RESEARCH REPORT

Institute of Transportation Studies | UNIVERSITY OF CALIFORNIA

Travel Behavior Impacts of Transportation Demand Management Policies: May is Bike Month in Sacramento, California

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16. Abstract

Active modes of transportation like bicycling and walking are extremely beneficial to society, including helping to reduce the amount of travel people may make by car (i.e., vehicle miles travelled) and in turn reducing congestion and transportation-related greenhouse gas emissions and air pollutants. Bicycling and walking also have direct and positive health impacts. Several steps have been taken to promote active transportation in cities and regions, including awareness campaigns, transportation demand management policies, building new bicycling infrastructure, and the launch of bikesharing programs. However, it is often unclear how much impact a specific strategy can have on actual rates of bicycling and walking in a community or region. UC Davis assisted the Sacramento Council of Governments (SACOG) in evaluating the impact of the agency's "May is Bike Month" campaign. The purpose of the campaign is to motivate residents working and/or living in the region to start using (or increase use of) bicycles as a mode of transportation. SACOG conducted a survey as part of the 2018 "May is Bike Month" campaign, which collected self-reported information from participants on the frequency of bicycling before and after the campaign, perceived barriers to bicycling, motivations for bicycling, travel habits, household and individual sociodemographic, and place of residence. UC Davis analyzed the survey data to better understand the role land use characteristics and transit accessibility have on bicycling rates. This information will be used to understand the variables that affect individuals' decisions to increase, decrease, or not change bicycling levels during and after the "May is Bike Month" campaign. This project helps SACOG identify the groups which are most and least receptive to the campaign, and ways these groups of individuals have reacted (in terms of changing their bicycling behavior) in response to the campaign. SACOG can use this information to make strategic changes to its annual "May is Bike Month" campaign in order to optimize the campaign's effectiveness in future years, and/or coordinate the campaign with additional initiatives to promote bicycling in the Sacramento region.

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About the UC Institute of Transportation Studies

The University of California Institute of Transportation Studies (UC ITS) is a network of faculty, research and administrative staff, and students dedicated to advancing the state of the art in transportation engineering, planning, and policy for the people of California. Established by the Legislature in 1947, ITS has branches at UC Berkeley, UC Davis, UC Irvine, and UCLA.

About the Sacramento Area Council of Governments

The Sacramento Area Council of Governments (SACOG) is an association of local governments in the six-county Sacramento region. Its members include the counties of El Dorado, Placer, Sacramento, Sutter, Yolo, Yuba and the 22 cities within. SACOG provides transportation planning and funding for the region, and serves as a forum for the study and resolution of regional issues. In addition to preparing the region's long-range transportation plan, SACOG approves the distribution of affordable housing in the region and assists in planning for transit, bicycle networks, clean air and airport land uses.

Acknowledgments

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Disclaimer

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Table of Contents

Table of Contents

List of Tables

List of Figures

Glossary

Acronym	Definition
MIBM	May is Bike Month
SACOG	Sacramento Area Council of Governments
TDM	Transportation Demand Management
VMT	Vehicle Miles Traveled

Executive Summary

Executive Summary

The rising vehicles miles travelled (VMT) in California is a concern for planners at the state and regional levels. This concern is mostly due to the negative externalities associated with driving motor vehicles, such as emissions of greenhouse gases and local air pollutants, as well as congestion. Thus, not surprisingly, regional and state level planning agencies invest significant resources to reduce vehicle miles traveled (VMT).

Changing people's behavior to drive less is a challenging task and requires several long- and short-term strategies, known as travel demand management (TDM) strategies. Some such strategies deployed in the past include: improving the accessibility of neighborhoods to reduce the demand for driving; pricing single-occupancy vehicle travel; building bike paths to promote less polluting vehicles; and pricing entry into certain areas ("hotspots") to reduce congestion. Campaigns promoting active modes of transportation, such as walking and bicycling, are another aspect of TDM. These strategies aim to improve awareness and change people's attitudes about alternative modes of transportation. Research has shown that such strategies are less effective in reducing VMT when compared with strategies such as land-use change and pricing. However, they usually require less investment and face less resistance from the public. Moreover, promoting active modes of transportation such as bicycling and walking have a positive effect on the health of people.

Every year, the Sacramento Area Council of Governments (SACOG) organizes the "May is Bike Month" (MIBM) campaign, to promote bicycling as a mode of transportation in the Sacramento region. Residents of Sacramento are recruited into the campaign through social media, advertisement, and SACOG's collaboration with schools and offices in the region. The participants are encouraged through small gift incentives to report their bicycling activities. This usually leads to friendly competition amongst participants and friends.

In 2018, SACOG conducted two online surveys—before the launch of the campaign and after its conclusion—to understand the effectiveness of the campaign in changing travel behaviors. Both surveys were administered online. Their purpose was to gauge the levels of bicycling of the participants before, during, and after the campaign. In addition, the survey included questions on the barriers and motivations people have towards bicycling.

In this study we sought to determine: (1) whether the 2018 May is Bike Month campaign in the Sacramento region had an impact on the frequency of bicycling among campaign participants; and (2) what characteristics of the participants or their neighborhoods (that were assessed or assessable) correlated with their tendency to increase bicycle frequency during or after the campaign.

We integrated the survey dataset with land-use information by geocoding the residential location of each participant and matching it with information on the built environment and a bikeability index of the home location (bikescore). We evaluate the increase in participants' bicycling frequency—by estimating three ordered logit models for the changes in bicycling frequency during three time periods: (1) before vs. during, (2) during vs. after, and (3) before vs. after the campaign.

According to our ordered logit models the following characteristics were significantly associated with an increase in bicycle frequency from before to during and from before to after the campaign (but not an increase from during, to after the campaign):

- Previously considering increasing the amount of bicycling (versus not considering this)
- Having one's primary mode of commuting be a car or some other mode besides a bicycle during the 6 months before the campaign
- Living in a neighborhood with an average, rather than a high or low, score on bikeability

The study also showed that the increases in bicycling frequency from during, to after the campaign tended to mainly relate to bicycling for recreational rather than commuting trips.

A change in bicycling frequency occurred in a much smaller proportion of survey participants when the comparison was from during-to-after the campaign than when it was from before-to-during or before-to-after. This may have been because the frequency had already increased during the campaign. As a result of the relatively rare change in bicycling frequency in the during-to-after comparison, the model corresponding to this comparison did not show a strong fit with the data. Accordingly, the above bulleted items that were significantly correlated with an increase in bicycling frequency from before-to-during and before-to-after did not have significant effects on the increase in bicycling frequency from during-to-after the campaign.

In addition, the analysis indicated that being 30 to 50 years old, as compared to being in other age categories, correlated with a greater likelihood of an increase bicycling frequency in the before-to-during and the before-to-after comparisons. However, the logit models revealed this age variable coincided with, and therefore was likely a proxy for, bicycling status before the campaign.

Policy Implications

The MIBM campaign led to an increase in bicycling frequency—or was an effective TDM strategy—for only a certain section of the population—individuals who usually drive but are interested in taking up bicycling as a mode of transportation. While changing land use and building bike infrastructure is certainly necessary for making bicycling an attractive mode of transportation, campaigns such as the one presented here complement these strategies. They tend to spread awareness among individuals who are generally oblivious to these new developments due to heavy dependence on private cars as a mode of transportation.

Contents

1. Introduction

Active modes of transportation such as bicycling and walking are extremely beneficial to society. They help reduce vehicle miles traveled (VMT) by motorized travel modes, as well as reduce congestion and transportation-related emissions of greenhouse gases and air pollutants. Bicycling also has a direct and positive health impact on individuals' lives. Cities use multiple strategies to promote active transportation—including awareness campaigns, transportation demand management (TDM) policies, the building of new bicycling infrastructure, and the launch of bikesharing programs, such as the JUMP Bike program in the region of study: the metropolitan area of Sacramento, California.

