Barcodes, Virtual Money, and Golden Wheels: How Davis, CA schools encourage bicycling to school

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ABSTRACT

While most of the literature on children bicycling to school focuses on the influence of infrastructure interventions, relatively few studies have robustly evaluated the influence of encouragement efforts. We analyze bicycle rack count data collected in the city of Davis, CA, where the city and local volunteers have recently undertaken three encouragement efforts: the Active4.me scanning program, the Monkey Money incentive system, and the national Bike-to-School Day celebration. After accounting for the schools' physical environment and characteristics, as well as the influence of weather and the natural environment, we find that all three of the encouragement efforts increase levels of bicycling to school. We conclude by suggesting that these encouragement programs have the potential for lasting influence by providing children with the skills and confidence to bicycle now and later in life and note the potential for further state support for the parent volunteers who operate these encouragement programs.

INTRODUCTION

Efforts to increase bicycling are often categorized according to the “5 E’s”: engineering, education, encouragement, enforcement, and evaluation *(1)*. While the first four E’s play clear and direct roles in increasing bicycling, planners and policymakers may be inclined to implement hurried, incomplete evaluations or omit this step altogether, despite its important role in estimating the influence of the first four E’s and thereby justifying their worth.

The city of Davis, CA has bucked this tendency by routinely collecting data on children bicycling to school over the course of a decade, from 2006 to the present. Davis has long been known for its bicycling since the town embraced the two-wheeled mode in the late 1960s, but bicycling levels have lulled since the 1990s *(2)*. Though bicycling remains a commonly-used mode of transportation to school *(3, 4)* and to work *(4)*, the city aspires to return to its previous levels of bicycling. In recent years, the city and a group of parent and community volunteers have undertaken comprehensive encouragement efforts to increase bicycling to school. This paper uses the decade of bike rack count data to provide evidence for the efficacy of these encouragement efforts.

LITERATURE REVIEW

We use an ecological model as a theoretical framework to consider the broad categories of potential influences on children’s school travel *(5)*. In our ecological model, we position the individual as the focal point, with broader influences such as the interpersonal, natural, built, and policy environments conceptualized as concentric rings around the individual. We use an ecological model to avoid the tendency in the field of travel behavior research toward over-reliance on studies focusing on only one level, when human behavior instead is known to be multi-faceted *(5)*.

Studies within the field of active school travel research have also been prone to emphasize the influence of the built environmental layer of the ecological model *(6)* while neglecting the influence of other levels, such as encouragement efforts in the policy level. In a review of both quantitative and qualitative research on active school travel, Stewart and his colleagues identified eight common factors that serve as a hindrance or a catalyst for active school travel *(7)*. Of those factors, the role of the built environment was the most frequently analyzed and encouragement the least. Furthermore, when transportation scholars analyzed the influence of school policies (i.e. encouragement efforts), they tended to focus on barriers rather than facilitators.

Nevertheless, a few notable studies have analyzed the influence of encouragement on active school travel. Using a similar approach to this study, McDonald et al. examined Safe Routes to School (SRTS) programs in Eugene, OR, comparing the influence of bicycling and walking infrastructure such as sidewalk and crosswalk construction, education efforts to increase walking and bicycling skills and awareness, and encouragement interventions such as BTSD and scanner incentive programs like the Active4.me program examined in this study. McDonald and her collaborators found that the encouragement efforts increased levels of bicycling by four to five percent *(8)*. In a similar paper looking at Texas elementary schools, Hoelscher et al. found that schools with non-infrastructure SRTS programs had higher active school travel than comparison schools *(9)*.

Though these two studies are likely to have strong internal validity, with appropriate controls and sophisticated statistical models, further studies are needed to continue to establish external validity of the relationships these authors have identified. Returning to our ecological model, this study's key explanatory variables are at the policy level: the programs to encourage bicycling to school. Variables from the natural and built environment levels are included as covariates, though we are unable to include characteristics from the individual and interpersonal levels of the ecological model due to the aggregate nature of the data.

