to schools through the comprehensive plan and any linked small-area or neighborhood plans. The goal would be to create an environment where planning for non-motorized school access is a normal part of neighborhood and transportation planning. Second, planners can amend subdivision regulations to require or encourage the provision of pedestrian and bicycle access to schools for new construction or redevelopment. Third, planners can consider access to school in the capital improvements planning process. For example, a multiyear sidewalk completion program could prioritize investments that are near a school or route to school. Fourth, local planners can work more closely with school facility planners to encourage construction of schools that can be reached by foot or bicycle and to identify routes to school (McDonald, 2010). The development of an ongoing, collaborative relationship between school and local planners could ensure that students effectively use infrastructure investments made by local communities. Finally, planners could pursue federal and state funding for non-motorized infrastructure for projects that will improve school travel. Such projects could be designed to benefit many users, such as a multiuse path that connects a school to several neighborhoods and other community amenities.

This analysis has several limitations. First, we were unable to use panel data methods to address concerns about self-selection bias or other potential confounding factors due to our use of fractional logit models and our unbalanced data set. However, we address self-selection bias by including contextual variables and estimating models on portions of our data set and find results are consistent with overall models. Second, the format of our data set includes multiple observations of each school at each survey date (e.g., walking in the morning and the afternoon). We address concerns about the impacts of dependence across these observations by using robust standard errors and estimating additional models on a subset of data with only one observation per time point. Again, submodels showed similar results to the overall models. Third, we evaluate the impact of broad interventions: engineering, education and encouragement, and enforcement. This approach reflects our goal of testing whether SRTS interventions had positive impacts on walking and bicycling and recognition that the selection of particular engineering or education programs depends heavily on local conditions that may be difficult to model. We recommend that future research provide more detailed case studies of how communities selected specific interventions and what their impacts were locally. These case studies would not be generalizable, but would provide important information to practitioners.

Conclusion

The SRTS program has demonstrated significant increases in walking and bicycling. Analysis of data from 801 schools in DC, Florida, Oregon, and Texas indicates an absolute increase of 5.5 percentage points or a relative change of 31% in the proportion of students walking and bicycling to school after five years of participating in a SRTS program. This study supports the efficacy of SRTS programs as a mechanism for increasing active travel in elementary and middle schools. The findings represent a beneficial extension of the existing literature using a strong research design and a large study area, which has not been done before, and thereby increasing confidence in the transferability of results. These results provide planners with strong evidence to support strategies that make the provision of safe walk and bicycle routes to school a normal part of the planning process. Planners have many tools to accomplish this goal, including comprehensive plans, subdivision regulations, and capital improvement planning and budgeting.

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Notes

1. For the small number of study schools with missing data in the NCES, we obtained comparable information from the school district or state education department's website.

2. We used the block group as a proxy for the school's neighborhood because we believe it is most likely to correlate with the school's attendance zone without including areas outside the zone. It was not possible to report demographics for the school's attendance zone because many schools do not have geographically defined attendance areas and because we were unable to systematically collect attendance zone maps for districts that do use them.

3. No bicycle-specific environmental measure was included because Bike Score data were not universally available for all schools in the study. However, the vast majority of reported active school travel was walking, not bicycling, and therefore we do not believe the lack of bicycle-specific environmental metrics is problematic.

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Technical Appendix

This appendix provides additional detail on the study data, model structure, estimation of marginal effects, model results, and tests of model robustness.

Study Data

Student reports of school travel were collected at the classroom level. Many schools conducted this survey for multiple days; these daily counts were averaged to produce a weekly count by mode for the trip to and from school by classroom. The classroom estimates were then aggregated to estimate the proportion of students walking and bicycling by grade. School-level estimates of walking and bicycling in the morning and afternoon were constructed by averaging the grade-level estimates. This approach standardized the reported rates of walking and bicycling by grade, which means that differential response rates by grade over time did not affect our results. Parent reports of the child's usual travel mode were available from a validated instrument that reported travel mode to and from school as well as the child's grade and school (McDonald, Dwelley, Combs, Evenson, & Winters, 2011). These individual-level reports were aggregated in the same manner as the student reports so that the proportion of students walking and bicycling to school was calculated by school, survey date, and time of day. No attempt was made to identify unique parent–child dyads because the data sets provide no way to link the two data sets.

