Parental Attitudes Toward Children Walking and Bicycling to School

Multivariate Ordered Response Analysis

Saamiya Seraj, Raghuprasad Sidharthan, Chandra R. Bhat, Ram M. Pendyala, and Konstadinos G. Goulias

Recent research suggests that, besides traditional sociodemographic and built environment attributes, the attitudes and perceptions of parents toward walking and bicycling play a crucial role in deciding which travel modes children take to school. However, little is known about the factors that shape these parental attitudes. The current study aims to investigate this unexplored avenue of research and to identify the influences on parental attitudes toward children walking and bicycling to school as part of a larger nationwide effort to make children more physically active and combat rising trends of childhood obesity in the United States. Through the use of a multivariate ordered response model (a model structure that allows different attitudes to be correlated), the current study analyzes five parental attitudes toward children walking and bicycling to school on the basis of data drawn from the California add-on sample of the *2009 National Household Travel Survey*. In particular, the subsample from the Los Angeles–Riverside–Orange County area is used in this study to take advantage of a rich set of microaccessibility measures that are available for this region. It is found that school accessibility, work patterns, current mode use in the household, and sociodemographic characteristics shape parental attitudes toward children walking and bicycling to school. The study findings provide insights on policies, strategies, and campaigns that may help shift parental attitudes to be more favorable toward children walking and bicycling to school.

In recent years, there has been an alarming increase in the rate of obesity among children in the United States. The latest statistics suggest that nearly one in five school-aged children is obese, a rate that has tripled from just 30 years ago (*1, 2*). Because obesity rates are being tied to sedentary lifestyles, there is a vast body of literature at the interface of transportation and public health that identifies and quantifies the influence of various factors on levels of physical activity and the use of active modes of transportation, namely, walking and bicycling (*3–5*). Despite the potential benefits associated with using nonmotorized modes of transportation for travel to and from school, these modes have experienced a dramatic decline in modal share over the past 40 years. Whereas in 1969 nearly one-half of all school trips were made by walking or bicycling, by 2009 that share had dropped to under 15% (*6*).

There is a vast body of literature that identifies and quantifies the influence of demographic, built environment, and socioeconomic characteristics on the mode of travel to school. Of the demographic variables, the child's age, gender, and ethnicity or race have been found to significantly impact the modal choice for school travel (*7–12*). In general, older children and boys are more likely to walk or bicycle to school than other children. On the issue of race, papers present conflicting results, with some studies attributing this difference to underlying factors, such as household socioeconomic status and residential location (*11*). Other papers suggest that these differences could be the result of cultural variations in attitudes and perceptions among parents of different ethnicities (*9*). Finally, built environment attributes and accessibility variables are also important determinants of children's modes of travel to school. The distance to school is one of the most notable variables that influence the choice to use nonmotorized modes of transportation (*13, 14*). There is a growing body of evidence that parental attitudes and opinions are also critical determinants of children's school travel mode. In a study based in Southern California, McMillan found that the attitudes and perceptions of parents regarding the safety and traffic situation of the neighborhood, as well as certain social norms, were more important in influencing the choice of school travel mode than built environment attributes (*9*). Children with parents who had greater concerns about traffic conditions or neighborhood safety were less likely to walk or cycle to school. Timperio et al. found that parental perceptions of the neighborhood were more strongly related to the choice of children's travel mode than the child's own perceptions of the neighborhood (*7*). Zhu and Lee reported similar findings and noted that parents' perceptions of barriers were greater deterrents to walking and bicycling than children's perceptions of barriers (*15*). Zhu and Lee found that a child was four times more likely to walk if the parent perceived the distance to be close enough for the child to walk. The Zhu and Lee (*15*) study, as well as the study of Wen et al. (*16*), showed that actual experience with the nonmotorized modes of transportation influenced parental attitudes and perceptions of the built environment and neighborhood safety. Parents of children who walked regularly to school perceived the built environment and neighborhood to be less dangerous than parents whose children did not walk or bicycle to school.

Despite studies that show the clear importance of parental attitudes and perceptions toward bicycling and walking in the choice of mode for school travel, there is a dearth of research on identifying and

S. Seraj, R. Sidharthan, and C. R. Bhat, Department of Civil, Architectural, and Environmental Engineering, University of Texas at Austin, 1 University Station C1761, Austin, TX 78712-0278. R. M. Pendyala, School of Sustainable Engineering and the Built Environment, Arizona State University, Room ECG252, Tempe, AZ 85287-5306. K. G. Goulias, Department of Geography, 1832 Ellison Hall, University of California, Santa Barbara, Santa Barbara, CA 93106-4060. Corresponding author: C. R. Bhat, bhat@mail.utexas.edu.

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quantifying the influence of various factors on these attitudes and perceptions. In the case of school-going children, parents are likely to play a strong decision-making role when it comes to modal choice for school-related travel. Thus, insights into the factors that shape parental attitudes and perceptions toward their children walking and bicycling to school would greatly aid professionals in designing policies, campaigns, and built environments that would help promote the use of these modes. A few studies provide initial indications of the factors that are likely to influence parental attitudes and perceptions. Timperio et al. noted that the age of the child and the household's socioeconomic status influenced parental attitudes and perceptions (*7*). Johansson, who looked broadly at children's leisure travel, found that parents of older children adopted a more positive attitude toward independent travel than parents of younger children (*17*). Parents in households with higher levels of car ownership were found to be more inclined toward chauffeuring their children by car and less inclined toward supporting independent travel by the child.