ENCOURAGEMENT EFFORTS IN DAVIS, CA

Consistent with the city's transportation objectives and plans, Davis primary schools began three efforts in the early 2010s to encourage bicycling to school: pioneering the Active4.me scanning program, starting a "Monkey Money" incentive system, and promoting the national Bike-to-School Day (see TABLE 1).

Active4.me and Monkey Money

In 2010, local Davis parent Tim Starback developed a website called "Save a Gallon" to help primary school students track their non-automobile school travel *(10)*. Students or parents would log on to the website and enter their school travel mode for the day. Despite initial enthusiasm for the website, the second year's participation flagged, in part due to the need for daily manual entry *(10)*. Starback and his collaborator, Phil Cox, therefore created a more convenient scanning system in which participating students were issued unique bar codes on plastic cards that were scanned by a parent volunteer when they arrived at school. The Save a Gallon program was thereafter rebranded as "Active4.me", and the program has taken off in Davis and seen widespread adoption around the US (Tim Starback, personal communication).

In the 2011-12 school year, Starback added another element to the Active4.me program, creatively called "Monkey Money". Starback was inspired to create the Monkey Money program by education research demonstrating the effectiveness of paying schoolchildren to adopt good study habits *(11)*. But rather than being paid in US currency, children participating in Active4.me were awarded small increments, typically $0.10, of virtual Monkey Money cash for each day they traveled to school by a non-automobile mode. On particular days, the participating children could then spend their accrued virtual cash at a Monkey Money party on baked goods, toys, and other incentives donated by parents. Anecdotally, this proved to be a popular incentive among the participating children.

A common refrain from interviews with key participants in the Davis encouragement efforts was that the work of parent volunteers, or "champions", is vital (Tim Starback, Christal Waters, personal communication). The logistical challenges of Active4.me and Monkey Money can be daunting for a busy parent, both to initiate a program at a school and to maintain it. At any particular school, one parent typically volunteers to serve as the Active4.me champion and serve as the main scanning volunteer every morning. In most cases the parent champion will also organize a core group of other parent volunteers to assist with scanning. The parent champion can then also choose to add the Monkey Money incentives to their Active4.me program, which requires additional organization of volunteers and donations to run and to fuel the Monkey Money party. At one point, Starback considered automating the scanning process through the installation of RFID towers at the schools, but ultimately decided that the benefit of the human touch of parent volunteers vastly outweighed the cost of the extra leg-work that comes with manual scanning (Tim Starback, personal communication).

TABLE 1 Timeline of Davis Schools' Bicycle Rack Counts and Encouragement Efforts

	School Year										
	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16
Birch Lane	X	X	X	X	X	X	ALL	ALL	ALL	ALL	ALL
Cesar Chavez	X	X	X	X	X	X	B	A & B	A & B	A & B	A & B
Davis Senior (HS)			X	X	X	X	X	X	X	X	B
Emerson (JH)			X	X	X	X	B	B	X	X	B
Harper (JH)			X	X	X	X	B	B	B	B	B
Holmes (JH)			X	X	X	X	B	B	B	B	B
King (HS)					X	X	X				
Korematsu		X	X	X	X	X	B	ALL	ALL	ALL	ALL
Montgomery	X	X	X	X	X	X	A & B	A & B	A & B	A & B	A & B
North Davis	X	X	X	X	X	X	A & B	A & B	A & B	A & B	A & B
Patwin	X	X	X	X	X	X	B	B	A & B	A & B	A & B
Pioneer	X	X	X	X	X	X	B	B	X	ALL	A & B
St. James			X	X	X	X	X				
Valley Oak	X	X	X			X					
Waldorf School			X	X	X	X	X				
Willett	X	X	X	X	X	X	A & B	A & B	A & B	ALL	ALL
Minimum	0	0	0	0	0	1	0	0	0	0	0
Median	1	2	2	1.5	2	2	6	7	8.5	9	7.5
Maximum	2	2	2	2	3	2	6	10	12	24	32

Note: "X" indicates that one or more bike rack counts were taken during that school year, while none of the 3 encouragement efforts analyzed in this paper were implemented.
"A" indicates that Active4.me was implemented during that school year and there was at least one bicycle count.
"B" indicates that Bike-to-School Day (BTSD) was celebrated during that school year and there was at least one bicycle count.
"ALL" indicates that BTSD, Active4.me, and Monkey Money were all implemented in the same school year and there was at least one bicycle count.
"HS" indicates that the school is a high school.
"JH" indicates that the school is a junior high school.
The count statistics refer to the minimum, median, and maximum number of counts conducted by each school in a given year.

