Title

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Impacts on Walking, Bicycling, and Pedestrian Safety

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This article evaluates California's pioneering Safe Routes to School (SR2S) program, which funds traffic improvement projects designed to improve safety for children's walking and bicycling to school and to increase the number of children who do so. Through surveys of parents and observations of vehicle and pedestrian traffic before and after project construction, we examined the impacts of 10 traffic improvement projects funded through the SR2S program. We measured changes in perceived safety and in safety-related behaviors associated with children's trips to school, and examined changes in the number of children walking and bicycling following these improvements. Five of the 10 traffic improvement projects we evaluated showed evidence of a successful impact. The findings have implications for California's SR2S program and for similar initiatives throughout the country.

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Safe Routes to School (SR2S) programs have generated tremendous interest among U.S. policymakers, planners, and public health officials in recent years. These programs target the walk to school as an essential point of intervention to improve pedestrian safety and increase physical activity among children.

In this article, we evaluate California's pioneering SR2S construction program, which was designed to improve safety for children's walking and bicycling to school, and to increase the number of children who do so, by funding traffic engineering improvements around schools. Through a systematic evaluation of 10 California SR2S traffic improvement projects near elementary schools, we examined the impacts of this influential state policy on children's travel behavior in these neighborhoods. We investigated changes in the perceived safety of children's trips to school, in safety-related behaviors tied to the trip to school, and in the number of children walking and bicycling to school following these improvements. The findings have implications for California's SR2S program and for similar initiatives throughout the country.

The Need for Safe Routes to School: Children, Physical Activity, and Pedestrian Safety

The last 2 decades have witnessed a significant decline in walking among children in the U.S. (Killingsworth & Lamming, 2001). Today, fewer than 16% of students ages 5 to 15 walk or bike to school, compared to 48% of these students 3 decades ago (U.S. Environmental Protection Agency, 2003). In contrast, over 50% are driven to school in private vehicles (Nationwide Personal Transportation Survey, 1997). These trends, coupled with changes in eating and physical activity, have serious implications for children's health, including increased rates of Type I and II diabetes and rising rates of obesity (Flegal, 1999; Huang & Goran, 2003; Ogden et al., 2002; Sallis & Owen, 1999).

Recent years have seen encouraging reductions in traffic accidents among child pedestrians. These declining accident rates may be attributed to reduced rates of walking, however, more than to other factors (National Safe Kids Campaign, 2004). When exposure is taken into account, walking and bicycling still emerge as two of the most risky modes of travel for the trip to school, calculated on a per-mile-traveled basis. A report released by the Transportation Research Board (2002) on the relative risks of school travel examined 9 years of injury and fatality data across all travel modes. The report identified 590 child pedestrian injuries and 2,050 bicycle injuries per 100 million miles of travel to school, compared to 90 injuries per 100 million miles for children riding in passenger cars driven by adults (the latter is the primary mode of travel for U.S. children today). The same trend was observed for fatalities per 100 million student-miles traveled to school, with 8.7 and 12.2 deaths per 100 million student-miles for child pedestrians and bicyclists respectively, compared to 0.3 for child passengers in adult-driven private vehicles.

An emergent movement among U.S. planners and public health experts targets the design of the physical environment as an important tool for promoting physical activity. Advocates call for design changes to make communities safer, more attractive, and more convenient for walking and bicycling as part of everyday life. Empirical research on the actual effectiveness of such environmental interventions has focused predominantly on adult activity and has generally shown that opportunities for physical activity (e.g., open space, nearby destinations) are important, as is access to such opportunities (Booth et al., 2000; Carnegie et al., 2002; Corti et al., 1996; Giles-Corti & Donovan, 2003; Handy, 1996; Hess et al., 1999; Hovell et al., 1991; King et al., 1999; Kitamura et al., 1997; Moudon et al., 1997; Shriver, 1997). A stronger empirical basis is needed to guide and to support, where appropriate, the development of policies and programs that aim to increase physical activity and to enhance safety for children through improvements to the physical environment. This study expands the basis of empirical research by examining the effectiveness of California's SR2S construction program.

Safe Routes to School

The city of Odense, Denmark, is credited with launching the SR2S movement in the 1970s, to respond to high child pedestrian accident rates in that city. This program led to the creation of a national SR2S program in Denmark and the development of similar programs in other countries (see, e.g., Appleyard, 2003).

In the U.S., local SR2S initiatives began to gather steam in the mid 1990s. It was not until 1999, however, that programming—and funding—for SR2S was implemented at the state level. A coalition that represented urban planning, engineering, public health, education, and law enforcement (among other fields) helped pass California Assembly Bill 1475 in October 1999, creating the first SR2S statewide construction program in the U.S. AB1475 authorized the set-aside of one third of California's federal Surface Transportation Program safety funds over 2 years (totaling $40 million). This set-aside was designated for construction projects that would increase the safety and physical activity of child pedestrians and bicyclists on routes to school by altering traffic conditions for vehicles, pedestrians, and bicyclists (e.g., installing speed bumps, cross walks, etc.).

The original 2-year program, administered by the California Department of Transportation (Caltrans), was re-authorized in 2001 for 3 more years and $75 million, under California Senate Bill 10. By fall of 2002, the program had completed three application cycles and approved funding for more than 270 projects. Each SR2S project is eligible for up to $450,000 in funding; a 10% minimum local match is required. In its first year, the program limited funds to engineering improvements. Subsequent application cycles allowed funds to increase education and awareness of traffic safety.

California's SR2S construction program spawned similar dedicated resource programs in other states. These programs, including those in Oregon, Washington, Texas, and Delaware, share a strong focus on engineering solutions. Other locales, such as Tallahassee and Clearview, Florida; Atlanta, Georgia; Chicago, Illinois; and Arlington, Virginia, target education on walking and bicycling safety and/or enforcement of traffic laws around schools (Transportation Alternatives, 2002). One of the most successful SR2S programs to date is in Marin County, California, where the combination of education, enforcement, and engineering, along with strong community partnerships and financial support, has led to a 64% increase in walking and a 119% increase in bicycling to school (Staunton et al., 2003).

Federal agencies such as the National Highway Traffic Safety Administration (NHTSA) and the Centers for Disease Control and Prevention (CDC) have invested considerable resources in safer, more pedestrian- and bicycle-oriented routes to school (CDC, 2004; NHTSA, 2002). The U.S. Environmental Protection Agency (EPA) also supported these efforts through its recent report on the consequences of poor school-siting decisions, which may include implications for school travel decisions (EPA, 2003). National organizations such as the Surface Transportation Policy Project, the American Planning Association, and the American Public Health Association currently advocate for the inclusion of a SR2S program in the 2004 federal transportation bill re-authorization. As of March 2005, both the Senate and the House versions of the bill included a national SR2S program, with the Senate version funded at

$70 million/fiscal year and the House version funded at $150 million for the first fiscal year (with increases in subsequent years; U.S. House of Representatives, 2005).