This paper is motivated by previous work that suggests the presence of strong associations between attitudes and travel behavior [see van Acker et al. (*18*)]. Theoretical frameworks that describe the underlying reasons for and the nature of the associations between attitudes and behavior are offered by Ajzen and Fishbein (*19*). Van Acker et al. developed a model, based on frameworks presented by Ajzen and Fishbein, that included a spatial component and a socioeconomic component from the theories of transport geography and a personality component from the theories of social psychology (*18*). In this context, this paper aims to shed additional light on parental attitudes and perceptions toward bicycling and walking as modes of transportation for children's school travel. The paper provides a more comprehensive examination of the factors that shape parental attitudes and perceptions toward these modes by simultaneously considering five attitudinal variables in a joint model system. Each attitudinal variable is an ordered response variable; the response indicates the extent to which the factor is considered by the parent to be an issue in their children walking or bicycling to school. A multivariate ordered response model is formulated and applied in this paper to account for the presence of possible correlations between unobserved attributes that simultaneously affect different attitudinal variables. The model system is estimated on a subsample of the California add-on of the 2009 National Household Travel Survey, which included a series of questions on parental attitudes toward children bicycling and walking to and from school. In particular, the subsample from the Southern California region covered by the Los Angeles–Riverside–Orange County consolidated metropolitan statistical area is chosen because of the availability of a rich set of microaccessibility measures that can be included in the model specification.

One of the key hypotheses that motivated this study was that parents of children who regularly walked or cycled were less likely to be concerned about the various factors that served as deterrents to the use of nonmotorized modes of transportation. It was postulated that such parents are likely to be more aware of the built environment and their children's navigational abilities than parents whose children did not walk or bicycle as much. In the absence of information, parents in the latter group are more likely to develop an exaggerated sense of danger associated with the use of nonmotorized modes and, thus, are less likely to permit their children to walk or bicycle to school.

The remainder of this paper is organized as follows. The second section presents the modeling methodology adopted in this paper. The third section describes the data used in this study and presents descriptive statistics of the sample. The fourth section presents model estimation results. The final section offers conclusions and a discussion of the policy implications of the results.

MODELING METHODOLOGY

A multivariate ordered response modeling structure is used for the current study. The modeling framework assumes the presence of an underlying set of multivariate continuous latent variables whose horizontal partitioning maps into the observed set of ordered outcomes (in the current empirical context this would be the degree to which a parent considers a certain factor to be an issue in children walking or bicycling to school). Such an ordered response system allows the use of a general covariance matrix for the underlying latent variables, which translates to a flexible correlation pattern between the observed ordered outcomes. Although there have been numerous applications of the univariate ordered response model in previous transportation literature, the application of multivariate ordered response models, especially for more than three ordered outcome variables, is extremely rare. Bhat et al. provide a summary of the literature in this area and propose the use of the composite marginal likelihood approach to estimate a multivariate ordered response model (*20*). Because the composite marginal likelihood approach uses a simple estimation technique and requires no simulation machinery, yet produces consistent and unbiased results, the composite marginal likelihood approach is used in this study to estimate model parameters. The remainder of this section presents a brief overview of the formulation.

Let q be an index for individuals ($q = 1, 2, \ldots, Q$), and let i be the index for attitudinal variables ($i = 1, 2, \ldots, I$), where I denotes the total number of attitudinal variables for each individual (in the current study, $I = 5$). Let the number of response values for attitudinal variable i be K_i (i.e., the discrete levels indexed by k belong in $\{1, 2, \ldots, K_i\}$ for variable i). In the usual ordered response framework notation, the latent propensity (y^*_{qi}) for each attitudinal category is written as a function of the relevant covariates and related to the observed ordered outcome (y_{qi}) through threshold bounds (*21, 22*):

$$y^*_{qi} = \beta_i' x_{qi} + \varepsilon_{qi},\ y_{qi} = k \qquad \text{if } \theta_i^{k-1} < y^*_{qi} < \theta_i^k \tag{1}$$

where

x_{qi} = $(L \times 1)$ vector of exogenous variables (not including a constant),
β_i = corresponding $(L \times 1)$ vector of coefficients to be estimated,
ε_{qi} = standard normal error term, and
θ_i^k = upper bound threshold for ordered response level k of attitudinal category i ($\theta_i^0 < \theta_i^1 < \theta_i^2 < \cdots < \theta_i^{K_i}$; $\theta_i^0 = -\infty$, $\theta_i^{K_i} = +\infty$ for each category i).

The threshold bounds define a range of the underlying latent continuous variable that corresponds to each observed discrete outcome. The ε_{qi} terms are assumed to be independent and identical across individuals (for each and all i). For identification reasons, the variance of each ε_{qi} term is normalized to one. However, the model allows correlation in the ε_{qi} terms across attitudinal variables i for each individual q. If $\varepsilon_q = (\varepsilon_{q1}, \varepsilon_{q2}, \varepsilon_{q3}, \ldots, \varepsilon_{qI})'$, then ε_q is multivariate

normally distributed (N) with a mean vector of zeros and a correlation matrix (Σ) as follows:

$$\varepsilon_q \sim N\left[\begin{pmatrix}0\\0\\\vdots\\0\end{pmatrix}, \begin{pmatrix}1 & \rho_{12} & \rho_{13} & \cdots & \rho_{1I}\\ \rho_{21} & 1 & \rho_{23} & \cdots & \rho_{2I}\\ \vdots & \vdots & \vdots & \ddots & \vdots\\ \rho_{I1} & \rho_{I2} & \rho_{I3} & \cdots & 1\end{pmatrix}\right]$$

or

$$\varepsilon_q \sim N[0, \Sigma] \tag{2}$$

The off-diagonal terms of Σ capture the error covariance across the underlying latent continuous variables of the different attitudinal variables. In other words, the off-diagonal terms of Σ capture the effects of common unobserved factors that influence the propensity of ordered response levels for each attitudinal variable. Thus, if ρ_{12} is positive, it implies that individuals with a higher than average propensity to cite the first attitudinal variable as an issue are also likely to have a higher than average propensity to cite the second attitudinal variable as an issue. As a special case, if all the correlation parameters (i.e., the off-diagonal elements of Σ stacked into a vertical vector Ω) are zero, the model system in Equation 1 collapses to a set of independent ordered response probit models.

The parameter vector of the multivariate ordered probit model is

$$\delta = (\beta_1', \beta_2', \ldots, \beta_I'; \theta_1', \theta_2', \ldots, \theta_I'; \Omega')'$$

where $\theta_i = (\theta_i^1, \theta_i^2, \ldots, \theta_i^{K_i-1})'$ for $i = 1, 2, \ldots, I$. Let the actual observed ordered response level for individual q and attitudinal variable i be m_{qi}. Then, the likelihood function (L) for individual q may be written as follows:

$$L_q(\delta) = \Pr(y_{q1} = m_{q1}, y_{q2} = m_{q2}, \ldots y_{qI} = m_{qI})$$

In other words

$$L_q(\delta) = \int_{v_1=\theta_1^{m_{q1}-1}-\beta_1'x_{q1}}^{\theta_1^{m_{q1}}-\beta_1'x_{q1}} \int_{v_2=\theta_2^{m_{q2}-1}-\beta_2'x_{q2}}^{\theta_2^{m_{q2}}-\beta_2'x_{q2}} \cdots \int_{v_I=\theta_I^{m_{qI}-1}-\beta_I'x_{qI}}^{\theta_I^{m_{qI}}-\beta_I'x_{qI}} \phi_I(v_1, v_2, \ldots, v_I|\Omega)dv_1, dv_2, \ldots, dv_I \tag{3}$$

where Pr denotes probability and ϕ_I is a probability density function of an I-dimensional multivariate normal distribution.

The likelihood function above requires the computation of an I-dimensional rectangular integral. The evaluation of such multidimensional normal integrals can be problematic in terms of computational effort, even for moderate sizes of I. Furthermore, such simulation methods become imprecise as the number of dimensions increases, leading to convergence problems during estimation. For these reasons, this paper employs a pairwise marginal likelihood estimation approach that corresponds to a composite marginal approach based on bivariate margins [see Apanasovich et al. (*23*) and Bhat et al. (*20*) for the use of the pairwise likelihood approach]. The pairwise marginal likelihood function (L) for individual q may be written as follows:

$$L_{\text{CML},q}(\delta) = \prod_{i=1}^{I-1}\prod_{g=i+1}^{I} \Pr(y_{qi} = m_{qi}, y_{qg} = m_{qg})$$

$$= \prod_{i=1}^{I-1}\prod_{g=i+1}^{I} \begin{bmatrix} \Phi_2(\theta_i^{m_{qi}+1} - \beta_i'x_{qi}, \theta_g^{m_{qg}+1} - \beta_g'x_{qg}, \rho_{ig}) \\ -\Phi_2(\theta_i^{m_{qi}+1} - \beta_i'x_{qi}, \theta_g^{m_{qg}} - \beta_g'x_{qg}, \rho_{ig}) \\ -\Phi_2(\theta_i^{m_{qi}} - \beta_i'x_{qi}, \theta_g^{m_{qg}+1} - \beta_g'x_{qg}, \rho_{ig}) \\ +\Phi_2(\theta_i^{m_{qi}} - \beta_i'x_{qi}, \theta_g^{m_{qg}} - \beta_g'x_{qg}, \rho_{ig}) \end{bmatrix} \tag{4}$$

and

$$L_{\text{CML}}(\delta) = \prod_q L_{\text{CML},q}(\delta)$$

where CML denotes composite marginal likelihood and Φ_2 () is the cumulative distribution function of a standard bivariate normal distribution.

The pairwise likelihood function above is easily maximized, and the effort involved is no more difficult than in a usual bivariate ordered probit model. The pairwise estimator $\hat{\delta}_{\text{CML}}$, obtained by maximizing the logarithm of the function in Equation 4 with respect to the vector δ, is consistent and asymptotically normally distributed. Additional inference details of the pairwise estimator are provided in Bhat et al. (*20*).

DATA DESCRIPTION

In this study, the Southern California portion of the California add-on sample from the 2009 National Household Travel Survey was used. This particular sample was used because the California add-on survey included a series of questions on the attitudes of adults toward their own bicycling and walking patterns, as well as a series of questions on the attitudes of parents toward their children walking and bicycling to school. The subsample from the Southern California region was from the Los Angeles–Riverside–Orange County consolidated metropolitan statistical area and was selected for analysis because a rich set of microaccessibility measures that describe the built environment was available for this geographical area.

