Title

Evaluation of the Safe Routes to Transit Program in California

Authors
Weinzimmer, David
Sanders, Rebecca L.
Dittrich, Heidi
et al.

Publication Date
2014-07-21

Peer reviewed

Evaluation of the Safe Routes to Transit Program in California

David Weinzimmer
dweinzimmer@berkeley.edu
Safe Transportation Research and Education Center
University of California, Berkeley
2614 Dwight Way, #7374
Berkeley, CA 94720
Tel: (925) 330-9154
Fax: (510) 643-9922

Rebecca L. Sanders
rebeccasanders@berkeley.edu
Safe Transportation Research and Education Center
University of California, Berkeley
2614 Dwight Way, #7374
Berkeley, CA 94720
Tel: (510) 316-5940
Fax: (510) 643-9922

Heidi Dittrich
hdittrich16@gmail.com
Safe Transportation Research and Education Center
University of California, Berkeley
2614 Dwight Way, #7374
Berkeley, CA 94720
Tel: (209) 499-5150
Fax: (510) 643-9922

Jill F. Cooper*
cooperj@berkeley.edu
Safe Transportation Research and Education Center
University of California, Berkeley
2614 Dwight Way, #7374
Berkeley, CA 94720
Tel: (510) 643-4259
Fax: (510) 643-9922

*corresponding author

Paper submitted for presentation at the 94th Annual Meeting of the Transportation Research Board, Washington D.C., January 2015 and publication in the Transportation Research Record, Journal of the Transportation Research Board

Word Count: 5,747 + 1,750 (3 tables + 4 figures) = 7,497 words
Submission Date: July 21, 2014

ABSTRACT

This paper elaborates on findings from an evaluation of the San Francisco Bay Area's Safe Routes to Transit (SR2T) program, which funded enhancements to increase walking and cycling to regional transit stations. To understand how the program influenced travel choices, behavior, and perceptions of safety and local air quality, researchers surveyed transit users and observed driver, pedestrian, and bicyclist behavior in the periods before and after the enhancements were made at multiple transit stations.

Data from the treatment and control stations suggest that the streetscape and roadway improvements made through the SR2T program positively influenced the propensity to walk, bicycle, and take the bus to transit stations as reported through surveys. In particular, results show that walking and bicycling increased by 3% among treatment sites compared with control sites. Bicycling also increased at control sites, indicating a general societal shift. Further, driving decreased 2.5% at treatment sites. Perceived air quality, in general, improved in the post-period. When asked about perceived traffic risk, bicyclists more than pedestrians reported feeling safer on the road, with 10% of the bicyclists, on average, feeling safer after the improvements. There were also economic benefits from this project—pedestrians and bicyclists were overrepresented in those who stopped en route to transit for food and drink.

The evidence suggests that the SR2T program positively impacted the decision to walk and bicycle to access transit. It is recommended that the program be expanded to additional sites in the future.

OVERVIEW

As of 2011, nearly 80% of working Americans drove to work *(1)*. This is a nearly 20% increase in the past 50 years. Although driving provides a convenient way of commuting to work, it also causes congestion, increases traffic risks to other roadway users, and damages the environment, air quality, and health. By improving the safety and convenience of walking and bicycling to public transit, the Safe Routes to Transit (SR2T) Program aims to encourage commuters to actively commute to transit. In doing so, SR2T intends to increase the number of, and enhance traffic safety for bicyclists and pedestrians accessing regional transit stations in the Bay Area, improve air quality, and decrease congestion.

SR2T was initiated in 2004 with the adoption of the Regional Measure 2 (RM2) which established a $1 increase in Bay Area bridge tolls. The goal of this funding mechanism was to support transportation projects to reduce congestion along the seven state-owned toll bridge corridors. RM2 awarded the SR2T Program $20 million to focus on enhancements to facilitate walking and bicycling to regional transit stations.

This paper reports the findings from an evaluation of the effectiveness of the SR2T Program. Of particular concern is the ability of these capital and planning projects to shift travel from single-occupant vehicles to non-motorized modes for the transit access trip and to increase the safety of pedestrians and bicyclists.

THE BUILT ENVIRONMENT, ACTIVE COMMUTING, AND HEALTH: A REVIEW OF THE LITERATURE

The Safe Routes to Transit (SR2T) program capitalizes on the potential of public transit to help communities directly address congestion and pollution, and indirectly address issues of chronic disease, obesity, stress, and traffic safety. By improving the infrastructure along street segments and at intersections around transit stations, SR2T aims to promote active and safe commuting to public transit, reduce stress, and decrease carbon emissions.

Studies have recommended active transportation as a way to increase daily physical activity and slow or reverse the growth of the obesity epidemic, as nearly 36% of the adult population in the U.S. was considered obese in 2012 *(2)*. Besser and Dannenberg suggested that by promoting public transit and active commuting to public transit, a greater proportion of Americans could reduce traffic congestion and their carbon footprint, as well as meet the CDC's physical activity requirements *(3)*. Hamer and Chida's study on the association between commuting, physical activity, and cardiovascular risk supports this claim *(4)*. Their research found that a combination of walking and bicycling to work led to an overall 11% reduction in cardiovascular risk.

Researchers and health professionals studying the connection between the built environment and health have found that the design of the built environment influences whether and how often people walk and bicycle *(5)*. In their meta-analysis of transportation research, Koren and Butler found that the built environment powerfully influences the ability and desire to choose to walk or bicycle *(6)*. Multiple studies have found that environments unattractive for walking and bicycling, e.g., with dispersed land uses, low levels of connectivity, and a lack of good sidewalks or bicycle facilities, are associated with higher levels of driving and lower levels of walking and bicycling *(7,8,9,10)*.

Bicycling seems to be particularly sensitive to design: numerous studies have documented a preference for roadways with bicycle-specific facilities such as physically separated or painted bicycle lanes *(11,12,13)*. In their research on several BART stations, Cervero et al. suggested that people will bicycle to transit if on-site infrastructure such as secure bicycle parking is installed at transit stations, and bicycle-friendly paths and roadways leading to the station are improved and increased *(14)*.