In this study, we evaluate one of the TDM campaigns launched by the Sacramento Area Council of Governments (SACOG) to promote bicycling in the region in terms of its impact on bicycling frequency. Every year, SACOG launches a "May is Bike Month" (MIBM) campaign. Throughout the campaign, participants are encouraged to pledge miles, register their bicycle trip miles, and challenge friends and family members to bicycle more often and win prizes. The campaign is promoted through social media, special events, websites, and in collaboration with local schools, offices, clubs, and teams. More details on this annual campaign are available through a detailed report from SACOG (2016).

The objective of this study is to understand the effect of the campaign launched by SACOG on the level of bicycling of the participants in the area of study. In particular, we seek to address the following research questions:

- How does the frequency of bicycling of the campaign participant's changes during and after the campaign?
- Which characteristics are shared by people most likely to increase their bicycling frequency during the campaign?
- What other factors affect the decision to change one's frequency of bicycling?
- What attributes of the place of residence affect the participants' likelihood of changing their frequency of bicycling?

The next section describes the concept of TDM strategies and reviews the literature on the factors that influence individuals' decisions to use bicycling as a mode of transportation. Section 3 summarizes the data collection effort for this study. In this section we also present our rationale for choosing ordered logit models to analyze the dataset and the thought process behind choosing key variables in our models. We then present the results and interpretation of results in Section 4. Finally, in the last section, we discuss the limitations of our analyses and draw policy recommendations from the evidence gathered.

2. Literature Review

In this section we first summarize the various kinds of TDM strategies available to policy makers and the rationale of choosing one over the other. We then summarize the status of the literature on bicycling-related demand management strategies. This review is helpful in guiding the analysis for this study.

TDM strategies can target various aspects of travel behavior—trip generation, trip distribution, mode choice, and route selection. The objective of strategies affecting trip generation is to eliminate the trip entirely. Some of the common strategies under this objective include mixed land-use and promotion of travel substitutes such as telecommuting and teleshopping. Diversion of trips from congested destinations fall under the category of trip distribution. Promotion of multiple urban centers and satellite activity locations such as onsite day care facilities, restaurants, etc. are some of the policies which can successfully divert trips in the intended direction. Transfer of trips from a drive-alone mode to alternate modes of transportation can be classified as a TDM strategy affecting mode choice. Policies such as increased pricing of parking, introduction of carpool lanes, and promotion of active modes—such as bicycling and walking—fall under this category. Route selection strategies such as congestion pricing, car free zones, etc. aim at diverting traffic from a congested zone to other locations (Ferguson, 1990).

The analysis presented by Meyer (1999) suggests that pricing, including congestion pricing and parking pricing, are some of the strategies associated with the highest reported reduction in VMT and trip reduction (maximum of 5.7% reduction in VMT). Change in land use is yet another policy with reported VMT reductions as high as 5.4%. On the other hand, TDM strategies such as building bicycling and walking infrastructure have a relatively low impact on VMT. However, Meyer points out that the effectiveness of a TDM strategy depends on the relationship between the targeted market segment for the travel behavior change and the 'travel' changing incentives and disincentives offered by the TDM strategy. Moreover, the effect size of the TDM strategy increases if it is implemented at a regional rather than local scale.

Several studies have investigated factors that affect the frequency of bicycling. Some such factors are lack of safety, reduced ability to run errands on a commute trip, and adverse weather conditions (Akar, Flynn, & Namgung, 2012; Cervero & Duncan, 2003; Rybarczyk & Gallagher, 2014). Cervero & Duncan (2003) also noted a general aversion to bicycling and walking at night. On the other hand, proximity to bicycle paths or lanes[1] and shortcuts, safe parking facility, and provision of showers at destinations are incentives that can increase bicycling frequency (Hunt & Abraham, 2007; Noland & Kunreuther, 1995; Sener, Eluru, & Bhat, 2009; Titze, Stronegger, Janschitz, & Oja, 2008; Wardman, Tight, & Page, 2007). Brezina & Hildebrandt (2016) suggested that improvements in urban intersection design and an increase in green light time can make bicycling more attractive, which may eventually increase the mode share of bicycling. On the other hand, a study conducted in elementary schools of Arizona concluded there was no significant relationship between the bikeability of the

[1] Special lanes on roads dedicated for safety and comfort of bicycle riders.

streets and the number of bikes parked at local schools, which was used as a proxy measure of bicycling in the neighborhood (Sisson, Lee, Burns, & Tudor-Locke, 2006).

Several studies have investigated the impacts of various TDM strategies on bicycling behaviors in various geographic contexts. For example, Fitch et al. (2016) in a before-after study in San Francisco found an increase in bicycling after the installation of additional bicycling infrastructure. The type and quality of bicycling infrastructure also matters. In 2014, a survey was conducted to understand the bicycling and walking barriers and motivators for people at the University of Michigan-Flint. Out of the three groups surveyed (students, staff, and faculty), students were most likely to adopt active modes of transportation. Main motivators of bicycling were safer routes, better lighting, and the presence of attractive destinations accessible at a bikeable distance. The main motivator for bicycling for staff members living close to the campus was an increase in prices for fuel or parking. In addition, seeing more bicyclists on the road and availability of more racks to lock bikes increased the likelihood of biking among students (Rybarczyk & Gallagher, 2014). Cervero & Duncan (2003) conducted a study to understand the effect of land use characteristics on active modes of transportation—bicycling and walking. The authors found that trip purpose was an important variable in predicting the choice of walking as a mode of transportation. The likelihood of walking increased when the trip purpose was shopping or leisure. Temporal variables were also significant, for example, walking was a more likely transportation mode choice on the weekends. Even after controlling for socio-economic factors such as vehicle ownership and income—African Americans were more likely to walk as compared to Whites or Asian Americans. The main impediments to walking in the San Francisco Bay area were long trips, adverse weather conditions, elevation of the walking path, and nighttime. The results showed that similar factors motivated individuals to bicycle. However, land use characteristics played a much more important role. A recent study from Clark et al. (2019) showed higher preference and likelihood to start riding a bicycle when separated bicycle lanes and cycle tracks[2] become available, compared to other types of bicycling infrastructure such as conventional on-street bike lanes. Outside of the US, Titze et al., (2008) found that bicycle lane connectivity is positively associated with cycling in Austria. The Australian Greenhouse Office (2005) tracked bike promotional programs in Australia. Ten (10) of 11 neighborhood programs and 8 of 10 worksite programs were successful in increasing bike trips in Australia. These comprehensive programs included targeted information, events, and incentives to promote bicycling.

The above summary points how use of bicycling as a mode of transportation depends on many factors, such as availability of bicycling infrastructure, access to destination, socio-economic characteristics of the population, weather, and safety. In addition, bicycling awareness campaigns are also found to have increased the attractiveness of bicycling.

[2] A higher-quality type of physically-separated bicycling infrastructure that is spaced away from other road infrastructure.

3. Data and Methods

In the current study we evaluate the change in the frequency of bicycling among participants in the 2018 MIBM campaign—a campaign conducted by SACOG over the past 11 years. The analysis was conducted using before-after surveys and examining how the land use characteristics of the neighborhood in which the respondents live influence their bicycling behavior.

3.1 Data Collection

In spring 2018, SACOG conducted a "before-and-after" survey to evaluate the impact of the MIBM campaign. The survey questions are shown in the Appendix. In addition to gauging the frequency of bicycling at three different times (before, during, and after the campaign), the two surveys collected information on the perceived barriers and motivations for bicycling, travel habits, and sociodemographic traits of the participants in the campaign, among other variables. The first round of data collection was completed when participants enrolled in the campaign. Figure 1 shows the spatial distribution of the respondents. A second "after survey" was conducted after the campaign was over, in June 2018. Figure 2 shows the timeline of the project. Both surveys were administered online. The "before survey" consisted of only four questions asking about the campaign participants' usual mode of transportation and the frequency of bicycling for recreational and transportation purposes (Appendix). In addition, participants were asked to report their "bicycling status" (details in the following paragraphs).

