The Reach of Bicycling in Rural, Small, and Low-Density Places

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Lessons derived from the urban experience of bicycling may not be broadly supportive of bicycling in rural, small, and low-density (RSLD) places because of differences in built environment, social, and political contexts. In this study, the hypothesis that bicycling was primarily an urban activity was investigated. Binary logistic regression was used to compare the frequency of bicycling and the population characteristics of bicyclists across urban and RSLD places. Multiple operational definitions of urban–rural continua were used to examine whether the results were sensitive to how RSLD places were defined. The data for bicycling were from the 2009 National Household Travel Survey, which was designed to represent the population of the United States. Bicycling was found to be primarily, but not exclusively, an urban activity. Moreover, women and youths were more likely to bicycle in RSLD places compared with urban places. These findings suggest that an urban perspective on bicycling could limit the success of initiatives aiming to increase the diversity of populations that bicycle. Developing a base of empirical knowledge of bicycling in RSLD places is a necessary step toward developing more inclusive and effective multimodal transportation strategies.

Key elements of bikeable places include supportive infrastructure, policy, education, encouragement, and enforcement programs. To be successful, these elements have to be sensitive to the local built environment, social, and political contexts. Yet, key aspects of the bikeability paradigm may not be context sensitive. In practice, this paradigm skews toward the experiences of urban places where the land use context is more supportive of the goal to increase bicycling for utilitarian purposes. For instance, strategies such as increasing bicycle commuting, adopting "complete streets" policies, and constructing on-street bicycle infrastructure networks have been derived from places with high-density activity centers that support utilitarian bicycling. In contrast, a different set of strategies, such as paved highway shoulders and historic preservation programming, might be needed to support bicycling in what are called rural, small, and low-density (RSLD) places where bicycling is more often considered a problem of tourism and recreation than a problem of transportation, if it is considered a problem at all.

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Transportation Research Record: Journal of the Transportation Research Board, No. 2662, 2017, pp. 134–142.
http://dx.doi.org/10.3141/2662-15

Providing empirical evidence about the patterns of bicycling in RSLD places is a necessary step for developing more inclusive and effective transportation planning practices and policies for multimodal transportation. Research that accounts for bicycling among RSLD populations is important because bicycling is a form of health-promoting physical activity, a potential mechanism of economic development, and an important mode of travel for people, especially youths, who do not have access to a vehicle.

In this study, the hypothesis that bicycling is primarily an urban activity was investigated. Binary logistic regression was used to compare the frequency of bicycling and the population characteristics of bicyclists, using two different definitions of urban–rural continua. The data for bicycling are from the 2009 National Household Travel Survey (NHTS), which was designed to represent the population of the United States. Two dependent variables that represent different levels of bicycling frequency were used: (*a*) bicycling only one or two times in the previous week and (*b*) bicycling three or more times in the previous week. Although the NHTS was not developed as a bicycling survey, it captures a wide range of RSLD environments in the United States as well as utilitarian and recreational bicycle trips.

The RSLD construct is used to refer to a diverse set of places that include remote and agricultural landscapes as well as low-density exurban and suburban settlements within urbanized areas. Despite the heterogeneity of these places, they tend to share a reliance on automobiles for their viability, and public transportation options are typically less developed than in traditional cities. Because the RSLD concept is expansive and heterogeneous, two different operational definitions of urban–rural continua were used to analyze the data: (*a*) rural–urban commuting areas that emphasize the economic characteristics of places and (*b*) population density categories that represent the built environment context. In addition, the influence of places with significant recreational economies and retirement communities was considered because bicycling may be uniquely prevalent in these settings.

BACKGROUND AND LITERATURE

In the urban context, bicycling is usually framed as an alternative to motorized travel. This framing may be suited to places where motorized traffic is problematic, but outside cities, bicycling is not a clear substitute for car travel, and residents in RSLD places may have different motivations and resource needs for bicycling.

Rural places are characterized by spatial dispersion of economic, social, and cultural activities (*1*). With the exception of peak tourism periods, they generally do not have urban transportation problems such as congestion, scarce parking, and noise and air pollution (*2*). Earlier studies about the concerns of rural transportation include questions of goods movement, heavy vehicle impacts on infrastructure, externalities of industrial traffic, and social isolation (*1–6*). In practice, mobility in rural places in the United States has been dominated by the automobile, whereas urban places have presented opportunities for a diverse multimodal system that relies on automobiles, transit, walking, bicycling, and variants of these modes (*2*).

In turn, prior research about bicycling has focused on bicycling for transportation and bicycle commuting in the context of cities (*7*). Very few studies have given attention to contemporary bicycling behaviors and attitudes among RSLD residents, despite the fact that these settings are fully engaged in dialogue about creating bikeable communities (*8–9*). Certain national and statewide studies of bicycling have included variables representing rural and suburban places. Pucher et al. investigated bicycling trends in the United States using definitions of urban and rural places (*10*). This study found that the bike share of all trips was higher in urban places compared with rural places (1.12% versus 0.78%), that rural places have a higher percentage of recreational bike trips compared with urban places (61.5% versus 46.9%), and that the share of workers making commute trips by bike is about four times as high in urban places compared with rural places (0.60 versus 0.16).