Beyond data from the National Center for Safe Routes to School, we also included information from previous research. In Florida, mode data on an additional 40 schools that did not receive SRTS interventions were available in four counties from previous research by Steiner et al.

(2011). In Oregon, supplementary data were obtained from the City of Portland, which developed their own survey instrument to collect annual mode data, and from a study of the SRTS program in Eugene (OR; McDonald, Yang, Abbott, & Bullock, 2013). In Texas, mode data were obtained from multiple resources, including the SRTS application data submitted to the Texas Department of Transportation and researchers' previous research projects (Abiodun et al., 2014; Lee, Zhu, Yoon, & Varni, 2013; Zhu & Lee, 2009; Zhu, Lee, Kwok, & Varni, 2011).

This approach yielded an initial sample of 810 schools with sufficient data on school travel mode and SRTS interventions. For these schools, there were 4,504 unique observations of school travel mode by school, survey date, time of day, and data source (parent vs. student). To ensure data quality, we dropped a number of cases. First, we eliminated records if the reported walk and bicycle share was 100% and information for other modes was missing ($n = 6$). These surveys were dropped from the analysis because of the likelihood of survey administration problems (i.e., survey administrators collected data on walkers and bicyclists only instead of all students). Second, observations were dropped if the reported proportion of students walking was missing ($n = 6$). Third, we also dropped observations where the survey response rates were less than 25% (approximately the 10th percentile) and sample sizes were less than 25 (approximately the 10th percentile; $n = 402$) because they may indicate nonrandom sampling. Survey response rates were estimated as the ratio of the number of survey respondents divided by the school enrollment. This approach underestimated the response rate for students slightly since it does not adjust for absences; it might also have significantly underestimated parent response rates since many parents have multiple children at the same school, yet the survey instructed them to answer only for one child. Response rates were quite high for student reports of travel mode with a median response rate of 73% and an interquartile range (IQR) of 39% to 90%. Response rates for parent surveys were lower, with a median response rate for parent surveys of 14% (IQR, 5% to 26%). The final sample included 801 schools with 4,090 observations of school travel mode.

Model Structure

As described in the study, we used a fractional logit model to estimate the impacts of the Safe Routes to School (STRS) program (Equation 1). We modeled the proportion of students at school i and time t that walked or bicycled, y_{it}, as a function of the presence and number of years of SRTS interventions, $SRTS_{it}$. The model also included statistical controls for the time period, D_t; neighborhood characteristics, Z_i; and school characteristics, X_{it}, to adjust for any systematic variation in active travel based on location, demographics, or time period (Equation 1). The fractional logit model required, by construction, that the outcome variable be between 0 and 1. The advantage of the fractional logit model over other approaches to dealing with dependent variables with limited outcomes is that the use of a fractional logit model allowed recovery of the marginal effects of interest; other approaches such as taking logarithms do not allow this (Papke & Wooldridge, 1996). We analyzed the data as a pooled cross-section because panel methods for fractional logit models with unbalanced data have not yet been developed (Papke & Wooldridge, 2008).

$$y_{it} = \frac{\exp(\alpha + \beta SRTS_{it} + \omega D_t + \gamma X_{it} + \eta Z_i)}{\left[1 + \exp(\alpha + \beta SRTS_{it} + \omega D_t + \gamma X_{it} + \eta Z_i)\right]} \qquad (1)$$

Estimation of Marginal Effects

We estimated the impacts of the SRTS program by focusing on the marginal effects. The effect of the presence of a SRTS intervention was estimated as a discrete effect, $\Delta E(y|x)/\Delta D_{srts}$ (Equation 2). These discrete effects provided an estimate of the absolute percentage point increase in walking and bicycling associated with SRTS interventions and were computed by calculating the discrete effect for each observation and then averaging over the sample (Equation 2). Models also included an indicator of the number of years since the SRTS intervention was implemented. The reported marginal effect provides an estimate of how walking and bicycling changes for a one-year increase in SRTS program participation. The reported marginal and discrete effect of SRTS participation was calculated for each observation and then averaged over the sample.