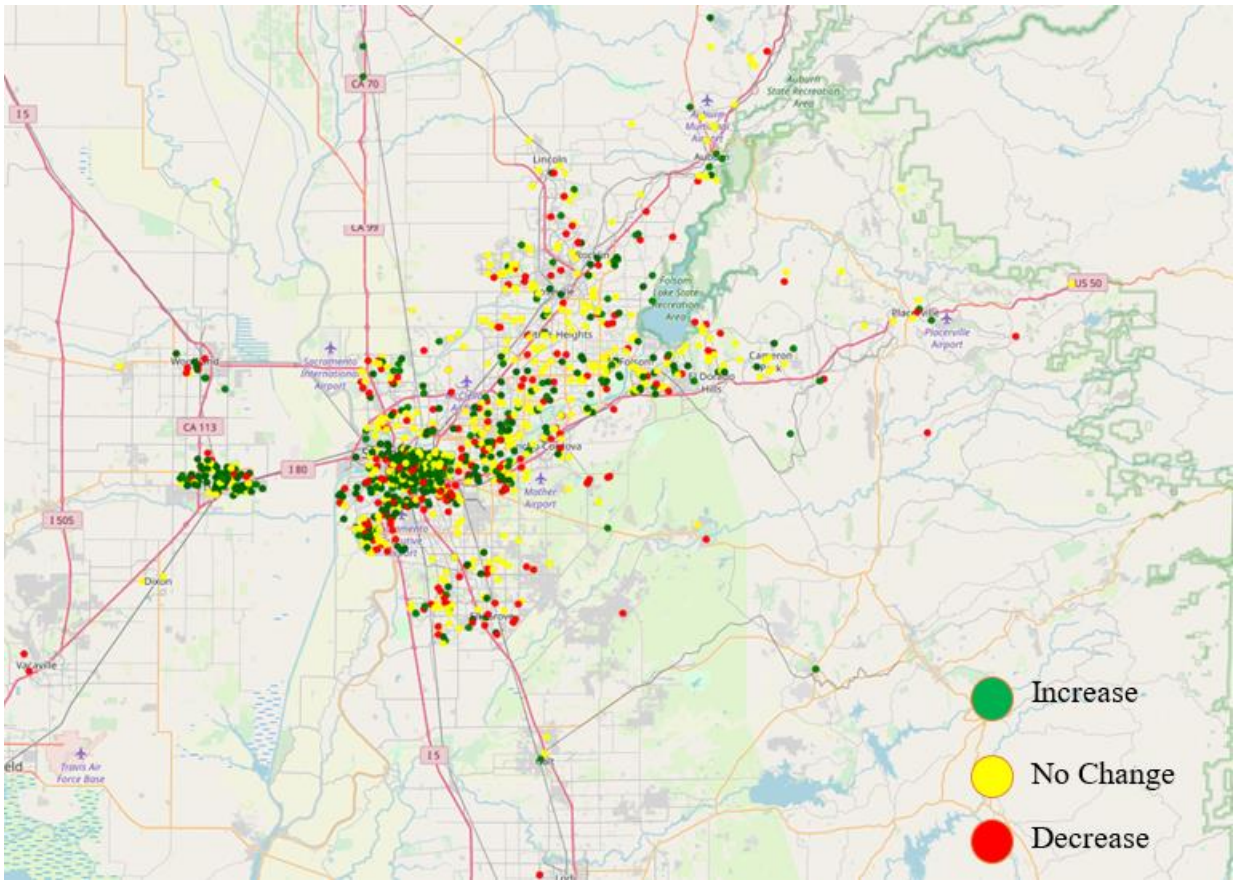

Figure 1. Spatial representation of change in the level of bicycling (before-after)

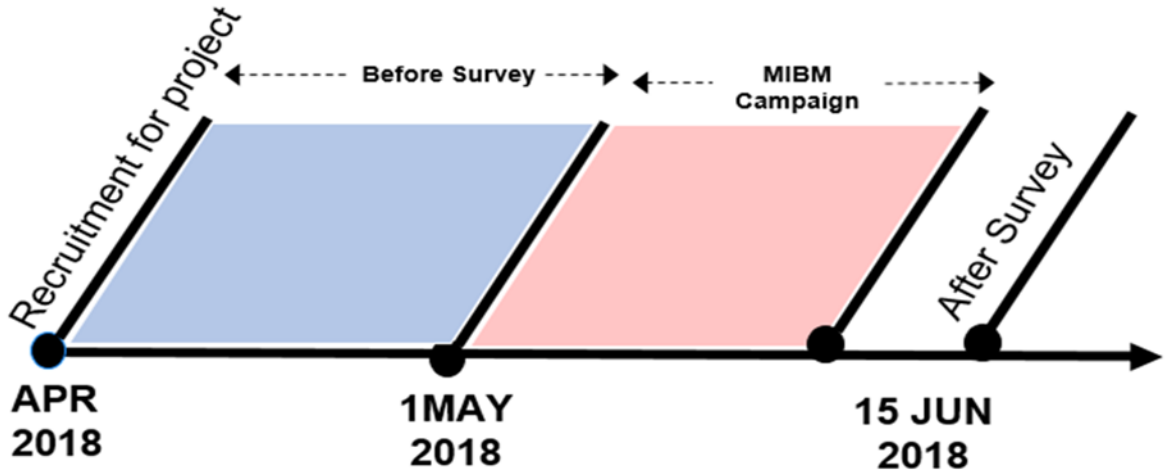

Figure 2. Timeline of the project

The "after survey" included other questions about the source of information from which participants heard about the campaign, the reason to join the campaign, perceived barriers to bicycling, incentives that were offered to the participant, and socio-demographics (Appendix). Most importantly, this survey asked participants (retrospectively) about levels of bicycling before, during, and after the campaign. The dataset that we used for the analysis presented here consisted of 1,970 survey responses from individuals who participated in both surveys. After data cleaning, the final sample included 1,727 survey responses.[3]

The dataset contains the addresses of the home locations of participants. After geocoding the data, this information was used to expand the dataset through integrating block-level information on the built environment in the places of residence of the participants. Table 1 summarizes the list of built environment variables that were imported, and the list of sources where the information was obtained.

Table 1. Variables extracted from web scrapping

Data used to extract information	Sources	Variables extracted
Address of participants	https://maps.googleapis.com/maps/api	Latitude, Longitude
Address, latitude, longitude	http://api.walkscore.com/score	Bikescore*: score (0-100) measuring the ease of biking at the block level Walkscore: score (0-100) measuring the ease of walking at the block level Transitscore: score (0-100) measuring transit availability at the block level
Address	https://alltransit.cnt.org/metrics	Overall transit score summarizing connectivity, access to land area and jobs, and frequency of service. Number of commuters who use transit Jobs located within 0.5 mile of transit Workers who live within 0.5 mile of transit and commute by walking Size of the average block within ½ mile of transit Households within 0.5 mile of transit Farmers markets within 0.5 mile of transit Jobs accessible within a 30-minute trip by transit

* Bikescore: a composite score given to a neighborhood; it combines the 1) degree of availability bike lanes; 2) slope gradient; 3) destinations accessible via bicycling; and 4) mode share of bicycling in the neighborhood.

[3] In the data cleaning process, we removed cases that included a high number of missing values and cases with missing information for the dependent variables – frequency of bicycling.

Table 2 and Table 3 summarize some of the descriptive statistics from the survey. About 85% of the respondents had engaged with the campaign previously. Only 14% of respondents reported that they had no intention of bicycling when they joined the MIBM campaign in May 2018. It is possible that this group of participants took the surveys (and, hence, "joined" the campaign) for the possibility of receiving the incentives or on the advice of their peers/colleagues, while at least initially not having intentions of changing their bicycling habits.

About 60% of the people reported that participation in the campaign directly impacted their decisions to ride a bicycle as a means of transportation. Certain demographic groups were found to be more likely to participate in the MIBM campaign and in the surveys. Consistent with expectations regarding the impact of TDM strategies mainly targeting office workers and students in the California capitol (and somewhat with the distribution of the population of bicyclists in the region), our sample includes a larger proportion of higher-income and more highly educated adults than in the general population of the region. In particular, individuals living in low-income households are particularly underrepresented: participants with an annual income of less $75,000 are barely a quarter of the sample but constitute 65% of the population the in the Sacramento County. Further, our sample tends to over-represent males—58% in the sample as opposed to 48% in Sacramento—and (not surprisingly) is skewed towards people who usually use bicycles as a primary mode of transportation (23% in the sample, only 1% in City of Sacramento) (ACS, 2019).

