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PEDESTRIAN AND BICYCLIST SAFETY EFFECTS OF THE CALIFORNIA SAFE ROUTES TO SCHOOL PROGRAM

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ABSTRACT

In the last decade, there has been an increased focus in California on encouraging children to walk and bicycle to school safely. In 1999, the California Legislature created the Safe Routes to School (SR2S) program, authorizing issuance of a competitive grant process for roadway construction projects. There has been an overall decline in the numbers of child pedestrian/bicyclist collisions in California as a whole. When compared with the control areas, the SR2S project areas did not show a greater decline in numbers of collisions. However, it is likely that the number of children walking/bicycling in the SR2S project areas increased over the relevant time frame. When changes in mobility in the program areas are taken into account, the SR2S program appears to be associated with a net safety benefit for affected school age students.

INTRODUCTION

In 1969, close to 50% of American children walked to school. Today, that figure is 12%. For children who live within one mile of school, the proportion declined from 87% to 31% in that same time period (1). Similar trends have been found in many other Western countries, and among diverse populations and settings. (2). Walking to school has primarily been replaced by transport in private vehicles driven by a parent. Martin *et al* (3) notes that distance and traffic are the primary reasons why parents do not let their children walk/bike to school. Also, a recent study by Fischbeck and Huey (4) found that bicycling and walking have the second and third highest fatality rate per trip among other types of school transport.

The California Legislature created the Safe Routes to School (SR2S) program in 1999 as a response to two concerns: the decline in numbers of children walking/bicycling to school, and the potential risk of death or injury for those who do walk/bike. This landmark legislation authorized issuance of a competitive grant process for roadway construction projects. The legislation had two goals: to reduce child injuries and fatalities near schools and to increase walking and bicycling activity among students at elementary, middle and high schools. Since its inception in 2000, the SR2S program has funded 570 projects with a total cost of over \$190 million.

This paper presents results of a study that estimated changes in pedestrian and cyclist safety that may be attributable to the SR2S program. The study is based on the evaluation of a representative sample of 125 of the 570 projects that received SR2S funding in the first three years of the program. The study complements previous research that assessed the impact of the SR2S program on rates of walking and bicycling to school. (5)

In this paper, we first describe the methods used for gathering and collating data. We then explain the methodology used to characterize the 125 SR2S projects that comprised our study sample. The effects on walking and bicycling are reported, followed by a quantitative and a qualitative investigation of changes in child pedestrian/bicyclist crash occurrence.

CALIFORNIA SAFE ROUTES TO SCHOOLS PROGRAM

In 1999, the Safe Routes to School (SR2S) highway construction program was created by the California State Legislature through Assembly Bill 1475. The bill provided for federal transportation funds to be used for the construction of bicycle and pedestrian safety and traffic calming projects. Five basic types of infrastructure improvements were allowed: sidewalk installation and upgrading, traffic calming and speed reduction measures, installation of traffic signals, pedestrian and bicycle crossing improvements, and construction of bicycle paths or other bicycle facilities. In the first cycle, funding was limited to engineering improvements; however, subsequent application cycles allowed funds to be used for education and traffic safety awareness programs to support the infrastructure changes.

The legislation that created the SR2S program also mandated that the California Department of Transportation study its effectiveness. Among other outcomes, the evaluation was to focus on the effectiveness of the program in reducing crashes, injuries and fatalities involving children in the vicinity of the projects. The University of California Traffic Safety Center (TSC) was contracted by Caltrans to conduct the evaluation, and a report to the California Legislature was submitted in early 2007.

DATA SOURCES

This evaluation used data from a numerous sources. Data on agency and program characteristics, schools, and program costs were obtained from the California Department of Transportation (CalTrans). These data came from several sources including the original application for funding that described proposed changes and pre-improvement conditions, a post-construction questionnaire (developed in conjunction with the California Department of Education) that provided details on actual improvements constructed, and both quantifiable and subjective information on the impact of the improvements.

School enrollment population data were obtained from the California Department of Education. Some individual schools provided enrollment data or maps of enrollment boundaries. Geographic information was obtained using Google Earth software. Collision data were obtained from the California Statewide Integrated Traffic Records System.