Safe Routes to School programs (SRTS) have funded infrastructural and non-infrastructural interventions to promote safe and active transportation to school. The goals of SRTS are to remove the barriers that prevent children from walking and bicycling safely to school and to encourage active commuting as a means to promote better health. Infrastructural efforts are similar to those of SR2T and have included sidewalks, traffic signals, intersection warning systems, flashing beacons, pedestrian countdown signal heads, speed humps, and speed warning signs. Evaluations of SRTS have found a positive effect on safety. For example, in their examination of 75 California schools that received SRTS funds, Ragland et al. found that pedestrian safety significantly improved in the vicinity of the countermeasure installations *(15)*. These improvements also led to an increase in the probability of a child walking to school, demonstrating how these infrastructural changes can cause mode shift.

In another SRTS evaluation, Boarnet et al. examined neighborhoods around nine schools in California for changes in trip-making before and after construction of infrastructural improvements *(16)*. In eight of nine schools, walking trips increased between 12% and 850%. Observers also noted distinct changes in the locations where students were walking, with students shifting walking from the travel lane or shoulder to sidewalks.

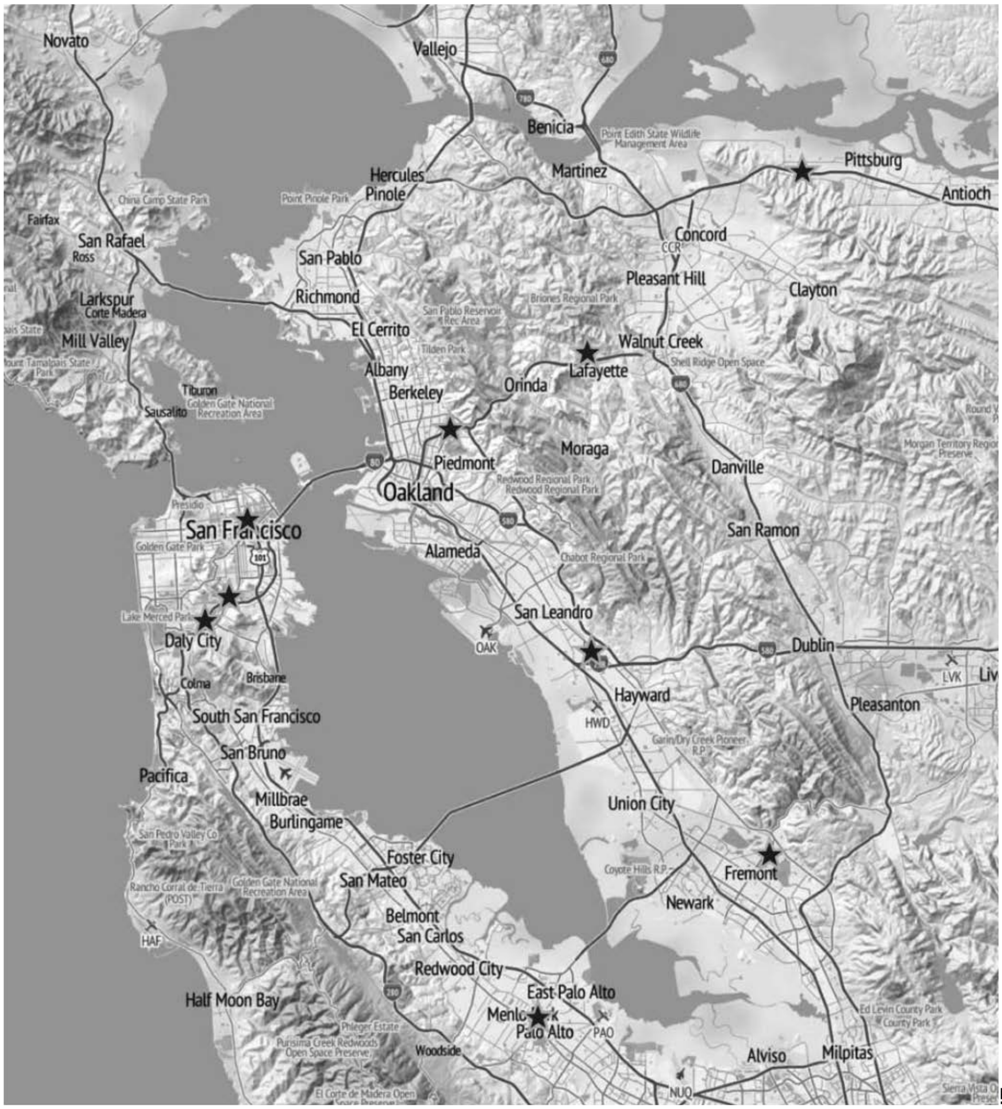
In light of the evidence of the connection between human health, physical activity, and the built environment, the Metropolitan Transportation Commission (MTC) launched the SR2T program to provide safer and more attractive routes to transit for those walking and bicycling. The following sections describe the SR2T effort and findings.

METHODOLOGY

Site Selection and Information

Transit stations were chosen based on key variables associated with travel behavior and mode choice, such as population density, employment density, and the percentage of households living beneath the poverty line. Among the sites chosen for analysis, the following BART stations received improvements in time for both pre- and post-improvement data collection: Balboa Park, Bay Fair, Civic Center, Glen Park, Lafayette, and Pittsburg (see Figure 1). The Palo Alto Caltrain station was also chosen as a treatment station, while the Fremont and Rockridge BART stations were selected as control sites.

FIGURE 1 Map of Transit Locations in the Bay Area



Source: Map tiles by Stamen Design, under CC BY 3.0. Data by OpenStreetMap, under CC BY SA.