Table 2. Distribution of key variables in the dataset

Variable	Description	Number of cases	% of total
How many years have you participated in MIBM	2018 was my first year	287	16.5%
	2-4 years	751	43.3%
	5-7 years	358	20.6%
	8-10 years	174	10.0%
	More than 11 years	165	9.5%
How much of a direct impact has the MIBM campaign had on your choice to ride your bike as a means of transportation	Direct impact	382	22%
	Some impact	698	40%
	Very little impact	251	14%
	No direct impact	389	22%
	Not Sure	15	1%
Self-assessment of bicycling status (from the Before survey)*	Pre-contemplation	250	14%
	Contemplation	186	11%
	Preparation	631	36%
	Action	84	5%
	Maintenance	584	34%

*Participants were asked which sentence best describes their attitude toward bicycling as a means of transportation.

- *Pre-contemplation*: "I do not bike for most of my trips, and I don't intend to make any changes."
- *Contemplation*: "I do not bike for most of my trips. I am considering bicycling more often, but I'm not sure how to make that change."
- *Preparation*: "I do not bike for most of my trips, but I intend to bicycle more often. I know how I want to do this, but I haven't yet gotten started."
- *Action*: "I bike for most of my trips, and have been doing so for less than six months."
- *Maintenance*: "I bike for most of my trips, and I have been doing so for more than six months."

Table 3. Comparison of distribution of key socio-demographic variables in the sample and the City/Council of Sacramento

Variable	Description	Number of cases	% of total	% of adults in Sacramento City	% of adults in Sacramento County
Age (years)	18-34	368	21%	34%	30%
	35-54	745	43%	34%	36%
	55-64	479	28%	15%	16%
	65 or older	143	8%	16%	17%
Annual Household Income	Less than $20,000	34	2%	9.4%	11.1%
	$20,000–$74,999	449	26%	12%	12.6%
	$75,000–$99,999	290	17%	12.8%	14.5%
	$100,000–$124,999	275	16%	25.3%	21.5%
	$125,000 or more	434	25%	40.6%	40.3%
	Prefer not to answer	253	15%		
Gender	Female	716	41%	51.3%	51.1%
	Male	1019	59%	48.7%	48.8%
Travel habit before MIBM	Drove alone	692	40%		77.3%
	Bicycled	409	24%		1%
	Mixed	278	16%		
	Carpooled	158	9%		10%
	Transit	133	8%		2.2%
	Walked	33	2%		1.8%
	(Other)	31	2%		6.6%

3.2 Model Estimation and Variable Selection

Using the data collected with the surveys (Appendix), we estimated three ordered logit models to study the changes in the frequency of bicycling of the participants during three time periods:

(1) before vs. during;
(2) during vs. after; and
(3) before vs. after the campaign.

Dependent Variable: To compute the dependent variable, i.e., bicycling frequency, in each of these models, the initial bicycling frequency (before the campaign) was retrieved from the before survey; and the bicycling frequencies during and after the campaign were retrieved from the after survey, where participants also (retrospectively) reported their level of bicycling during the campaign in May 2018.

In all frequency questions, respondents were asked to report whether they rode a bicycle as a means of transportation less than 1 day per month, 1–3 days per month, 1–2 days per week, 3–4 days per week, or 5 days per week in each of these time periods. Figure 3 shows the responses in the three periods. We used these frequency categories to compute the approximate number of days respondents bicycled as a means of transportation in the various months (April, May, and June 2018). We then used the difference in these numbers to calculate the change in the frequency of bicycling—before-during, during-after and before-after the campaign—and generated ordinal variables to measure the magnitude and direction of the changes. The five ordinal levels of a change in bicycling frequency are: a strong decrease (reduction in the frequency of 7 bicycling days or more per month), a decrease (reduction of less than 7 bicycling days per month), no change, an increase (increase of less than 7 bicycling days per month), and a strong increase (increase in the frequency of 7 bicycling days or more per month).

Figure 4 shows the distribution of these changes in the sample, in the three comparison phases. A direct comparison between Figure 3 and Figure 4 can be misleading. Figure 4 is an intra-individual comparison. While Figure 3 is a cross-sectional view of the biking frequency in the sample at three points in time. As later confirmed with models, there were some participants (especially the younger individuals) who were biking at very high frequency (5-7 days/week) before the campaign and marginally dropped their biking frequency during the campaign. On the other hand, there were a few individuals who had a very low biking frequency before campaign but showed a huge increase during and after the campaign. Therefore, even though Figure 3 shows, cross-sectionally, a large increase in biking (on an average) during and after the campaign, at the individual level, there were some who decreased their biking during and after the campaign, as reflected in Figure 4.

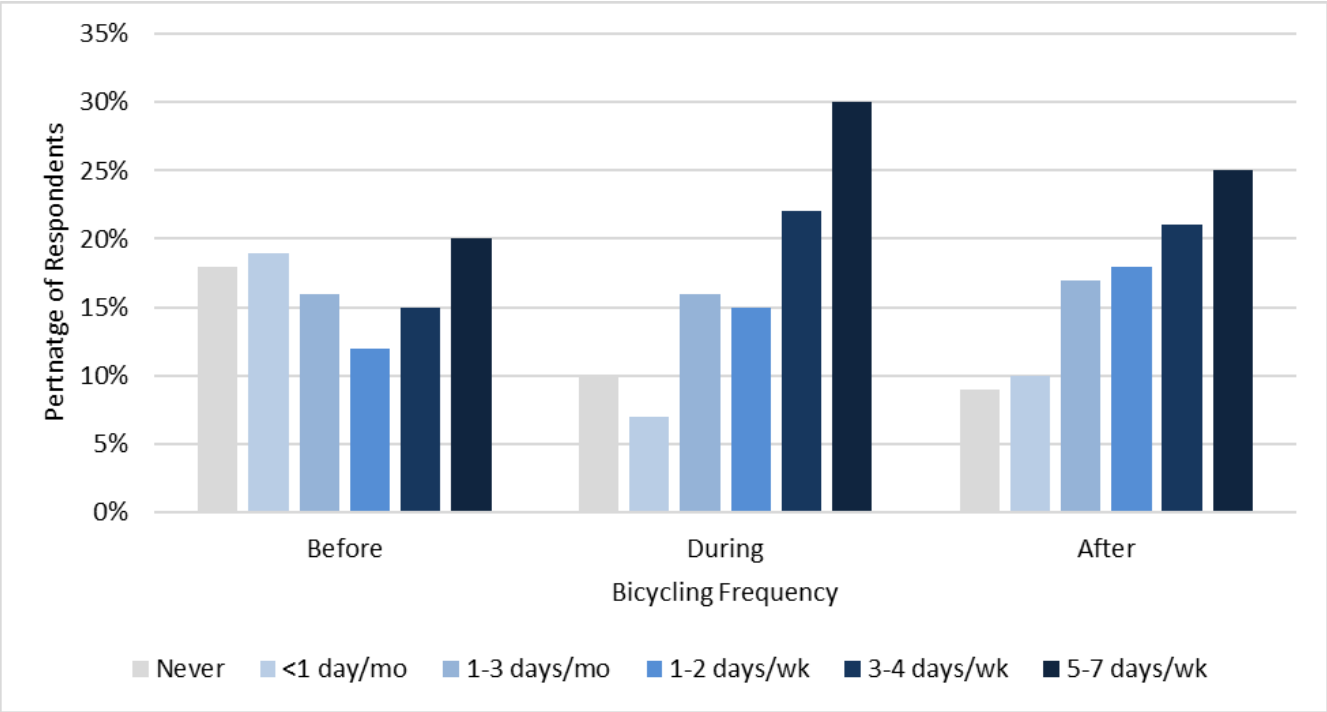

Figure 3. The distribution of frequencies of bicycling before, during, and after the may is bicycle month campaign. Darker shades indicate higher bicycling frequencies. Note: There is a greater percentage of respondents bicycling during and after the campaign, as compared to before.