Noland et al. conducted a survey-based study of bicycling for New Jersey, a state with a range of dense urban places, low-density suburbs, and agricultural areas (*11*). The survey included both recreational and utilitarian bicycle trips, and the majority of bicycle trips were for recreation. With respect to area-level characteristics, urban, rural, and suburban categories were not predictive of the propensity to bicycle, nor was the density of county roads. Consistent with other research, the personal characteristics of survey respondents were stronger determinants of bicycling and bicycling frequency than environmental characteristics. Bicycling increased with population density when personal and household factors were controlled for, but bicycling was still prevalent in low-density places.

Despite a lack of research focused on RSLD bicycling, examples from practice suggest that it can be a culturally and economically significant form of transport and recreation for RSLD residents. There are numerous examples of RSLD places that are making investments in bicycling, and these example offer insight into some of the opportunities that RSLD places present. The Cowboy Trail in northern Nebraska is among the longest bicycle trails in the country and is a recreation and tourism asset for the state. The Tour de Farm in western Georgia promotes the region's agriculture industry and local economies. In South Carolina, the Lower Savannah Council of Governments pursued a bicycle planning process and the resulting plan emphasized widening and paving shoulders on county roads. RSLD bicycling tends to emphasize off-street infrastructure, recreational bicycling, and bicycle programming and education strategies. Traditional issues of safety, education, enforcement, and design are present, but they may be pursued with strategies that are distinct from those typically used in urban areas with higher population densities. More research is needed to understand the effectiveness of these strategies across the urban–rural continuum.

The Rails to Trails Conservancy, with financial support from bicycle advocacy groups, conducted a study of active transportation in rural places in the United States. Comparing all-trip mode share and bicycle commute share across an urban–rural continuum, the authors found that bicycling is "far more prevalent in rural places than many would expect" (*9*). However, Loh et al. did not control for social and demographic factors (e.g., gender, age, and income) that are known to influence estimates of the propensity to bicycle (*9*). Therefore, the study's estimates for rural places may not reflect the unique contributions of place to bicycling. In addition, the study may be sensitive to the operational definition of the urban–rural continuum. The current analysis built on this previous approach by using multivariate regression analysis, which permitted the examination of the independent effect of urban–rural status on bicycling frequency. In addition, multiple operational definitions of urban–rural continua were used to examine whether the results were sensitive to how RSLD places are defined.

PHYSICAL ACTIVITY IN RSLD PLACES

The physical activity literature from public health draws attention to emerging goals to promote bicycling in RSLD places. Research comparing overall levels of physical activity across urban and RSLD places has generally found that physical inactivity is highest in rural places, and that rural places are less likely to have specific resources and facilities, such as trails, that promote physical activity (*12–17*). However, other studies have found that sprawl, a characteristic of certain RSLD places, is not associated with physical inactivity (*18*).

A review study of physical activity and rural built environments found that research in this area is limited. Prior research has been cross sectional, has neglected older adults, and has been limited in its geographic scope; high-risk regions such as the Southeast and Midwest have received relatively less attention. Moreover, prior research on rural physical activity has used a mix of definitions to represent RSLD places, which makes it difficult to draw conclusions from the various studies (*14*).

The implication is that existing research and professional practices do not adequately understand bicycling outside the urban context, which is a gap in knowledge that could limit the success of multimodal and active transportation initiatives in RSLD places. For example, a recent study about the effectiveness of the Safe Routes to School program found that "children in rural communities often miss out on the health and academic benefits that Safe Routes to School initiatives bring" (*19*).

This research took steps to address these gaps by using more fine-grained definitions of urban and rural places as well as nationally representative data for children, youth, and adults (ages five and older). This empirical information can help bring RSLD bicycling into the mainstream of multimodal transportation planning and research.

DATA AND METHODS

The 2009 NHTS was used for this analysis because the NHTS captures both utilitarian and recreational travel, is representative of the U.S. population (ages five and older), and includes the widest range of urban and RSLD places. The sample included all responding individuals ($N = 285{,}634$).

An important limitation of this study is the likely underrepresentation of populations that are least likely to be included in the NHTS, such as nonwhite respondents and groups that are difficult to reach by telephone (*20*). Also, the distinction between recreational and utilitarian bicycling is not always clear and a bicycle trip may be motivated by both reasons (*12*). The NHTS distinguishes between four main types of trips: work, shopping, social–recreational, and other. Social–recreational trips include motivations such as leisure, exercising, relaxing, visiting friends, going out (e.g., entertainment, bar, event), and visiting public places, such as libraries and parks.

Analyses were conducted with two different dependent variables: (*a*) self-reported bicycling one or two times in the previous week

(N = 15,884) and (b) self-reported bicycling three or more times in the previous week (N = 14,980). These trips included bicycling for any purpose. In addition to representing the likelihood of bicycling, these two outcome variables represent different levels of bicycling frequency and therefore potentially different populations of bicyclists.

