Examining Long-Term Impact of California Safe Routes to School Program

Ten Years Later

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California was the first state to legislate a Safe Routes to School (SR2S) program under Assembly Bill 1475 (1999). SR2S funds construction projects that make it safer for children to walk or bicycle to school and encourages a greater number of children to choose these modes of travel for the school commute. The main goal of this project was to assess the long-term impact of program-funded engineering modifications on walking and bicycling levels and safety. Improvements were evaluated with a targeted method to determine the countermeasures that resulted in safety and mode shift. The major results indicated that the safety of pedestrians increased within 250 ft of an infrastructure improvement, such as a sidewalk. There was also evidence of mode shift near improvements. Positive results for safety and mobility, as well as improved data collection for funded programs, should make SR2S programs competitive among other transportation needs.

For more than 10 years, efforts to encourage children to walk and bicycle to school have attracted concerted programmatic and policy attention to address the issues of physical inactivity and pedestrian injury risk around schools and in local communities in the United States (*1*). In 1969, 42% of U.S. schoolchildren aged five to eighteen walked or bicycled to school. By 2009, this number had declined to 12.7% (*2*).

A 2008 report from the Centers for Disease Control and Prevention investigating why more children do not walk to school found traffic safety to be the second most common barrier (*3*). Overall, children are involved in about one-third of all pedestrian-vehicle crashes (*4*). Children aged 5 to 15 years bicycle more than any other age group. In 2011, children under the age of 16 years comprised 21% of those injured and 11% of those killed in a bicycle crash (*5*).

Research on the barriers and opportunities to walk and bicycle to school has consistently found that distance between home and school is a primary factor influencing how children travel to school (*3, 6–17*). A study of 16 California elementary schools participating in the California Safe Routes to School (SRTS) project found that children who lived within a mile of school were three times more likely to walk to school than to travel by private vehicle (*12*).

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Engineering-related factors that increase pedestrian and bicycle safety may also influence walking and bicycling to school. Separation of pedestrians, bicyclists, and motor vehicles onto different elements of the transportation system is a possible area of engineering modifications. For example, modifications could involve providing sidewalks, bike lanes, and bike paths. Conflict points between pedestrians and bicyclists and motor vehicles could be reduced by providing marked crosswalks and crossings at traffic lights, altering signal timing so there is a pedestrian-only phase, and reducing traffic volumes and speeds around schools. A study of 19 elementary schools in Australia found that children were less likely to walk or bicycle to school if they had to travel along a roadway with busy traffic and no lights or crossing points (*14*). At three elementary schools in California, parents reported a 38% increase in how often children walked to school after an SRTS sidewalk improvement was completed (*18*).

Safe Routes to School (SR2S) is a program that was initially developed in Odense, Denmark, in the 1970s after studies revealed that Denmark had the highest child pedestrian collision rate in Europe. The Odense program created a series of engineering improvements to reduce safety hazards. Ten years after implementation, child pedestrian casualties had decreased by more than 80% (*19*). The first program in the United States was initiated in 1994 in the Bronx, New York. Like the Odense program, this community SR2S program focused primarily on reduction of pedestrian injury and death through engineering improvements.

In 1999, California became the first state to pass legislation for a state-level program, which allocated federal transportation funds for engineering modifications near schools. The goals of the policy are to increase walking and bicycling activity among students at elementary, middle, and high schools and to reduce child and adolescent injuries and fatalities. The dual program goals are key: focusing on safety as well as mobility means that broader public health goals can be attained compared with just focusing on mobility or safety alone. Subsequently, federal funds were made available to schools through the SR2S project allocated by the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2009), the transportation authorization in place between 2005 and 2010. The acronym of the federal program, SRTS, will be used throughout the rest of this paper for the sake of clarity.

The California program provides funding to municipalities for engineering modifications such as sidewalks, crosswalk placement and painting, traffic lights, and speed humps near schools. The municipality is required to provide a minimum of 10% in local matching funds. From its inception in 1999 to the end of 2006, the California SRTS program funded 570 projects with a total cost of more than $190 million. The projects were equitably distributed across the state, with proportional representation achieved geographically and by population (*20*). The California legislature has reauthorized the program three times over the past decade.