Bike-to-School Day

The first national Bike-to-School Day (BTSD) was held on May 9th, 2012, and the celebration has been held each subsequent May to promote safe bicycling to school as part of the broader aims of National Bike Month *(12)*. Davis schools have participated since the outset, with promotions and prizes such as a "Golden Wheel" trophy and a party for the school with the highest proportion of children bicycling to school on BTSD. Incentives, including bike and helmet decorations, have also been provided by the city's "Street Smarts" Safe Routes to School program. In addition, schools participating in the Monkey Money program awarded extra virtual cash rewards for bicycling to school on BTSD.

METHODOLOGY

Data Collection

Since 2006, the City of Davis has collected bicycle rack counts at 16 of the city's schools (including both private and public elementary, junior high, and high schools) for ongoing monitoring and evaluation purposes (see TABLE 2 for an overview of the schools' characteristics). City transportation staff initially conducted counts every fall and spring. But after the introduction of Active4.me, city staff began collecting more frequent data for comparison with the number of children participating in the Active4.me program.

We supplemented the bicycle rack count data with classroom travel tallies collected by the schools' Safe Routes to School programs (see the National Center for Safe Routes to School's report for analysis and copy of the tally sheet *(13)*). In contrast to the bicycle rack count data, which provides, with a small amount of measurement error, an accurate picture of overall school bicycle mode share, the SRTS data only includes information from participating classrooms. In this case, because a majority of classrooms typically participate in the tallies and we assume that there is no selection bias between the classrooms that conducted tallies and those that did not, we view the participating classrooms as representative of the entire school. We therefore coded the total number of children in participating classrooms as the school's enrollment and the total number of children bicycling to school in participating classrooms as the number of bicycles in the bicycle racks. Though this may seem incompatible with the bike rack count entries with total bicycles and total enrollment, it yields a similar interpretation and our later statistical analysis easily accommodates this approach. Over the study period, 705 rack counts or SRTS tallies were conducted on 207 days. Multiplying school enrollment by the number of observations, this study has an effective sample size of 378,875 observations.

After consolidating the bicycle rack count data into a single database, we assembled other relevant details regarding the school's physical environment and characteristics as well as aspects of the natural environment on the rack count collection dates (see TABLE 3 for a full description of the variables collected). Most notably, we gathered data on the timing and presence of the Active4.me and Monkey Money encouragement efforts by examining the aggregate, anonymized Active4.me data. We determined whether a count observation was on a BTSD through online resources published by the National Center for Safe Routes to School *(12)*.

TABLE 2 School Characteristics

Schools	Average Enrollment	Walk Score[1]	Bike Score[1]	Magnet School Status[2]	School Level
Birch Lane	602	31	86	Montessori	Elementary
Cesar Chavez	609	49	93	Spanish Immersion	Elementary
Davis Senior	1,709	47	92	-	High
Emerson	476	39	87	-	Junior High
Harper	693	12	76	-	Junior High
Holmes	727	49	93	-	Junior High
King	58	84	100	-	High
Korematsu	436	34	84	GATE	Elementary
Montgomery	448	37	87	Spanish Immersion	Elementary
North Davis	541	44	91	GATE	Elementary
Patwin	431	51	89	Neighborhood	Elementary
Pioneer	544	28	84	GATE	Elementary
St. James	299	59	90	-	Elementary
Valley Oak	519	66	99	-	Elementary
Waldorf School	175	20	83	-	Elementary
Willett	519	47	91	GATE	Elementary

Note: [1] Walk Score and Bike Score are scores on a scale from 0 to 100, developed by WalkScore.com with the intent to measure the walk and bicycle accessibility of a given street address to nearby destinations *(14)*.