Table 1 presents a descriptive summary of the variables included in the regression analysis. In addition to social and demographic factors, it was hypothesized that urban–rural status predicts bicycling frequency and propensity. Therefore, information about the urban–rural status of each respondent (determined on the basis of their residential census tract) was included.

Operational Definitions of RSLD Places

Because categories such as "urban" and "rural" do not have an intrinsic meaning, they must be translated into operational definitions for analysis (*24–26*). The following operational definitions of urban–rural continua were used to represent urban–rural status.

Rural–Urban Commuting Areas

Rural–urban commuting area (RUCA) definitions reflect the intensity of commute flows between places; this definition emphasizes economic relationships between places rather than urban form (*21*). For instance, a place may be located in an agricultural environment outside a large metropolitan area, but if a significant proportion of its population commutes to work inside the metropolitan area, this place will be considered more urban than rural.

The RUCA system includes 33 categories that can be aggregated into specialized urban–rural continua. In this research, the 10 primary RUCA categories were used; they were not aggregated into a special definition. These 10 categories follow:

Level 1. Metropolitan area core, with primary commuting within an urbanized area (UA);

Level 2. Metropolitan area, high commuting, primary flow 30% or more to UA;

Level 3. Metropolitan area, low commuting, primary flow 10% to 30% to UA;

TABLE 1 Summary of Self-Reported Bicycling Frequency by Individual, Household, and Area Characteristics, 2009 National Household Travel Survey (*21–23*)

		NHTS Self-Reported Bicycling Activity in Past Week			
Variable	Category	N	0 Trips (%)	1 or 2 Trips (%)	3 or More Trips (%)
Sex	Male	133,211	86.2	6.8	7.0
	Female	152,423	91.8	4.5	3.7
Age	<18	43,103	63.1	16.0	21.0
	18 or older	242,531	93.8	3.7	2.5
Household income	Less than $100,000	218,335	90.4	4.8	4.9
	More than $100,000	67,299	85.4	8.2	6.4
Race of household respondent	White	245,238	89.1	5.6	5.3
	African American, black	16,395	91.1	4.2	4.7
	Asian only	6,673	89.1	6.5	4.4
	American Indian, Alaskan Native	2,236	90.3	4.5	5.1
	Native Hawaiian–other Pacific	884	87.3	7.5	5.2
	Multiracial	1,879	87.9	5.5	6.6
	Hispanic	9,125	87.3	6.6	6.1
	Other	3,204	89.8	5.4	4.8
Children in household, among respondents age 18+	No	183,078	89.0	5.4	5.8
	Yes	59,453	91.0	6.2	3.0
Population density (person per square mile)	High-density urban (>12,500)	77,055	91.6	4.2	4.2
	Urban (2,400–12,500)	71,699	89.1	5.8	5.1
	Suburban (1,200–2,400)	40,926	88.7	5.9	5.4
	Low-density suburban (200–1,200)	87,770	88.6	5.9	5.4
	Rural (<200)	8,184	89.8	4.9	5.3
RUCA	Most urban, Level 1	188,200	88.7	6.0	5.3
	Level 2	40,629	89.2	5.3	5.5
	Level 3	2,661	89.6	5.0	5.3
	Level 4	17,531	89.7	5.0	5.3
	Level 5	7,776	90.4	4.4	5.2
	Level 6	1,623	92.0	3.0	5.0
	Level 7	9,821	91.7	4.0	4.3
	Level 8	2,512	92.5	3.3	4.2
	Level 9	1,586	91.1	4.0	4.9
	Most rural, Level 10	13,295	91.0	4.1	4.9
Recreation county	No	275,032	89.2	5.5	5.2
	Yes	10,602	88.0	6.0	6.0
Retirement county	No	231,281	89.6	5.4	5.0
	Yes	54,353	87.6	6.2	6.2

NOTE: RUCA = rural–urban commuting area.

Level 4. Micropolitan area core, primary flow within an urban cluster (UC) of 10,000 to 49,999;

Level 5. Micropolitan high commuting, primary flow 30% or more to a large UC;

Level 6. Micropolitan low commuting, primary flow 10% to 30% to a large UC;

Level 7. Small town core, primary flow within a UC of 2,500 through 9,999;

Level 8. Small town high commuting, primary flow 30% or more to a small UC;

Level 9. Small town low commuting, primary flow 10% to 29% to a small UC; and

Level 10. Rural areas, primary flow to a tract outside a UA or UC (including self).

The Level 1 RUCA was considered to be the "urban" category and all other levels were considered to be RSLD categories.

Population Density Categories

The second urban–rural continuum definition that was applied was developed on the basis of population density. Population density represents the built environment characteristics relevant to bicycling behavior. For instance, towns and villages in rural areas may have relatively high population densities and an urban form that closely resembles older cities. Similarly, places that are considered part of UAs (according to the Census Bureau definition) may have rural population densities and urban form. These are differences that matter for the propensity to bicycle, particularly for transportation. The 2010 U.S. census was used to calculate population density for each census tract, on the basis of total population and land area.