Descriptive statistics for the sample used in the analysis of this paper are presented in Tables 1 to 4. After extensive data cleaning and filtering, the final sample available for analysis included 1,000 respondents. Only one parent in each household answered these attitudinal questions for one randomly chosen school-aged child. The availability of automobiles was high, with only 2% of households indicating zero-car ownership. Nearly one-half of the households fell into the highest income category (of the three categories used in this paper) of $80,000 and above, thereby suggesting that the sample used for the analysis in this paper was relatively affluent. As expected, household size distribution was skewed toward larger households, as the sample chosen for analysis included only those households that had at least one child. A vast majority of the households were located in an urban area (as defined by the urban–rural classifications in the 2000 census). A majority of children were found to travel to and from school by car. However, the percentage of children bicycling or walking to school was about 21%, which was higher than the national average of 13% (*24*). About 38% of the children resided less than 1 mi from the school location; about an equal percentage resided more than 2 mi from school. The former group was a candidate for walking and bicycling to school; the use of such modes was likely to

TABLE 1 Sample Data for Parental Attitudes

Characteristic	Number of Responses
Crime	
Not an issue	437
Little bit of an issue	178
Somewhat of an issue	154
Very much an issue	87
A serious issue	144
Weather	
Not an issue	592
Little bit of an issue	183
Somewhat of an issue	141
Very much an issue	43
A serious issue	41
Speed of traffic	
Not an issue	180
Little bit of an issue	115
Somewhat of an issue	223
Very much an issue	179
A serious issue	303
Volume of traffic	
Not an issue	175
Little bit of an issue	125
Somewhat of an issue	199
Very much an issue	188
A serious issue	313
Distance to school	
Not an issue	285
Little bit of an issue	126
Somewhat of an issue	135
Very much an issue	156
A serious issue	298

NOTE: Sample size = 1,000.

be a challenge for the latter group (*13*). About 15% of the children attended private school, which is another indicator that the sample was relatively affluent. The parents in the sample were rather well educated, with about 70% indicating their education level as "some college or above." Of the fathers, 87% were workers; the corresponding percentage for mothers was lower, at just under 60%. In households with both a father and a mother, 54% indicated that both parents were workers. Thirty percent of these households listed both parents as working full time. It is likely that these latter households, in particular, face time–space constraints associated with work schedules and locations that affect their children's activity-travel patterns and mode choices.

TABLE 2 Sample Data for Household Characteristics

Characteristic	Percentage	Characteristic	Percentage
Household size		Race	
2	2.3	Caucasian	59.9
3	19.9	Hispanic	19.7
4	43	Asian	9.6
5 and above	34.8	African-American	4.6
Vehicles		Other	6.2
0	2.1	Location	
1	14	Urban area	95
2	47.7	Nonurban area	5
≥3	36.2		
Income			
Low	22.8		
Medium	29		
High	48.2		

NOTE: Sample size = 1,000.

TABLE 3 Sample Data for School Characteristics

Characteristic	Percentage	Characteristic	Percentage
Mode to school		Distance to school	
Car	68.7	<1 mi	38.4
Bus	9.4	1–2 mi	22.9
Walk or bike	20.7	>2 mi	38.7
Other	1.2	Type	
Mode from school		Public school	85
Car	63.2	Private school	15
Bus	11		
Walk or bike	24.9		
Other	0.9		

NOTE: Sample size = 1,000.

The parents were asked to describe the level of concern they had about the dangers and difficulties their children might face while walking or bicycling to school. Responses to these questions constituted the dependent variables in this study. More specifically, the five interrelated dependent variables in this study were the responses that parents gave when they were asked to indicate the extent to which each of the following items was an issue in the context of their children bicycling or walking to school:

- Distance between home and school,
- Violence or crime along the route to school,
- Speed of traffic along the route to school,
- Amount of traffic along the route to school, and
- Poor weather or climate in the area.

The response scale ranged from one to five, with a response of one indicating that the item was not considered an issue and a response of five indicating that the item was considered to be a serious issue or deterrent to the parent allowing the child to bicycle or walk to and from school. Table 1 presents the distribution of responses provided by parents to these five attitudinal variables. Of the five attitudinal factors considered in this paper, the three factors that were most cited as being serious issues were the volume of traffic, the speed of traffic, and the distance to school (in that order). About 30% of the parents considered these three items to be serious issues that acted as deterrents to their children walking and bicycling to school. About 60% of the parents considered weather not to be an issue,

TABLE 4 Sample Data for Parental Characteristics

Characteristic	Percentage
Father	
Worker	87.3
Education: some college or above	73
Mother	
Worker	58.7
Education: some college or above	69.7
Both parents	
Both parents are workers	54.5
Both parents are full-time workers	30

NOTE: Sample size = 1,000.

generally reflecting the favorable weather conditions in the Southern California region. About 44% of the parents considered crime not to be an issue. This statistic may be reflective of the larger share of high-income households (recall that nearly one in two households fell into the highest income category used in this study) that are likely to be located in safer and more affluent neighborhoods. However, perceptions of personal safety were important, as evidenced by the nearly 20% of parents who considered crime to be very much an issue or a serious issue when it came to their children walking or bicycling to school.