The following definitions are used in this section:

- *Agency*: A city or a county that received funding. An agency may have more than one project associated with it.
- *Project*: A set of related improvements for which an agency received funding in a single funding cycle. The project may involve only one school, or it may involve several schools in close proximity.
- *School*: A single school that has had one or more improvements through a SR2S project.
- *Improvement*: A specific goal, such as the construction of a new sidewalk or installation of a crossing signal. Each improvement is linked to a particular project, but may affect more than one school.

Projects and schools included

Of 570 projects funded by the SR2S program at the time of analysis, 125 were included in this evaluation. Projects were included in the analysis if they met the following conditions:

- Funded in first three SR2S funding cycles (n=273); and
- Construction of improvements completed by December 31, 2005 (n=231); and
- Agency returned questionnaire with sufficient information provided (n=130, response rate of 56%); and
- No significant overlap of school or collision data with other projects (n=125).

These 125 projects reported 350 individual schools that had the potential to be affected by the SR2S-funded improvements (some project improvements were proximate to multiple schools). Full details on data sources and methods used for data sources, gathering and exclusion can be found in the Report to the California Legislature. (6)

The data collected on each project and school came from several sources including the original application for funding that described proposed changes and pre-improvement conditions, and a post-construction questionnaire (developed in conjunction with the California Department of Education) that provided details on actual improvements constructed and both

quantifiable data and subjective opinions on the impact of the improvements. This information was supplemented by data from external sources including official school addresses and attendance boundary maps, detailed land-use maps and satellite imagery, collision data from the California Statewide Integrated Traffic Records System, and data on conditions on streets and intersections surrounding these schools.

Collision Data

The California Statewide Integrated Traffic Records System (SWITRS) is a database of police-reported collisions operated by the California Highway Patrol. Local police departments are required to submit information on all reported traffic collisions involving any injury or fatality. Data were obtained from this records system for the period of January 1, 1998 through December 31, 2005. A working data file was created of collisions that involved a pedestrian or bicyclist aged 5-17 years and in which at least one injury was reported.

Effects on Mobility

The number of SR2S projects or schools that have quantitatively examined effects on mobility is extremely limited, and fewer than five agencies responded to requests for data on changes in mobility resulting from their projects. Data on mobility changes were therefore augmented by a previous study conducted by Boarnet, Anderson, Day, McMillan and Alfonzo and reported in their 2003 *Report to the Legislature*. (4) Boarnet *et al.* assessed changes in mobility from the SR2S program through on-site observation and via parental survey. The study found increases in mobility as a result of the SR2S projects. The estimated effect varied greatly from school to school and also varied depending on the estimation method. Direct observations yielded increases that were often in the range of 20%-200%. Parental estimates were more conservative, generally in the range of a 10% increase overall. However, only a small number of schools were examined, and not all were among the 125 in the present study.

METHODS

Overview

The safety analysis is based on a comparison of school areas that were affected by SR2S projects (*school areas*), and nearby areas that were unlikely to be affected by the SR2S improvements (*control areas*). For both the school areas and the control areas, the change in number of collisions was compared for the period before the SR2S construction took place (the *pre-construction* phase) and the period after the SR2S construction was completed (*post-construction*).

School Areas

School areas were based on the list of affected schools provided by the agencies. For each school, a boundary area was defined that circumscribed both the SR2S improvements and a proximate area that was likely to have been impacted by the improvements. The boundary area was created from an examination of street maps and aerial photographs of the neighborhood. In

addition, school attendance boundary maps were useful in identifying areas that were likely to have been impacted by the program and to exclude nearby areas that, despite their proximity, would not have been plausible routes along which children travel, given the geographic areas served by that school.

Most school areas enclosed only one school. However, a number of projects affected several schools that were in close proximity ($<1/2$ mile apart and sharing a number of intersections used by students). In these cases, the nearby schools were grouped into a single “school area” unit, and were treated as one unit in the analysis. All areas inside the boundary were assigned to that one school area. This was done to avoid double counting collisions for geographically proximate schools.