The original California legislation included mandates for two periods of evaluation to measure any changes in mobility and safety. A research team from the University of California (UC), Irvine, conducted the first study, which focused on the impact of the program on levels of walking and bicycling to school and traffic safety characteristics (e.g., vehicle speeds, yielding, and pedestrian and bicyclist travel patterns) near schools (*21, 22*). In the second evaluation, a research team from the UC Berkeley examined the effectiveness of the program in reducing crashes, injuries, and fatalities involving children in the vicinity of the projects (*20*).

The UC Irvine evaluation collected pre- and post-construction data at 10 schools and found increased rates of walking and bicycling to school after the engineering modification was completed near a school, particularly when the modification was along a child's chosen route to school. In addition, the evaluation found that traffic safety conditions improved at several schools. For example, children were walking on a newly constructed sidewalk rather than the shoulder of the roadway, and yielding rates of motor vehicles to pedestrians and bicyclists at intersections improved after the installation of a traffic signal (*21, 22*).

The UC Berkeley evaluation, which examined 125 California SRTS projects funded between 2000 and 2005, found an overall decline in the number of child pedestrian and bicyclist injuries in the SRTS project areas, the study control areas, and in California as a whole, consistent with national data. However, when compared with the control areas, the SRTS project areas did not show a greater decline in the number of injuries. But once increases in walking rates were taken into account in the project areas, the California program did suggest a decreased rate of injury and a net benefit in terms of safety for the affected students. Other reported safety benefits included reductions in near misses, increased perceptions of safety, less vehicle traffic, and improved driver and pedestrian behavior (*20*).

EVALUATION METHODOLOGY AND MAJOR FINDINGS

The present study was conducted with a grant from the Robert Wood Johnson Foundation Active Living Research Program. Researchers from UC Berkeley updated the safety study (*20*), and two members of the original UC Irvine research team conducted the mobility study (*21, 22*). Forty-seven schools throughout California were included in the safety study, and nine schools from southern California were included in the mobility study.

The goals of the SRTS evaluation were to

1. Assess the long-term impact of safety around schools that have implemented SRTS-funded infrastructure improvements around schools and
2. Assess the long-term impact of SRTS-funded engineering modifications on walking and bicycling activity.

The focus of this research was to develop analyses that were location-specific, that is, to look at safety and mobility near specific SRTS infrastructure improvements. Overall, the method that was used provided a model for future evaluation research. The methodology and major findings are described separately below for safety and mobility.

Safety Study

Methodology

The safety analysis was based on a comparison of school areas that were affected by SRTS projects (school areas) and nearby areas that were unlikely to be affected by the SRTS improvements (control areas). For the school areas and the control areas, the change in the number of collisions was compared for the period before the SRTS construction took place (preconstruction) and the period after the SRTS construction was completed (postconstruction). This location-based analysis required compiling data from several sources: agencies, schools, and the location of SRTS funded countermeasures and collision data.

Program Data

Data on funded agencies were available from the California Department of Transportation SRTS website. Follow-up contacts with individual agencies provided information on the schools affected by the project, locations of constructed countermeasures, and construction start and end dates. The study contacted 313 agencies through e-mail and 93 agencies responded to the request for data.

School Data

Program data were available at the agency level. An SRTS program can affect one or multiple schools. Each school listed in an agency's application was matched to the California Department of Education's database of public schools. The database contains information on each school on enrollment, grade level, opening dates, latitude and longitude coordinates, and other factors. Each school is assigned a County-District-School code, which was used as a unique identifier to match all schools used in the analysis.

Countermeasure Data

A funded project at a school site can list zero, one, or multiple countermeasures. For example, an SRTS project could fund the construction of sidewalks, curb ramps, and radar speed feedback signs for a school. One countermeasure could affect multiple schools. For example, a project could fund the construction of a sidewalk expansion that would affect two schools that are close to each other. Some project data did not specify the location of the countermeasure.