The Project Sites: Background and Other Relevant Information

This section provides information on each of the project sites for which pre- and post-data were gathered. Table 1 includes a summary of each site's basic information.

TABLE 1 Basic Site Information & Summary Site Improvements for Each Transit Station

Name of Station	Location	Setting (Population)	Motorized Transit Available at Site	Site Improvements
Treatment Sites				
Balboa Park	San Francisco	Urban/ Neighborhood (789,172)	BART and Muni	**Station Improvements** • Transit Plazas; expanded bicycle/pedestrian BART entrance **General Street Improvements** • Curb extensions; crosswalk restriping; elimination of free right-turn, left-turn pockets • Landscaping; transit shelters with NextBus display • Light-rail station improvements
Bay Fair	San Leandro	Urban/ Shopping Center (84,950)	BART and AC Transit	**General Street Improvements** • Pedestrian bridge including lighting, pathway treatments, and wayfinding signage for pedestrians and bicyclists
Civic Center	San Francisco	Urban/ City (789,172)	BART, Muni, and Golden Gate Transit	**General Street Improvements** • Market Street Safety Calming Zone improvements
Glen Park	San Francisco	Urban/ Neighborhood (789,172)	BART and Muni	**General Street Improvements** • Class II and III bicycle lanes • Intersection and off-ramp improvements • I-280 on/off ramp improvements • Parking removal and lane width reduction
Lafayette	Lafayette	Suburban/ Small Town (23,769)	BART and County Connection busing	**Station Improvements** • 24 electronic bicycle lockers
Palo Alto Transit Center	Palo Alto	Urban/City (62,486)	Caltrain, SamTrans, Shuttles, and VTA Light Rail	**General Street Improvements** • Electronic bicycle-sharing system with bicycles and pods
Pittsburg/ Bay Point	Pittsburg	Urban/ Neighborhood (61,723)	BART, Tri-Delta Transit, and Delta Breeze busing	**Station Improvements** • 8 electronic bicycle lockers **General Street Improvements** • Bus shelters and benches • Reconstructed and landscaped medians • Intersection improvements; Class II bicycle lane improvements **Trail Improvements** • Lighting and landscaping fixtures
Control Sites				
Fremont	Fremont	Suburban/ Neighborhood (214,089)	BART, AC Transit, and VTA	As a control site for this study, no improvements were made as part of the SR2T program.
Rockridge	Oakland	Urban/ Neighborhood and Shopping Center (390,724)	BART and Bus	As a control site for this study, no improvements were made as part of the SR2T program.

Note: Statistics for this table were obtained from MTC *(17)*, BART *(18)*, and Caltrain *(19).*

Survey Instruments and Protocol

Postcard surveys were used to capture basic information about the respondent's journey from home to the transit station (e.g., home location, all intermediate stop location(s), travel time by mode, out-of-pocket costs), and were designed to be completed in one minute by respondents. These survey forms were offered to as many people as possible while they waited for trains on the platform.

Intercept surveys included the same questions as the postcard surveys, as well as additional information about the respondents' perceptions of pedestrian and bicycle safety, air quality, and awareness of changes to the roadway environment in the area around the station. This form was designed for data collectors to record answers from respondents, and was intended to be completed in three to five minutes. If two or more people were traveling in a group, only one person from the group was surveyed.

The combination of postcard and intercept surveys was used to maximize sample size. The postcards provided a large sample size with demographic and basic trip information that could be supplemented with the more detailed information from the intercept surveys to generalize about the larger population of transit users.

Data Collection

Baseline data postcard and intercept surveys were collected in the fall of 2011 and follow-up surveys in the fall of 2012 and 2013. In addition to the surveys, intersection observations were conducted in station areas to record driver, pedestrian, and bicyclist travel behavior at each site.

Surveying was conducted with permission from BART on fair-weather weekdays (Tuesday, Wednesday, or Thursday) between 6 and 11 a.m., in English, Spanish and Mandarin. Data collectors aimed to collect a minimum of 150 postcard surveys and 60 intercept surveys at each station.

Statistical Methodology

The study design was a before-after analysis using treatment and control sites. This study design conforms as closely as possible to a "natural experiment" in which the treatment site receives an intervention and the control site does not, thereby allowing the researcher to investigate causality between the intervention and the variable of interest. Such a study design allows for the best possible understanding of how the SR2T capital projects affect travel behavior and safety.

To determine the statistical significance of the effects of treatments, the research team used a "difference in difference" methodology. Difference in difference measures the "effect of the treatment on the treated" *(20)* by calculating the mean values for each group and determining whether the treated group followed a different trajectory than the untreated group in the post-treatment period. A significant result implies that the change in the examined behavior at the treatment sites was significantly different than the change in the examined behavior at the control sites. All statistical tests were performed using Stata 12. Aside from pre- versus post-treatment periods, some results were also analyzed by whether stations were in urban or suburban areas. Stations in San Francisco, Oakland, and Palo Alto were designated as "urban," while the rest of the sites were designated as "suburban."

FINDINGS AND DISCUSSION

This section discusses findings about the survey population, including demographic characteristics, travel behavior, and perceptions of traffic safety and air pollution at the various sites. Comparisons are made between the pre- and post-data collection periods at the treatment and control sites, as well as between the urban and suburban areas. Where changes at particular sites were notable, their significance was tested individually.

Mode Choice

A key point of this study was to understand whether and by what magnitude the investments would influence mode shift among respondents. To better understand the influence of these investments, mode choice of respondents traveling to the BART or Caltrain station were examined in two different ways. The first is *mode shares*, measuring the share of all respondents who reported more than 5 minutes traveling on each access mode, and the second is *main mode shares*—the access mode for which each respondent reported the greatest amount of time spent.