The analysis for this paper considered a host of explanatory variables that might affect parental attitudes toward children bicycling and walking to and from school. The explanatory variables could be broadly classified into five categories: school attributes, children's attributes, parent's attributes, household attributes, and built environment attributes. Built environment attributes included a host of accessibility variables that measured transportation access and destination opportunities. Accessibility measures included, for example, the total network length that a household could access within 10 min of the residential location by driving a car at 30 mph. Destination opportunity–based measures captured the number of employees in the types of industry that could be accessed within various travel time buffers (10 min, 20 min, and 50 min). Accessibility measures were developed for 15 types of industry. Additional details on the formulation and development of these measures may be found in Chen et al. (*25*).

MODEL ESTIMATION RESULTS

This section presents a detailed discussion of the model estimation results. One of the key hypotheses that motivated this study was that as children walked or bicycled more, parents were less likely to be concerned about the perceived deterrents to the use of nonmotorized modes of transportation. It was postulated that such parents would be more likely to be aware of the actual walking and bicycling conditions and confident about their children's ability to safely navigate the built environment than parents whose children did not walk or bicycle as much. The latter group, in the absence of information about the actual walking and bicycling environment and their children's navigation abilities, would be more likely to have an exaggerated sense of danger associated with bicycling and walking. This exaggerated sense of danger would, in turn, make them less likely to permit their children to walk or bicycle to school. The model estimation results (as will be discussed in this section) generally confirmed that this hypothesis could not be rejected. Therefore, understanding the influences behind these parental attitudes is very important because such an understanding would be crucial in the design of policies, campaigns, and built environments that would help make attitudes toward bicycling and walking more positive.

The remainder of this section provides a discussion of the results, organized according to the set of explanatory variables under consideration. The multivariate ordered response model system estimated in this paper included a set of five equations, one for each attitudinal variable. The complete model estimation results are presented in Table 5. As the focus of the analysis was exclusively on the extraction of behavioral relationships (as opposed to forecasting applications), it was considered sufficient to perform model estimation on the unweighted survey sample. Given the nature of the model form and specification, the relationships found in this analysis may be considered representative of the nature of the influences of various attributes on parental attitudes. Most of the model coefficients were statistically significant at the .05 level (these are the estimates in Table 5 with no superscript identifiers). A few variables were, however, not statistically significant even at the .1 level; these variables were retained in the model specification for their intuitively appealing behavioral interpretation.

Effect of School Attributes on Parental Attitudes

The first set of variables presented in Table 5 pertains to school attributes, namely, the distance to school and whether the school is a public or private school. As expected, when the distance to school was less than a quarter-mile, parents were less likely to consider weather or distance to be impediments to walking or bicycling to school. As the distance increased, the coefficients showed an increasing trend for the variable that represented distance to school, thereby signifying that parents considered the distance to school to be an increasingly serious issue as the actual distance of the school from their homes increased. When the distance was over 2 mi, parents also considered the speed and the volume of traffic to be major issues (as evidenced by the positive coefficients of 0.303 and 0.390 in Table 5). The findings here were quite consistent with those reported in the literature concerning the adverse effect of distance on the modal shares of bicycling or walking to school (*13, 15*). However, crime was considered less of an issue in the context of the distance to school being greater than 2 mi. This counterintuitive result merits further investigation, but it is possible that when the distance is greater than 2 mi, other considerations (such as traffic) become more serious issues than crime, thus resulting in the negative coefficient for this variable. It was found that parents of children who attended private schools were quite sensitive to crime and to the speed and volume of traffic. It is possible that private schools are located farther away from the home location, which raises concerns about these factors. As private school children tend to be more car dependent (*26, 27*), it is also possible that the lack of first-hand knowledge of the walking and bicycling environment may result in parents being more concerned about these factors than parents whose children have experienced the built environment for themselves. The greater level of car dependence among private school children (and the resulting absence of exposure to weather) may explain why parents of private school children were less concerned about the weather.

Effect of Children's Attributes on Parental Attitudes

As expected, children's ages and genders, as well as the children's current levels of bicycling and walking activities, influenced their parents' attitudes toward walking or bicycling to school. As the age of the child increased, parents were less likely to consider the speed of traffic and the distance to school to be serious issues associated with walking or bicycling. This is intuitive because parents are likely to consider older children to be more independent and mature and, thus, capable of navigating the path to and from school safely. These findings were consistent with those reported by Timperio et al. (*7*), Alton et al. (*8*), and Johansson (*17*), all of whom noted that age was a significant variable associated with the choice of children's travel mode and independent travel.

Parents of boys were less likely to be concerned about crime, the speed of traffic, and the distance to school. It appears that parents