As shown in Figure 4, approximately a third of the participants increased (light and dark blue bars) their frequency of bicycling during the campaign (compared to before the campaign). A similar number of participants decreased (light and dark orange bars) their bicycling frequency during the same period, possibly due to concurrent factors such as the end of the school year for some schools. Almost 70% of participants reported that their bicycling frequency after the end of the campaign was similar to the frequency during the campaign (grey bars). There could be two potential explanations for a large number of respondents claiming the same behavior during and after the campaign. First, the change in the behavior could have persisted after the campaign was over. Second, the after survey was conducted merely 15 days after the campaign was over, when the 'during' behavior may still be lingering, so that a survey at a slightly later time may allow for a better understanding of the behavior after the campaign.

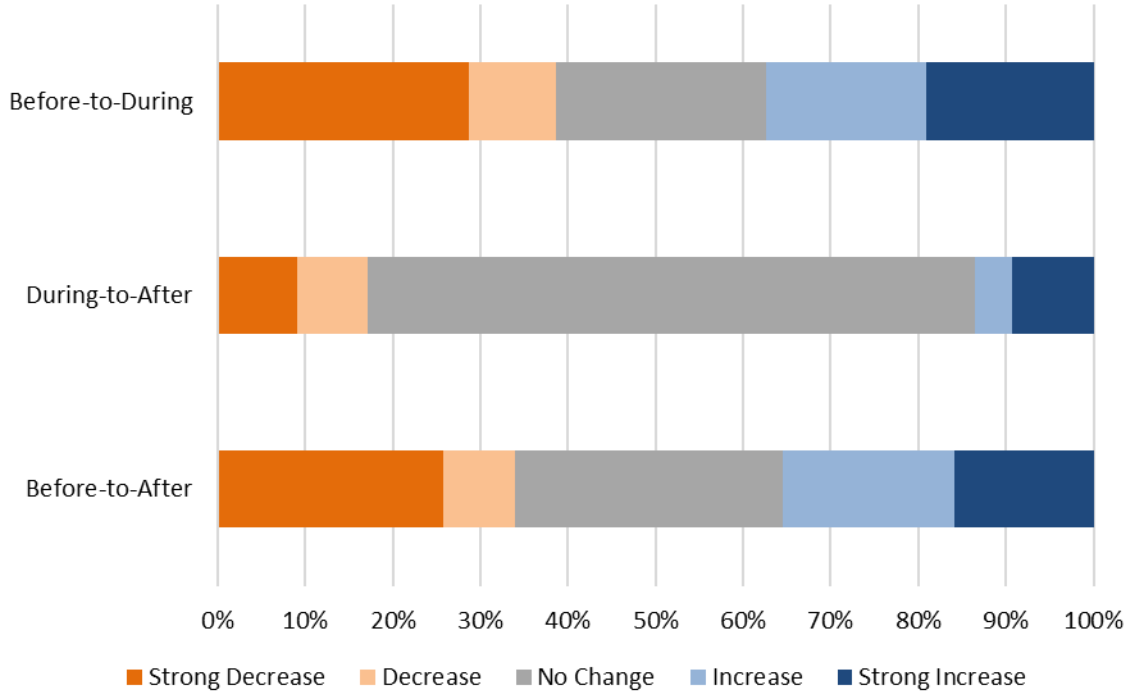

Figure 4. Change in frequency of bicycling from before-to-during, during-to-after, and before-to-after the campaign. (Strong decrease is by ≥ 7 bicycling days/month; Decrease, by < 7 bicycling days/month; Increase, by < 7 bicycling days/month; Strong Increase, by ≥ 7bicycling days/month.) Note that a negative and positive change (orange and blue shades, respectively) each occurred in about 30-40% of participants when comparing before to during or to after the campaign; but no change occurred for the majority of participants from during to after the campaign.

These changes in the bicycling cannot be solely attributed to the campaign. Other changes during the study period such as changes in weather conditions, seasonal effects, and the introduction of the JUMP bikesharing

program in the city of Sacramento also occurred during the same period. These factors could not be fully controlled for in this study and separated from the impact of the MIBM campaign.

In the before and after surveys, we analyzed many covariates that could explain the changes in behavior of the participants. At first, we explored how socio-demographic variables co-vary with the dependent variables. Among the socio-demographic variables, we looked at age, gender, and household income of the respondent. Out of the three, only age showed a noteworthy co-variation with the dependent variables. More than other age groups, younger people (< 34 years) decreased their bicycling frequency in the before-during and before-after comparisons. Possibly, they were already at the peak of bicycling before campaign started. In the initial analysis of each independent variable (e.g., participant characteristic) in relation to the dependent variable, without consideration of interaction between the independent variables, age 30–50 years was significantly associated with an increase in bicycle frequency. However, this association lost its significance in the models after we included 'bicycling status'. 'Bicycling status' is an intention towards bicycling. Conceptually, according to the theory of reasoned action (Ajzen, 1991), intentions and attitudes lead to observed behavior (change in bicycling behavior). Thus, we concluded that age was acting as a proxy for bike status and removed it from our final model.

Bicycling Status: In the before-survey, the respondents were asked to report their bicycling status. This variable attempted to measure respondents' attitude toward bicycling as mode of transportation by asking them to choose from one of the statements shown in the footnote to Table 2 as the best description of their bicycling status.

Most of the respondents who had a bicycling status of *Action*, *Contemplation*, and *Preparation* increased their bicycling frequency during and after the campaign. Individuals with the *Maintenance* status, however, decreased their bicycling levels (Figure 5).

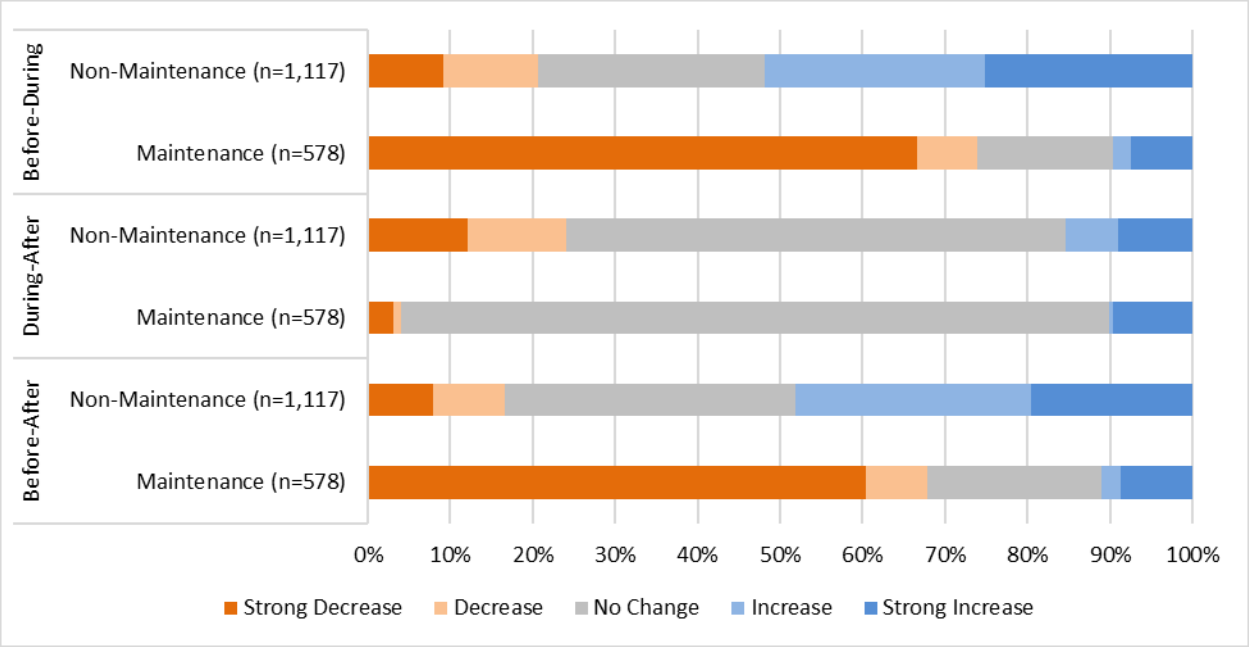

Figure 5. Effect of bicycling status on change in bicycling frequency. "Not Maintenance" indicates a bicycling status of *Preparation, Pre-contemplation, Contemplation,* or *Action*. (Strong decrease is by ≥ 7 bicycling days/month; Decrease, by < 7 bicycling days/month; Increase, by < 7 bicycling days/month; Strong Increase, by ≥ 7bicycling days/month.) The numbers in parentheses after each type of bicycling status indicate the number of survey respondents with this status. Note that "decrease" and "strong decrease" (shades of orange) are largest among the maintenance groups in the "Before-After" and the "Before-During" comparisons. Also, note that the "no change" category is largest in the "During-After" comparison.