Figures 2 and 3 depict respondents' mode shares and main mode shares, respectively. The data indicate that walking increased slightly as a mode at treatment sites, and increased 3.1% when measured as difference-in-difference ($p<0.05$). As a main mode, walking decreased slightly at treatment sites, though still increased 1% when measured as difference in difference. The increase in mode share and decrease in main mode share at treatment sites can be interpreted as an increase in multi-modal trips. Walking for more than 5 minutes occurred in more access trips in the post-period, but the increases in main mode occurred for those traveling by bike and bus. These observations suggest that SR2T may have increased walking in a way that is complementary to other sustainable transportation modes. Buses in particular increased substantially as a mode and main mode, though the changes and difference-in-difference were not statistically significant with the limited sample sizes of this study. While it is difficult to draw direct causal links, increases in bus mode and main mode shares may have been supported by the pedestrian safety improvements around treatment sites, since most people get to and from buses by walking.

FIGURE 2 Change in Mode Share Among Survey Population (percentage points)

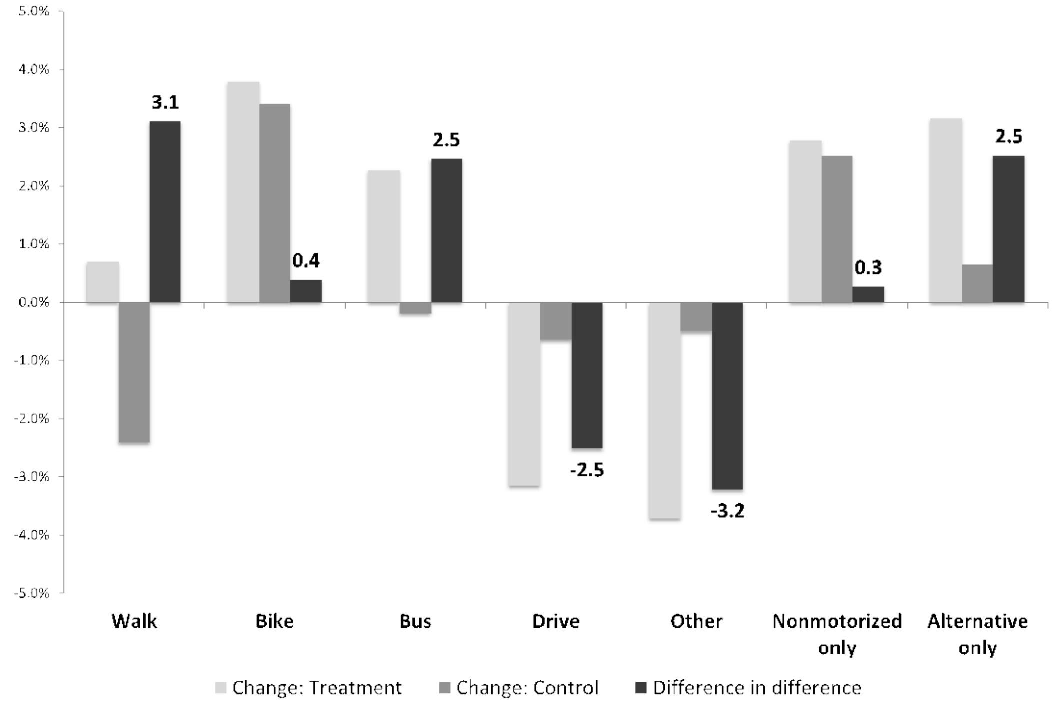
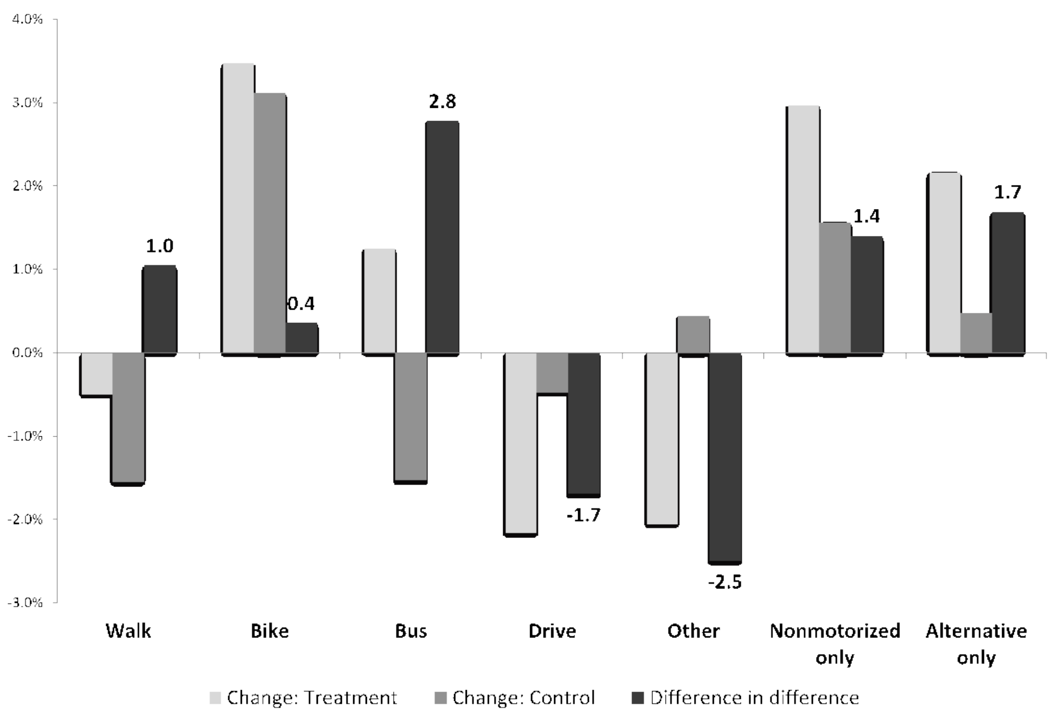


FIGURE 3 Change in Main Mode Share Among Survey Population (percentage points)



The data indicate that bicycling increased between 3.1% and 3.8% at both treatment and control sites, when measured either by mode or main mode, with all changes being statistically significant ($p \leq 0.05$). The changes in bicycle mode share at both treatment and control sites were similar in magnitude, so the difference-in-difference metric is insignificant. However, it is important to note that Fremont, one of the two control stations, also underwent bicycle facility improvements during the study period, although they were separate from and not funded by Safe Routes to Transit. The other control station, Rockridge, is in an urban neighborhood with relatively good bicycling infrastructure. In this context, it is more reliable to consider differences between the pre- to post-time periods, rather than difference-in-difference. Bicycling was the mode with the greatest gains between the pre- and post-periods in both mode share and main mode share, with the increases slightly higher at treatment sites.