The cutoff points for each level in this continuum were determined using the distribution of population densities for the state of Colorado as a reference, as well as research about suburban sprawl (*22*). The categories included rural (fewer than 200 persons per square mile), low-density suburban (200 to 1,200 persons per square mile), suburban (1,200 to 2,400 persons per square mile), urban (2,400 to 12,500 persons per square mile), and high-density urban (more than 12,500 persons per square mile). For instance, urban places in Colorado are generally in the urban category, whereas cities such as Boston, Massachusetts; Chicago, Illinois; New York, and San Francisco, California, tend to be in the high-density urban category because they include more census tracts with population densities that are greater than 12,500 persons per square mile. The rural, low-density suburban, and suburban categories were considered to be RSLD and the urban and high-density urban categories were considered urban.

Counties with Recreation-Focused Economies and Retirement Communities

It was hypothesized that counties with recreation-focused economies and large retirement communities could have a unique influence on bicycling behavior. Beale and Johnson developed a methodology to identify "recreational counties" in nonmetropolitan areas to develop research and policy to address the widespread population increases in these amenity-rich locations (*27*). The definition of recreational counties accounts for phenomena such as second homes and high levels of recreation-focused employment and income (*28*). Similarly, the category "retirement counties" includes places that have significant populations of retired persons and associated housing and services.

Analytical Approach

Binary logistic regression was used to estimate the likelihood of a respondent bicycling in the previous week, using two different dependent variables representing different frequencies of bicycling (i.e., one or two times, three times or more). The binary logistic regression model explains the relationship between the covariates and the binary outcome variable. The parameter coefficients in a logit regression model are expressed as log odds, which can be transformed into odds ratios. Odds ratios are defined as the probability that an event occurs divided by the probability that it does not occur. For example, a .5 probability of an event occurring has an odds ratio of 1.0. In the context of multivariate regression, the odds ratio represents the association of a covariate (x) on the outcome variable (Y), holding all other covariates constant.

The model form is given by the following equation:

$$\Pr(Y) = \frac{e^{(\beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n)}}{1 + e^{(\beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n)}}$$

where

Y = survey respondent reported bicycling at the given level,
x = covariate (reported in tables below),
β_0 = intercept parameter, and
β = parameter estimate.

The model was specified using a purposeful approach developed on the basis of theoretical relationships, prior empirical research, bivariate relationships between the dependent variables and potential covariates, and the Akaike information criterion as a measure of model fit (*29*). Interaction terms were included to examine the differential effects of age, gender, and income by urban–rural status. Ordinal logistic models with a dependent variable representing the three different bicycling frequencies (i.e., zero times, one or two times, three or more times) were also tested. The results were similar to those of the binary logistic models. Only the results of the binary logistic models are presented because of their relative clarity.

RESULTS AND DISCUSSION

Table 1 presents a descriptive summary of the frequency of bicycling by personal, household, and area-level factors. The majority of men and women in the sample reported not making any trips by bicycle in the previous week (86% and 92%, respectively). The proportion of respondents who reported bicycling one or two times in the previous week was 7% among men and 5% among women, and a similar proportion reported bicycling three or more times in the previous week (7% and 4%, respectively). People under the age of 18 reported the highest levels of bicycling activity: 16% bicycled one or two times in the previous week and 21% reported bicycling at least three times.

Bicycling frequency estimates varied depending on which urban–rural continuum definition was used. Using the population density definition, urban, suburban and low-density suburban places had the highest proportion of respondents reporting bicycling one or two times in the previous week (all about 6%), and high-density urban places had the lowest proportion (4%). Pearson chi-square tests confirm that these differences are statistically significant ($p < .0001$). However, the Mantel-Haenszel test rejected a linear relationship between bicycling frequency and urban–rural status, as measured by population density category ($p = .263$). Therefore, differences in these proportions should be interpreted cautiously. Descriptive results for bicycling three or more times in the previous week were similar, and both chi-square test statistics were significant for this variable.

The RUCA definition produced the opposite gradient. When places were stratified by RUCA, the most urban places (Levels 1, 2, 3, and 4) had the highest proportion of bicycling one or two times in the previous week (between 5% and 6%). Both chi-square test statistics were significant for the RUCA definition ($p < .0001$). Results for bicycling three or more times in the previous week were similar.

The differences between the two definitions of urban–rural continua may arise because the most urban RUCA (Level 1) includes a wide range of population densities. Places that have very high population density and relatively low levels of bicycling may be too few to lower the proportion estimated for RUCA Level 1.

Model Results

Tables 2 and 3 present adjusted odds ratios from the regression analyses. These figures control for individual, household, and area-level variables as well as the interaction effects of age, gender, and income by urban–rural status. The interaction effects for race and ethnicity were not significant and were not included in the model.