Travel Habits: Individuals who usually travel by car, foot, or transit more often reported an increase in bicycling during and after the campaign. In contrast, about 80% of the participants who already bicycle as a regular mode of transportation decreased their bicycling frequency in the before-after and in the before-during comparisons.

Perceived Impact: Respondents were asked to report whether they felt the MIBM campaign had an impact on their bicycling behavior. About 50% of those who claimed MIBM had a *Direct Impact* or *Some Impact* on their bicycling behavior increased their bicycling frequency after and during the campaign.

Land-use: The land-use characteristics of the neighborhood in which an individual lives can explain their travel behavior (Handy & Niemeier, 1997). As explained above, we collected the 'bikescore' of the neighborhood in which each participant lives. 'Bikescore' is a measure of the ease with which someone can ride a bicycle in the neighborhood.[4] The ease of bicycling includes a number of factors such as safety, accessible destinations in a range which can be covered on a bicycle, infrastructure, etc. Figure 3 shows a wide distribution of bikescores for the neighborhoods of the respondents' home locations.

Figure 6 shows that an increase in bicycling frequency after the campaign did not change linearly with change in the bikescore. Respondents who showed a decrease in bicycling frequency during and after the campaign lived in neighborhoods with high bikescores (and in those with extremely low bikescores). In contrast, those who lived in neighborhoods with average bikescores showed an increase in bicycling frequencies. This motivated us to not use bikescore as a continuous variable in our final model. Instead, we split this variable into three categories: ≤25, 26–74, ≥75.

[4] Bikescore: a composite score given to a neighborhood; it combines the 1) degree of availability bike lanes; 2) slope gradient; 3) destinations accessible via bicycling and 4) mode share of bicycling in the neighborhood.

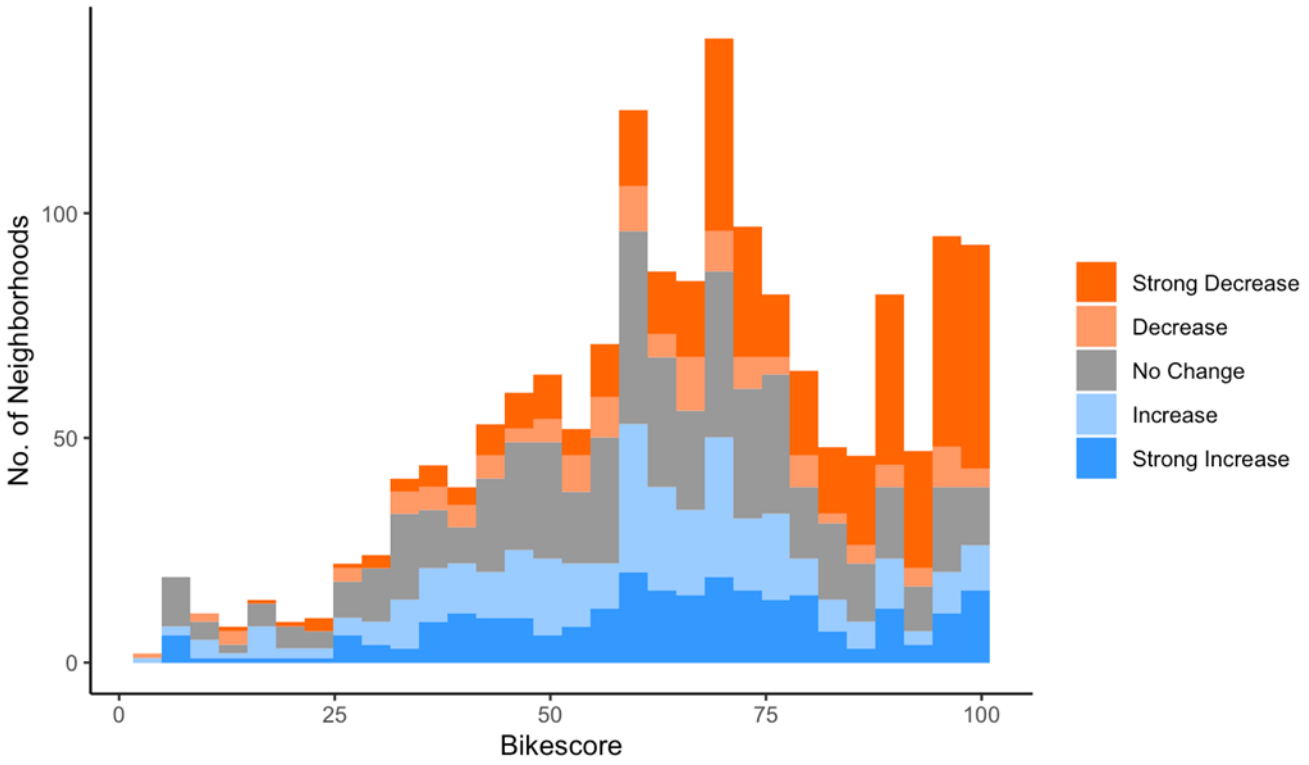

Figure 6. Effect of neighborhood bikescore on change in bicycling frequency. (Strong decrease is by ≥ 7 bicycling days/month; Decrease, by < 7 bicycling days/month; Increase, by < 7 bicycling days/month; Strong Increase, by ≥ 7bicycling days/month.) Note that the highest numbers of respondents with an 'increase' and 'strong increase' (longest light + dark blue bars) occur where the bikescore is between 25 and 75 (rather than at the lower and higher extremes), and that the highest numbers of respondents with a 'decrease' and 'strong decrease' (longest light + dark orange bars) occur in the neighborhoods with high (75-100) bikescores.

Types of trips covered on bicycle: Respondents were asked to report what percentage of their bicycle trips during the MIBM campaign were for commuting vs. recreation. Figure 7 shows two distributions of levels of change in bicycling frequency from during to after the MIBM campaign—one distribution for commuting trips, the other for recreational trips. An "increase" (light blue bars) in frequency (i.e., by 1 to 6 bicycling days/month) was more common for recreational than for commuting trips.