TABLE 5 Coefficients from Model Estimation Results

Variable	Crime	Weather	Speed of Traffic	Volume of Traffic	Distance to School
Threshold 1	–0.358	–0.149[b]	–1.100	–0.670	–1.652
Threshold 2	0.114[a]	0.408	–0.714	–0.242	–1.235
Threshold 3	0.575	1.064	–0.110[a]	0.307	–0.818
Threshold 4	0.913	1.438	0.379	0.822	–0.311[a]
School					
Distance to school <.25 mi	—	–0.419	—	—	–1.670
Distance to school .25–1 mi	—	—	—	—	–1.287
Distance to school 1–2 mi	—	—	—	—	–0.867
Distance to school >2 mi	–0.218	—	0.303	0.390	
Private school	0.176[b]	–0.254	0.173[b]	0.230	
Child					
Age	—	—	–0.023	—	–0.037
Male	–0.114[b]	—	–0.090[b]	—	–0.165
Number of bike or walk trips per week	–0.012[b]	—	—	—	–0.015
Household					
Race: Hispanic, Asian	—	0.365	—	—	—
Race: Caucasian	—	—	—	0.135	—
Race: multiple	—	—	0.703	—	—
Race: Pacific Islander, American Indian, Alaskan Native	—	—	—	—	0.320
Race: Caucasian, African American, Pacific Islander	–0.280	—	—	—	—
High income (≥$80,000)	–0.188	–0.368	—	—	—
Number of workers in household	0.056[a]	—	—	—	—
Household size	—	—	—	—	0.064
Renter	—	—	—	—	0.145[b]
Parent					
Father uses public transit	–0.287	—	—	–0.178	–0.175[a]
Mother uses public transit	0.136[a]	—	—	—	—
At least one parent uses public transit	—	0.165[b]	—	—	—
Father: number of hours walked or bicycled	—	—	0.023	—	—
Mother: number of hours walked or bicycled	—	—	0.016[b]	—	—
Mother: number of walk and bike trips	—	—	—	—	–0.009[a]
Mother's education: some college or above	0.133[b]	—	—	0.264	—
Mother's education: graduate school	—	—	0.272	—	0.225
Father's education: less than high school	—	–0.248[a]	—	—	–0.380
Mother has telecommuting option at work	—	–0.325[a]	—	—	—
At least one parent has flexible work hours	–0.094[a]	–0.131[a]	—	—	—
Mother has flexible timing at work	—	—	—	—	–0.185
Both parents full-time workers	—	—	–0.107[a]	–0.199	—
Father has telecommuted from home	—	—	—	–0.214[b]	—
Father's mode to work: transit, walk, bicycle	—	—	—	–0.373	—
Mother's mode to work: transit, walk, bicycle	—	—	—	–0.287[b]	—
Father's arrival time at work: a.m.	—	—	—	—	0.136
Built environment					
Length of arterials (km) accessible in 10 min	0.001	—	—	—	—
Length of freeways (km) accessible in 10 min	—	–0.004	–0.002	—	—
Household is in nonurban location	—	—	—	–0.154[a]	—
Error correlations					
Crime	1.000	0.374	0.376	0.353	0.297
Weather	—	1.000	0.223	0.214	0.259
Speed of traffic	—	—	1.000	0.838	0.450
Volume of traffic	—	—	—	1.000	0.544
Distance to school	—	—	—	—	1.000

NOTE: Coefficients significant at .05 level unless otherwise noted; — = not statistically significant at the 0.1 level or not intuitive sign, or both.
[a]Not statistically significant.
[b]Statistically significant at .1 level.

consider boys to be less vulnerable to crime and better able to handle longer distances and higher-speed traffic environments. In general, this finding is consistent with expectation, and there is evidence in the literature to support these results. Studies by Prezza et al. (*10*), McMillan (*9*), and McDonald (*28*) indicated that boys were generally allowed to travel more independently than girls. However, a few studies [e.g., Alton et al. (*8*) and Johansson (*17*)] found no significant gender differences in independent travel to and from school. The results in this paper appear to suggest that gender does play a role in how parents view the ability of the child to travel independently to and from school. This viewpoint, in turn, is likely to impact modal choice, as evidenced in a review by Sirard and Slater that found parental evaluation of a child's navigational abilities to be a big influence on modal choices (*29*).

Parents of children who bicycled and walked regularly were less concerned about crime and the distance to school. As these children have already shown that they can safely navigate the built environment and travel independently by bicycling and walking, it is not surprising that parents of these children consider issues of crime and distance to be less serious than other parents do. Moreover, these parents are likely to be more aware of the actual walking and bicycling conditions, and the greater level of awareness may help ameliorate concerns about crime, safety, and the abilities of their children. These findings are consistent with the results reported by Cooper et al., which suggested that children who walked or cycled to school were more physically active overall than their counterparts who traveled to school by motorized transport (*30, 31*). Information campaigns aimed at providing better information about crime and safety in neighborhoods may help shift parental attitudes positively toward their children bicycling and walking to and from school.

Effect of Household Attributes on Parental Attitudes

With respect to the role of household attributes in shaping parental attitudes, parents in higher-income households generally had lower levels of concern about crime and weather. It is possible that these households are in safer, more affluent neighborhoods in which crime is not an overriding concern in the context of bicycling or walking to school. In addition, these households are likely to be more automobile oriented (suburban, higher–car ownership households); hence, there may be a lower level of sensitivity to weather from parents in these households. Car ownership itself did not prove to be significant in explaining parental attitudes toward bicycling and walking. One reason for this may be that virtually all the households had at least one car, thus making car ownership a nonissue in terms of its influence on parental attitudes toward bicycling and walking. In a region such as Southern California, where car ownership is quite universal, it is reasonable to expect car ownership to play virtually no role in shaping attitudes about walking and bicycling. Perhaps an effect would have been observed had there been a sizable number of households with no cars.

A variety of race and ethnicity variables affected parental attitudes toward walking and bicycling. There was no discernible pattern, but the fact that several race variables entered the model specification and were statistically significant suggests that there are potential sociodemographic and cultural differences across racial groups that affect parental attitudes toward bicycling and walking. As noted by McDonald, it is possible that the racial differences are attributable to other underlying reasons, and the race variables themselves are simply proxies in capturing such effects (*11*).

As the number of workers in a household increased, parents tended to be more sensitive to crime, although the coefficient was statistically insignificant. It is not clear why this may be the case, but there may be a heightened sense of concern for the safety of children among parents in households in which the adults all work outside the home. Parents in households of larger size and who are renting their residence are more prone to considering the distance to school to be an issue that deters walking and bicycling, perhaps because these households are farther from the school location.