Identifying Affected Intersections

Because collisions in SWITRS are coded according to the nearest intersection, intersections within a $1/4$ -mile radius of a school’s main entrance were selected for the collision analysis. The distance of $1/4$ mile is arbitrary, but represents an area of capturing the majority of children approaching the school on foot or bicycle. A number of intersections outside the $1/4$ mile radius were included, and some within the radius were excluded. The inclusion and exclusion decisions were based on roadway and land form characteristics. The selected areas were termed “school areas.”

Control Areas

The control area was defined as all intersections in the city boundaries that were not included as intersections affected by a SR2S project. The control areas covered a significant portion of the state of California, as they comprised all surface streets (outside of “school areas”) in towns and cities that had an SR2S project in one of the first three cycles. When measured as a proportion of the total child pedestrian/bike collisions in California, the control areas represented almost 40% of the state.

Pre- and Post-Construction Dates

The pre-construction phase was defined as the period between January 1, 1998 and the award date for the SR2S project. The post-construction phase was defined as the period between the completion of construction on the project and December 31, 2005. The amount of time in the two phases varied between different projects, as projects had different award dates, and different construction completion dates. This difference is represented in Figure 1 below. There was an average of 283 weeks in the pre-construction period, and an average of 102 weeks in the post-construction period, although the length of these periods varied greatly for different projects.

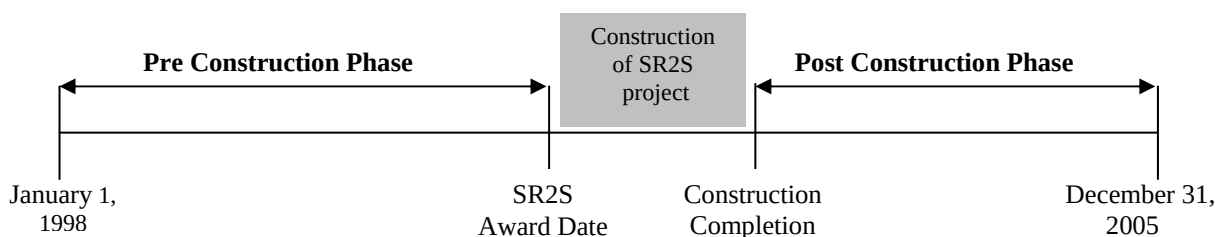


FIGURE 1 Pre-construction and post-construction phases.

Statistical analysis

Rates were calculated as injury counts per unit of time. Post-intervention rates were compared with pre-intervention rates, summing across all school areas. An estimate of the average yearly change in injury occurrence in the control areas was obtained by fitting a linear regression to collision injury counts. The changes in collision rates in the school areas were estimated with rate ratios obtained from a Mantel-Haenzsel person-time rate ratio estimator and were adjusted by the change observed in the control areas over the same average time period. All analyses were performed with Stata software.

RESULTS

Characteristics of SR2S projects

Most projects—well over half—included some type of sidewalk upgrade as part of the improvements. Upgrading intersection crossings was also a high priority for applicants, with more than one-third of projects including this component. Most projects included multiple improvement types. The greatest proportion of schools affected by SR2S projects were elementary schools.

Collision trends throughout California

It has been noted elsewhere (7) that the numbers of collisions involving school-age pedestrians and bicyclists have been decreasing over time in California. Some of this decrease may be due to better safety measures or to increased awareness of traffic safety by the pedestrians or by drivers. However, it has also been suggested that this decline is the result of decreased exposure; the number of children walking and bicycling has also been in decline, and the fewer number of pedestrians and bicyclists leads to fewer collisions.

The graph below presents the number of child pedestrians and bicyclists who were injured (fatally or non-fatally) in California for the years 1998-2005 (Figure 2). The data was taken from SWITRS and includes injured children ages 5-18. The data included all areas of California, including SR2S project areas, control areas, and all other areas in the state. The number of injured children declined approximately 22% over the period, from 9,271 in 1998 to 7,236 in 2005.