For all this attention, there have been few evaluations of SR2S programs. The evaluation of the Marin County SR2S program (Staunton et al., 2003) is an exception. In the present study, we go beyond Staunton et al. (2003) by assessing results at 10 schools and using data from multiple sources, including surveys and observations, to examine the success of a larger number of different traffic improvements.

Evaluating California's SR2S Program

California's SR2S program funds six possible types of traffic improvements: sidewalk improvements (e.g., new sidewalks); traffic calming and speed reduction projects (e.g., speed bumps); pedestrian and bicycle crossing projects (e.g., crosswalks); bicycle facilities (e.g., bicycle paths); traffic control devices (e.g., traffic signals); and traffic diversion improvements (e.g., closing streets to vehicle traffic to create pedestrian walkways). These traffic improvement projects cannot be directly compared to each other, since different types of improvements have different expected impacts on increased safety and walking opportunities. The success of traffic improvement projects funded by the SR2S program must be evaluated in terms of the *expected outcomes* of each improvement for pedestrian and/or bicyclist safety, or for encouraging walking and/or bicycling. For example, the expected outcome of installing sidewalks where none existed would be a reduction in the number of children walking in the street or on the shoulder, while the expected outcome of installing speed bumps would be a slowing of vehicle traffic.

Existing research has examined the efficacy of some types of traffic improvements that are implemented as part of the California SR2S program. For instance, recent research by the National Safe Kids Campaign (2004) found marked crosswalks, in-pavement crosswalk signals, and pedestrian-activated flashing warning systems to be effective at increasing pedestrian visibility at crossing points. The impact of these improvements on vehicular behavior (e.g., speeds, yielding behavior) and conflict rates are mixed, however, partly due to setting and roadway design (Van Derlofske et al., 2003; Zegeer et al., 2003). Researchers have not systematically evaluated the impact of a SR2S construction program such as California's at the scale of the evaluation reported here.

Our evaluation of 10 SR2S traffic improvement projects assessed each project in terms of its expected outcomes for pedestrian and bicycle safety and for amount of walking and bicycling. Our analysis examined the following expected short-term outcomes of specific traffic improvements:

1. relocate walking from the street or shoulder to the sidewalk;
2. reduce the speed of vehicles;
3. increase yielding by vehicles to pedestrians and/or bicyclists;
4. increase walking and bicycling. (This outcome could follow indirectly from changes in perceived safety or convenience of walking or bicycling related to one of the first three outcomes).

We determined expected outcomes for each project by identifying how that type of improvement is generally expected to impact walking/bicycling levels and/or pedestrian and bicyclist safety.

Methods

Study Design

We evaluated 10 traffic improvement projects funded through the California SR2S program by comparing the measured outcomes to expected outcomes for each project. Using a multiple case study design, we assessed factors related to perceived pedestrian and bicycle safety; to behaviors that impact actual safety (e.g., yielding, traffic speeds); and to the amount of children's walking and bicycling. We compared findings before and after construction of SR2S traffic improvements at each of 10 elementary school sites.

This case study approach has limitations. It does not capture the impacts of the program at all 186 sites (first two rounds of SR2S funding) where improvements were made. Our sample of 10 sites is larger than that employed in other studies of the impact of the built environment on physical activity, however, increasing our confidence in the findings (see Corti et al., 1996; Handy, 1996; Hess et al., 1999; Kitamura et al., 1997; Moudon et al., 1997; Shriver, 1997). Additionally, the case study approach allowed us to consider the impact of each construction project in the context of its surrounding neighborhood and community.

This evaluation employs data collected from two sources: (1) observations of the characteristics of vehicle, pedestrian, and bicycle traffic at each site that are potentially related to perceived and actual traffic safety (e.g., vehicle speeds); and (2) surveys of parents of 3rd to 5th graders at each study school to collect information on children's travel behavior and parents' perceptions related to walking and bicycling (e.g., importance of walking to school for children.) We also collected data on the characteristics of the urban environment in neighborhoods around study schools that might be related to overall levels of walking and bicycling (e.g., length of blocks, amount of graffiti, etc.) The latter data is not included in this evaluation.

Our research team was contracted by Caltrans to conduct an evaluation of the California SR2S program, which was required under the authorizing legislation. Caltrans' priorities—namely, to assess the impacts of several types of traffic improvements in varied locations, and to inform future funding priorities—and its time and budget constraints shaped specific decisions regarding methodology.

School Site Selection Criteria

Our evaluation included traffic improvements that were funded during rounds one and two of SR2S funding. Our sample of sites included only improvements located near elementary schools, since most SR2S projects funded in the first and second cycles of the program (70%) were associated with elementary schools. Traditionally, elementary schools are often sited to serve local populations, suggesting that walking might be feasible for many elementary school students who live nearby (EPA, 2003).

The 10 schools included in the evaluation are located in nine cities plus one unincorporated area in three counties in California. We attempted to include schools in urban, suburban, and rural settings. Most schools funded in the first two cycles of the SR2S program were located in suburban settings, however, limiting the variation of the sites in our study. In selecting projects to evaluate, we also considered the compatibility of a project's anticipated construction schedule with our research schedule.

The renewal of the authorizing legislation for the SR2S program, SB 10, required that the evaluation of the program be delivered to the legislature by December 31, 2003. This deadline limited potential study sites to projects that had not begun construction in spring of 2002, when funding for the research was released, but that would be completed by fall of 2003. The project team contacted all elementary schools that fit the SR2S construction timeline. Not all schools were willing to participate in the study, which required that teachers distribute the parent survey to children in their classes, and then collect and return surveys to the research team. Sixty-four percent of the schools contacted agreed to participate; all were accepted as participants in the study.

As noted earlier, California's SR2S program funded six different types of traffic improvements. Our sample of sites does not include traffic calming or traffic diversion projects. Our initial sample included a total of 16 projects that represented all six types of improvements funded by the program. We collected "before construction" data at these 16 sites. At the time that the evaluation research was completed in fall of 2003, 6 of the original 16 projects had not completed construction, despite schedules that proposed earlier completion dates. The 6 delayed projects were therefore excluded from this analysis. Table 1 identifies the traffic improvement projects included in this study.