Effect of Parents' Attributes on Their Own Attitudes

This section offers a discussion of how the characteristics of the parents impact their attitudes toward walking and bicycling. If the father used public transit, then the parents were less likely to be concerned about crime, the volume of traffic, and the distance to school. The greater level of awareness and knowledge of the environment that comes from public transit use potentially contributed to this lower level of concern. However, when the mother used public transit, there was a heightened sensitivity to crime (though this variable was statistically insignificant). When at least one parent used public transit, the results showed a greater concern for weather. Similarly, as the time spent by the father or mother walking or bicycling increased, there was a greater level of concern related to the speed of traffic. In other words, it appeared that the level of awareness and experience in using the built environment for walking and bicycling might work both ways. In the case of crime, the volume of traffic, and the distance to school, the sensitivity was reduced, but in the case of weather and the speed of traffic, the sensitivity was heightened. These findings were quite intuitive and consistent with expectations. The frequency of walking and bicycle trips on the part of the mother lowered concerns regarding the distance to school, once again suggesting that familiarity and knowledge of the built environment may lower concerns related to distance. The use of alternative modes of transportation for work travel on the part of the parents specifically lowered concerns related to the volume of traffic. If a father or mother takes transit, bicycles, or walks to work, then it is likely that he or she has a greater level of knowledge and awareness of the actual traffic conditions and this knowledge, in turn, lowers the level of sensitivity associated with traffic volumes.

With respect to the educational attainment of the parents, higher levels of education for the mother were associated with greater levels of sensitivity and concern for virtually all attitudinal variables except weather. It appears that parents in such households tend to amplify the level of concern associated with various deterrents to walking and bicycling to school, although it is not exactly clear why that might be the case.

The work arrangements of the parents play a key role in shaping their attitudes toward bicycling and walking as modes of transportation to and from school. In general, greater levels of flexibility associated with work arrangements and schedules lowered the level of concern or sensitivity with respect to various attitudinal measures including crime, weather, distance, and traffic volume. It is likely that parents who have flexible work arrangements and schedules feel more confident that they can be available for the child and respond to emergency situations in a timely manner. In addition, parents who have flexible work arrangements and schedules are more likely to be

able to walk or cycle with their children to and from school, thus lowering concerns about personal safety, distance, and traffic conditions. However, parents who have rigid work schedules are more likely to chauffer their children to and from school because of schedule constraints. This finding is consistent with those reported by Yarlagadda and Srinivasan, who found that mothers with fixed work schedules were more likely to drive their children to school than mothers with flexible work schedules (*32*). Similarly, Zhu and Lee found that children of parents who thought that "walking their kids to school required too much planning" were less likely to walk or bicycle to school, presumably because these parents were just too time constrained to undertake such planning (*15*). This observation is further supported by the finding in this paper that a father's need to arrive at work in the morning (rigidity in the work schedule) heightened the level of concern associated with the distance to school. From a policy standpoint, it appears that providing parents with flexible work arrangements could have a positive impact on their attitudes regarding children bicycling or walking to and from school. It is not entirely clear why parents in households in which both parents work full time consider the speed of traffic and the volume of traffic to be of less concern than other parents. This finding merits further investigation; it may be that these parents consider crime and distance to be greater deterrents than traffic conditions to walking and bicycling.

Effect of Built Environment Attributes on Parental Attitudes

The final set of variables included in the model system represents the built environment. A host of variables were considered, but only a few eventually made their way into the final model. As the length of primary arterials accessible to the household increased, the parents tended to be more sensitive to crime. Because areas with greater street access and density are perceived to have higher crime rates, as evidenced in studies by Harries (*33*) and Foster and Giles-Corti (*34*), it is reasonable to expect parents in such areas to be more worried about personal safety for their children. Parents in households that had greater levels of access to freeways were found to be less sensitive to weather and traffic speed considerations. As expected, parents in households in a nonurban location considered the volume of traffic to be less of an issue than parents in households in an urban location. This observation is presumably attributable to the lower levels of traffic volumes in nonurban locations that naturally lead to lower levels of concern for this measure. None of the built environment measures affected parental attitudes related to the distance to school. For example, it could be hypothesized that higher levels of access and street connectivity could potentially lead to lower levels of concern about distance. However, no such effects were found in this study. Further research is needed to explore how microaccessibility measures formulated at different spatial scales affect parental attitudes toward their children's mode of travel to school.

Error Correlation Matrix and Data Fit

The use of the multivariate ordered response model formulation allowed the estimation of correlations between the unobserved error components of the five attitudinal dependent variables considered in this paper. Information about correlations across error terms provides valuable insights on how different attitudinal variables are related to one another and how policies that address one attitudinal measure might have an impact on other attitudinal measures. The estimated error correlations are shown in Table 5.

As expected, the unobserved error terms associated with attitudes toward the volume of traffic and attitudes toward the speed of traffic were highly positively correlated. This finding suggests that measures to reduce speed, such as the implementation of traffic calming devices, would not only lessen parents' anxieties about the speed of traffic, it would also make parents less worried about the volume of traffic that their children have to encounter. This correlation of attitudes is natural given that both of these attitudes measure perspectives on traffic conditions.