[2] Schools offering special programs are considered “magnet” schools, as they attract students from outside of the school’s normal catchment. GATE stands for “Gifted and Talented Education”.

TABLE 3 Variable Descriptions and Sources

Level of Ecological Model	Variable	Description	Source
Dependent Variable	**Bicycles**	The number of children's bicycles parked in the bicycle racks at a school	City of Davis
Number of Trials	**Enrollment**	The number of children attending a school	*(15–17)*
School Physical Environment	**Rapid rectangular flashing beacon (RRFB)**	Dummy variable indicating the presence of a RRFB within half a mile of a school	City of Davis
	Walk score	A score representing how accessible a school is by walking	*(14)*
	Bike score	A score representing how accessible a school is by riding a bicycle	*(14)*
	Neighborhood or magnet school	Three dummy variables describing whether a school was a Spanish Immersion, Gifted And Talented Education, or Montessori magnet school, respectively	City of Davis
	School level	The school's level: elementary, junior high, and high school	*(15)*
Week Characteristic	**Time**	The number of days since the first observation on March 15, 2006	-
	Day of the week	The days of the school week, derived from the observation date	-
Natural Environment	**Season**	One of the four seasons, derived from historic equinox and solstice data	-
	Temperature (maximum)	The maximum daily temperature, from historic weather data	*(18)*
	Precipitation	Dummy variable indicating the presence of rain (0 = no rain, 1 = rain)	*(18)*
Policy Environment: Encouragement Efforts	**Active4.me program**	Dummy variable indicating the presence of an Active4.me scanning program	Tim Starback
	Monkey Money program	Two dummy variables indicating the presence of a Monkey Money incentive program one to four days a week or all five days a week	Tim Starback
	Monkey Money party	Dummy variable indicating the presence of a Monkey Money party within the next three weeks	Tim Starback
	Bike to School Day	Dummy variable indicating whether the observation is on BTSD (0 = no, 1 = yes)	*(12)*

Due to the staggered introduction of these three programs, we were able to employ a quasi-experimental design, using non-adopting schools as controls against which to compare the schools adopting one of these three encouragement interventions. Our use of a quasi-experimental design represents an important contribution to the literature, as intervention studies are difficult to organize and execute due to their intensive time and resource requirements, and are therefore rarely implemented *(19)*.

Most of the variables were coded as dummy variables. The exceptions to this pattern were the bike count day's temperature, the Walk Score variables, and the time variable. For each of these variables, we rescaled their value from their original scale (e.g. Fahrenheit, days) by subtracting each value from the overall mean value in our sample and dividing by two standard deviations. We adopted this approach in order to improve later statistical modeling *(20)* and to allow for more direct comparison with the dummy variables *(21)*.

Statistical Modeling

We use the R statistical programming language and the *rstan* and *rethinking* packages to estimate our statistical models *(22–24)*. Based on the schools' enrollment, we model the number of children bicycling to any given school as an aggregate binomial process (see

TABLE 4 for the full model formula). We view each child's decision to bicycle to school as a Bernoulli trial, and the sum of the children's decisions at each school leads to a binomial likelihood with the number of bicycles in bike racks as the outcome and the total enrollment as the number of trials.

Given the repeated observations within schools, we account for the strong possibility of correlated observations within a school by employing a Bayesian multilevel binomial regression model. This model specification estimates a random intercept for each school, which helps prevent model overfitting by pooling the information across schools *(20)*. By design, the multilevel model also accounts for the imbalance in sampling present in this study *(20)*, which otherwise could bias parameter estimation. Each school's intercept can be interpreted as capturing aspects of the school that aren't included explicitly in the model as covariates, such as the physical environment or unique school policies.