Countermeasures were classified as being located either at an intersection or along a corridor. A countermeasure data set was created that had one record per countermeasure per school. The data set was then geocoded with a combination of ArcGIS software and Google Maps. Intersections were batch-geocoded with ArcGIS 10 and Streetmap North America. Corridors were initially created with Google My Maps by tracing the roadway between the specified start and end points. The corridors were then imported into ArcGIS software. A buffer of 250 ft (76.2 m) was created around each countermeasure. Previous research by the Florida Department of Transportation and FHWA used the same buffer measurement (*23, 24*). It was determined that collisions within 250 ft of a countermeasure could reasonably be expected to be affected by the countermeasure.

When available, the expected effectiveness of SRTS infrastructure improvements was gauged by consulting the FHWA guide for crash reduction factors (CRFs). Table 1 summarizes the CRFs for the countermeasures in the final data set. The CRF is a number giving the expected percentage reduction in collisions for a particular countermeasure. For example, among the set of infrastructure countermeasures identified in this study, the countermeasure with the highest CRF was to install sidewalk (to avoid walking along roadway), with CRF = 74 (Table 1). CRF = 74 means that there is a 74% expected reduction in pedestrian-involved collisions for that countermeasure. It was expected that countermeasures with high CRFs would yield a safety benefit. With this evaluation, the purpose of applying CRFs was to determine whether, a priori, the installed infrastructure improvements had a demonstrated effectiveness based on previous systematic studies. The data set of geocoded countermeasure buffer zones included 25 corridors and 50 intersections.

Preconstruction and Postconstruction Dates

Each program area was assigned a preconstruction period and a postconstruction period. The assignment was based on the construction start and end dates provided by the agencies. The preconstruction start date was designated as the later date of the date the school opened or 48 months before the end date. The preconstruction end date was the reported date that construction started. The start date for the postconstruction period was the reported date of construction completion. The end date was selected as the earliest of 48 months after the start date, the date the school closed, or December 31, 2009.

Collision Data

Collision data were obtained from the California Statewide Integrated Traffic Records System (SWITRS) (*25*). SWITRS is a database of police-reported collisions maintained by the California Highway Patrol. The collisions were subsequently geocoded and then made accessible to researchers through the Transportation Injury Mapping System (*26*). SWITRS injury and fatality data were obtained from Transportation Injury Mapping System for the period from January 1, 1998, through December 31, 2009. Pedestrian- or bicycle-involved collisions occurring between 6 a.m. and 6 p.m. from September through May were selected for the analysis.

Data Set of Localized Collisions

Collisions occurring within 250-ft countermeasure buffer zones (program areas) or quarter-mile school buffer zones (control areas) were selected for the statistical analysis. A binary variable was created that described location: either within the improvement zone (program area) or outside the improvement zone (control area). A numeric code (1 through 75) was used to stratify the sample by school. The code represented 150 program and control areas around 75 constructed countermeasures. Of the countermeasures, 32 were intersection based and 15 were corridor based. The countermeasures were localized to 47 schools; the breakdown of schools within the sample is presented in Table 2. A school could appear multiple times in the data set if multiple countermeasures were constructed around it.

Analysis

Random-intercept Poisson and random-intercept negative binomial regression models were applied to the data, with the methods discussed in Diggle et al. (*27*), Rabe-Hesketh and Skrondal (*28*), and Rothman et al. (*29*). The Stata statistical software package was used for all data management and analysis procedures and the generalized linear latent and mixed models procedure was used to implement the models (*30*). A Huber-White sandwich estimator of the variance-covariance matrix was specified to protect against violations of distributional assumptions. Overdispersion is a common problem with Poisson regression. The random intercept and the robust variance estimator were used to address the overdispersion.

Major Findings

Mapping the locations made the following points clear: (*a*) on average, the intersections were within 0.23 mi (0.37 km) of the nearest school and (*b*) collisions were often situated in locations that were unlikely to be affected by the SRTS infrastructure improvements (Figure 1).

TABLE 1 Countermeasures and Crash Reduction Factors in Data Set

Countermeasure	Count	CRF
Install sidewalk (to avoid walking along roadway)	25	74
Install traffic signal	11	38
Install dynamic advance intersection warning system	2	70
Install flashing beacons as advance warning	1	30
Replace existing "Walk–Don't Walk" signals with pedestrian countdown signal heads	2	52
Install speed humps	3	50
Install changeable speed warning signs for individual drivers	4	46
Improve superelevation (for drainage)	7	45
Total countermeasures	55	na

NOTE: na = not applicable.