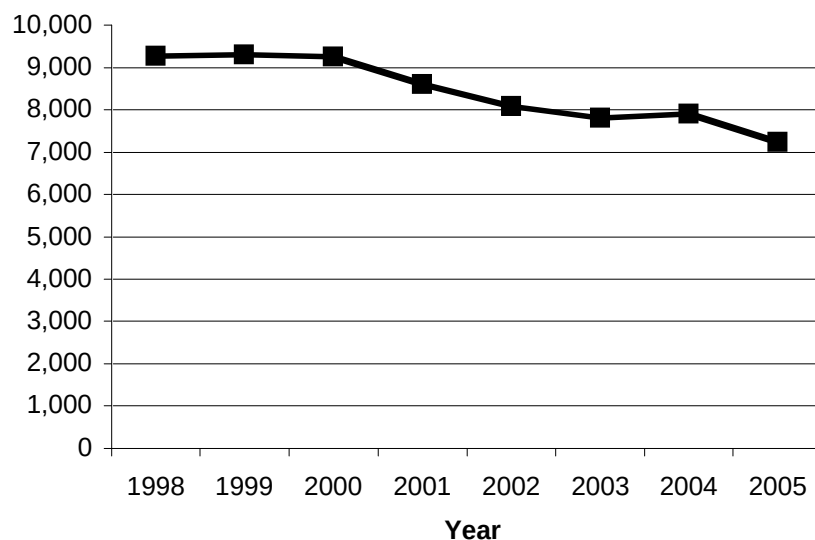


FIGURE 2 Child pedestrians/bicyclists injured in collisions, all of California, 1998-2005.

While a pronounced downward trend in collisions is seen among children ages five to twelve, a similar trend is not observed for older children, ages 13 to 18. The decrease among younger children is 36% over the eight-year period, whereas the net change for older children is less than 9%. This difference shows that the decrease in overall collisions is driven by a change primarily among younger children. The change could result from increased safety awareness and behaviors among these children, or more likely from a societal shift away from walking in this age group. It is important to note that young children bear a higher risk for being injured or killed in pedestrian-related motor vehicle crashes.

There were approximately 25% fewer collisions involving bicyclists than pedestrians. As mentioned previously, bicycling is a much rarer activity than walking among this age group, but the per-trip fatality rate tends to be much higher.

Collisions in SR2S project areas

Between January 1, 1998 and December 31, 2005, 11 children were killed and 1,449 were injured in the vicinity of the 350 schools in the study. Of these, 644 (44%) were bicyclists and 816 (56%) were pedestrians. It is likely that bicyclists made up a disproportionately high percentage of collision victims, relative to the number of cyclists. Other surveys have shown that the mode share for bicycling to school is low (national average of 2%), but the fatality rate is more than two times higher than for pedestrians. Approximately 52% of those injured or killed in our sample were age 12 or less; 20% were ages 13-14 (roughly corresponding to junior high/middle school); and 3,128 were ages 15-17.

TABLE 1 School Area Victims for 350 Schools in Study

	Number	Percent
Total number of victims	1,460	100%
Injury severity		
Fatal	11	0.75%
Severe injury	109	7.5%
Minor injury	774	53%
Complaint of injury	566	39%
Mode of transport		
Pedestrian	816	56%
Bicyclist	644	44%
Victim age		
12 or less	764	52%
13-14	294	20%
15-17	402	28%

It is not appropriate to construct a time-series graph similar to Figure 2 for SR2S project areas, as the individual projects had widely varying construction dates. Instead, the statistical analyses accounted for the different lengths in pre- and post-construction periods for each school area.

Changes between pre-intervention and post-intervention periods

For the SR2S school areas, the overall change observed between the pre-intervention and the post-intervention periods was a 13% reduction in annual numbers of injured child pedestrian/bicyclists. The 95% confidence interval for this figure is between 2% and 23%.