Urban–Rural Status

The model results suggest that bicycling is primarily—but not exclusively—an urban activity, which is consistent with the findings of Loh et al. (*9*). Residents of certain types of RSLD places were as likely to bicycle as their urban counterparts. This pattern was true for different bicycling frequencies and different definitions of urban–rural continua. Moreover, according to the population density definition, residents of the highest-density urban places were less likely to bicycle one or two times in the previous week, compared with residents living in the urban category [odds ratio (OR) = 0.69 (0.55, 0.85)].

For the RUCA definition, respondents who reside outside the most urban category had lower odds of bicycling one or two times the past week than their urban counterparts, all else being equal. However, not all of these differences were significant at the $\alpha = .05$ level. Levels 3 and 9 were statistically equivalent to the most urban level [OR = 1.00 (0.74, 1.37) and OR = 0.75 (0.48, 1.17), respectively]. These categories represent metropolitan areas with low commuting to a UA and small towns with low commuting to UCs, respectively. The results were similar for bicycling three days or more, but the patterns were slightly different. For more frequent bicycling, micropolitan areas with various degrees of commuting (Levels 4, 5, 6, and 9) were statistically equivalent to the most urban levels [OR = 0.97 (0.84, 1.12), OR = 0.87 (0.70, 1.08), OR = 0.82 (0.50, 1.35), and OR = 0.84 (0.53, 1.35), respectively].

Urban–rural differences in bicycling were slightly attenuated for the population density definition. Respondents from low-density suburban and suburban places were as likely as urban residents to bike one or two times in the previous week, all else being equal. In contrast, respondents in the most rural category and the high-density urban category were less likely than others to bicycle one or two times in the previous week. Respondents from rural and low-density places were also less likely to report bicycling three or more times in the previous week compared with their urban counterparts [OR = 0.80 (0.73, 0.88) and OR = 0.90 (0.82, 0.99), respectively].

For both dependent variables, and for both the population density and RUCA models, respondents residing in recreation counties and retirement counties were more likely than others to report bicycling in the previous week. The odds ratios across the different models and definitions of urban–rural continua were in the range of 1.21 to 1.40. This suggests that niche environments combining social, cultural, and built environment factors may attract bicyclists through self-selection, and that these niche factors may be more useful for understanding bicycling behavior than constructs representing urban–rural status.

Personal and Household Factors

Consistent with prior studies, men were more likely to bicycle than women, and more so when considering bicycling three or more times per week. For the RUCA definition, the odds ratios comparing male with female bicycling were OR = 1.62 (1.56, 1.69) for bicycling one or two times in the past week and OR = 1.96 (1.86, 2.04) for bicycling three or more times in the past week. The results were similar for the population density definition.

Children and youths under 18 years old had the highest odds of bicycling, with odds ratios of seven or more. Household composition also mattered: adults aged 18 and older with children in the household were more likely to bike than those in households without children, and the effect was stronger for bicycling only one or two times in the past week. For the RUCA definition, the odds ratios were OR = 2.15 (2.06, 2.24) for bicycling one or two times in the past week and OR = 1.33 (1.26, 1.41) for bicycling three or more times per week.

Household income greater than $100,000 per year had a positive association with bicycling, and its effect was also stronger for bicycling only one or two times in the past week. For the RUCA definition, the odds ratios were OR = 1.42 (1.36, 1.48) for bicycling one or two times in the past week and OR = 1.07 (1.02, 1.12) for bicycling three or more times in the past week.

Respondents who identified as non-Hispanic white, Native Hawaiian–other Pacific, multiracial, and other were statistically equally likely to report bicycling one or two times in the past week, whereas respondents of other races and ethnicities were less likely to bicycle. Respondents who identified as non-Hispanic white, American Indian–Alaskan Native, and multiracial were statistically equally likely to report bicycling three or more times in the past week, whereas respondents of other races and ethnicities were less likely to bicycle.

Differential Effects of Age, Gender, and Income by Urban–Rural Status

This analysis extends prior understanding of bicycling in RSLD places by examining the interaction effects of age, gender, and income by urban–rural status. Compared with urban bicyclists, RSLD bicyclists are more likely to be women and youths, which are

TABLE 2 Logistic Regression Models for Bicycling Frequency by Rural–Urban Commuting Area, 2009 National Household Travel Survey (*22, 30*)