TABLE 2 Schools in Data Set

Grade Served	Number of Schools
Kindergarten–Grade 4	1
Kindergarten–Grade 5	24
Kindergarten–Grade 6	11
Kindergarten–Grade 7	1
Kindergarten–Grade 8	2
6–8	4
6–9	1
9–12	3
Total	47

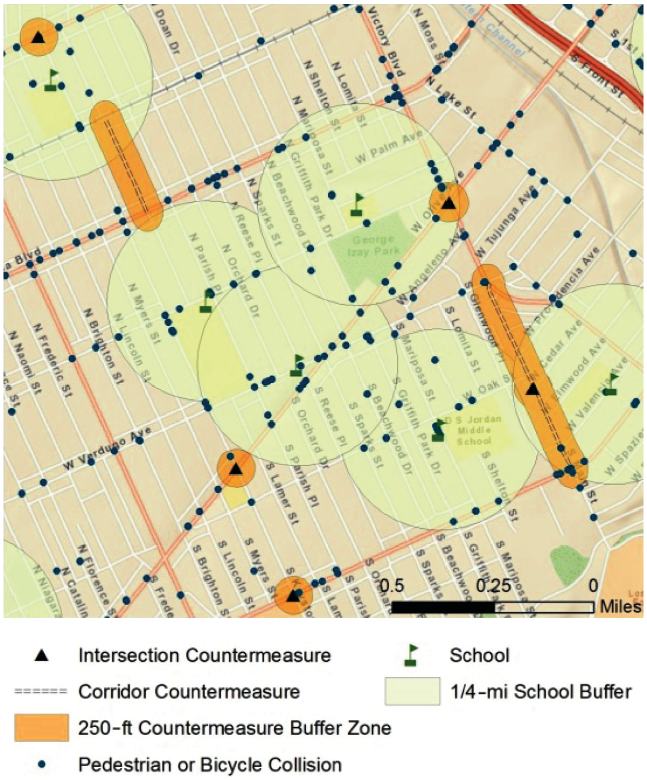

FIGURE 1 Sample SRTS injury collision and SRTS countermeasure map, Los Angeles, California.

The analysis focused on changes in the numbers of injury collisions that occurred within 250 ft of the funded countermeasure. The injury collisions were then compared with changes in the numbers of injury collisions that occurred beyond 250 ft of the countermeasures but within a quarter mile of the school. This approach was based on the assumption that countermeasures would affect pedestrian and bicyclist safety closest to the installation location of the countermeasure. Countermeasures would not be expected to affect pedestrians or bicyclists arriving outside the range of the countermeasure. For example, if a sidewalk was built on the east side of a school, those living on the west side would not be expected to benefit from it on the trip to school. The analysis was conducted twice: first, for pedestrians and bicyclists ages 5 to 18 years and, second, for pedestrians and bicyclists of all ages.

The first analysis, which used collisions involving pedestrians and bicyclists ages 5 to 18 years, found an incident rate ratio (IRR) of 0.47 (Table 3). This IRR corresponded to a 50% reduction in collisions in the treatment area (within 250 ft of the countermeasure) in relation to the area outside the treatment area. However, the effect did not reach the statistically significant level of 0.05. The patterns for subcategories of injuries were similar.

The second analysis used collisions involving pedestrians and bicyclists of all ages (Table 4). The analysis found an IRR of 0.26, corresponding to a collision reduction of about 75%. This result was statistically significant ($p = .003$). The pattern was similar for most of the collision subcategories, such as fatalities, serious injuries, and minor injuries. Although the primary rationale for the SRTS program is to increase safety for students on their way to and from school, countermeasures for increasing safety for students also improve safety for pedestrians and bicyclists of all ages.

The strengths of the analysis were the high case ascertainment, through the use of police-reported collisions in SWITRS, and the comparison of pre- and postcollisions within the distance of countermeasure impact. The safety portion of the study involved the development of analyses that were more appropriate for the specific location-based SRTS infrastructure improvements in comparison with the schoolwide analyses that were conducted in a previous study (*20*).