The various categories of collisions and victims were not affected uniformly. As shown in the table below, the largest change was observed among children ages 5 to 12, with an observed reduction in injuries of 27.6% among this group. While this group also had the largest decrease in the control areas, the SR2S program appears to have had additional impact among this group. In other words, the SR2S program made the most noticeable safety improvements among children ages 5 to 12. Also notable is that minor injuries were clearly reduced, while this reduction was not observed among fatal/severe injuries. However, because the numbers of fatal/severe injuries were extremely low in the SR2S project areas, it is impossible to articulate any trend with statistical certainty.

TABLE 2 Change in Collisions Among Collision and Victim Categories

	Number of collisions in this category	Change in Collisions	95% Confidence Interval
Overall	1,460	-13%	(-23% to +2%)
Mode of transportation			
Bicycle	644	-11.6%	(-26.4% to +5.8%)
Walking	816	-13.9%	(-26.8% to +1.1%)
Severity of injury			
Fatal or severe injury	120	+28%	(-14.5% to +90%)
Minor or complaint of injury	1,340	-16.1%	(-26.1% to -4.9%)
Age			
5 to 12	764	-27.6%	(-39.4% to -13.9%)
13 to 17	696	+5.0%	(-11.3% to +23%)

SR2S project areas vs. control areas

As shown above, both the control areas and the rest of California experienced a decline in numbers of injured children over the time frame during which the SR2S projects were implemented. Therefore, an attempt was made to control the observations for the overall downward shift in collisions.

The same pre-intervention and post-intervention periods used for the school areas were applied to the control areas, as described in the Methods, above, and the change in collisions for the control areas was estimated for that time interval. This change was found to be a decrease of 15%, similar to the 13% found for the SR2S intervention areas. Alone, this finding would indicate that the SR2S program resulted in no net benefit in terms of reducing numbers of crashes among affected students. However, these results are based on an assumption of similarity between the SR2S intervention areas and the control areas. In fact, these areas are likely to be different in one important way that may affect the safety analysis.

Mobility impacts on safety

As noted above, there is an overall trend in decreasing numbers of child pedestrians in California, and this decrease may be responsible for the decline in collisions seen both in California and in the control areas: fewer pedestrians means fewer collisions. However, as mentioned earlier, there is evidence that the SR2S program may have succeeded in increasing walking/cycling rates among children. If that is the case, we would have expected to see an increase in the numbers of collisions among the SR2S project areas. The fact that the numbers did not increase, but instead decreased, may mean that the SR2S project was indeed successful in improving safety for the affected children.

The number of schools that quantitatively assessed changes in walking/biking are few, and their results varied greatly. Therefore, we do not feel that there is a single best estimate of the change in mobility that likely occurred across the SR2S program. Table 3 below models SR2S safety improvements for a range of possible changes in mobility. The top row shows five

levels of possible change in mobility. The first possibility is “same as control areas”, which represents an unspecified decrease in walking/bicycling that is the same as that which occurred in the control areas (the general downward trend in California and the US). The other levels of mobility change are increases in walking/biking of 10%, 25%, 50% and 100%. All these figures are well within the range of actual observed changes in mobility that resulted from the SR2S program. The figures below the row entitled “change in collision rate” show the net change in collisions that would result from each level of change in mobility. For example, an increase of 50% in walking/bicycling would mean that the overall collision rate decreased 32% from before to after the SR2S project.

TABLE 3 Changes in Safety with Changes in Mobility

	Increase in walking/bicycling				
	Same as control areas (decrease)	10%	25%	50%	100%
	Change in collision rate				
Overall	+2%	-7%	-18%	-32%	-49%
Mode of transportation					
Bicycle	+9%	-1%	-13%	-28%	-46%
Walking	-2%	-11%	-22%	-35%	-51%
Severity of injury					
Fatal or severe injury	+52%	+38%	+21%	+1%	-24%
Minor or complaint of injury	-1%	-10%	-21%	-34%	-51%
Age					
5 to 12	-6%	-14%	-25%	-37%	-53%
13 to 17	+11%	+1%	-11%	-26%	-44%

Table 3 shows that expected changes in mobility have likely resulted in a net improvement in safety associated with the SR2S program. The only scenario that signifies no program benefit is the scenario of no change (0%) in walking and bicycling in the program community, which the mobility data do not support. The overall benefit ranges from a 2% increase to a 50% decrease in the collision rate. While it not possible to know with any degree of certainty which of the scenarios is closest to the truth, the exposure reductions that are consistent with the available evidence on mobility are associated with significant reductions in injury risk to children.