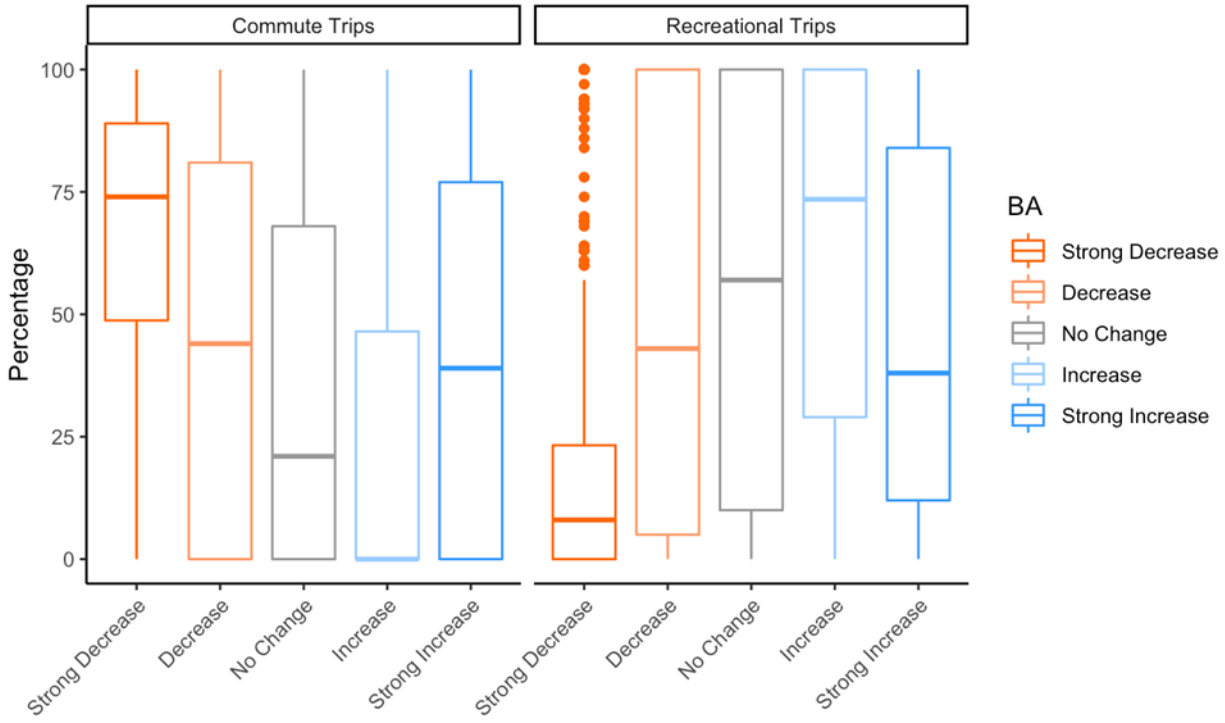

Figure 7. Change in the percentage of commute and recreational trips made on bicycle. (Strong decrease is by ≥ 7 bicycling days/month; Decrease, by < 7 bicycling days/month; Increase, by < 7 bicycling days/month; Strong Increase, by ≥ 7bicycling days/month.) Note that a "Strong Decrease" and a "Decrease" in bicycling were more commonly recorded among those who bicycle for commute purposes. An "Increase" in bicycling was more commonly recorded among those who bicycle for recreational purposes.

Barriers and motivators: The after survey (Appendix) asked respondents to report the factors that reduced their ability to bicycle. *Bad weather conditions* and *no alternative to driving* were found to be significant barriers to increases in bicycling. The survey also asked respondents their reason for participating in the MIBM campaign. Among the motivators, *fun* was a significant variable in describing the change in frequency of bicycling during and after the campaign. The survey instrument in the Appendix shows the entire list of barriers from which respondents could select the one applicable to them.

4. Results and Discussions

The results of the estimation of the three ordinal models are shown in Table 4. Overall, the Before-After and Before-During models show a good fit (ρ^2 = 0.18). However, the During-After model has a poor model fit—an indicator that either the dependent variable has low variance or the variables measured in the two surveys do not explain a large proportion in the variance of the dependent variable (the changes in the During-After model). In the current case, it seems that a combination of these two factors is at play. However, of note, some of the key explanatory variables (such as bike status and perceived impact) have statistically significant effects in all three models.

The models show that bicycling frequencies were more likely to increase in the Before-During comparison for individuals with a bicycling status of *action*, *contemplation*, *pre-contemplation* or *preparation* than for those with a bicycling status of *maintenance*. This implies that the MIBM campaign has more of an impact on bicycling frequency (travel behavior) for individuals who are already thinking about taking up bicycling. The campaign may then act as a final push for this segment of the population to start (or increase) bicycling. The decrease in the frequency of bicycling in the maintenance category is counter-intuitive, but this is probably due to the higher "space" for an increase in bicycling in the former groups. However, the signs of these coefficients are reversed in the During-After model. These coefficients must be interpreted with caution. Respondents who increased their bicycling frequency in the Before-During model are least expected to show another increase in the During-After model. Thus, respondents with a bicycling status of *action*, *contemplation*, *pre-contemplation* and *preparation* were not likely to increase their bicycling frequency (in comparison to the *maintenance* status) in the During-After model. However, a positive coefficient in the 'Before-After' model assures that individuals in the former group overall increased their bicycling frequency after the campaign was over, relative to their bicycling frequencies before the start of the campaign.

In a similar fashion, respondents who stated that the MIBM campaign had a "Direct Impact" or "Some Impact" on their bicycling activity were more likely to have an increase in their bicycling frequency in the Before-During and Before-After comparisons than were individuals who stated that the campaign had "No Impact" on their bicycling activity. However, the reverse was true in the During-After model—i.e., respondents who indicated that the campaign had a "Direct Impact" or "Some Impact" were *less* likely than those who indicated "No Impact" of the campaign to have an increase in bicycle frequency, a sign that the campaign largely had only a temporary effect on the frequency of bicycling for many participants.

This again reinforces the idea that the MIBM campaign had an impact on travel behavior for only a segment of the population and it led to them increasing their bicycling frequency during and after the campaign, as compared to before the campaign, even if the longer-lasting increases in bicycling frequency that extended after the campaign were more limited.

Consistent with the descriptive statistics, the model estimation results show that individuals whose main mode of transportation was anything other than bicycling were more likely to increase their bicycling frequency during and after the campaign than were those whose main transportation mode was bicycling. Overall, individuals who stated they joined the campaign because "it was fun" were unlikely to increase their bicycling frequency. This again raises a speculation that those who actually increased their bicycling frequencies in the Before-After comparison of the campaign joined the campaign with an intention to do so. Individuals who stated that weather is a barrier to bicycling increased their bicycling levels after the campaign (at the beginning of summer, when the weather is warmer).

The bikescore of the neighborhood in which the individuals live has an interesting impact on their bicycling behavior in the Before-During and Before-After comparisons of the campaign. As noted in the previous section, bikescore did not have a linear impact bicycling behavior. Individuals who lived in neighborhoods with an average bikescore (26-75), as compared to those in neighborhood with a high bikescore (>75), were more likely to increase their bicycling frequencies in the Before-During and Before-After comparisons of the campaign. One explanation could be that those living in bicycle-friendly neighborhoods are more likely to already be bicycling more often and a campaign like MIBM (which raises awareness about bicycling, often among those who do not bicycle) might not have meaningful effects on them. Instead, the models indicate that MIBM might be a more appropriate strategy among the individuals living in neighborhoods with an average bikescore.

Table 4. Model estimation results for the three ordered logit models to describe the change in bicycling frequencies in Before-During, During-After, and Before-After comparisons.

	Before-During		During-After		Before-After	
	Estimate	p value	Estimate	p value	Estimate	p value
Bike Status (ref=Maintenance)						
Action	1.24	0.00	0.11	0.59	1.34	0.00
Contemplation	1.20	0.00	-0.89	0.00	0.67	0.00
Pre-contemplation	0.99	0.00	-0.77	0.00	0.44	0.01
Preparation	1.32	0.00	-0.59	0.00	1.02	0.00
Mode used for 75% of commute trips (ref=Bicycle)						
Carpooled	1.47	0.00			1.57	0.00
Drove alone	1.73	0.00			1.74	0.00
Mixed	1.05	0.00			1.02	0.00
Teleworked	0.90	0.02			1.42	0.00
Transit	1.57	0.00			1.64	0.00
Walked	1.56	0.00			1.61	0.00
Commute Trips	-0.04	0.00			-0.04	0.00
Perceived Impact (ref=No Impact)						
Direct impact	0.91	0.00	-0.33	0.06	0.80	0.00
Not Sure	-0.18	0.74	0.96	0.08	0.58	0.29
Some impact	0.79	0.00	-0.40	0.01	0.54	0.00
Very little impact	0.26	0.10	-0.13	0.46	0.17	0.28
Neighborhood Bikescore (ref=more than 75)						
< 25	0.03	0.87			0.04	0.84
26 –74	0.33	0.00			0.30	0.01
"Need Car" stated as a barrier to bicycling(ref=No)						
Yes			0.56	0.01		
"Weather" stated as a barrier to bicycling (ref=No)						
Yes					0.27	0.02
"Fun" stated as a reason to joining MIBM campaign (ref=No)						
Yes					-0.36	0.01
Cut Offs						
Strong Decrease | Decrease	0.96	0.00	-2.97	0.00	0.36	0.09
Decrease | No Change	1.75	0.00	-2.21	0.00	1.03	0.00
No Change | Increase	3.21	0.00	1.33	0.00	2.90	0.00
Increase | Strong Increase	4.37	0.00	1.76	0.00	4.19	0.00
LL(null)	-2639.63		-1748.38		-2591.78	
LL(model)	-2153.97		-1716.87		-2131.51	
McFadden R^2	0.18		0.018		0.18	

5. Conclusions

Bicycling as a mode of transportation offers health benefit to travelers and reduction in VMT/GHG emissions from the transportation sector. In this study, we evaluated the effectiveness of a TDM strategy—May is Bike Month—administered by the metropolitan planning organization SACOG to promote bicycling in the Sacramento region. In 2018, SACOG conducted surveys of the participants before and after the campaign. The surveys were designed to understand individual attitudes towards bicycling, their reasons for joining the campaign, perceived barriers to bicycling, etc. The survey measured the frequency of bicycling of the participants before, during, and after the campaign. Since the participation in the campaign was voluntary, our sample has a significant self-selection bias, thus it is not representative of the population in the region. Further, our sample overrepresents high-income, male, and white individuals. These characteristics are shared by most bicyclists, especially bicycling commuters, in the region of study.