		Bicycling 1–2 Times per Week Versus 0 Times[a]			Bicycling 3 Times per Week or More Versus 0–2 Times per Week[b]		
Variable	Category	Odds Ratio	95% Confidence Interval	Probability	Odds Ratio	95% Confidence Interval	Probability
Sex (ref. = female)	Male	1.62	(1.56, 1.69)	***	1.96	(1.86, 2.04)	***
Age (ref. = 18+)	Under 18	7.63	(7.30, 7.99)	***	9.73	(9.29, 10.20)	***
Race/ethnicity (ref. = white)	African-American/ black	0.72	(0.66, 0.78)	***	0.84	(0.77, 0.91)	***
	Asian	0.82	(0.74, 0.91)	***	0.65	(0.58, 0.74)	***
	American Indian, Alaskan Native	0.73	(0.60, 0.90)	**	0.86	(0.70, 1.04)	
	Native Hawaiian–other Pacific	0.97	(0.74, 1.26)		0.71	(0.52, 0.96)	*
	Multiracial	0.88	(0.72, 1.08)		1.09	(0.90, 1.33)	
	Hispanic	0.84	(0.77, 0.92)	***	0.78	(0.71, 0.86)	***
	Other	0.83	(0.70, 0.97)	*	0.78	(0.66, 0.92)	**
Children in household (ref. = no)	Yes	2.15	(2.06, 2.24)	***	1.33	(1.26, 1.41)	***
Household income >$100,000 (ref. = no)	Yes	1.42	(1.36, 1.48)	***	1.07	(1.02, 1.12)	**
RUCA categories (ref. = most urban, Level 1)	Level 2	0.86	(0.79, 0.94)	***	0.81	(0.73, 0.90)	***
	Level 3	1.00	(0.74, 1.37)		0.57	(0.38, 0.87)	**
	Level 4	0.86	(0.75, 0.98)	*	0.97	(0.84, 1.12)	
	Level 5	0.80	(0.66, 0.98)	*	0.87	(0.70, 1.08)	
	Level 6	0.55	(0.33, 0.92)	*	0.82	(0.50, 1.35)	
	Level 7	0.71	(0.59, 0.85)	***	0.68	(0.55, 0.84)	**
	Level 8	0.62	(0.42, 0.91)	*	0.55	(0.35, 0.87)	**
	Level 9	0.75	(0.48, 1.17)		0.84	(0.53, 1.35)	
	Level 10	0.75	(0.64, 0.87)	***	0.74	(0.62, 0.89)	***
Recreation county (ref. = no)	Yes	1.42	(1.29, 1.55)	***	1.29	(1.17, 1.42)	***
Retirement county (ref. = no)	Yes	1.22	(1.17, 1.27)	***	1.33	(1.27, 1.38)	***
Age * RUCA (ref. = most urban, Level 1)	Level 2	1.17	(1.06, 1.29)	**	1.66	(1.50, 1.85)	***
	Level 3	1.32	(0.91, 1.91)		1.98	(1.34, 2.93)	**
	Level 4	1.11	(0.95, 1.29)		1.17	(1.01, 1.35)	*
	Level 5	1.08	(0.85, 1.37)		1.84	(1.48, 2.30)	***
	Level 6	1.56	(0 87, 2.81)		2.61	(1.53, 4.39)	**
	Level 7	1.14	(0.92, 1.42)		1.55	(1.26, 1.92)	***
	Level 8	1.55	(0.98, 2.44)		2.80	(1.78, 4.41)	***
	Level 9	0.71	(0.40, 1.25)		1.84	(1.08, 2.93)	*
	Level 10	1.26	(1.05, 1.51)	*	1.71	(1.43, 2.04)	***
Male * RUCA (ref. = most urban, Level 1)	Level 2	0.89	(0.81, 0.98)	*	0.85	(0.77, 0.94)	**
	Level 3	0.72	(0.50, 1.03)		0.97	(0.66, 1.43)	
	Level 4	1.02	(0.88, 1.18)		1.00	(0.86, 1.16)	
	Level 5	0.84	(0.67, 1.06)		0.84	(0.68, 1.06)	
	Level 6	0.68	(0.38, 1.22)		0.57	(0.35, 0.92)	*
	Level 7	0.90	(0.73, 1.12)		0.95	(0.76, 1.18)	
	Level 8	0.67	(0.42, 1.05)		0.85	(0.55, 1.31)	
	Level 9	0.97	(0.58, 1.63)		0.66	(0.41, 1.08)	
	Level 10	0.79	(0.66, 0.95)	*	0.86	(0.72, 1.03)	
Household income >$100,000 * RUCA (ref. = most urban, Level 1)	Level 2	0.99	(0.89, 1.09)		0.85	(0.76, 0.96)	**
	Level 3	0.55	(0.34, 0.89)	*	1.55	(1.02, 2.36)	*
	Level 4	1.01	(0.84, 1.21)		0.97	(0.79, 1.18)	
	Level 5	1.27	(0.97, 1.68)		0.68	(0.49, 0.95)	*
	Level 6	0.82	(0.37, 1.82)		0.45	(0.18, 1.09)	
	Level 7	1.10	(0.83, 1.46)		1.04	(0.76, 1.42)	
	Level 8	1.04	(0.56, 1.93)		0.38	(0.16, 0.92)	*
	Level 9	1.38	(0.73, 2.59)		1.24	(0.65, 2.38)	
	Level 10	0.90	(0.70, 1.17)		0.98	(0.75, 1.26)	

NOTE: Ref. = reference category; AIC = Akaike information criterion.
[a]Summary statistics: $N_{\text{total}} = 270{,}654$; $N_{\text{bike one time = 1 or bike three times = 1}} = 15{,}884$; AIC intercept only = 120,898.10; AIC intercept and covariates = 108,031.75.
[b]Summary statistics: $N_{\text{total}} = 285{,}634$; $N_{\text{bike one time = 1 or bike three times = 1}} = 14{,}980$; AIC intercept only = 117,484.21; AIC intercept and covariates = 98,362.92.
* $p < .05$, ** $p < .01$, *** $p < .001$.
SOURCES: Rural Health Research Center. 2016. http://depts.washington.edu/uwruca/ruca-codes.php. U.S. Department of Transportation. 2010.

TABLE 3 Logistic Regression Models for Bicycling Frequency by Population Density, 2009 National Household Travel Survey

		Bicycling 1–2 Times per Week Versus 0 Times[a]			Bicycling 3 Times per Week or More Versus 0–2 Times per Week[b]		
Variable	Category	Odds Ratio	95% Confidence Interval	Probability	Odds Ratio	95% Confidence Interval	Probability
Sex (ref. = female)	Male	1.71	(1.61, 1.81)	***	2.18	(2.04, 2.33)	***
Age (ref. = 18+)	Under 18	7.04	(6.61, 7.51)	***	7.90	(7.40, 8.44)	***
Race/ethnicity (ref. = white)	African-American/ black	0.73	(0.67, 0.79)	***	0.84	(0.78, 0.91)	***
	Asian	0.85	(0.76, 0.94)	**	0.66	(0.58, 0.74)	***
	American Indian, Alaskan Native	0.73	(0.59, 0.90)	**	0.86	(0.70, 1.05)	
	Native Hawaiian–other Pacific	1.00	(0.77, 1.30)		0.73	(0.53, 0.99)	*
	Multiracial	0.90	(0.73, 1.10)		1.10	(0.90, 1.33)	
	Hispanic	0.89	(0.81, 0.97)	**	0.82	(0.74, 0.90)	***
	Other	0.86	(0.74, 1.01)		0.80	(0.67, 0.95)	**
Children in household (ref. = no)	Yes	2.16	(2.06, 2.25)	***	1.34	(1.26, 1.41)	***
Household income >$100,000 (ref. = no)	Yes	1.52	(1.43, 1.61)	***	1.17	(1.09, 1.25)	***
Population density (ref. = urban)	Rural	0.86	(0.79, 0.93)	***	0.80	(0.73, 0.88)	***
	Low-density suburban	0.97	(0.89, 1.05)		0.90	(0.82, 0.99)	*
	Suburban	1.04	(0.95, 1.14)		0.99	(0.89, 1.10)	
	High-density urban	0.69	(0.55, 0.85)	***	0.99	(0.79, 1.25)	
Recreation county (ref. = no)	Yes	1.30	(1.19, 1.42)	***	1.28	(1.17, 1.40)	***
Retirement county (ref. = no)	Yes	1.21	(1.16, 1.26)	***	1.32	(1.27, 1.38)	***
Age * density level (ref. = urban)	Rural	1.28	(1.17, 1.40)	***	2.08	(1.89, 2.28)	***
	Low-density suburban	1.28	(1.17, 1.39)	***	1.73	(1.57, 1.90)	***
	Suburban	1.05	(0.94, 1.17)		1.37	(1.22, 1.53)	***
	High-density urban	0.81	(0.64, 1.03)		0.50	(0.40, 0.64)	***
Male * density level (ref. = urban)	Rural	0.82	(0.75, 0.90)	***	0.75	(0.68, 0.83)	***
	Low-density suburban	0.88	(0.81, 0.96)	**	0.79	(0.72, 0.87)	***
	Suburban	0.93	(0.84, 1.04)		0.88	(0.79, 0.99)	*
	High-density urban	1.32	(1.04, 1.67)		1.37	(1.07, 1.76)	*
Household income >$100,000 * density level (ref. = urban)	Rural	0.96	(0.87,1.06)		0.91	(0.82, 1.01)	
	Low-density suburban	0.91	(0.87, 1.06)		0.79	(0.71, 0.87)	***
	Suburban	0.89	(0.80, 0.99)	*	0.85	(0.75, 0.96)	***
	High-density urban	0.89	(0.69, 1.17)		0.82	(0.61, 1.09)	

[a]Summary statistics: $N_{\text{total}} = 270{,}654$; $N_{\text{bike one time = 1 or bike three times = 1}} = 15{,}884$; AIC intercept only = 120,898.10; AIC intercept and covariates = 108,034.40.
[b]Summary statistics: $N_{\text{total}} = 285{,}634$; $N_{\text{bike one time = 1 or bike three times = 1}} = 14{,}980$; AIC intercept only = 117,484.21; AIC intercept and covariates = 98,147.92.
*$p < .05$; **$p < .01$; ***$p < .001$.

two groups at the center of efforts to expand the reach of bicycling beyond adult men.

Youths More Likely to Bicycle in RSLD Environments

Although bicycling frequency is highest in urban places according to both the RUCA and population density definitions of urban–rural status, the relationship between bicycling and urbanicity was reversed when age (under 18 years old) was considered as an interaction term.

For the population density definition, younger people were more likely than adults to report bicycling one or two times in the previous week when they lived in rural or low-density suburban places [OR = 1.28 (1.17, 1.40) and OR = 1.28 (1.17, 1.39), respectively]. The differential effects of urban–rural status were stronger for bicycling three or more times in the previous week. Youths in rural places had twice the odds of bicycling as adults in urban places [OR = 2.08 (1.89, 2.28)]. In addition, youths who lived in the high-density urban category were less likely to bicycle three or more times per week compared with adults in the urban category [OR = 0.50 (0.40, 0.64)].

The results were mixed for the RUCA definition: for each level of the urban–rural continuum, youths were increasingly likely to bicycle in more rural places when bicycling three or more times per week was considered, but this relationship was true for only Levels 2 and 10 when bicycling one or two times in the previous week was considered.

Rural and Suburban Environments May Be More Amenable to Women's Bicycling

Men were more likely than women to report bicycling three times per week or more in the high-density urban places, but this outcome was less likely at every other level of the urban–rural continuum. The results were similar for bicycling one or two times per week, but the effect was significant only for rural and low-density suburban places. For both outcome variables, male respondents from high-density urban area were more likely to bike compared with the female respondents from urban areas [OR = 1.32 (1.04, 1.67), OR = 1.37 (1.07, 1.76), respectively]. These results were weaker for the RUCA definition.

Interaction Effects Mixed with Respect to Income

The interaction term with household income did not reach statistical significance for most categories of urban–rural status. Certain RSLD environments appeared to support bicycling among households with incomes lower than $100,000 per year, but the effect depended on the definition of the urban–rural continuum.

CONCLUSIONS

In this study, the hypothesis that bicycling is primarily an urban activity was tested. Bicycling was found to be primarily, but not exclusively, urban. In certain types of places, RSLD residents are as likely to bicycle as their urban counterparts. The most important finding, however, is that the population characteristics of urban and RSLD bicyclists are different.

First, young people had lower odds of bicycling in high-density urban places, compared with other environments. This means that a paradigm of bikeable communities that replicates patterns of urban bicycling that work well for adults may exclude children and youths. For example, a policy and programming emphasis that encourages employers to support bicycling for commuting (e.g., a bike to work day) would not be widely relevant to people who do not have an employer. However, this is not to say that youths and children would not benefit from utilitarian bicycling options. Youths and children do not drive cars and therefore their relatively limited mobility may be expanded by bicycling. Useful models for youth-oriented bicycle mobility could emerge from RSLD settings.

Second, on the basis of a population density definition of RSLD places, women had lower odds of bicycling in high-density urban places compared with those with relatively lower population densities. Despite efforts from mainstream bicycle advocacy groups to increase women's cycling, an underlying urban bicycling paradigm may also be a mismatch, holding back programs to create gender parity in bicycling. The reasons for this difference are unknown but may include different levels of comfort bicycling with heavy traffic, or perhaps different underlying activity patterns across settings.

It was also found that for both dependent variables, and for both the population density and RUCA models, respondents residing in recreation counties and retirement counties had higher odds of reporting bicycling in the previous week. This suggests that niche environments combining social, cultural, and built environment factors may be more relevant to bicycling than constructs representing urban–rural status. In addition to offering amenities that support bicycling, these places may encourage bicycling for economic reasons. Research on rural economic development has found that economic growth, population growth, and land development in recreational places are accompanied by a higher cost of living, particularly higher housing costs (*31*). Therefore, if bicycling is a lower-cost mode of transportation in expensive recreational settings, particularly rural recreational settings, bicycling may be used to offset higher housing costs. This example suggests a need to better understand the nature of bicycling in RSLD places. If bicycling for transportation purposes is more common among lower socioeconomic groups, then considering the transportation and commuting needs of RSLD residents is an important topic for future research and policy with respect to promoting bicycling in RSLD places.

Other results from this study are consistent with prior research, particularly the propensity to bicycle among groups with higher socioeconomic status. For example, respondents with household incomes of more than $100,000 per year had higher odds of bicycling compared to those with incomes of less than $100,000. Additionally, respondents who identify as white had higher odds of bicycling compared with most other racial or ethnic groups. These findings may vary by trip purpose, which was not controlled for; this is a limitation of this study. A further limitation is the potential undercoverage of nonwhite travelers in the NHTS data, as well as of other groups that may be hard to reach given the survey's methods. These respondents who are difficult to reach may include bicyclists across urban and RSLD places, and the potential bias caused by their missing data is unknown. Data collection and research designs that capture information about hard-to-reach populations are next steps for understanding the full reach of bicycling across places and populations.

Future research on bicycling in RSLD places should also investigate whether the cultural meaning of bicycling differs between urban and RSLD places in ways that are important for how communities approach bicycle policy, planning, and design. For example, an urban model of bicycling that emphasizes an urban built environment and a car-free lifestyle may conflict with a smaller community's values, lifestyles, and physical environments. Specialized data collection and analysis comparing RSLD and urban places with respect to motivations for bicycling and the strategies that they use to create a bikeable community are important next steps.

ACKNOWLEDGMENT

This research received support from the University of Colorado, Denver.

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The Standing Committee on Bicycle Transportation peer-reviewed this paper.