Increases in alternative transportation modes were matched by decreases in driving, both as a mode and main mode at treatment and control sites. Furthermore, decreases in driving were more substantial at treatment sites, to the extent that driving to treatment sites decreased 2.5% as a mode share and 1.7% as a main mode share when measured as difference-in-difference. It is notable that these changes were observed over a time period during which the economy in the Bay Area was generally improving, which could be expected to encourage automobile use. The reductions in driving and the greater magnitude of that reduction at treatment sites are in line with the mode shift and air quality goals of the Safe Routes to Transit program.

The Influence of Respondent Characteristics on Mode Choice

In order to understand the challenges and opportunities to shifting access trips towards walking and bicycling among transit riders, main mode shares were examined by a variety of demographic and household characteristics (see Table 2). These data are combined across all sites and both time periods. The data indicate that men were slightly more likely to walk, although this difference was not statistically significant (p=0.279). The greatest difference by gender was in bike mode share, with bicycling having a 7.2% main mode share for men and 2.4% for women. This difference was highly statistically significant (p<0.0001). However, both women and men saw substantial increases in bicycle main mode share, with women's bicycle main mode increasing from 1.6% to 3.1% (p=0.111) and men's bicycle main mode share increasing from 4.8% to 9.1% (p=0.007).

TABLE 2 Main Mode Share by Demographics of the Survey Population

	Obs. (n=)	Walk (%)	Bike (%)	Bus (%)	Drive (%)	Other (%)	Non-motorized modes (%)	Alternative modes (%)
Gender								
Male	1,092	31.4	7.2	15.8	41.8	3.8	38.6	58.2
Female	1,170	29.3	2.4	15.4	50.3	2.6	31.7	49.7
Age Group								
18-24	351	30.5	2.6	26.8	38.7	1.4	33.0	61.3
25-34	674	33.2	6.7	15.4	40.5	4.2	39.9	59.5
35-44	514	31.9	5.8	10.9	47.7	3.7	37.7	52.3
45-54	362	26.2	5.0	13.3	52.8	2.8	31.2	47.2
55-64	233	27.9	1.3	14.2	53.2	3.4	29.2	46.8
65+	67	20.9	0.0	9.0	68.7	1.5	20.9	31.3
Number of Adults in Household								
1	501	36.9	5.2	19.4	35.5	3.0	42.1	64.5
2	1,163	29.1	4.9	10.7	51.4	3.9	34.0	48.6
3	266	22.6	2.6	20.7	52.6	1.5	25.2	47.4
4+	202	22.8	6.9	21.8	46.0	2.5	29.7	54.0
Number of Children in Household								
0	1,621	32.0	4.8	17.6	42.2	3.5	36.8	57.8
1	359	28.1	5.0	11.4	52.9	2.5	33.1	47.1
2	283	24.7	6.0	8.1	58.0	3.2	30.7	42.0
3+	82	24.4	3.7	23.2	48.8	0.0	28.0	51.2
Number of Automobiles in Household								
0	444	43.5	7.4	28.8	16.0	4.3	50.9	84.0
1	680	38.7	6.3	18.7	31.9	4.4	45.0	68.1
2	756	24.1	2.8	9.3	61.9	2.0	26.9	38.1
3+	463	15.3	3.9	9.3	69.3	2.2	19.2	30.7

Note: Mode shares sum horizontally to 100%.
"Non-motorized modes" are walk and bike. "Alternate modes" are walk, bike, bus, and other.

When examined by age group, the main mode share data indicates that walking is the main mode for at least 25% of the population except for the highest age group (age 65+). Bicycling follows trends similar to walking, in that younger patrons are more likely to use it as a mode. Interestingly, bicycling does not drop off substantially until the 55+ age groups. This suggests that the segments of the population that could take advantage of bicycling improvements are broader than might be expected, with bicycling still having a relatively high main mode share of 5%, even in the age group of 45-54 among respondents. Meanwhile, driving does not reach a majority of main mode share until it reaches the age group of 45-54. Unsurprisingly, there was a much higher rate of driving and the lowest likelihood of using any non-motorized or alternative mode among those aged 65+.

Household size also seemed to influence mode choice. Households with one adult were the most likely to report a main mode of walking, and households with either 1 or 4+ adults were the most likely to report bicycling as a main mode. This is likely due to correlations with age, since these types of households are the most likely to be young, non-family households. Meanwhile, a greater number of children in a household was correlated with lower rates of walking as a main mode and increased rates of driving as a main mode. This suggests that having dependent children makes driving more attractive, while non-family households are more likely to walk. In general, this relationship held true at the station level, varying from Rockridge, where the walking main mode share was 3.1% higher for households without children, to Palo Alto, where the same difference was 11.0%.