Data Collection

Observation of Vehicle, Pedestrian, and Bicycle Traffic Patterns. A team of observers collected data on traffic patterns at each school. Observers recorded the number of child and adult pedestrians and bicyclists at the site of the proposed traffic improvement project. Observers also recorded information on yielding behavior of drivers, pedestrians, and bicyclists, focusing on whether parties yielded as would be required by the California Vehicle Code. In addition, observers used a stopwatch to calculate vehicle traffic speeds.[1]

Data were collected during 2-day periods both before and after construction of the SR2S project at each site. Care was taken to avoid conducting observations on days when students had irregular class schedules and during the first or last week of the school session. At most sites, traffic was observed from 30 minutes before to 15 minutes after the beginning of the school day, and from 15 minutes before to 30 minutes after the end of the school day.

In observing traffic patterns, we evaluated behaviors and perceptions linked to pedestrian safety (e.g., vehicle speeds), rather than actual changes in accident rates at these sites. Pedestrian and bicycle accidents are rare events, and tracking the effect of SR2S traffic improvements on accident rates would require a time series of accident data extending for several years before and after project construction. The requirements of the authorizing legislation and the strong interest in SR2S programs among advocates and policymakers warranted a more timely evaluation.

Survey of Parents on Perceived Safety, Children's Travel Behavior. The sample for the parent survey consisted of all parents with children in the 3rd through 5th grade attending the school that was linked to each traffic improvement. Sample sizes varied across schools based on the number of children in each grade. The survey collected information on the parent's self-report of the child's method of travel to and from school, and the parent's own walking and bicycling in the neighborhood. Parents were instructed to respond pertaining only to the child bringing home the survey. The survey asked parents about their perceptions of driving behavior around school, their perceptions of safety and crime near school, and their attitudes towards walking and bicycling to school. Additionally, the survey asked par-

School	Improvement	City and context
Sidewalk improvement projects		
Juan Cabrillo Elementary	Install pathway of decomposed granite bordered by wood curb, with appropriate signage	City of Malibu, in a predominantly residential area with a rural character, including large lots and low-density housing. The neighborhood is located a few blocks from the ocean.
Murrieta Elementary	Install sidewalk, curb, gutter	City of Murrieta, in a rural area that is becoming suburban. Neighborhood includes mixed residential, commercial, and civic land uses, with large lots and long blocks. A busy arterial is near the school.
Sheldon Elementary	Install sidewalk gap closures	City of El Sobrante, in a suburban area in the San Francisco Bay Area. An arterial near the school divides the neighborhood into two areas: one with curvilinear roads and a steep grade, and one with a moderate grade and grid-like streets.
Valley Elementary	Install sidewalk gap closures	City of Yucaipa, in a bedroom community in San Bernardino County. The area is growing and changing from rural to suburban in character. Residential uses occupy large lots.
West Randall Elementary	Install sidewalk gap closures	Located in an unincorporated area in San Bernardino County. This older neighborhood follows a typical suburban pattern, with low-density residential land uses and no commercial development.
Traffic signal improvement projects		
Cesar Chavez Elementary	Install traffic signal to replace four-way stop sign	City of Bell Gardens, in south central area of Los Angeles near a major arterial. Neighborhood has urban character, including traditional grid streets with mixed land uses and mostly single-family detached homes.
Newman Elementary	Install traffic signal to replace four-way stop signs	City of Chino, near Los Angeles, San Bernardino, and Riverside counties. This older suburban neighborhood has a modified grid pattern with culs-de-sac and linking pedestrian pathways, and residential land uses.
Crosswalk and crosswalk signal improvement projects		
Glenoaks Elementary	Install in-pavement crosswalk signal system to alert vehicles of children in the crosswalks	City of Glendale, an older suburban city in Los Angeles. Highway overpass divides the neighborhood into a community of single-family homes on one side and multifamily housing on the other.
Jasper Elementary	Install pedestrian-activated flashing warning signal system	City of Rancho Cucamonga, a suburban bedroom community in San Bernardino County. Residential neighborhood has longer blocks and curvilinear streets. Project was located on a quiet residential street.
Mt. Vernon Elementary	Add pedestrian count-down signals to traffic signal system	City of San Bernardino, in mostly residential neighborhood with some mixed uses. Most streets follow a grid pattern, but one area has a more suburban street pattern with longer blocks and more culs-de-sac.
Valley Elementary	Install crosswalk and crosswalk signs	See description above.
Bicycle path improvement projects		
Murrieta Elementary	Install bike lanes	See description above.

Table 1. Study sample of SR2S traffic improvement projects.

ents to estimate the distance that they live from the schools and their length of residence within their neighborhoods. The survey also collected basic demographic information.

The survey was administered in English and Spanish and designed for completion in approximately 15 minutes. The survey was distributed in the classroom to be sent home and returned through the student. There was no follow-up to capture those who did not respond. Surveys were distributed and collected by teachers for students to take home for their parents to complete. All surveys were anonymous; no information was collected on the identities of those who completed surveys. We did not follow up with nonresponders because of the burden that would have created for teachers to monitor parents' completion of the survey and to selectively follow up with parents who had not responded.

We distributed a second survey to 3rd through 5th grade parents after construction of traffic improvements. The second survey included the questions discussed above, plus questions on parents' opinions of the effectiveness of the SR2S traffic improvement project. A total of 1,778 parents completed the "before" survey and 1,243 parents completed the "after" survey. Table 2 reports the number of survey respondents at each school.

Results

As discussed, expected outcomes of SR2S projects varied with the type of traffic improvement. Our evaluation of these 10 projects hinged on whether the actual or measured impacts were consistent with the expected impacts. We classified projects as having evidence of success if the measured outcomes corresponded to expected outcomes, if the measured outcomes exceeded the sample error in the survey data or the estimated human error in data collection (as appropriate), if the data provided a consistent indicator of project success, and if the magnitude of impact was reasonably large. We found evidence of success in 5 of the 10 projects evaluated. These criteria for success are stringent, requiring that a project produce a near-term, measurable impact that can be observed. Improvements that contribute to behaviors that cannot be easily measured but that contribute to safety would not be ranked as successful by these criteria.

Projects with evidence of success did not necessarily achieve the same level of impact on all expected outcomes. Sidewalk gap closures and replacement of four-way stop signs with traffic signals appeared to have high potential for success. All 5 projects that displayed evidence of success were of these types. Below, we discuss the results grouped by project type, beginning with sidewalk improvement projects.

Sidewalk Improvement Projects

Sidewalk improvement projects included three sidewalk gap closure projects (Sheldon, Valley, and West Randall Elementary); the construction of a decomposed granite path and appropriate signage (Juan Cabrillo Elementary); and the installation of new sidewalks and sidewalk gap closures (Murrietta Elementary). (Pedestrian crossing improvements at Valley Elementary project are discussed separately, below.)