We estimate three statistical models to facilitate model comparison. The first model is an intercept-only model, which estimates the average bicycling rate across schools as well as a unique intercept for each school. This model indicates how different each school is from another, in the absence of other predictors, and serves as a useful base for comparison with later models. The second model adds covariates to the intercept-only model in an effort to determine the relative influence of various independent variables, including physical characteristics, such as weather and day of the week, as well as features of the built environment, such as the installation of rectangular rapid flashing beacons (RRFBs). The final model adds the three independent variables of interest – the presence of an Active4.me program at a school, the addition of Monkey Money incentives and parties, and the celebration of BTSD – to the covariate model to account for their independent contribution to Davis children's probability of bicycling to school, and also estimates random slopes for BTSD by school.

We use weakly informative priors to avoid overfitting *(20)*, and we compare our models out-of-sample predictive ability using the widely applicable information criteria (WAIC) and Akaike weight *(25)*. We make inferences about our variables' influence using the parameter posterior distributions rather than employing null hypothesis testing to generate p-values, which are notoriously difficult to interpret properly *(26)*.

TABLE 4 Full Model Formula

Model		Model Elements
$Bicycles_{ij}$	$\sim Binomial(Enrollment, p_{ij})$	Binomial likelihood
$logit(p_{ij})$	$= \alpha + \alpha_j +$	Fixed and varying intercepts
	$+ \beta_{cov}[covariates_i]$	Fixed slopes
	$+ \beta_{a4m}[Active4me_i]$	
	$+ \beta_{mm}[Monkey\ Money_i]$	
	$+ (\beta_{btsd} + \beta_{btsdi})[BTSD_{ij}]$	
α	$\sim Normal(0,10)$	Prior for fixed intercept
$(\beta_{cov}, \beta_{a4m}, \beta_{mm}, \beta_{btsd})$	$\sim Normal(0,10)$	Priors for fixed slopes
$\begin{pmatrix}\alpha_j \\ \beta_{btsdj}\end{pmatrix}$	$\sim MVNormal\left(\begin{pmatrix}0 \\ 0\end{pmatrix}, SRS\right) \quad j = 1 \ldots 16$	Prior for the distribution of varying intercepts and slopes
$(\sigma_j, \sigma_{btsdj})$	$\sim HalfCauchy(0,1)$	Prior for standard deviations
R_j	$\sim LKJCorr(2)$	Prior for correlation matrix

Note: The subscript "i" refers to the ith observation and "j" to the jth school.

Limitations

Though this study benefits from the collection of data over the course of a decade, the implementation of encouragement efforts such as Active4.me and Monkey Money may suffer from selection effects, whereby these programs may be directed toward schools with particular characteristics, rather than being randomly assigned. These characteristics could include differences in the outcome variable (i.e. schools that have very little bicycling are more likely to be targeted) or aspects of the school, such as the enthusiasm of a particular parent, interest of a school official or teacher, or a conducive physical environment and infrastructure for bicycling. In this case, the main criteria for introduction of Active4.me was the presence of a willing parent to champion the program.

As these encouragement programs were part of a city-wide effort, it was impractical to reduce the threat of selection bias through random assignment. However, our quasi-experimental design accounts for the possibility of bias through the influence of unobserved variables through the use of control and intervention cases and the collection of longitudinal data. Our multilevel regression models also control for differences in the schools' physical environment and variation in the natural environment across observations.

The nature of the bike rack count data, collected at the school level, limited our ability to analyze variables shown in the literature to strongly influence bicycling to school. We therefore are unable to account for individual characteristics that might influence the decision to bicycle to school, such as age, gender, and parental attitudes and rules. Accounting for the effect of infrastructure changes was also more challenging with school-level observations, as we could not estimate or determine what proportion of children, or indeed, which specific children, would be affected by the change.

RESULTS

Our models' parameters' posterior densities are approximately Gaussian-distributed, allowing us to summarize the parameters by their mean and standard deviation values (

TABLE 5). We briefly describe the model results in the following sections before examining their implications in the subsequent discussion section.

Intercept Model

Our first model, including only an overall intercept and varying intercepts for each of the 16 schools in our sample, estimates that there is substantial variation (standard deviation of 0.78 for the varying intercepts) between schools in bicycling levels. It also estimates that, on average, 20 percent of Davis children bicycle to school.

Covariates Model

The installation of rectangular rapid flashing beacons within a half mile of a school was associated with small decreases in bicycling, conditional on the influence of the other variables in our model. Our model's estimate for the influence of Walk Score was strongly negative yet uncertain. Similarly, schools with high Bike Scores were more likely to have high bicycling rates, but the effect was also uncertain.

Though all 3 magnet programs had highly uncertain parameter estimates, the GATE and Montessori schools had substantially higher probabilities of bicycling to school, while Spanish Immersion was effectively equivalent to a neighborhood school. Junior high students are substantially more likely to bicycle to school than elementary school children, while the model estimates for high school students was small and had a wide 89% confidence interval spanning 0.

Over the course of the decade, rates of bicycling to school increased, conditional on the presence of the other variables in this model. Compared to Mondays, the model estimates that children are more likely to bicycle to school on Tuesdays and Wednesdays and less likely to bicycle on Thursdays, while Fridays have similar rates of bicycling to school.

Compared to winter, the model estimates that children are more likely to bicycle to school in the Fall, Spring, and Summer, in ascending order of increasing probability. As maximum temperatures increase, children are more likely to bicycle to school. Rain appears to be a strong deterrent to bicycling.

Even after accounting for school characteristics, physical characteristics, and aspects of the built environment, substantial variation remains between schools. However, inclusion of covariates slightly reduces the standard deviation of random intercepts, and in some cases, reduces previously large random intercepts almost to zero.

Full Model

We tested a number of different ways to summarize and conceptualize the influence of Active4.me program, including the mere presence of a parent volunteer on the bike rack count day, the number of scans during the week of the count, and the number of preceding weeks in which a parent volunteer scanner was present. The variable with the best explanatory power was the number of scans during the week of the count.

Schools with strong Active4.me programs, with parent volunteers present all five days of the week of the count, increased the probability that children would bicycle to school. In contrast, less robust Active4.me programs in which parent volunteers were only present one to four days during the count week, strongly decreased the probability of children bicycling to school, compared to the baseline of no Active4.me program at all.

TABLE 5 Model Parameter Estimates

		Intercept Model		Covariate Model		Full Model	
	Variables	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
	Mean intercept	-1.37	0.20	-2.22	0.33	-2.21	0.33
	S.D. of random intercepts by school	0.78	0.15	0.62	0.17	0.63	0.18
	S.D. of BTSD random slopes by school	-	-	-	-	0.56	0.14
Random intercepts	***Birch Lane***	0.30	0.20	0.05	0.60	-0.02	0.65
	Cesar Chavez	-0.33	0.20	0.04	0.44	-0.02	0.46
	North Davis	0.33	0.20	0.10	0.35	0.07	0.33
	Montgomery	-0.51	0.20	0.05	0.45	0.12	0.46
	Willett	0.46	0.20	0.26	0.34	0.32	0.32
	Pioneer	-0.46	0.20	-0.54	0.35	-0.58	0.33
	Korematsu	0.17	0.20	0.29	0.39	0.28	0.35
	Patwin	0.12	0.20	1.06	0.34	1.00	0.37
	Emerson	1.03	0.20	0.03	0.34	-0.03	0.36
	Holmes	1.22	0.20	-0.09	0.46	-0.09	0.45
	Harper	0.80	0.20	0.07	0.45	0.10	0.48
	Valley Oak	-0.36	0.20	0.01	0.46	0.05	0.45
	St. James	-1.59	0.22	-0.77	0.44	-0.65	0.47
	Waldorf School	-1.02	0.22	-0.43	0.50	-0.42	0.49
	Davis Senior	0.20	0.20	0.26	0.53	0.18	0.56
	King	-0.26	0.25	-0.23	0.52	-0.25	0.55
	Rectangular Rapid Flashing Beacon	-	-	-0.04	0.01	0.00	0.01
	Walk Score	-	-	-0.56	0.66	-0.57	0.66
	Bike Score	-	-	0.80	0.74	0.81	0.71
	Spanish Immersion	-	-	0.13	0.58	0.11	0.56
	GATE	-	-	0.80	0.46	0.80	0.45
	Montessori	-	-	0.95	0.69	1.04	0.77
	Junior High School	-	-	1.80	0.49	1.87	0.51
	High School	-	-	0.46	0.58	0.59	0.63
	Time	-	-	0.17	0.01	0.10	0.01
	Tuesday	-	-	0.15	0.02	0.16	0.02
	Wednesday	-	-	0.29	0.02	0.09	0.02
	Thursday	-	-	-0.09	0.02	-0.06	0.02
	Friday	-	-	-0.01	0.02	0.00	0.02
	Fall	-	-	0.14	0.01	0.14	0.01
	Spring	-	-	0.18	0.01	0.05	0.01
	Summer	-	-	0.34	0.02	0.24	0.02
	Temperature (F)	-	-	0.12	0.01	0.16	0.01
	Presence of Rain	-	-	-0.27	0.01	-0.29	0.01
	Active4.me: 1-4 days a week	-	-	-	-	-0.12	0.02
	Active4.me: 5 days a week	-	-	-	-	0.04	0.02
	Monkey Money	-	-	-	-	0.01	0.02
	Monkey Money x Bike-to-School Day	-	-	-	-	0.08	0.05
	Monkey Money Party	-	-	-	-	0.04	0.02
	Bike-to-School Day	-	-	-	-	0.55	0.17
	WAIC	413009.9		408775.6		406574.1	
	Akaike weight	0		0		1	
	Number of observations	705		705		705	

Note: All models converged with $\hat{R} < 1.01$, number of effective samples > 1000 (see *(27)* for details of these two convergence metrics), and with Markov chains showing stationarity and good mixing for all parameters.

The Monkey Money program provides a small and uncertain bump in the probability of children bicycling to school. This variable can be seen as an interaction term with Active4.me, as Monkey Money can only be accrued if Active4.me is present at the school. Therefore, Monkey Money can be seen as boosting the effectiveness of Active4.me. The practice of distributing higher amounts of virtual Monkey Money on BTSD increased bicycling rates, though this is likely primarily due to BTSD. Our model estimates that Monkey Money parties increase rates of bicycling in the weeks leading up to the party. Furthermore, Bike-to-School Day dramatically and unsurprisingly increases the likelihood that children bike to school.

Our model estimated that all but a few notable covariate coefficients had the same influence on the probability of bicycling to school. The influence of RRFBs decreased in magnitude to a mean parameter estimate of zero. Our model's estimate for the influence of time dropped by half, likely due to the inclusion of the encouragement effort variables, which were implemented in the second half of our sample timeframe. Similarly, the parameter estimates for Wednesdays and for spring decreased likely because BTSD is celebrated on Wednesdays in May.

DISCUSSION

Implications for Active School Travel

Our finding that a robust Active4.me program boosts bicycling to school is consistent with anecdotal evidence from across Davis primary schools. Perhaps the most surprising finding, was the strongly negative coefficient estimate for less robust Active4.me programs. It may be that introducing a system of tracking behavior has potential unforeseen adverse consequences. The decreased number of children bicycling to schools with less consistent Active4.me programs could be the result of extrinsically encouraging a behavior that was previously intrinsically motivated, consistent with findings from other fields *(28)*.

The increased level of bicycling in the weeks leading up to a Monkey Money party suggest that the children were riding more frequently in anticipation of being able to spend their accrued virtual money on the prizes donated by parents.

We were initially surprised to find that the magnet schools were estimated to have higher rates of bicycling than the neighborhood school, Patwin Elementary. However, we strongly suspect that this model result reflects the fact that Patwin schoolchildren are using a different active mode to get to school: walking. Evidence for this conjecture comes from the full model with varying slopes for the effect of BTSD: Patwin has the highest random slope by far, indicating that on BTSD, the Patwin neighborhood schoolchildren can easily bicycle to school, and do so in droves.

Our model estimates for the influence of RRFBs would seem to contradict the transportation safety literature, where before-after studies of RRFB crosswalks have shown increased driver yielding *(29)*. However, these facilities may be primarily used by children walking, rather than bicycling, to school and therefore not display any influence in our model.

Implications for Future Travel

American children and young adults are bicycling at historically low levels, and at levels well below those of "cycling nations" such as the Netherlands and Denmark *(30)*. These patterns persist into adulthood, suggesting that in addition to national efforts to build bicycling facilities, bicycling experiences as a child can increase the probability of later adult bicycling. We feel that this is an important consideration, given active transportation's ability to increase the average American's level of physical activity and help address our nation's environmental challenges.

Policy Implications: Funding for Parent Involvement

The parent champions' hard work to run Active4.me scanning programs was ultimately a volunteer effort. However, our statistical models suggest that the efficacy of an Active4.me program is predicated on the consistent presence of parent volunteers, each day of the week. Given the resources dedicated to encouragement and coordination, such as supplies for Monkey Money parties, it may be worth reimbursing parent volunteers with a small stipend. The eligibility determination guidance suggests this is possible using funds from California's Active Transportation Program (ATP) or Congestion Management and Air Quality (CMAQ) Improvement Program, as long as the stipend is clearly not being used to pay volunteers for their time *(31)*. As long as this condition is being met, we argue that reimbursing parent volunteers should be a welcomed attribute of a healthy Safe Routes to School program, particularly in other, less affluent cities, if finding volunteers is more challenging due to most households having dual-earning parents with less flexible schedules.

The MAP-21 federal authorization bill introduced a focus on performance and outcome-based evaluation of metropolitan planning organization's long range plans *(32)*. We suggest that in addition to evaluating existing policies, the feedback loop from policy evaluation to policy change should also include evaluation of programs not included in the initial policy's scope as a way to identify new avenues to achieve the same policy goals.

Suggestions for Future Research

The National Center for Safe Routes to School and the Safe Routes to School National Partnership have recently prioritized the ease of data collection and access as a key organizational goal *(33)*. Though admittedly low-tech, bicycle rack counts' ease of implementation and low cost was likely a key component in enabling the high frequency and long duration of the city of Davis' decade-long evaluation effort. We recommend this approach to cities interested in evaluating school-level policies and programs.

Despite the non-random application of the Active4.me and Monkey Money programs at Davis schools over time, the temporal pattern nonetheless yielded a robust quasi-experimental design. We suggest that forward-thinking planners bake this into their programming plans from the beginning – by only having a few schools adopt a new program or policy at any given time, other schools are able to serve as control cases in later evaluation. This approach also eases the implementation burden and allows for lessons learned at first schools to be applied from the beginning at others.

This study demonstrates that the encouragement efforts of Active4.me and Monkey Money can increase rates of bicycling to school. Further studies could evaluate other aspects of these programs, such as the influence of stipends to reimburse parent volunteers for their time or the impact of changing a magnet school to a neighborhood school. We also feel that researching the influence of the human element in the Active4.me scanning program is worthwhile, as comparable scanning programs (e.g. "Boltage") relied on RFID towers rather than parent volunteers *(8)*.

CONCLUSION

We analyze a decade of data collected by the city of Davis on local schools' bicycle rack occupancy to evaluate the influence of three major encouragement efforts: Bike-to-School Day, Active4.me, and Monkey Money. In addition to well-established physical, environment and school characteristics, we find that all three programs increase the probability of children bicycling to school, though with varying strength and certainty. A robust Active4.me program increases rates of bicycling to school, as does the approach of a Monkey Money party within the next few weeks. BTSD dramatically increases the number of children bicycling to school, particularly in neighborhood schools. We suggest that the parent volunteer efforts to run encouragement programs such as these could benefit from stipends and that the results of these successful encouragement efforts have positive long-term implications for children's later travel patterns as adults.

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