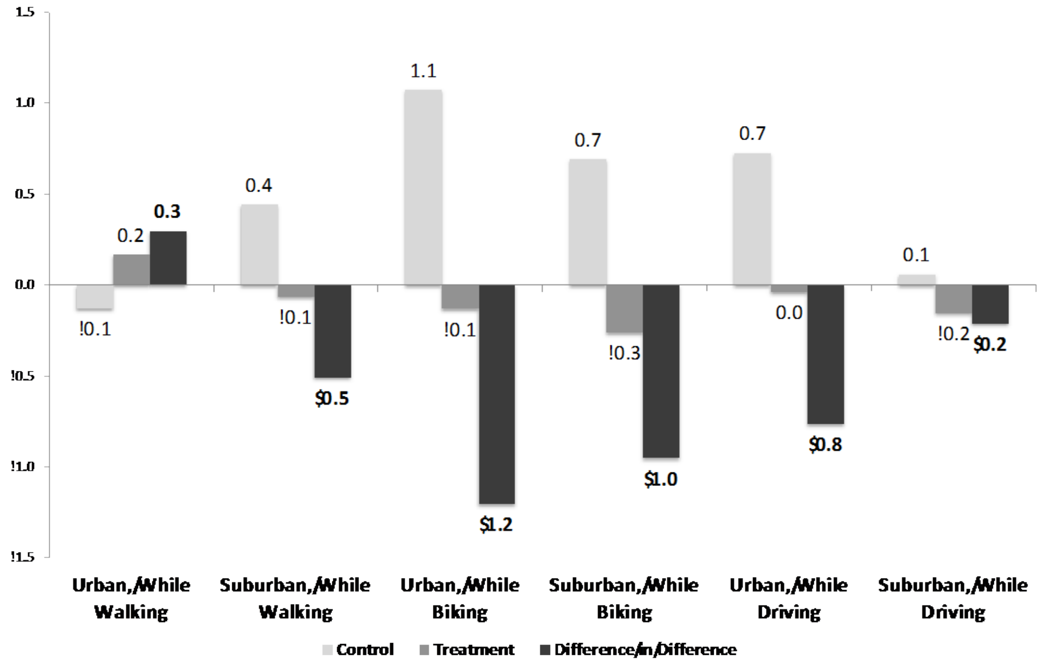
Not surprisingly, automobile ownership strongly predicts non-motorized and alternative mode use. While 43.5% and 7.4% of respondents in car-free households had a main mode of walking and bicycling, respectively, those figures are dramatically lower among two-car households (24.1% and 2.8%, respectively). Meanwhile, from car-free to single-car households, driving as a main mode doubles (from 16.0% to 31.9%), and from single-car to two-car households it nearly doubles again (to 61.9%). While the data from this project indicate that pedestrian and bicycle safety improvements do encourage walking and bicycling, these demographics suggest that broader strategies around auto ownership are necessary to widely affect mode shift to more sustainable modes.

The gender and age demographics of respondents in the pre- and post-periods were examined to test for possible sampling bias. Chi-squared tests of respondents' gender across time periods showed that differences in gender composition of the sample were not significant overall (p=0.152). Gender differences between the two time periods were also not significant within the treatment (p=0.445) and control groups or among urban and suburban stations. The age groups of respondents across time periods differed significantly at the 5% level, both overall and within treatment sites (p=0.042 and p=0.047, respectively), but the magnitude of these differences was small, with the greatest difference in the share of any age group between the pre- and post-periods being less than 5%. Thus, while the differences were significant, they were not large in magnitude, and are unlikely to have biased results substantially. Furthermore, one might expect to have seen some of the observed shifts because of improvements around stations leading to increased walking and bicycling. At treatment sites and overall, the shares of those under age 35 increased, which could be partially attributed to increases in the number of bicyclists, who are disproportionately younger.

Perceptions of Traffic Risk

This project also measured changes in perceived traffic risk around the stations. Perceived traffic risk was measured on a 5-point Likert scale, with higher scores indicating a greater level of concern while walking, bicycling, or driving to the station. Figure 4 shows improvements in perceptions of traffic risk for all three modes when measured as difference-in-difference. In this case, pedestrians reported the least improvement in risk perceptions among the modes, with improvements being small and not statistically significant. Improvements in bicycling perceptions of safety were the strongest, with levels of concern decreasing 0.8 Likert scale points overall and 1.2 Likert scale points at urban stations when measured as difference-in-difference. The changes in bicycling perceptions were significant at the 10% level (p=0.059) when measured as difference-in-difference overall, as well as difference-in-difference at suburban sites (p=0.083). Seeing improvements in perceptions of traffic risk is a promising finding, as these perceptions factor into mode choice. These perceptual changes (based on actual on-the-ground improvements funded by the Safe Routes to Transit program) support mode shift to walking and bicycling.

FIGURE 4 Changes in Average Perceptions of Traffic Risk, by Location Type
(Average Likert Scores; Lower = Less Concerned)



Interestingly, Figure 4 shows that traffic risk perceptions while driving to the station also improved significantly at the 10% level when measured as difference-in-difference at urban sites (*p*=0.078). This finding is consistent with research showing that drivers welcome pedestrian and bicycle improvements and the increased predictability they bring, particularly in urban areas where there are more likely to be multiple types of road users in constrained space *(21,12)*.

When perceptions of traffic risk were analyzed by geography and gender, the data revealed notable differences. In general, women were more concerned about safety while walking to the station. Interestingly, women's safety concerns while bicycling to stations decreased significantly from the pre- to post-time periods, while men's increased.

It should be noted that, while respondents in urban areas expressed traffic safety concerns about bicycling, this did not necessarily mean they then chose not to bicycle. Bicycle main mode share was 16% among urban respondents who expressed safety concerns about bicycling (defined here as a Likert score of 4 or 5). Similarly for walking, 44% of those who expressed concerns about safety while walking to the station still chose walking as their main mode. This is in contrast to what is observed in suburban areas, where only 29% of those expressing concerns about walking choose it as a primary mode. Being concerned about safety for any of the three modes is linked to higher rates of driving at the suburban stations.