School	Number of responses (response rate)		Change (%)
	"Before" survey	"After" survey	
Cesar Chavez Elementary	N = 251 (56.00%)	N = 207 (48.80%)	−44 (−7.2%)
Glenoaks Elementary	N = 209 (72.00%)	N = 142 (57.00%)	−67 (−25%)
Jasper Elementary	N = 143 (55.60%)	N = 77 (31.60%)	−66 (−24%)
Juan Cabrillo Elementary	N = 58 (34.70%)	N = 38 (23.03%)	−20 (−11.67%)
Mt. Vernon Elementary	N = 179 (68.85%)	N = 138 (54.12%)	−41 (−14.73%)
Murrieta Elementary	N = 223 (53.61%)	N = 125 (29.34%)	−98 (−24.27%)
Newman Elementary	N = 215 (51.07%)	N = 130 (30.37%)	−85 (−20.7%)
Sheldon Elementary	N = 71 (35.50%)	N = 80 (40.82%)	+9 (+5.32%)
Valley Elementary	N = 157 (42.90%)	N = 125 (32.55%)	−32 (−10.35%)
West Randall Elementary	N = 272 (44.52%)	N = 181 (40.22%)	−91 (−4.3%)
Total	N = 1778 (51.75%)	N = 1243 (38.59%)	−535 (−13.16%)

Table 2. Responses and response rates for parent survey, by school.

Expected outcomes of these sidewalk improvement projects were to increase walking and to relocate walking from the street or shoulder to the sidewalk.

We evaluated changes in amount of walking in two ways: (1) on-site counts of walking and (2) parents' survey responses on whether the child walked or bicycled to school more after the SR2S project was constructed (differentiating between those who reported that their children *did* and *did not* pass the particular project site along their route to school). We evaluated changes in location of walking through on-site observations. Table 3 describes expected and actual outcomes for sidewalk improvement projects.

Sidewalk Improvement Projects with Evidence of Success. For each of the three sidewalk gap closure projects, observed walking increased from "before construction" to "after construction" (see Table 4). In the analysis of the survey results, we split children into two groups: those who walked past the project and those who did not (based on parents' responses to a question about whether their child would pass the project on his or her walk to school). At all three of these schools, children who would pass the project on their way to school were significantly more likely to have reported increases in walking, compared to children who would not have passed the project on their way to school (t=2.43 at Sheldon; t=3.01 at Valley; t=3.15 at West Randall; see Table 5; for details on how this portion of this analysis was conducted, see Boarnet et al., 2005).[2,3] The results provide evidence that these sidewalk gap projects induced an increase in walking for the students who travel past the projects on their way to school.

The three sidewalk gap closure projects demonstrated statistically significant decreases in the number of observed child pedestrians walking on a street or shoulder, from "before construction" to "after construction" observations (t=5.55 at Sheldon; t=6.79 at Valley; t=39.23 at West Randall Elementary; see Table 4). For some schools, the magnitude of the observed shift from the street or shoulder to the sidewalk was large. For example, at West Randall Elementary, 75% of observed child pedestrians walked in the street or on the shoulder before construction of the new sidewalks, while only 5% walked in the street or on the shoulder after SR2S construction (see Table 4).

School	Project description	Expected vs. actual outcomes	Walking impacts: Amount [a]	Walking impacts: Location [b]
Sheldon Elementary	Sidewalk gap closures	Expected: Actual: [c]	*Increase* *Increase*	*On sidewalk* *On sidewalk*
Valley Elementary [d]	Sidewalk gap closures	Expected: Actual:	*Increase* *Increase*	*On sidewalk* *On sidewalk*
West Randall Elementary	Sidewalk gap closures	Expected: Actual:	*Increase* *Increase*	*On sidewalk* *On sidewalk*
Juan Cabrillo Elementary	Pathway of decomposed granite	Expected: Actual:	Increase Evidence of both increase and no change	*On sidewalk* *On sidewalk*
Murrieta Elementary	New sidewalks and sidewalk gap closures	Expected: Actual:	Increase Increase [d]	On sidewalk None

Note: Italic indicates outcomes that corresponded with expectations.

a. *Amount* refers to the total number of pedestrians observed during the 2-day observation period. The analysis summed across morning and afternoon periods for both days.

b. *Location* refers to walking only and whether walking occurs on sidewalk/path or street/shoulder. We analyzed data on the number of pedestrians (summed over both observation days) that walked exclusively on a sidewalk or path, as opposed to pedestrians walking on the street or on the shoulder of a street. *On sidewalk* indicates an expected increase in walking on a sidewalk or path.

c. *Actual result* is the measured outcome from study data observed after construction of the SR2S traffic improvement project.

d. Change is small and/or inconclusive.

Table 3. Expected versus actual outcomes of SR2S sidewalk improvement projects.

The shift of walking from the shoulder or street to the sidewalk can be an important safety improvement when it occurs at schools where many children walk. At Sheldon Elementary, for example, the SR2S project funded sidewalk construction along a busy thoroughfare where the study team clocked average vehicle speeds from 32 to 42 miles per hour after SR2S construction, depending on the time of day. As Figure 1 shows, the sidewalk provided a substantially safer walking environment, helping to separate children from fast-moving vehicle traffic.

Sidewalk Improvement Projects with Limited or No Evidence of Success. Two of the five sidewalk improvement projects were associated with limited or no evidence of success. The construction of a decomposed granite path and appropriate signage along a street near Juan Cabrillo Elementary achieved expected outcomes in relocating walking away from the street or shoulder (t=2.70; see Table 4), though few children walked to this school before or after this improvement. Research findings provided evidence of both an increase (see Table 4) and no change (see Table 5) in the amount of walking after installing the path. The change in the amount of walking after construction was not statistically significant (t=1.04; see Table 5).[4]

The installation of new sidewalks and sidewalk gap closures at Murrieta Elementary demonstrated mixed or no evidence of success. Walking did increase after construction of the project, but the number of children observed walking was low both before and after construction (see Table 4), as was the number of children observed walking on the street or shoulder (Boarnet et al., 2003). Children who passed along the project on their way to school reported both more (t=2.12) and less (t=3.31) walking compared to children who did not pass the project (see Table 5), a result with an ambiguous interpretation. Because this sidewalk project surrounded the school on all sides, many students may have passed a portion of the project, possibly weakening the ability to distinguish its effect by comparing students who would and would not pass it.

Figure 1. Example of a SR2S traffic improvement project. San Pablo Dam Road near Sheldon Elementary School before (above) and after (below) the SR2S-funded project to install new sidewalks.