The error term associated with distance was found to be positively correlated with the volume and speed of traffic. Again, this finding is consistent with expectations because concerns about distance are likely to be related to concerns about exposure to traffic because the likelihood of coming across bad traffic conditions increases with distance. In other words, it appears important to have good schools in close proximity to residential neighborhoods. Reducing the distance between home and school not only reduces concerns about distance but also reduces concerns about the volume and speed of traffic to which children would be exposed. Other unobserved error components showed moderate positive correlations.

The estimated multivariate model was evaluated by comparing the model with a restricted model that corresponded to independent ordered response estimations for each of the five attitudinal variables. The two models were compared through the adjusted composite likelihood ratio test [see Pace et al. (*35*) and Bhat (*36*) for details]. This statistic had a chi-squared asymptotic distribution with 10 degrees of freedom. The statistic was 368.9, which was higher than the corresponding critical chi-squared value with 10 degrees of freedom at any reasonable level of significance. This finding indicated the clear data fit superiority of the multivariate model estimated here and indicated that unobserved factors had the same direction of effect on the different parental attitude variables regarding children walking or bicycling to school.

CONCLUSIONS

This paper aims to examine the factors that influence parental attitudes toward children walking or bicycling to school in the context of a larger effort to make children more physically active and combat rising trends in childhood obesity. As parents tend to be the primary decision makers with respect to children's modes of travel, it is critical to understand the factors that shape parental attitudes. On the basis of data from the California add-on sample of the 2009 National Household Travel Survey, a multivariate ordered response model was estimated through the composite marginal likelihood approach. The data set included information on five attitudinal variables that represented the extent to which parents considered different factors to be deterrents or issues in the context of their children walking or bicycling to school. The five attitudinal measures were related to crime, weather, the volume of traffic, the speed of traffic, and the distance to school. The multivariate ordered response model formulation accommodated error correlations across equations in the model system. Model estimation results showed that there were significant error correlations and that the goodness of fit of the joint model was statistically superior to that of the independent model system that ignores error correlations. These findings illustrate the importance of using a multivariate model system in the empirical context considered in this paper.

It was found that a host of variables affect parental attitudes toward children walking or bicycling to school. These results have important policy implications. First, proximity of schools to residential neighborhoods is critical to shaping favorable parental attitudes toward walking and bicycling. Cities, counties, and school districts should consider how best to size and position a school relative to the surrounding residential neighborhoods so that it is feasible for children to bicycle and walk to school. Second, schools and communities should institute programs that help bring about awareness and knowledge of the walking and bicycling environment among parents and children. Organizing "walk to school" days could help bring about this awareness because parents and children would feel obligated to walk to school on such days and experience the environment first hand. To motivate children even more, schools could set up an incentive-based program, through which, at the end of a specific time period, the child who has walked or bicycled the most could win some small token prize (*37*). Schools should also hold regular safety demonstrations that would help children become safe pedestrians or cyclists. These demonstrations could help to quell some parental concerns about the dangers of active commuting and promote more independent travel by children. Another way of alleviating parental fears is by instituting special programs such as the "walking bus," through which a group of children from a neighborhood walk or bicycle to school together with an adult escort (*37, 38*). The adult escorts are usually the parents of the children, and the walking buses are set up on a rotating routine. By taking turns to escort the children, the parents get to save time, yet still ensure that their child is accompanied by an adult on the way to school. Third, there should be a concerted effort to enhance flexibility in the workplace for parents. It was found that parents with greater levels of work flexibility were less concerned about various issues related to their children bicycling or walking to school. Those parents are likely to be more favorable to the use of nonmotorized modes of transportation because the parents are, presumably, less time constrained—therefore, they have time to walk or bicycle with their child to school—and are more confident that they can respond to any emergency situation.

A key finding of this paper was that error terms associated with different attitudinal variables were correlated with one another. Correlations were strongest between the speed and volume of traffic, between distance and traffic variables, and between crime and traffic variables. In general, these findings suggest that transportation engineers could design built environments that simultaneously ease multiple parental concerns about children walking or bicycling to school. For example, traffic calming measures might help to alleviate concerns related to the speed and volume of traffic. Grid street patterns that reduce travel distances by providing direct connectivity between home and school and eliminating the need for the child to walk along busy arterials may ease concerns about the distance to school and the volume and speed of traffic. In turn, these designs would also reduce concerns about crime. Thus, a series of urban design strategies could help shift parental attitudes favorably toward their children walking and bicycling.

Future efforts in this arena should be aimed at further enhancing the measurement of built environment attributes (accessibility measures) and modeling their impact on parental attitudes toward bicycling and walking. In this study, only a very limited influence of accessibility measures was found. Additional secondary variables on crime statistics, traffic patterns, and street connectivity would prove useful in better understanding how these factors affect attitudes. In addition, further research needs to be conducted to understand better the direction of relationships between attitudes, contextual attributes, and choices. Future efforts should also attempt to control for the effects of self-selection that may be at play because people are inclined to locate themselves in environments consistent with their modal preferences. Another potential issue that might warrant attention is the exploration of the extent to which responses to the attitudinal questions in the survey were conditioned by behavioral choices. For example, a parent whose child walks to school might have been inclined to say that it was a safe neighborhood to justify the choice of letting his or her child walk to school (regardless of the true safety record of the neighborhood). Finally, data about children's attitudes toward bicycling and walking should be collected and analyzed to see how children's own attitudes are shaped by various factors, and how these attitudes, in turn, influence choices.

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