Summary of safety analysis

There has been an overall decline in the numbers of child pedestrian/bicyclist collisions in the SR2S project areas, the study control areas, and in California as a whole. When compared with the control areas, the SR2S project areas did not show a greater decline in numbers of collisions. However, it is likely that the number of children walking/bicycling *decreased* in the control areas, and *increased* in the SR2S project areas over the relevant time frame. When the change in

mobility in the program areas is taken into account, the SR2S program appears to have had a net benefit in terms of safety for affected students.

Limitations of safety analysis approach

The quantitative analysis above provides important information and represents one way to assess potential improvements in safety associated with the SR2S program. However, the quantitative analysis does not tell the whole story, and there are several important considerations.

First, collisions are relatively rare events, although they often have catastrophic consequences. As a result, a small variation in the number of collisions in a certain area—even if it is the result of random circumstances—can greatly influence the outcome of the analysis.

Second, collisions result from a combination of circumstances: how many vehicles are in the area, combined with the number of pedestrians (including bicyclists), and the behavior of both the vehicles and pedestrians. The SR2S projects are designed to impact safety mainly by altering behavior: causing drivers to slow down or to yield to pedestrians, or removing pedestrians from the roads and onto sidewalks. It is also hoped that there will be relatively more pedestrians and fewer vehicles as a result. However, the numbers of vehicles and pedestrians were not, for the most part, assessed before and after these projects. As a result, the *exposure* of pedestrians to vehicles – that is, the risk that pedestrians face – has not been assessed, and is not therefore taken into account in the safety analysis.

Lastly, collisions are only one aspect of safety. Other safety-related benefits of the SR2S program include near-misses, personal perceptions of safety, amounts of vehicle traffic, and vehicle and pedestrian behaviors.

Qualitative Evaluations of Safety

The research team also assessed the potential improvements in safety associated with the SR2S program from a qualitative perspective. For this assessment, we used information provided by school and agency officials and others who have been present to observe changes in behavior and safety as a result of the interventions. These opinions and observations bring out aspects of improvements not otherwise documented, such as impacts on the community and changes in pedestrian or driver behavior.

This information directly complements the quantitative information that describes the impact in terms of reducing injuries and providing cost-effective improvements. 114 sets of comments were received in response to specific questions asking about perceptions of changes in safety and the impact of the program. Only two of the sets of the comments were not, on balance, favorable. Satisfaction was expressed by a wide range of stakeholders: parents, school boards, school officials and administrators, teachers, local communities and residents, and other involved parties.

Few schools conducted before- or after-implementation surveys of traffic counts or crashes. However, many subjective opinions were provided on the effect of the SR2S interventions on collisions or near-collisions. Several agencies reported a change in driver yielding behavior after implementation of project improvements. Driving yielding behavior is related to crashes between pedestrians/bicyclists and motor vehicles. Students, other pedestrians and drivers appeared to conform to the new behaviors indicated by the infrastructure changes.

Several agencies felt that significant and important improvements occurred those were unlikely to be documented by collision statistics, due to the infrequency of collisions. These agencies emphasized the importance of continuing safety-related infrastructure improvements, even in the absence of “hard” numerical evidence.

CONCLUSION AND FUTURE DIRECTIONS

The Safe Routes to School program has captured the attention of traffic engineers, public health advocates, schools, communities and families. Anecdotally it has been a resounding success. Through the quantitative and qualitative analyses conducted as part of the legislative mandate, the SR2S program appears to have been effective in achieving its goals of increasing walking/bicycling and improving safety.

A significant challenge is the lack of data for evaluating the success of individual projects. Future assessments of changes in traffic data can be improved through obtaining reliable, quantifiable estimates of the change from before the SR2S construction and after. This specificity of data will also help in the identification of the types of projects that result in the greatest safety increases and the populations that most greatly benefit.

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