TABLE 3 IRRs for Program Effect, Analysis 1

		95% Confidence Level		
Collision Characteristic	IRR	LL	UL	*p*
Total	0.47	0.20	1.12	.09
Fatal or severe injury	0.35	0.03	3.63	.38
Minor injury	0.68	0.34	1.39	.29
Morning (6–9 a.m.)	0.59	0.17	2.10	.42
Afternoon (3–6 p.m.)	0.45	0.10	2.00	.30
Elementary	0.44	0.14	1.39	.16
Middle	0.93	0.23	3.70	.91
High school	0.15	0.01	1.84	.14

NOTE: LL = lower limit; UL = upper limit.

Mode Shift Study

The study also measured the impact of 10 years of the SRTS program in California on walking and bicycling and whether infrastructure improvements funded through the program encouraged children to walk to school. A parent survey form developed by the National

TABLE 4 IRRs for Program Effect, Analysis 2

		95% Confidence Level		
Collision Characteristic	IRR	LL	UL	*p*
Total	0.26	0.11	0.63	.003
Fatal or severe injury	0.15	0.01	1.85	.14
Minor injury	0.27	0.12	0.63	.003
Morning (6–9 a.m.)	0.56	0.17	1.87	.34
Afternoon (3–6 p.m.)	0.09	0.02	0.45	.004
Elementary	0.36	0.13	1.09	.05
Middle	0.15	0.02	1.42	.10
High school	0.12	0.02	0.76	.02

Center for Safe Routes to School was used to collect data on mobility and determine reported barriers to walking to school (*31*). The survey was administered at eight of the original 16 schools that participated in earlier evaluations of SRTS. Participating schools distributed the parent survey forms to all students. A total of 1,999 forms were returned from the eight schools.

The parent surveys indicated the distance and travel mode to school. The surveys also indicated the nearest intersection to the family residence. The research team identified and geocoded SRTS funded countermeasures near each of the eight schools. The intersection information from the parent surveys was geocoded and the distance between the household and the SRTS countermeasure was calculated. The probability of walking to school was compared for households within 250 ft of the countermeasure versus households farther than 250 ft but less than a quarter mile from the school. The analysis found that living within 250 ft of an SR2S project increased the probability that a child walked to school (coefficient = 0.82, Z-statistic = 2).

Parents' Perceptions of Safety of Walking and Bicycling

The parent surveys showed that parents generally agreed that walking and biking to school were beneficial to their children's health, but that there were significant barriers in terms of distance, built environment, and risk. Noninfrastructural improvements that included encouragement activities and adult supervision of children, such as walking to school buses, crossing guards, and higher levels of enforcement, showed positive effects in encouraging walking.

Implications for Evaluation of Safety in Future SRTS Programs

Buffer Zones for Evaluation It was observed that the installed countermeasures were spatially limited and often located some distance from the school and therefore not expected to have an impact on the entire area around the school. One of the most important conclusions was that changes to the infrastructure should be evaluated in the area in which the countermeasure was expected to have an impact. Previous analyses suggested the use of a much wider buffer zone (*21, 22*). This breadth would be appropriate for programs that included systemic approaches, such as education, enforcement, and areawide speed limits, which might be expected to have an impact on the entire area surrounding a school.

Data on Infrastructure Improvements Data on the installation of infrastructure improvements are critical; however, this information was only available for a subset of the funded projects. Systematic reporting on infrastructure improvements (type, location, and so forth) should be a condition of funding for future SRTS programs. The U.S. Government Accountability Office discussed the importance of conducting program evaluation of the federal SRTS program in its report on the implementation of SRTS (*32*).

Time of Analysis The initial analyses were conducted between the hours of 6 a.m. and 6 p.m. from September through May. Countermeasures would be expected to have a positive impact beyond this time frame.

Age Range of Observations The original analyses of mode shift were limited to pedestrians and bicyclists ages 6 to 18 years; however, countermeasures would be expected to have a positive impact beyond youth. Future analyses should also include pedestrians and bicyclists of other ages and other time spans to assess the full impact of the funded countermeasures.