Presence of SRTS Program:

$$\frac{\Delta E(y\,|\,x)}{\Delta SRTS_{it}} = \frac{1}{N}\sum_{n}(E(y|x, SRTS_{it} = 1) - E(y|x, SRTS_{it} = 0). \qquad (2)$$

Model Results

Table A-1 shows the full model results with coefficients as well as marginal effects.

Tests of Model Robustness

As noted in the study, there were two potential methodological concerns with our approach to estimating the effects of the SRTS program. First, there were

Table A-1. (Continued)

	Model 1: Presence/absence of SRTS		Model 2: Type of SRTS intervention	
	Coefficient	**Marginal effect**	**Coefficient**	**Marginal effect**
June	–0.073	–0.011	–0.030	–0.005
July	–1.625***	–0.158***	–1.604***	–0.156***
August	–0.084	–0.013	–0.074	–0.011
September	–0.011	–0.002	0.008	0.001
October (reference)				
November	0.217	0.036	0.219	0.037
December	–0.136	–0.021	–0.112	–0.017
Unknown	–0.224	–0.034	–0.215	–0.032
No. observations	4,090		4,090	
No. schools	801		801	
LL	–1404.04		–1402.41	
AIC	–2878.1		–2884.8	

Notes: Coefficients from month of survey administration and constant terms are not shown. AIC = Akaike information criterion; Educ. & Enc. = education and encouragement; HH = household; FRL = free or reduced-price lunch; LL = log likelihood; SRTS = Safe Routes to School.
*$p < .05$; **$p < .01$; ***$p < .001$.

multiple observations from the same school and survey date (e.g., morning and afternoon reports of travel mode). Such observations are not independent. We adjusted for potential correlation by using robust standard errors adjusted for clustering across schools. However, we also wanted to test whether our findings changed if we limited observations to one observation for each school and survey date, a situation that eliminates potential correlation by school and survey date. After limiting the data set to one observation by school and survey date (selected randomly), we found our results unchanged (Table A-2). This suggests that correlation across observations from the same school and survey date is not problematic.

The second methodological concern was self-selection bias. Program evaluation is difficult, particularly when assignment to treatment—in this case receiving an SRTS intervention—is not exogenous. Schools and communities made their own decision about whether or not to apply for SRTS funding, and states selected schools that would receive the grants. It is not unreasonable to expect that schools that applied to the SRTS program were different from schools that did not apply. For example, schools that sought funding might have an identified safety problem, have a strong champion of walking and bicycling, or be places where communities valued walking and bicycling. The type of places that applied for the SRTS program might be places where the program was more likely to be effective. This self-selection bias creates difficulties for modeling program impacts. In the study, we address self-selection bias by including statistical controls for school and neighborhood characteristics. Here, we conduct an additional analysis that compares schools receiving the SRTS program with schools that applied for but did not receive funding. Schools that applied for the SRTS program, but did not receive funding, should be more similar to funded schools on unobservable characteristics such as attitudes favorable to walking and bicycling than schools that never applied for SRTS funding. As shown in Table A-3, we find our results unchanged when only including the 708 schools that applied for SRTS funding. Our final check included only the 378 schools that had a SRTS program during the study period. In effect, this used observations on schools prior

Table A-2. Marginal effects of Safe Routes to School interventions with one observation per school and survey date.

	Marginal effect	p value
SRTS intervention		
Presence	0.005	0.700
Length (years)	0.013	0.001
No. schools	801	
No. observations	1649	
LL	–568.0	

Note: Models include all variables included in Model 1 from Table A-1.