Perceptions of Air Pollution

Perceptions of pollution were measured on a 5-point Likert scale, with higher scores indicating a greater level of concern while traveling to the station. Perceptions may not correlate perfectly with actual air quality around stations, but still offer insights into how it may affect willingness to walk or bicycle. When measured as difference-in-difference, perceptions of air pollution improved relatively substantially for all travel modes at treatment stations. These changes were significant at the 10% level overall for bicycling and at urban stations for driving. The decrease in concern about air pollution while walking was also statistically significant at the 10% level (p=0.081), and the decrease in concern while bicycling was both highly significant and substantial in magnitude (change of -0.7, p=0.014). These improvements in perceptions of air pollution are promising, especially given that in general the public seems to be increasingly concerned and aware about the health and environmental impacts of air pollution.

Perceptions of pollution while walking were approximately twice as high at suburban stations, with similar patterns observed in the pre-improvement time period for respondents while walking and bicycling to stations, likely due to the presence of arterials with high volumes of traffic at most suburban stations. Interestingly, concerns were higher at urban stations while bicycling and driving in the post-improvement time period. There was substantial heterogeneity among perceptions of pollution at the station level, although small sample sizes at the site level should temper any conclusions drawn from the data.

Additionally, all survey respondents were invited to report their perceptions of air pollution on all three modes, regardless of their access mode to the station. Among responses collected about perceptions of air pollution while bicycling, only 5.2% in the pre-period and 6.3% in the post-period were by respondents who reported bicycling to the station. Further research and a larger sample size would be necessary to better understand how improvements such as those funded by SR2T influence perceptions of air pollution among active bicyclists in particular.

Economic Implications

The primary goals of the SR2T program focus on safety, health, and sustainability effects from mode shift and improved air quality. However, the data suggest that there are also economic benefits from encouraging walking and bicycling. Table 3 presents data across both the pre- and post-time periods, comparing the main mode shares among groups with different behavior with regard to stopping on the way to the transit station at which they were surveyed. It is useful to compare mode shares within each group to the overall main mode shares to understand whether a mode is over- or under-represented within each group.

TABLE 3.–_Main Mode Shares by Whether Stopped and Type of Stop

Type of Stop	Walk (%)	Bike (%)	Bus (%)	Drive (%)	Non-motorized modes (%)	Alternative modes (%)
Overall Main Mode Shares	30.3	4.9	15.7	46.0	35.2	54.0
Made no stops	28.5	5.3	15.3	47.5	33.8	52.5
Made any stop	37.1	3.5	17.1	40.0	40.6	60.0
Stopped for food/drink	42.1	6.3	16.4	33.3	48.4	66.7
Stopped for childcare	18.4	0.0	10.5	68.4	18.4	31.6

Notes:
Mode shares sum horizontally to 100% with category "other" not presented here.
"Non-motorized modes" include walk and bike. "Alternative modes" include walk, bike, bus, and other.

Those whose main mode was driving were slightly over-represented among those who made no stops, and under-represented among those who made any stop at all. Drivers were particularly under-represented regarding stopping for food and drink (33.3% compared with their overall mode share of 46.0%). The only type of stop for which drivers were over-represented was childcare, with 68.4% of those who stopped for childcare stating a main mode of driving. This is consistent with patterns seen in the demographics section of this report with respect to main mode choice of households with children. By contrast, those with a main mode of walking were much more likely to make stops on the way to transit. They were over-represented both in making any stop at all (37.1% compared with an overall mode share of 30.3%), and among those who stopped for food and drink (42.1%), which is a type of stop with direct neighborhood economic benefit. Interestingly, while respondents with a main mode of bicycling were slightly under-represented within the group of those who made any stop at all, they are over-represented among those who stopped for food and drink (6.3% compared with overall mode share of 4.9%). In general, all users of sustainable access modes (walk, bicycle, and bus) were more likely than drivers to generate local economic activity through stops for food and drink on the way to transit stations.

LIMITATIONS OF THE DATA

The findings discussed in this paper are subject to three main limitations. First, the scope of the project required the participation of many student data collectors over a 2-1/2 year period. While there was consistency in the training team and protocol, the large cadre of intercept surveyors could have resulted in subtly different samples across stations and time periods. Additionally, given the relatively low mode share of bicycling, the analyses of bicycling in this study need to be viewed in light of the relatively small sample of bicyclists. Finally, the Safe Routes to Transit program took place at the same time as the implementation of other streetscape and roadway improvements unrelated to the SR2T program, as well as within the context of a national and statewide conversation about the importance of active transport and larger trends of increased bicycling. For these reasons, it is impossible to give complete credit to SR2T for changes observed.

THE SUM OF THE PARTS: CONCLUSIONS AND RECOMMENDATIONS

The data suggest that the streetscape and roadway improvements made through the Safe Routes to Transit (SR2T) program positively influenced the propensity to walk, bicycle, and take the bus to transit stations. This study occurred in the context of other regional efforts to encourage active transport as well as general societal trends toward reduced driving and increased bicycling, and does not claim that the SR2T program is responsible for all of the observed changes. Nonetheless, the fact that the treatment sites routinely showed shifts toward walking, bicycling, and bus use, as well as improvements in the perceptions of safety and air pollution, suggests that the SR2T program did, on its own, contribute to the shifts observed.

In particular, the data indicate the following:

- Walking and bicycling, whether as the sole access mode to transit or as part of a multi-modal trip to access the various stations, generally increased from the pre- to the post-period at the treatment sites.
- Perceived traffic risk decreased significantly among cyclists and drivers. Research suggests that decreased perceptions of traffic risk may encourage bicycling, and that a change in drivers' perceptions may result from realized benefits of enhanced pedestrian and bicycle infrastructure.
- Perceived air pollution decreased among all groups at the sites, a finding that may both result from and contribute to increased walking and bicycling.
- Bicyclists and pedestrians were over-represented among those who stopped for food or drink on the way to the transit station, whereas those driving to the stations were much less likely to stop for anything but childcare along the way. Improvements that enhance walkability and bikability may therefore result in secondary economic benefits to the surrounding areas.

The data also indicate that future research would help clarify how these types of improvements affect mode shift to bicycling and perception of safety among current and potential cyclists. Additionally, future research is needed to better understand the factors leading to significant increase in bus usage observed and how walking and bicycling interact with such factors.