Traffic Signal Improvement Projects: Evidence of Success

Two of the 10 projects were traffic signal improvements: specifically, the replacement of four-way stop signs with traffic signals at Cesar Chavez and Newman Elementary. Expected outcomes were the regulation of yielding behavior and the slowing of vehicle speeds (see Table 6). Conceivably, replacing four-way stops with traffic signals could also have the opposite effect on speed, if drivers speed through green or yellow traffic signals. More speculatively, the traffic signal projects might also increase pedestrian counts by enhancing sense of safety among pedestrians. Both traffic control improvement projects demonstrated evidence of success.

At both schools, the actual impacts of these projects on yielding confirmed expectations and were statistically significant (t=5.42 at Cesar Chavez; t=3.44 at Newman Elementary; see Table 7). In addition, the traffic improvement projects at both schools were associated with expected (but speculative) increases in pedestrian counts, measured both through observations and survey responses (see Tables 4 and 5). Impacts on vehicle speed were mixed, with some changes at both schools falling within estimated human error (see Table 7).[5] Observed reductions in vehicle

School	Project description	Amount of child walking: Before project	Amount of child walking: After project	Amount of child walking: Difference	Location of child walking (% on street or shoulder)[a]: Before project	Location of child walking (% on street or shoulder)[a]: After project	Location of child walking (% on street or shoulder)[a]: Difference (percentage points)	*t*-statistic[c]
Sidewalk improvement projects								
Sheldon Elementary	Sidewalk gap closures	138	152	+10%	66%	35%	−31	5.55
Valley Elementary	Sidewalk gap closures	64	89	+39%	42%	4%	−38	6.79
West Randall Elementary	Sidewalk gap closures	692	1146	+66%	75%	5%	−70	39.23
Juan Cabrillo Elementary	Pathway of decomposed granite	274	302	+10%	7%	2%	−5	2.70
Murrieta Elementary	New sidewalks and sidewalk gap closures	2	19	+850%	0%	5%	+5	1.03
Traffic signal improvement projects								
Cesar Chavez Elementary	Traffic signal replaces 4-way stop sign	1701	2047	+20%	—	—	—	—
Newman Elementary	Traffic signal replaces 4-way stop sign	143	250	+75%	—	—	—	—
Crosswalk and crosswalk signal improvement projects								
Glenoaks Elementary	In-pavement crosswalk lighting	X[b]	974	X[b]	—	—	—	—
Jasper Elementary	In-pavement flashing warning light	51	57	+12%	—	—	—	—
Mt. Vernon Elementary	Pedestrian count-down signals	193	137	−29%	—	—	—	—

Note: This table includes only those SR2S projects that were expected to impact amount or location of walking; "—" indicates that no impact on this dimension was expected.

a. *Location* refers to walking only and whether walking occurs on sidewalk/path or street/shoulder. We analyzed data on the number of pedestrians (summed over both observation days) that walked exclusively on a sidewalk or path, as opposed to pedestrians walking on the street or on the shoulder of a street.

b. An error in defining the observation catchments area during 1 day of "before construction" observations introduced irregularities for this measurement; these data are therefore not shown.

c. The t-test for the significance of a difference in sample proportions is

$$\frac{p1 - p2}{\sqrt{\dfrac{p1(100 - p1)}{N1} + \dfrac{p2(100 - p2)}{N2}}}$$

where $p1$ and $p2$ are the two sample proportions and $N1$ and $N2$ are the sizes of the two samples.

Table 4. Impacts of SR2S traffic improvement projects on amount and location of observed child walking.

School	Project description	Children who walk more after project			Children who walk less after project		
		Project on route	Project not on route	Difference (*t*-statistic)	Project on route	Project not on route	Difference (*t*-statistic)
Sidewalk improvement projects							
Sheldon Elementary	Sidewalk gap closures	15.63%	0.00%	15.63% ($t = 2.43$)	50.00%	32.00%	18.00% ($t = 1.40$)
Valley Elementary	Sidewalk gap closures	11.59%	0.00%	11.59% ($t = 3.01$)	10.14%	20.00%	−9.86% ($t = -1.02$)
West Randall Elementary	Sidewalk gap closures	28.57%	7.41%	21.16% ($t = 3.15$)	14.29%	22.22%	−7.93% ($t = -1.11$)
Juan Cabrillo Elementary	Pathway of decomposed granite	6.67%	0.00%	6.67% ($t = 1.04$)	13.33%	18.75%	−5.42% ($t = -0.41$)
Murrieta Elementary	New sidewalks and sidewalk gap closures	13.73%	2.38%	11.34% ($t = 2.12$)	17.65%	0.00%	17.65% ($t = 3.31$)
Traffic signal improvement projects							
Cesar Chavez Elementary	Traffic signal replaces 4-way stop sign	20.59%	6.15%	14.43% ($t = 2.52$)	16.18%	13.85%	2.33% ($t = 0.38$)
Newman Elementary	Traffic signal replaces 4-way stop sign	10.94%	0.00%	10.94% ($t = 2.80$)	18.75%	30.00%	−11.25% ($t = -1.16$)
Crosswalk and crosswalk signal improvement projects							
Glenoaks Elementary	In-pavement crosswalk lighting	12.00%	7.69%	4.31% ($t = 0.76$)	8.00%	20.00%	−12.00% ($t = -1.91$)
Jasper Elementary	In-pavement flashing warning light	3.13%	0.00%	3.13% ($t = 1.02$)	9.38%	16.67%	−7.29% ($t = -0.41$)
Mt. Vernon Elementary	Pedestrian count-down signals	19.05%	5.71%	13.33% ($t = 1.85$)	28.57%	22.86%	−5.71% ($t = -0.57$)

Note: This table includes only those projects that were expected to impact the amount of children's walking to school.

Table 5. Impacts of SR2S traffic improvement projects on amount of reported child walking.

speed during the morning off-peak, afternoon peak, and afternoon off-peak periods at Cesar Chavez Elementary and during the afternoon off-peak period at Newman Elementary were outside of the estimated human error range. Thus, at both schools, projects achieved expected outcomes in terms of yielding and achieved expected (though speculative) outcomes in terms of pedestrian counts. Impacts of these traffic control projects on vehicle speeds were more mixed and modest, with only the Cesar Chavez site giving consistent evidence of vehicle speed reductions larger than the estimated human error range associated with the measurement of vehicle speeds.

Crosswalk and Crosswalk Signal Improvement Projects: No or Limited Evidence of Success

Four of the 10 traffic improvement projects involved improvements to crosswalks and/or crosswalk signals. These projects included two pedestrian-activated, in-pavement flashing warning light systems at crosswalks (Glenoaks and Jasper Elementary); a pedestrian-activated, "count down" light to warn pedestrians of the amount of time remaining to cross (Mt. Vernon Elementary); and a new crosswalk and crosswalk signs (Valley Elementary). Expected outcomes included improved yielding of vehicles to pedestri-

			Walking impacts	Traffic impacts	
School	Project description	Expected vs. actual outcomes	Amount [a]	Yielding [b]	Vehicle speeds
Cesar Chavez Elementary	Traffic signal replaces 4-way stop sign	Expected:	*Increase* [e]	*Increase*	*Decrease*
		Actual: [c]	*Increase*	*Increase*	*Decrease*
Newman Elementary	Traffic signal replaces 4-way stop sign	Expected:	*Increase* [e]	*Increase*	Decrease
		Actual:	*Increase*	*Increase*	Decrease [d]

Note: Italic indicates actual outcomes that corresponded to expected outcomes.

a. *Amount* refers to the total number of pedestrians observed during the 2-day observation period. We summed across morning and afternoon periods for both days.

b. *Yielding* refers to yielding of vehicles to pedestrians/bicyclists only.

c. *Actual outcome* is the measured outcome from study data observed after construction of the SR2S traffic improvement project.

d. Change is small and/or inconclusive.

e. Outcome is somewhat speculative.

Table 6. Expected versus actual outcomes of SR2S traffic signal improvement projects.

ans (Glenoaks, Jasper, and Valley Elementary) and reduced vehicle speeds (Glenoaks, Jasper, and Valley Elementary, with this outcome being somewhat speculative at Valley Elementary). Additional expected outcomes included more walking travel because of improvements in safety (Glenoaks, Jasper, and Mt. Vernon Elementary, with this outcome being somewhat speculative at Glenoaks and Mt. Vernon Elementary). In all four instances, these projects provided only limited or no evidence of success (see Table 8).

Yielding increased at Glenoaks Elementary (t=1.78, statistically significant at the 10% level; see Table 7). Increased yielding was the most substantial positive outcome at this school. At Jasper and Valley Elementary, the increase in yielding was not statistically significant (t=1.02 at Jasper; t=0.97 at Valley; see Table 7). Expected reductions in speed were not seen. At Glenoaks and Valley Elementary, changes in speed were either positive or within the range of human error (see Table 7).[6] At Valley Elementary, rain interference made it difficult to identify a measured change in vehicle speeds during the afternoon observation period after construction of the crosswalk. At Jasper Elementary, vehicle speed increased. This increase was likely attributable to the completion of a nearby freeway.[7] SR2S projects at these three schools did not achieve the expected impacts in the amount of walking (see Tables 4 and 5). At Glenoaks Elementary, an error in defining the observation catchments area during one day of "before construction" observations introduced irregularities in measuring changes in walking through on-site observations. At Mt. Vernon Elementary, the findings indicated a small decline in overall walking (see Tables 4 and 5).

Bicycle Path Improvement Projects: Limited or No Evidence of Success

The evaluation included one bicycle path improvement project: the installation of on-street bike lanes at Murrieta Elementary. Observations showed four bicyclists before and fourteen bicyclists after SR2S construction. These values are too low to make inferences regarding the success of the project. We conclude that there was little observed impact on bicycling.

Parents' Perceptions of SR2S-Funded Traffic Improvement Projects

Previous research indicates that parents feel that traffic safety and perceived travel distances to school are major barriers to walking and bicycling to school (Dellinger & Staunton, 2002; McMillan, 2003). Parents also suggest that the streets closest to the school are some of the most dangerous locations for children who travel to school on foot, due to the high period-specific traffic volumes and erratic driving behavior of parents who are dropping children off at school (Anderson et al., 2002; Bradshaw, 2001).

Parents were highly positive in their appraisal of the SR2S-funded traffic improvement projects that were evaluated in this study. Surveys for each school briefly

School	Project description	Percentage change in vehicle speed (error range) A.M. Off-peak	A.M. Peak [b]	P.M. Off-peak	P.M. Peak	Number of vehicles yielding to pedestrians (%) [a] Before project	After project
Traffic signal improvement projects							
Cesar Chavez Elementary	Traffic signal replaces 4-way stop sign	−7% (−11,−3)[d]	−1% (−5,+3)	−6% (−10,−2)	−19% (−23,−15)	584 (95.42%)	205 (100%) $t = 5.42$
Newman Elementary	Traffic signal replaces 4-way stop sign	−0% (−3,+3)	+3% (0,+6)	−15% (−18,−12)	+10% (+7,+13)	277 (94.86%)	265 (99.62%) $t = 3.44$
Crosswalk and crosswalk signal improvement projects							
Glenoaks Elementary	In-pavement crosswalk lighting	−4% (−10,+2)	+11% (+5,+17)	+5% (−1,+11)	+12% (+6,+18)	225 (94.14%)	128 (97.71%) $t = 1.78$
Jasper Elementary	In-pavement flashing warning light	+23% (+16,+30)	+11% (+4,+18)	+14% (+7,+21)	+17% (+9,+24)	28 (96.43%)	30 (100%) $t = 1.02$
Valley Elementary	Crosswalks and crosswalk signs	+6% (+2,+12)	+11% (+6,+16)	X [c]	X [c]	18 (95.00%)	12 (100%) $t = 0.97$

Note: This table includes only those projects that were expected to impact vehicle traffic.

a. The number of vehicles that yielded to pedestrians or bicyclists was summed over morning and afternoon observation periods. Yielding of vehicles to other vehicles is not included in this data. Numbers in parentheses show the fraction of vehicles observed that yielded to pedestrians or bicyclists.

b. The peak vehicle speed period is the 10 minutes when vehicle speeds are at their lowest. Average vehicle speeds for all 10-minute intervals in an observation period were calculated, and the 10-minute period with lowest average speeds was the peak. Thus peak period is not the same 10-minute period at each school. Instead, peak periods were chosen to illustrate the maximum variation in the data.

c. On one day of "after construction" observations, rainfall interfered with traffic observations. For that reason, afternoon vehicle speeds are not shown.

d. Numbers in parentheses in the first four columns are error ranges for percentage change in vehicle speeds, based on assumed human error as discussed in endnote 5. In the right-most two columns, the number in parentheses is the percentage of vehicles yielding to pedestrians.

Table 7. Impacts of SR2S traffic improvement projects on vehicle traffic.

described the SR2S project at that school in neutral language, including a one-sentence description of the project itself and its location. The survey then asked parents whether they had noticed the SR2S project at their child's school, as follows: "Have you noticed this project?"