Statistical Methods The analyses conducted for a pre–post evaluation of SRTS projects by necessity had a quasi-experimental design, subject to bias by regression to the mean effects. To address this, evaluators should collect sufficient data and conduct Bayesian analyses to control, as much as possible, for regression to the mean effects.

LIMITATIONS

The project encountered four major challenges:

1. In the case of the mobility analysis, despite a $1,000 incentive to the school and repeated attempts to contact administrators, only eight schools that fit the criteria for use in the analyses participated. To increase participation, the response deadline for schools was extended and substantial outreach was undertaken to encourage school participation.
2. The mobility analysis used self-reported data from the parent survey to identify the location of the household from the constructed countermeasure. Of the total 1,999 reported intersections from the parent survey forms, 25% could not be geocoded. The intersections were either incorrectly identified or actually parallel streets. Although the regression found that children living closer to the countermeasure were more likely to walk to school, the sample size was small: only 125 households. The mode to school was also self-reported in the parent survey. This was not a good substitute for actual counts of the modes by which children arrive at school.
3. In the case of the safety analysis, it was difficult to obtain a strong response rate from the funded agencies (departments of transportation and public works) for information on infrastructure improvements, despite repeated e-mails and calls to each agency. One reason for the lack of response may have been that the agencies have a degree of turnover, which made it difficult to contact the appropriate person to get information about the SRTS grants written and the projects implemented. Although it was difficult to reach many agencies, the local agencies that did respond were quite helpful and the evaluation could not have been conducted without their input.
4. It was apparent that participating agencies need to collect more reliable and consistent data about the programs they fund. Although the proposed funding information was available, it was unclear without agency response whether the agencies actually deployed the proposed improvements or selected others. Part of the difficulty in evaluating the program was that the agencies were under no obligation to report which improvements were actually deployed. To improve evaluations in the future, agencies could be required to pinpoint exact construction locations on a map. Although the questionnaire could be modified to obtain this specific information, the data would still be limited to those agencies that responded.

Further, the schools and improvements for which there were available data may not have been representative of the entire program. Another weakness, explored in further detail below, is the possibility of a regression to the mean phenomenon influencing the findings. Insofar as infrastructure locations are influenced by the occurrence of crashes, that is, statistically high crash location, a regression to the mean effect might result in reduced observed crashes following countermeasure installation even if the countermeasure had no impact. In other words, regression to the mean refers to the fact that a crash at one intersection does not necessarily mean there will be crashes there every year hence. Installing a countermeasure may affect safety or it may have no effect since, regardless of the countermeasure, there may not be any more crashes at that location. Statistical techniques, such as an empirical Bayes approach, may be a partial remedy for correcting this potential bias. Such an analysis was outside the scope of this study, given the data involved, but the approach is recommended for future studies of safety in SRTS programs.

CONCLUSIONS

SRTS programs hold much appeal as an effective way to increase safety and walking or bicycling to school. Positive results for safety and mobility, as well as improved data collection for funded programs, should make SRTS programs competitive among other transportation needs. Understanding the potential for walking to school can help in identifying appropriate countermeasures and evaluating safety and mode shift.

Substantial funds have been allocated to SRTS programs across the country. Although evaluations have measured changes in mobility and perceived safety, few evaluations have been able to quantify the effect on safety. The National Center for Safe Routes to School, in its Federal Safe Routes to School Evaluation Plan (*33*), recommended the use of three evaluation components that can help in evaluating the extent to which changes in walking and bicycling and safety occur:

1. Documenting state program processes,
2. Monitoring implementation of projects and overall walking and bicycling trends, and
3. Conducting project effectiveness studies.

Crash outcomes are the recommended long-term outcome measure for safety and may affect walking and bicycling. The development of methods to evaluate the impacts of infrastructure has mirrored what has been established for vehicle safety and volume. Evaluation is necessary in competing against other programs for limited transportation dollars. Not only can evaluation inform the funding of programs, it can also support public policy efforts to promote active transportation with scientific evidence. The lack of quantifiable results has limited the establishment of active transportation programs and funding for programs that compete with traditional transportation safety programs. Evidence from this research can contribute substantially to the field.

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