In terms of expectations from programs like SR2T, this program funded improvements to support walking and bicycling to transit in an effort to improve air quality, increase active transportation, decrease congestion, and improve safety. This program seeks to reverse decades-long, automobile-dominant commute and travel trends. It is through this lens that results from this analysis should be interpreted. Given the promising movement toward active transportation and use of transit, support for programs like SR2T should be given strong consideration, support, and funding.

ACKNOWLEDGEMENTS

Thank you to Sean Co and the Metropolitan Transportation Commission (MTC) for funding this research, and to Matthew Ridgeway and Meghan Mitman of Fehr & Peers Transportation Consultants for including us. Many thanks also to Dr. Robert Schneider for his design of the research, and to the many student data collectors. Sherry Ryan of Chen Ryan Associates, formerly of Fehr & Peers, provided early leadership in sampling and research design. We also want to thank Grace Felschundneff for editing this report.

REFERENCES

1. U.S. Census Bureau Public Information Office. 2013. *Megacommuters*. U.S Census Bureau. http://www.census.gov/newsroom/releases/archives/american_community_survey_acs/cb13-41.html. Accessed Feb. 7, 2014.
2. Centers for Disease Control. 2012. *Physical Activity Statistics: Introduction*. http://www.cdc.gov/nccdphp/dnpa/physical/stats/. Accessed Nov. 25, 2013.
3. Besser, L. M., and Dannenberg, A. L. Walking to Public Transit: Steps to Help Meet Physical Activity Recommendations. *American Journal of Preventive Medicine*, Vol. 29(4), 2005, pp. 273–280. doi:10.1016/j.amepre.2005.06.010.
4. Hamer, M., and Chida, Y. Active commuting and cardiovascular risk: A meta-analytic review. *Preventive Medicine*, Vol. 46(1), 2008, pp. 9–13.
5. Frumkin, H., Frank, L., and Jackson, D. R. *Urban Sprawl and Public Health: Designing, Planning, and Building for Healthy Communities*. Island Press. 2004.
6. Koren, H. S., and Butler, C. D. The Interconnection Between the Built Environment Ecology and Health. In B. Morel & I. Linkov (Eds.), *Environmental Security and Environmental Management: The Role of Risk Assessment.* Springer Netherlands. 2006, pp. 109–125.
7. Cervero, R. 1995. *Rail Access Modes and Catchment Areas for the BART System*. http://trid.trb.org/view.aspx?id=523020. Accessed Feb. 7, 2014.
8. Cervero, R. (2001). Walk-and-Ride: Factors influencing pedestrian access to transit. *Journal of Public Transportation*, Vol. 7(3), 2001.
9. Schlossberg, M., and Brown, N. Comparing Transit-Oriented Development Sites by Walkability Indicators. *Transportation Research Record: Journal of the Transportation Research Board*, *No. 1887*(-1), Transportation Research Board of the National Academies, Washington, D.C., 2004, pp. 34–42.
10. Marshall, W., and Garrick, N. Effect of Street Network Design on Walking and Biking. *Transportation Research Record: Journal of the Transportation Research Board*, *No. 2198*(-1), Transportation Research Board of the National Academies, Washington, D.C., 2010, pp. 103–115.
11. Dill, J., and McNeil, N. (2013). Four Types of Cyclists?: Examination of Typology for Better Understanding of Bicycling Behavior and Potential. *Transportation Research Record: Journal of the Transportation Research Board*, *No. 2387*(-1), Transportation Research Board of the National Academies, Washington, D.C., 2013, pp. 129–138.
12. Sanders, R. L. *Examining the Cycle: How Perceived and Actual Bicycling Risk Influence Cycling Frequency, Roadway Design Preferences, and Support for Cycling Among Bay Area Residents*. University of California Transportation Center, Working Paper No. qt6ct7x8hp. University of California Transportation Center. 2013.
13. Winters, M., & Teschke, K. Route preferences among adults in the near market for bicycling: findings of the cycling in cities study. *American Journal of Health Promotion: AJHP*, Vol. 25(1), 2010, pp. 40–47.
14. Cervero, R., Caldwell, B., and Cuellar, J. *Bike-and-Ride: Build It and They Will Come*. University of California Transportation Center. 2012.
15. Ragland, D., Pande, S., Bigham, J., and Cooper, J. F. *Ten Years Later: Examining the Long-Term Impact of the California Safe Routes to School Program.* Safe Transportation Research and Education Center, University of California, Berkeley, 2014.

16. Boarnet, M. G., Anderson, C. L., Day, K., McMillan, T., and Alfonzo, M. Evaluation of the California Safe Routes to School legislation: Urban form changes and children's active transportation to school. *American Journal of Preventive Medicine*, Vol. 28(2, Supplement 2), 2005, pp. 134–140.
17. MTC-ABAG Library. 2011. *Bay Area Census—Cities.* http://www.bayareacensus.ca.gov/cities/cities.htm. Accessed Jan. 31, 2014.
18. BART. 2014. *Station List.* http://www.bart.gov/stations. Accessed Jan. 31, 2014.
19. San Mateo County Transit District. (2014). *Palo Alto Station.* http://www.caltrain.com/stations/paloaltostation.html. Accessed Mar. 31, 2014,
20. Goulding, K. 2011. Differences-in-Differences estimation in R and Stata. *the Tarzan*. http://thetarzan.wordpress.com/2011/06/20/differences-in-differences-estimation-in-r-and-stata/. Accessed Jan. 31, 2014.
21. Sanders, R., and Cooper, J. F. Do All Roadway Users Want the Same Things? Results from a Roadway Design Survey of Pedestrians, Drivers, Bicyclists, and Transit Users in the Bay Area. *Transportation Research Record*, *2393*, Transportation Research Board of the National Academies, Washington, D.C., 2012, pp. 155–163.