The survey asked parents how important they thought this project was, as follows:

> Thinking about the possible traffic projects that could have been built near your child's school, would you say that the Safe Routes to School project described above was:
>
> a. The single most important construction project that could have been built
> b. Among the few most important construction projects that could have been built
> c. Helpful, but not that important
> d. Not at all important

School	Project description	Expected vs. actual outcomes	Walking impacts: Amount [a]	Traffic impacts: Yielding [b]	Traffic impacts: Vehicle speeds
Glenoaks Elementary	In-pavement crosswalk lighting	Expected:	Increase [e]	**Increase**	Decrease
		Actual: [c]	X [d]	**Increase**	None
Jasper Elementary	In-pavement flashing warning light	Expected:	Increase	Increase	Decrease
		Actual:	None	None	Increase
Mt. Vernon Elementary	Pedestrian count-down signals	Expected:	Increase [e]	—	—
		Actual:	None	—	—
Valley Elementary	Crosswalk and crosswalk signs	Expected:	—	Increase	Decrease [e]
		Actual:	—	None	None

Note: Boldface indicates actual outcomes that corresponded to expected outcomes; "—" indicates that no impact on this dimension was expected.

a. *Amount* refers to the total number of pedestrians observed during the 2-day observation period. We summed across morning and afternoon periods for both days.

b. *Yielding* refers to yielding of vehicles to pedestrians/bicyclists only.

c. *Actual result* is the measured outcome from study data observed after construction of the SR2S traffic improvement project.

d. An error in defining the observation catchments area during one day of "before construction" observations introduced irregularities for this measurement; these data are therefore not shown.

e. Outcome is somewhat speculative.

Table 8. Expected versus actual outcomes of SR2S crosswalk and crosswalk signal improvement projects.

A separate question asked parents about several possible effects that the construction project could have. Parents were asked to respond "yes" or "no" as to whether they thought that the construction project had made walking or bicycling safer for children, made it easier for children to cross the street, slowed car traffic near the project, made drivers more aware of children walking or bicycling, and/or separated walkers or bicyclists from car traffic.

Large majorities of parents at all sites noticed the SR2S construction projects (from 65% to 85% of parents; see Table 9). Most parents stated that the project near their child's school would increase safety (from 64% to 87% of parents), and most thought the project was important (from 59% to 78% of parents). Sometimes, a larger fraction of parents stated that they believed the project would increase safety than stated that they noticed the project. In those cases, a few parents likely offered a favorable opinion about the traffic improvement project based on the brief description in the "after construction" survey. The description of the SR2S-funded project in the survey was minimal, however, and was written in neutral terms that would not signal any judgment about the effectiveness or wisdom of the project. Hence, the strong positive opinion ratings provide evidence of parental approval of the projects funded by the SR2S program.

Two tests were used to assess whether parents' awareness or their opinions of the SR2S project at their child's school influenced their child's propensity to walk or bicycle to school. Dividing the survey respondents into two groups, those parents who noticed the SR2S project and those who did not, revealed a difference of only 3.2% in the proportion of children reported to walk or bicycle to school more (t=1.33, p=.18). We also found no significant correlation between parents' assessment of the importance of the SR2S project near their child's school and children's reported walking behavior (r=.039, p=.258). These findings suggest that reported increases in children's walking and cycling do not differ based on whether parents noticed the SR2S projects, or whether parents regarded the SR2S projects as important.

Education Campaigns and Increased Walking and Bicycling to School

During the period in which this evaluation was conducted, the California SR2S program focused its funding on construction projects. Schools or cities were not required to provide education on walking or bicycling to school in order to receive SR2S funds. It is possible, however, that some education of parents and children on the importance of walking and bicycling to school occurred coincident with this study. If so, such education may have increased the propensity of children's walking and bicycling at these schools during the time of this evaluation. To understand whether schools provided education or information materials on walking and bicycling coincident with SR2S project construction, administrators at the 10 study schools were queried in fall 2003 as to whether they had participated in National Walk to School Day during the period immediately before or immediately after SR2S project construction. Five of the 10 study schools stated they did not participate in National Walk to School Day; two schools had participated. At three schools, no official was available who could verify whether or not they had participated. While participation in National Walk to School Day does not cover the full range of education initiatives, it suggests that many schools in the study did not change their education or information programs related to walking and bicycling during SR2S project construction, implying that what is reported in this paper is an evaluation of primarily built environment changes.

Conclusions and Recommendations

Overall, the research team found evidence of success in 5 of the 10 traffic improvement projects we evaluated. As noted, we used strict criteria for project success. These criteria require that a project produce a near-term, measurable impact that can be observed. Projects that contribute to behaviors that cannot be easily measured but that contribute to safety would not be judged successful by these criteria. For example, crosswalk lighting systems that increase driver awareness of pedestrians might not increase yield rates if yielding was already high, and also might not measurably slow vehicle speeds if most vehicles slowed for pedestrians before installation of the warning light. Given that collisions with pedestrians are rare events, an increase in safety from such a crosswalk lighting system could be real, but the measured outcomes of this study would not mark the project as successful. Lastly, other events or programs could confound some impacts of these SR2S-funded projects. At Jasper Elementary, for example, the nearby opening of the I-210 freeway extension could have masked any effect that the pedestrian/bicycle crossing project might have had on slowing vehicle speeds. Overall, the ranking of "evidence of success" may understate the success of California's SR2S program.

Some SR2S-funded traffic improvements clearly delivered more immediate and measurable success than did others. A lack of immediate success does not necessarily indicate a failure of the project, however. The sidewalks and bicycle lanes near Murrieta Elementary, for example, could be justified as necessary infrastructure that, with later improvements, might contribute to increases in walking and bicycling. In the quarter-mile circle around Murrieta Elementary, only 8% of the blocks had a complete sidewalk before the SR2S project, one of the lowest percentages of sidewalks at any project site evaluated. Thus the sidewalks at Murrieta Elementary might be justified not based on any prospect for immediate impact, but because the neighborhood had very poor walking infrastructure.

School	Noticed project	Project made walking/bicycling safer	Project was most important or important	Project was most important
Caesar Chavez Elementary	82%	85%	76%	40%
Glenoaks Elementary	70%	77%	70%	51%
Jasper Elementary	86%	64%	68%	44%
Juan Cabrillo Elementary	82%	87%	63%	50%
Mt. Vernon Elementary	65%	71%	59%	37%
Murrieta Elementary	86%	85%	75%	60%
Newman Elementary	87%	81%	86%	38%
Sheldon Elementary	75%	84%	78%	44%
Valley Elementary	77%	77%	78%	50%
West Randall Elementary	69%	69%	71%	39%

Table 9. Parents' opinions of the SR2S-funded traffic improvement projects.

Some patterns emerge from examining the evidence of project success across different types of traffic improvements. Among the 5 sidewalk improvement projects studied, 3 sidewalk gap closure projects showed evidence of success. In all three cases, the evaluation of the project as successful was based primarily on improvements in separating pedestrian traffic from vehicle traffic. The fraction of children observed walking exclusively on the sidewalk increased from 35% before SR2S construction to 65% after SR2S construction at Sheldon Elementary, from 58% to 96% at Valley Elementary, and from 25% to 95% at West Randall Elementary. These changes connote substantial safety improvements. Based on the experiences at these schools, sidewalk gap closures at locations with moderate or heavy pre-existing pedestrian traffic are good candidates for funding for traffic improvements. (In contrast, at the two schools where sidewalk projects did not show strong evidence of success—Juan Cabrillo and Murrieta Elementary—few children walked on the street or shoulder before the SR2S project, so there was limited potential to shift students from the street or shoulder to the sidewalk.)

The replacement of four-way stops with traffic signals at two schools both showed evidence of success. This suggests that traffic signals that regulate vehicle yielding can produce important improvements in safety, especially near schools with much walking and bicycle travel.

None of the four schools with pedestrian/bicycle crossing improvements showed more than limited evidence of success. While this success seems less impressive than for the sidewalk improvement projects, note that the impact of pedestrian/bicycle crossing improvements might be more difficult to measure. Pedestrian/bicycle crossing improvements may function by making pedestrian crossings more visible and by directing pedestrians into a single, well-marked crossing, thus making drivers and pedestrians more aware of the presence of the other. Both drivers and pedestrians may behave more predictably, thus decreasing conflicts. Any increase in awareness should be reflected in yielding, but yielding rates are so high at some locations that it may be difficult to show an increase. To the extent that pedestrian/bicycle crossing improvements increase driver or pedestrian awareness, safety could increase in ways that would not be measured by the methods used in this study. Findings from this study do not shed light on this question either way.

The only bicycle facility (on-street bicycle lanes near Murrieta Elementary) showed no evidence of success. There was little observed bicycling before or after construction of this SR2S-funded project. Had there been more bicycle traffic before construction, the project might have had important value by separating that traffic from vehicles. As is, the bicycle lane by itself appeared to do little to increase the amount of bicycle travel. If we can draw conclusions from evaluation of this single bike lane project, it may be that bicycle facilities might be restricted to either schools with moderate or high pre-existing levels of bicycle travel or to schools where a bicycle lane brings a reasonable *a priori* expectation of increases in bicycle travel.

California's SR2S program and programs in other states can build on the lessons learned in this study. Specifically, we recommend the following:

- Projects should be supported that would fill sidewalk gaps near schools with moderate or high amounts of walking. Findings suggest that such projects are capable of improving conditions linked to pedestrian safety.
- Projects should also be supported that include traffic control devices to regulate yielding at intersections where large volumes of vehicle and pedestrian traffic intersect.
- At schools with low levels of walking or bicycle travel, traffic improvements by themselves may be insufficient to increase nonmotorized travel to school. At such locations, it may be that SR2S construction funding would be more effective if coupled with other efforts (e.g., education campaigns or additional construction improvements) to encourage students to walk or bicycle to school.
- In general, schools should be encouraged to leverage funds for traffic improvements by providing education that encourages students to walk and bicycle safely to and from school. Including participation in National Walk to School Day as a criterion for evaluating applications for SR2S funding is one way to couple education more tightly with construction programs.

Future research should continue to track the outcome of SR2S construction programs. Research is needed on traffic calming and traffic diversion projects in particular. As noted earlier, it was not possible to examine such projects in this evaluation, though attempts were made to do so. Traffic calming and traffic diversion projects constitute an important component of the toolkit available to planners and engineers to address pedestrian and bicyclist safety issues. Such projects should be included in future evaluations of the impact of built environment changes on walking and bicycling. Future research should also examine more long-term outcomes of SR2S construction. One example would be studies that would track accident rates, taking advantage of longer time series than were available in this study.

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Notes

1. A segment of street (200 feet or more) was chosen that began and ended at least 50 feet from any intersection. The time required for a vehicle to travel the measured segment was recorded by hand. When travel time was recorded for one vehicle, another vehicle was identified, timed, and recorded.

Using a stopwatch to measure speed gives an average speed and is applicable regardless of speed or congestion. With radar, the more common methodology, it is difficult to identify which vehicle is being measured under crowded conditions. Furthermore, the instantaneous speed provided by radar is difficult to interpret under stop-and-go conditions. Our research team has used stopwatches to measure speed previously (Agran et al., 1996).

2. Responses are from a question asking parents whether their children walked or bicycled to school more than, less than, or the same amount now as compared to before construction of the SR2S-funded project. This question did not ask parents to assess whether the project caused changes in walking or cycling; instead, it simply asked them to assess whether their children's walking or cycling travel to school changed in the period of time that spanned from before project construction to after the project was completed. This comparison controls for factors that might have generally increased or decreased walking or bicycling travel to school during the period of SR2S project construction. Examples of such factors include a highly publicized child abduction and murder that occurred in California between "before construction" and "after construction" observations for some of the schools, and so might have contributed to general decreases in walking or bicycling travel among elementary school children in California. By comparing changes in children's walking and bicycling by location of the project relative to children's paths, findings control for broader societal or neighborhood changes in walking and bicycling that might not be associated with the SR2S-funded project.

3. There is some conflict between survey results at West Randall Elementary—which indicate, on net, little change in walking—and the observations at West Randall, which show a large increase in walking travel (see Tables 4 and 5). Note that some of the foot traffic near West Randall Elementary might be associated with another nearby school. It was not possible to differentiate observed pedestrians as to the school they attended.

4. Survey responses reported that few children walked to school at Juan Cabrillo Elementary, yet the number of children observed walking was high. We observed that many parents who drove their children to this school parked nearby and then walked the children into school. Hence, observed walking travel directly in front of the school was higher than one would expect based on the reported mode of travel to school, and we conclude that the amount of walking to school at Juan Cabrillo Elementary was modest.

5. Vehicle speeds were calculated based on measured times that vehicles took to travel a fixed distance. Because these measurements were timed using a stopwatch, a 0.3 second error associated with starting and stopping the stopwatch is assumed. That 0.3 second error was propagated through to the speed calculations, and is used to bound error ranges around the estimates of vehicle speeds.

6. Since traffic in front of Glenoaks Elementary was already heavily congested during drop-off and pick-up times, however, further slowing of vehicle speeds (averaging 12 miles/hour in the morning and 15 miles/hour in the afternoon) might have been unlikely.

7. Between the collection of "before construction" and "after construction" data, the nearby extension of Interstate 210 was completed and opened to traffic. This highway is located approximately 1,000 feet away from the SR2S traffic improvement. The study team's traffic counts at Jasper Elementary decreased by approximately 20% from before to after SR2S construction, suggesting that traffic was diverted to the completed Interstate 210, which could explain the increase in vehicle speeds.

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