We examined the land-use characteristics of the neighborhoods where the participants lived. We estimated three ordered logit models to identify the factors influencing the changes in bicycling frequencies of the participants between Before-During, During-After, and Before-After comparisons.

Our analyses showed that the changes in the bicycling behaviors during the campaign persisted after the campaign. However, the after survey was conducted only 15 days after the campaign. Therefore, these observed behavioral changes might have not persisted over longer periods. We recommend that future studies evaluating the efficacy of such TDM strategies must have repeated follow-up surveys.

Certain segments of the population in the sample had more of an increase in bicycling frequencies than did other segments. For example, participants who were motivated to take up bicycling as a mode of transportation (identified by the 'bicycling status' variable) were more likely to increase their bicycling frequencies than other groups. Participants who felt that the MIBM campaign had an impact on their behavior also showed an increase in bicycling levels. Finally, participants who lived in neighborhoods with average bikescores were most likely to increase their bicycling.

5.1 Policy Implications

All of these factors indicated MIBM cannot be a blanket TDM strategy for the entire population. It has an impact only on a segment of the population. Individuals from this segment do not bicycle on a regular basis but are motivated to change their behavior. TDM projects like the MIBM campaign help them to translate this goal into action.

We also found that there is another segment of population in our sample that participated in the campaign but was substantially unaffected by it. This segment consisted of individuals who bicycle on a regular basis, live in bicycle friendly neighborhoods, and already had high bicycling frequencies before the campaign started. They

showed a decrease in bicycling in the Before-During and Before-After comparisons of the campaign. This decrease likely did not have any direct relationship with the campaign but was rather the result of other seasonal effects (e.g., closing of schools, etc.) that were unfortunately not captured in the survey. In any case, the study shows that TDM strategies like these campaigns are not ideal to further increasing bicycling levels for this segment of the population. Accordingly, we conclude that campaigns like MIBM certainly have some impact on travel behavior, but they do not work equally well across all population segments and could become more effective if complemented with other TDM strategies to target all segments of the society.

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Appendix

Before Survey (Administered before the May is bike Month campaign)

1. Please select the statement that best describes you:

>PRE-CONTEMPLATION I do not bike for most of my trips, and I don't intend to make any changes.

>CONTEMPLATION I do not bike for most of my trips. I am considering bicycling more often, but I'm not sure how to make that change.

>PREPARATION I do not bike for most of my trips, but I intend to bicycle more often. I know how I want to do this, but I haven't yet gotten started.

>ACTION I bike for most of my trips, and have been doing so for less than six months.

>MAINTENANCE I bike for most of my trips, and I have been doing so for more than six months.

2. In the past six months, how did you make most of your trips? Select the means of travel you used for the majority of your trips:

>Drove alone

>Carpooled

>Took Lyft, Uber, or a taxi

>Walked

>Bicycled

>Transit

>Teleworked

>Mixed

3. On average, how often do you ride a bicycle for recreation purposes?

>Less than 1 day per month

>1-3 days per month

>1-2 days per week

-3-4 days per week

>5 days per week

4. On average, how often do you ride a bicycle as a means of transportation (e.g., to go to work, go shopping, etc.)?

>Less than 1 day per month
>1-3 days per month
>1-2 days per week
>3-4 days per week
>5 days per week

After Survey (Administered after the May is Bike Month campaign)

1. How did you hear about May is Bike Month? (Check all that apply.)

>Received a flyer/brochure
>Newspaper article
>Employer or Transportation Management Association/Organization
>School
>Bike shop
>Family member, co-worker, or friend
>Radio/Television
>Commuter Club Website
>Saw notice on the internet
>Social media
>City/County
>Other (please specify):

2. Why did you participate in May Is Bike Month? (Check all that apply.)

>Friendly competition amongst my Team/Club
>Friendly competition amongst my coworkers/employer
>The campaign motivates me to choose bicycling as a mode of transportation instead of driving
>I currently live a bicycle-centric lifestyle and find the campaign fun
>Free prizes i.e., socks and t-shirts

3. How many years have you participated in May is Bike Month?

>2018 was my first year
>2-4 years
>5-7 years
>8-10 years
>More than 11 years

4. How often do you ride your bike as a means of transportation (to school, the store, a restaurant, to work, etc.)? Choose one option each for before, during, and after the campaign. *Please do not include recreation trips.*

>Before

- >Never
- >Less than 1 day per month
- >1-3 days per month
- >1-2 days per week
- >3-4 days per week
- >5-7 days per week

>During

- >Never
- >Less than 1 day per month
- >1-3 days per month
- >1-2 days per week
- >3-4 days per week
- >5-7 days per week

>After (estimate)

- >Never
- >Less than 1 day per month
- >1-3 days per month
- >1-2 days per week
- >3-4 days per week
- >5-7 days per week

5. How much of a direct impact has the May is Bike Month campaign had on your choice to ride your bike as a means of transportation?

>No direct impact
>Very little impact
>Some impact
>Direct impact
>Not Sure

6. Select the statement that most applies to you, since participating in May Is Bike Month:

>I do not bike for most of my trips, and I don't intend to make any changes
>I do not bike for most of my trips.
>I am considering bicycling more often, but I'm not sure how to make that change.
>I do not bike for most of my trips, but I intend to bicycle more often.
>I know how I want to do this, but I haven't yet gotten started.
>I bike for most of my trips, and have been doing so for less than six months
>I bike for most of my trips, and I have been doing so for more than six months.

7. What barriers do you face when determining whether or not to choose a bicycle as your main mode of transportation? (Check all that apply.)

>Do not feel safe/no safe route
>Do not like to ride in inclement weather
>Need my car for work
>Too far to ride on a regular basis
>No place to shower or change after riding
>No place to store my bicycle
>More convenient to drive
>Scheduling conflicts
>I have nobody to ride with me
>Not applicable - I already bike as my main mode of transportation
>Other (please specify):

8. Does your employer offer any of the following commute assistance information or services to employees who bike to work? (Check all that apply.)

>Information on bicycle routes
>Bicycle racks
>Bicycle lockers, locked bike cage
>Personal lockers, locker room
>Showers on-site
>Cash or other financial benefits for employees who bicycle to work
>No, my employer does not offer any of these services
>Other (please specify):

9. Which of the following groups includes your age:

>Under 18
>18-34
>35-54
>55-64
>65 or older
>Prefer not to answer

10. Which one of the following best describes your racial background:

>White
>Black or African-American
>American Indian or Alaska Native
>Asian
>Native Hawaiian or Other Pacific Islander
>Hispanic
>Prefer not to answer
>Other (please specify)

11. Please indicate the category that best represents your household's total annual income:

>Less than $20,000
>$20,000- $74,999
>$75,000- $99,999
>$100,000- $124,999
>$125,000 or more
>Prefer not to answer

12. Please indicate your gender:

>Male
>Female
>Non-Binary
>Prefer not to answer

13. If you have any suggestions for how we could improve May is Bike Month, please provide them below: