Factors affecting bicycling demand: Initial survey findings from the Portland region

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ABSTRACT

Levels of bicycling in the U.S., particularly for non-recreation purposes and among adults, are very low. Only about one percent of the trips people make in the U.S. are on bicycles, including less than five percent of trips under one-half mile. Factors influencing rates of cycling include demographics and environmental factors. Environmental factors can be measured both objectively (e.g. miles of bike lanes, average temperature, and street connectivity) and subjectively (e.g. people's rating or perception of the bicycling environment). People's attitudes about travel and mobility also likely play a role. This paper uses results from a random phone survey of adults in the Portland, Oregon region to explore the relationships between levels of cycling and demographics, objective environmental factors, perceptions of the environment, and attitudes. The survey revealed several significant differences, though additional analysis is necessary. Objective measures of proximity to off-street trails and bike lanes was not associated with higher levels of cycling. However, positive perceptions of the availability of bike lanes was associated with more cycling and the desire to cycle more. Higher levels of street connectivity were associated with more cycling for utilitarian trips.

INTRODUCTION

With rates of obesity, heart disease, and related health problems increasing in the U.S., health professionals, urban planners, and policy makers are looking for ways to increase physical activity through changing urban form. Much of the focus is on walking. While walking is an attractive option for many reasons, bicycling offers many benefits and warrants further research. According to the 2001 Nationwide Household Travel Survey (NHTS), over 60% of all personal trips are five miles or less in length – a reasonable distance to ride a bike – and nearly 40% are two miles or less. However, only about 14% are within reasonable walking distance, ½ mile or less. Despite the potential, only about one percent of the trips people make in the U.S. are on bicycles, including less than five percent of trips under ½ mile. There are, however, some communities where bicycle use is much higher. Bicycle use in several European countries is over ten times higher than the U.S., even with high standards of living and relatively high auto ownership (1, 2). In addition, bicycles are used more often in these countries for utilitarian purposes, rather than just for recreation. In the U.S. there are some cities, particularly college towns, with particularly high rates of cycling – ten percent and more of commute trips (3). Even for large cities, rates of bicycling for commuting can range from nearly zero to about three percent (4). In addition, bicycling is a popular form of recreation throughout the country. A 2002 nationwide survey of people 16 and older found that 27% had bicycled in the past 30 days, with recreation being the most common purpose (5). Data from the 2001 Nationwide Household Travel Survey indicates that about half of the households in the U.S. have an adult-sized bicycle.

Given the potential for bicycling for both utilitarian travel and recreational purposes, why aren't more people cycling? There is very little research in the U.S. on bicycling. What does exist provides some general indications, but is limited in scope and often employs unreliable methods (6). This research project aims to help fill some of the gaps in knowledge. Specifically, the project aims to examine the relationship between community environmental factors (e.g. bicycle infrastructure, land use, network connectivity, etc.) and people's decision to bicycle, along with other intervening factors influencing the decision to bicycle, such as weather, topography, attitudes and perceptions of subjective and objective factors, and socio-demographics. The first part of the project, some results of which are presented in this paper, involved a survey of a random sample of adults in the Portland, Oregon region with extensive questions about bicycling.

LITERATURE REVIEW

There are many factors that influence a person's decision to bicycle (3). These factors can be categorized as (1) objective or environmental; (2) subjective; and (3) demographic. While the *National Bicycling and Walking Study* identified a comprehensive range of factors, there is limited objective evidence as to how these factors influence the *decision* to bicycle.

Objective environmental factors include climate/topography, land use, and infrastructure. Infrastructure includes the bicycle facility network (lanes, paths, shared roads, etc.), bicycle parking, and support facilities (e.g. showers at work sites and racks on buses), as well as the infrastructure provided for other, competing modes. Several studies support the notion that providing bicycle infrastructure, particularly lanes and paths, can increase bicycle use. However, most of the existing research relies upon aggregate data, stated preference questions, and/or limited populations. A study of large cities in the U.S. found that higher levels of bicycle commuting were associated with higher densities of bicycle lanes (4). Similar results were found in the Portland region at the census tract-level (7). These studies, however, relied on Census data at the aggregate level, making it difficult to examine the direct relationship between infrastructure and behavior. Moreover, commuting is only one trip purpose. Several studies have shown that cyclists prefer to use bike lanes or paths and may take a slightly longer route to use such facilities (8, 9). In an intercept survey of commuting cyclists at four locations in Seattle, Shafizadeh and Niemeier (10) concluded that some cyclists may travel further distances on separate paths, compared to cycling on streets with vehicles. However, all of these studies are based primarily on responses from regular cyclists. A random survey of Seattle area residents found that proximity to a trail increased the likelihood of cycling, but bike lanes did not (11).

Given the lack of bicycle lanes in most areas, the street network is relied upon by most cyclists for utilitarian cycling (12). The level of connectivity of a street network may affect cycling rates, particularly for utilitarian cycling. Travel behavior theory is based largely on the concept that people want to minimize their travel time. For a cyclist, this would mean having the most direct route between his or her origin and destination. A more connected network (e.g. grid versus cul de sacs) should provide shorter routes, in addition to a choice of routes. Some studies using travel survey data have found positive correlations between network connectivity and non-auto travel (13). Commuter cyclists in Ontario, Canada were found to deviate only slightly from the most direct route, indicating a preference for on-road facilities for utilitarian cycling and the importance of connectivity (14).

Observations of cyclists on the road indicate that the type and width of a bicycle facility has a significant effect on the distance between cyclists and motor vehicles (15). Landis, Vattijuti and Brannick (16) found that pavement condition, motor vehicle volumes and speeds, and the width of the outside motor vehicle lane are important factors in the level of comfort experienced by cyclists. However, neither of these studies is able to make the link between these facility characteristics and the likelihood of using a bicycle for travel or recreation.

Land use determines the location of origins and destinations; when combined with infrastructure, it determines the objective length of potential bicycle trips. However, even less research exists linking bicycling and land use, compared to infrastructure. This is partly because of the low rate of bicycling in urban areas, where extensive travel surveys are conducted. These travel surveys are often the basis of research linking travel behavior and urban form. However, they are often based on one day diaries that may miss many bicycling trips. Many of the studies combine walking and bicycling into a single category because of the lack of data. There are a few exceptions. In a study of San Francisco Bay Area residents, Cervero and Duncan (13) found that increased land use diversity at a trip origin increased the likelihood that a trip would be made on bike, as did bike friendly design, including street network connectivity. In their research in the Seattle area, Moudon et. al. found that the presence of convenience stores had a negative impact on cycling, particularly when the size of the parcels was taken into account. Potential reasons for this finding were that such stores are often located with a gas station and/or along major arterials. The study also found that subjectively measured environmental variables, e.g. the respondent's perception of their neighborhood, were important. In particular, the perceived presence of bike lanes and trails was associated with more cycling, while the presence of destinations such as stores and schools was negatively associated with levels of cycling (11).

Climate and topography likely influence the choice to bicycle. Cold and wet weather is generally considered a deterrent to bicycling (17). Dill and Carr (4) found that the number of days of rain was negatively correlated with bicycle commuting. However, some of the top bicycling cities have wet and cold winters, including Minneapolis, MN and Portland, OR. The impact of terrain is less clear. A study in the Portland region found a weak negative relationship between slope and bicycle commuting (7). In a stated preference survey, Stinson and Bhatt (9) found that cyclists preferred flat ground and moderate hills over very steep hills. But, the survey respondents were self-selected and included a high share of active cyclists. This may have resulted in the second finding that cyclists preferred moderate hills to flat ground. Cervero and Duncan (13) found that increased slope decreased bicycling and that rainfall did not dissuade people from bicycling. While these factors are beyond the direct control of policy makers and planners, understanding their influence on cycling behavior can improve policy making. For example, some cities may inappropriately dismiss cycling as an option if they think the influence of these factors is stronger than it is. Providing bicycle facilities may, in fact, diminish the impact of rain and hills to some extent. Or, providing bike access on transit may provide an option for regular cyclists on poor weather days, or in the uphill direction of their round-trip. This research will help provide this policy guidance.

Subjective factors include safety perceptions, convenience, cost, time valuation, exercise valuation, habits, attitudes/values, and peer group acceptance. The *National Bicycling and Walking Study* also includes distance as a subjective factor because each individual decides what distance is acceptable for bicycling. In addition, a person's perception of the environment and infrastructure may not match the objective measure and can influence decisions (18). All of these subjective factors may vary by trip purpose and by demographics.

Perception of safety is perhaps one of the most important factors influencing the decision to bicycle. The perception that cycling is more dangerous is somewhat justified. In 2001, bicyclists in the U.S. were 12 times more likely to get killed than car occupants per mile traveled (19). Many researchers have examined how specific infrastructure features impact cyclists' route choice or sense of safety, through both revealed and stated preference techniques. The research often relies upon regular or expert cyclists. This research has found that cyclists prefer striped bike lanes over wide shoulders, for example (16). While useful to transportation planners in designing facilities, it does not provide clear insight into how to get non- or irregular-cyclists to cycle more. A 2002 survey found that adults who had not bicycled in the past 30 days were less satisfied with how their communities were designed with regards to bicycle safety (5). Additional bicycle facilities was the most frequently recommended change to the community respondents asked for. However, the survey did not have data on the actual levels of bicycle infrastructure in the respondents' neighborhoods. Perceptions of neighborhood crime may also influence the decision to bicycle.

Attitudes can also have a significant influence on travel behavior and physical activity. A study of five neighborhoods in the San Francisco Bay Area found that attitudes related to urban life, such as being pro-environment, were significant factors in explaining people's travel behavior (20). Psychosocial factors are also important explanatory factors, including social support, self-efficacy, and positive beliefs about physical activity, and may interact with the environmental characteristics in the decision to bicycle (18).

Demographic factors can include physical condition, family circumstances, income, age, race/ethnicity, immigration status, and sex, among others. A recent nationwide survey of people 16 and older found that 27% had bicycled within the past 30 days. Of these, Hispanics were most likely to have cycled, followed by non-Hispanic whites, other races, and blacks (5). This survey and data from the 1995 Nationwide Personal Transportation Survey indicate that men are more likely to bicycle than women, and age is negatively correlated with bicycling (1). There is conflicting evidence on the correlation of bicycling with income (1, 3). The Seattle study by Moudon et. al. found that cycling increased for white, middle-aged, and male respondents, as well as people who spend fewer hours at work and have more than one car per adult (11). With respect to age, they found that people 25-45 rode more than those 18-21.

METHDOLOGY

Background

The lack of good information on cycling is a problem. The Bureau of Transportation Statistics (BTS) identified "comprehensive and systematic data on usage, including potential usage" as perhaps the highest priority for bicycle data needs (6). BTS also identified "data on user preferences, attitudes, and expressed needs of existing and potential bicyclists and pedestrians" as an important priority.

Much of the literature examining the link between urban form and travel behavior from the planning field uses travel or activity diaries (18). These self-report techniques are not ideal for bicycle research. Most diaries cover only one or two days of travel. Cyclists may not ride their bike every day. While this will average out over a large random sample, there are often not enough bicycle trips to analyze them in detail. Some researchers thus combine bicycle and walking trips. Moreover, many researchers believe that respondents forget to report their walking and bicycling trips, particularly recreational trips. Large scale travel surveys also rarely ask questions about attitudes and perceptions that influence decisions regarding cycling. Similarly, the Census provides data on commuting, including bicycling, but lacks information on subjective and most environmental factors. Other surveys also only collect information on commuting. But, commute trips are only a fraction (less than 20-30% in most areas) of all trips. Finally, because bicycling is generally considered a "fringe" mode by many transportation planning agencies, little funding has been devoted to research in this area. Some of the studies mentioned above rely on low-cost methods (e.g. internet surveys) that reduce validity. With increasing interest in walking and cycling, there have been more recent efforts that focus on these modes, including that by Moudon and colleagues in the Seattle area (11).

Portland Survey

The survey discussed in this paper is part of a larger project examining the effects of the built environment on bicycling behavior. The second part, currently underway, involves using GPS technology to measure actual bicycle use. The survey was conducted in November 2005 in the Portland, Oregon metropolitan region, using random digit dialing with a sample of phone prefixes for zip codes located within the region’s urban growth boundary. The survey included an initial question that eliminated people with a physical limitation that prevented them from riding a bicycle. There were 566 completed surveys from adults 18 an over, representing 23% of the eligible phone numbers. Early on the survey also asked people how they would describe themselves as a bicyclist. Respondents indicating that they never ride a bicycle did not answer questions in sections A and B. Of the 566 respondents, 221 (39%) categorized themselves this way. Just over half (51%) said that they rode a bicycle occasionally, and 10% said that they rode regularly.

The survey including the following sections of questions:

A. Riding in the past summer and non-summer months. This included questions about how many times the person rode their bike for various purposes per month and how long they rode their bike. The section included specific questions about riding on off-street paths, the amount of riding compared to last year, experience with collisions.

B. Bike trip data. The respondent was asked to remember the last day they rode their bike from their home in the previous three months. For each trip, the survey collected information on the origin, destination, types of facilities they rode on, trip purpose, trip length, car availability, reason for bicycling, and threats experienced on the trip(s).

C. Experiences with bicycling and other forms of travel. This section asked about experience cycling as a child, cycling habits of household members, neighbors, and co-workers, perceptions of neighborhood environment, barriers to bicycling, importance of bicycle infrastructure in choice of residence, and attitudes about mobility and various modes of travel.[1]

D. Demographics. This section included standard demographic questions (sex, age, income, education, employment, race/ethnicity), as well as questions about overall health, number of vehicles in the home, and home location (to allow the geographical analysis, below).

As with most survey methods, trade-offs were made in the research design. Compared to many travel and activity surveys, the focused phone survey allowed for more in depth questioning of cycling behavior, experiences, and attitudes. However, because the survey relied on recall of events (riding a bicycle) that may have happened days, weeks or even months earlier, the data may not be as accurate as with a travel diary.

Geographical Analysis

In addition to the survey data, this analysis used the 2005 release of the Regional Land Information System (RLIS) from Metro (Portland’s regional planning agency) for information on streets and the bike lane and path network, and 30 Meter National Elevation Dataset (NED) data from the USGS for elevation information. Data were formatted and manipulated as ESRI shapefiles and grids. ArcView 3.3 plus extension “Point and Polyline Tools,” as well as ArcGIS 9.1 plus the “Hawth’s Analaysis Tools” and “Spatial Analyst” extensions were used to perform analysis.

Survey respondents’ home addresses were geocoded using RLIS street data. Of the 566 respondents, 10 refused to give any address information, 99 gave street intersections, and 457 gave a house number and street. The geocoding occurred in two phases. During the first run, an

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[1] The attitude questions were developed by Susan Handy and Patricia Mokhtarian at the University of California, Davis and used with permission.

address locater based solely on street address was used to perform an automated match with spelling sensitivity set to 80, match score at 30 and potential match at 10. Interactive matching was then performed on addresses that did not meet the criteria of the automated process. If unmatched addresses had one or more candidates, the most appropriate location was chosen based on human judgment. Addresses that were tied, or had no candidates were bypassed. During the second run, the addresses that possessed a tied match score, as well as unmatched addresses were examined. In some cases, mistakes in spelling or incomplete information were found and corrected. After this second process 79% of the sample matched with a score of 80 – 100 (397), 25% of the addresses matched with a score below 80 (143) and 5% of the sample remained unmatched (26). After this second matching effort errors were analyzed, and addresses were grouped into three quality categories based on a quality score of 0 – 100. Matches with scores between zero and 40 could not be matched to any location or, because of missing information, had so many address possibilities that it was impossible to determine which street or intersection was referenced. Matches with scores ranging from 41 to 57 usually had missing suffix information (e.g. NE or SE). In the City of Portland, where most addresses are identified in part by their directional suffix, an address missing this information could easily be located in at least two geographic areas. Therefore, they were not included in the analysis. Imperfect matches scoring from 69 to 100 usually had correct directional prefixes, but were often missing the suffix for road type. All of these addresses were included in the analysis, 106 of which scored 69-80. Therefore, of the 556 respondents who provided some address information, 503 were geocoded and used in this analysis. The respondents were distributed throughout the region (Figure 1).

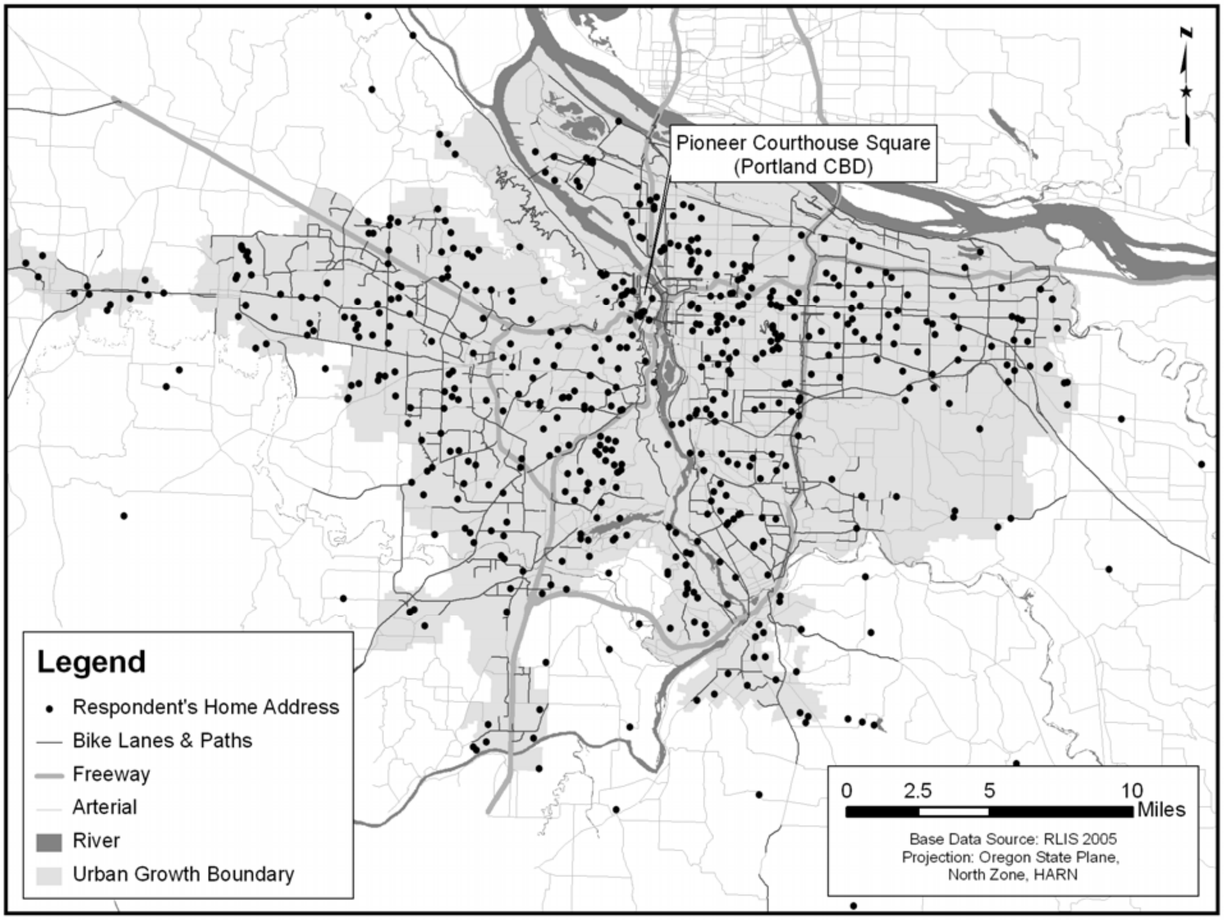

Figure 1: Survey respondents and the bicycle network

After geocoding, the addresses were buffered to measure urban form within one-quarter mile of each respondent. Measurements within this buffer included density of striped bike lanes (miles per square mile) as well as functional street classes defined as freeways, arterials, local streets and other. The average percent slope of each area was taken to determine what sort of topographic challenges a respondent might face near their home. Measures of street connectivity included connected node ratio (CNR) and intersection density (number of intersections per square mile). In GIS, a node represents each end of a road segment, including intersections and dead ends or the end of cul-de-sacs. CNR is a ratio of number of nodes that are intersections (hence “connected”) divided by the total number of nodes. In an area with a grid street system and no dead ends, the CNR would be 1.0. A lower CNR means that the network is less connected, with fewer direct routes between two points. A less connected network will usually lead to increased travel distances.

Two variables were created to measure a survey respondent’s proximity to attractive biking locations – regional off-street trails and downtown Portland, a commercial and cultural hub. Off-street trails of regional importance, classified by Metro, were buffered at distances of one-quarter, one-half, and one mile. To determine the distance from downtown, Pioneer Court House Square, Portland’s ‘living room’ was chosen as a central location to measure length. Metro’s street layer, minus road facilities closed to non-motorized vehicles, was used to calculate trip length from each geocoded address.

FINDINGS

Given the extensive data collected from the survey, only selected results are presented here. Each respondent was first categorized based upon a combination of how they described themselves as a cyclist and how often they stated that they rode during the past summer and during non-summer months. Three categories were developed:

- **Non-cyclist:** Respondents who said "I never ride a bicycle" (39%) and who claimed to be an occasional or regular cyclist, but when asked, did not ride during the past summer or in non-summer months (11%)
- **Irregular cyclist:** Respondents who rode in the past summer, but not in non-summer months (21%) and those that rode year-round, but less than once a week year-round (9%)
- **Regular year-round cyclist:** Respondents who rode year-round, including once a week or more in summer and/or non-summer (20%)

The share of respondents in each category is noted above. However, it should not be assumed that this represents the distribution of adults in the Portland region. While the survey was conducted using random digit dialing, the respondents do no necessarily represent the population. The analysis of the data focuses on similarities and differences between these groups, rather than the size of each group. The categorization may be useful if one policy objective is to increase the amount of cycling. The irregular cyclists are likely targets for policy, planning, and marketing efforts, rather than non-cyclists. Understanding more about them may help inform these efforts.

In addition, respondents were categorized by whether they made a utilitarian trip on their bike in the past summer. This included any trips for work, school, shopping, dining out, running errands, visiting people, going to the movies, "or similar activities with a destination." Respondents who never rode or only rode for recreation and exercise were categorized as "no" for this analysis (78% of respondents). This variable was created because some urban form features may influence the rate of utilitarian cycling differently than overall cycling. For example, if trails and paths nearby don't connect to destinations such as workplaces or stores, the facilities may encourage recreational but not utilitarian cycling. Similarly, a well-connected street system might encourage utilitarian cycling because destinations are closer, but have little effect on recreational cycling.

Younger adults and men were more likely to be regular and utilitarian cyclists (Table 1). The significant drop off in regular and utilitarian cycling among respondents occurred at age 55 and above. The differences between adults 18-34 years and 35-54 years old were not significant. There is no clear relationship between categories of cyclists and self-reported health status. The vast majority of respondents had a driver's license. Respondents with the highest incomes ($100,000 and above) were most likely to be regular cyclists, but not more likely to ride for utilitarian purposes. The pattern of regular and utilitarian cycling among the income groups is not straightforward. Aside from those that refused to answer the income question, respondents in the middle income category ($50,000-74,999) were least likely to be regular or utilitarian cyclists. Vehicle availability relates to rates of utilitarian cycling; 28% of respondents in households with less than one vehicle per adult make a utilitarian trip, compared to 20% of those with one or more vehicles per adult. The direction of the relationship is not clear, however. Having a vehicle available may discourage cycling, or cycling may allow households to own fewer vehicles.

Table 1: Demographics and Bicycling

	Type of cyclist				**Rode for utilitarian purpose in past summer**		
	Non-	**Irregular**	**Regular**	**n**	**No**	**Yes**	**n**
Age							
18-34	41%	32%	27%	103	68%	32%	103
35-54	39%	38%	23%	243	71%	29%	243
55-64	51%	31%	19%	107	86%	14%	107
65 and older	80%	13%	7%	110	96%	4%	110
	Chi-square significant (p<0.05)				*Chi-square significant (p<0.05)*		
Sex							
Male	43%	30%	27%	247	72%	28%	246
Female	56%	31%	13%	319	83%	17%	318
	Chi-square significant (p<0.05)				*Chi-square significant (p<0.05)*		
Health							
Poor or fair	63%	16%	21%	43	77%	23%	43
Good	51%	30%	19%	134	78%	22%	134
Very good	49%	36%	15%	210	82%	18%	209
Excellent	46%	29%	25%	177	73%	27%	176
	Chi-square not significant (p<0.05)				*Chi-square not significant (p<0.05)*		
Driver's license							
No	69%	7%	24%	29	76%	24%	29
Yes	49%	32%	19%	537	78%	22%	535
	Chi-square significant (p<0.05)				*Chi-square not significant (p<0.05)*		
Income							
< $35,000	64%	19%	17%	129	78%	22%	129
$35,000-49,999	47%	31%	22%	74	72%	28%	74
$50,000-74,999	55%	31%	14%	120	81%	19%	120
$75,000-99,999	36%	40%	23%	77	73%	27%	77
$100,000 & above	34%	36%	30%	86	77%	23%	86
Refused	54%	32%	14%	59	89%	11%	57
	Chi-square significant (p<0.05)				*Chi-square not significant (p<0.05)*		
Vehicle availability							
One or more vehicles per adult in household	48%	33%	19%	431	80%	20%	430
Less than one vehicle per adult	54%	24%	22%	134	72%	28%	134
	Chi-square not significant (p<0.05)				*Chi-square significant (p<0.05)*		

To explore the potential influence of social support systems and childhood experiences on current cycling behavior, the survey included several questions on the respondent's exposure to cycling. Half of the respondents never biked to school as a child and 31% frequently biked to school. But, equal shares of those groups are now regular year-round cyclists. There is no difference between the frequent school cyclists and non-school cyclists in the share that now cycle regularly, infrequently, only in the summer, or never. However, there was a difference with respect to how often they rode for fun or to go places other than school as a child. Overall, 73% of the respondents said that they rode a bicycle for fun or non-school destinations as a child frequently, 22% occasionally, and 5% never. Those that rode more were significantly more likely to be regular or irregular cyclists. Nearly one-third (32%) of the people who indicated that they have co-workers who cycle to work are regular cyclists, compared to 16% of those who did not have co-workers (only asked of those who work). However, it is unclear if there is a cause-effect relationship here and what that might be. For example, current cyclists might be more aware of other cyclists. Alternatively, this may be influenced by employers that have a cycling-friendly environment or location. Finally, respondents who stated that they saw adults cycling on their street once a week or more (compared to never or less than once a week) were more likely to be regular cyclists.

Table 2 shows the differences for the “objective” environmental factors – those measured using GIS tools. There are few statistically significant differences. The exceptions are for whether respondents made a utilitarian bicycle trip during the past summer. Respondents who lived in neighborhoods with higher street connectivity, closer to downtown, and closer to a freeway were more likely to ride for utilitarian reasons. These independent variables are correlated with each other; the neighborhoods closer to downtown are older, with grid street patterns. In addition, the freeway system is denser near downtown. Living in a neighborhood with a higher density of bike lanes is not related to whether people are regular or utilitarian cyclists.

Table 2: Objective environmental factors and cycling

	Type of cyclist				Rode for utilitarian purpose in past summer		
	Non-	**Irregu-lar**	**Regular**	n	**No**	**Yes**	n
Proximity to a regional trail							
Within ¼ mile	45%	35%	20%	55	**67%**	**33%**	55
Beyond ¼ mile	51%	29%	20%	448	**79%**	**21%**	447
Density of bike lanes within ¼ mile (miles of lanes per square mile)							
Lowest density Bottom 2 quartiles (0 mi/sq mi)	49%	32%	19%	256	80%	20%	255
Medium density 3rd quartile (1-2.3 mi/sq mi)	47%	31%	22%	121	71%	29%	121
Highest density 4th quartile (>2.3 mi/sq mi)	56%	25%	20%	126	80%	20%	126
Proximity to freeways (within ¼ mile)							
None	52%	29%	19%	388	**81%**	**19%**	388
One or more	43%	35%	22%	115	**68%**	**32%**	114
Street connectivity (Connected node ratio within ¼ mile)							
Least connected (<0.635)	53%	29%	17%	126	**83%**	**17%**	125
2nd quartile (.635-0.741)	60%	21%	19%	126	**84%**	**16%**	126
3rd quartile (0.742-0.887)	48%	34%	18%	126	**79%**	**21%**	126
Most connected (>0.887)	40%	35%	25%	125	**65%**	**35%**	125
Distance to downtown Portland (network distance)							
Closest (<5.06 miles)	46%	33%	22%	125	**65%**	**35%**	124
2nd quartile (5.07-8.27 miles)	44%	35%	21%	127	**76%**	**24%**	127
3rd quartile (8.28-11.88 miles)	55%	30%	15%	125	**85%**	**15%**	125
Furthest (>11.88 miles)	56%	23%	21%	126	**86%**	**14%**	126
Average slope (within 1/4 mile radius)							
Flattest (< 0.76%)	55%	26%	19%	127	76%	24%	127
2nd quartile (0.76-1.39%)	47%	32%	21%	126	74%	26%	126
3rd quartile (1.40-2.88%)	54%	27%	19%	126	82%	18%	126
Steepest (>2.88%)	44%	36%	20%	124	81%	19%	123

***Bold** indicates a significant difference, p<0.05 (Chi-square)*

There were several significant differences with respect to respondents' perceptions of their neighborhood (Table 3). Respondents who agreed that there were bike lanes in their neighborhood that were easy to get to and connect to places were more likely to be regular and utilitarian cyclists. This is in contrast to the findings above that showed no difference based on the actual density of bike lanes within one-quarter mile. This may be because people who do bicycle regularly are more aware of the bicycle facilities nearby. Respondents may also define their neighborhood at a larger scale than the one-quarter mile distance used for the GIS-based analysis above. Respondents who agreed that there were quiet streets that connected to places they needed to get to were also more likely to be regular and utilitarian cyclists. The two questions about quiet streets were intended to test that concept of bike boulevards that the City of Portland is pursuing in older neighborhoods without streets with bicycle lanes. Respondents who thought the speed of traffic on their own and nearby streets was slow were not more likely to bicycle regularly or for utilitarian purposes.

Table 3: Perceptions of environment and cycling

		% of those that dis/agree who…		
		are regular cyclists	**rode for utilitarian purpose in past summer**	n
There are off-street bicycle trails or paved paths in or near my neighborhood that are easy to get to	Disagree	16%	20%	230
	Agree	22%	24%	319
There are bike lanes in my neighborhood that are easy to get to	Disagree	**14%**	**16%**	228
	Agree	**24%**	**26%**	321
There are bike lanes in my neighborhood that connect to places I need to get to	Disagree	**16%**	**19%**	260
	Agree	**26%**	**27%**	263
There are quiet streets in my neighborhood, without bike lanes, that are easy to get to on a bicycle	Disagree	14%	**13%**	84
	Agree	21%	**24%**	465
There are quiet streets in my neighborhood, without bike lanes, that connect to places I need to get to	Disagree	**12%**	**10%**	153
	Agree	**23%**	**27%**	393
There is so much traffic along the street I live on that it make it difficult or unpleasant to bicycle in my neighborhood	Disagree	**22%**	24%	364
	Agree	**16%**	18%	196
There is so much traffic along nearby streets that it make it difficult or unpleasant to bicycle in my neighborhood	Disagree	22%	**25%**	254
	Agree	18%	**19%**	299
The speed of traffic on the street I live on is usually slow	Disagree	20%	23%	178
	Agree	19%	22%	384
The speed of traffic on most nearby streets is usually slow	Disagree	19%	21%	293
	Agree	21%	23%	264
Bicyclists on the streets in my neighborhood can easily be seen by people in their homes	Disagree	18%	**17%**	132
	Agree	20%	**24%**	413
There is a high crime rate in my neighborhood	Disagree	19%	**20%**	462
	Agree	23%	**31%**	88
There are stores and restaurants within a reasonable biking distance from my home	Disagree	19%	**11%**	102
	Agree	20%	**25%**	460

Bold *indicates a significant difference between the two proportions, p<0.05 (one-tailed)*

The survey included a series of 31 questions about their attitudes towards different travel modes and travel in general. The differences in the responses to these questions indicate that attitudes may have a significant influence over the decision to bicycle. Results for the questions where there were significant differences between the groups are shown in Table 4. Not surprisingly, respondents who like riding a bike and have other positive attitudes towards biking were more likely to be regular and utilitarian cyclists. A dislike for driving also seems to be a factor explaining cycling for utilitarian purposes. There also appears to be a relationship between environmental values and cycling. Respondents who thought air quality was a problem, try to limit their driving to help improve air quality, and thought the region did not need to build more highways were more likely to be regular and utilitarian cyclists.

Table 4: Differences between types of cyclists – Attitudes about travel

		% of those that dis/agree who…		
		are regular cyclists	**rode for utilitarian purpose in past summer**	N
I like riding a bike	Disagree	**1%**	**1%**	131
	Agree	**26%**	**29%**	427
I prefer to bike rather than drive whenever possible	Disagree	**9%**	**10%**	346
	Agree	**40%**	**45%**	202
Biking can sometimes be easier for me than driving	Disagree	**12%**	**12%**	382
	Agree	**39%**	**45%**	174
I like driving	Disagree	25%	**32%**	130
	Agree	18%	**19%**	432
Traveling by car is safer overall than riding a bike	Disagree	**29%**	**32%**	105
	Agree	**18%**	**20%**	452
I use my trip to or from work productively	Disagree	**15%**	23%	149
	Agree	**22%**	21%	391
Getting to work without a car is a hassle	Disagree	**29%**	**30%**	119
	Agree	**17%**	**19%**	430
My household could manage pretty well with one fewer car than we have	Disagree	**17%**	20%	367
	Agree	**24%**	26%	197
My household spends too much money on owning and driving our cars	Disagree	18%	**18%**	362
	Agree	23%	**30%**	193
Fuel efficiency is an important factor for me in choosing a vehicle	Disagree	**4%**	**9%**	47
	Agree	**21%**	**23%**	514
Air quality is a major problem in this region	Disagree	**17%**	**18%**	288
	Agree	**23%**	**27%**	271
I try to limit my driving to help improve air quality	Disagree	**13%**	**17%**	171
	Agree	**23%**	**25%**	383
Vehicles should be taxed on the basis of the amount of pollution they produce	Disagree	18%	**16%**	187
	Agree	21%	**26%**	361
The region needs to build more highways to reduce traffic congestion	Disagree	**23%**	**27%**	260
	Agree	**16%**	**16%**	288

***Bold** indicates a significant difference between the two proportions, p<0.05 (one-tailed)*

The last question on the list of attitudes was “I would like to travel by bicycle more than I do now.” To examine the potential to increase cycling, answers to this question were compared for different groups. Those categories for which there were statistically significant difference are shown in Table 5. As expected, few people categorized as non-cyclists want to cycle more. Over three-quarters of the other types of cyclists want to cycle more. Younger adults were more likely to want to cycle more, as were men. Respondents who rode as children for fun, rather than to school, were more likely to want to cycle more now, as were respondents who had other householders or co-workers who cycled regularly.

People who saw people riding on their street frequently were also more likely to want to cycle more. This might indicate a demand to cycle more in neighborhoods that are already bicycle-friendly. However, there were few differences in demand to cycle more with respect to perceptions of the respondent’s neighborhood. For example, respondents who were satisfied with how their neighborhood was designed for making bike riding safe were equally as likely to want to cycle more as those who were not satisfied. The two exceptions to the lack of differences were respondents who stated that they had bike lanes and quiet streets without bike lanes that connected to places they needed to get to. Those who did have connecting bike lanes and quiet streets were more likely to want to bicycle more.

Table 5: Which respondents want to travel more by bicycle

	I would like to travel by bicycle more than I do now	
	Disagree	**Agree**
Cyclist Category		
Non-cyclist	55%	45%
Irregular cyclist, summer only	17%	83%
Irregular cyclist, year-round, less than once a week	10%	90%
Regular cyclist	16%	84%
Social support		
How often respondent rode bike as a child for fun or to go places other than school		
Never	59%	41%
Occasionally	48%	52%
Frequently	25%	75%
There are other adults in household who ride bike regularly		
No	34%	66%
Yes	14%	86%
There are co-workers who ride bike regularly		
No	32%	68%
Yes	16%	84%
How often respondent sees adults riding a bike on their street		
Never	41%	59%
Less than once a week	41%	59%
One or more days a week, but not every day	30%	70%
Every day	24%	76%
Perceptions of neighborhood environmental factors		
There are bike lanes in my neighborhood that connect to places I need to get to		
Disagree	32%	68%
Agree	25%	75%
There are quiet streets in my neighborhood without bike lanes that connect to places I need to get to		
Disagree	39%	61%
Agree	27%	73%
Demographics		
Age		
18-34	25%	75%
35-54	22%	78%
55-64	35%	65%
65 and older	56%	44%
Sex		
Men	25%	75%
Women	36%	64%

All differences significant at $p<0.05$.

Another question on the survey asked about environmental barriers to biking or biking more. For those respondents who indicated that they did want to travel more by bicycle, too much traffic was the most often cited barrier (Table 6); 56% of the people who wanted to travel more by bicycle stated that this was a barrier. The next most cited barrier was having no bike lanes or trails, followed by having no safe places to bike nearby.

Table 6: Barriers to biking and biking more

Do any of the following environmental barriers keep you from biking or biking more?	% of respondents who would like to travel by bicycle more who listed this barrier
Too much traffic	56%
No bike lanes or bike trails	37%
No safe places to bike nearby	33%
Too many hills	30%
Distances to places are too great	28%
Poorly maintained streets or rough surfaces	23%
No interesting places to bike to	19%

CONCLUSIONS AND FUTURE RESEARCH

The survey found that demographic characteristics vary between types of adult cyclists and the desire to cycle more. Men and younger adults (under 55) cycled more and were more likely to want to cycle more. The relationship between income and vehicle ownership and cycling was less clear. While cycling to school as a child was not associated with higher levels of cycling as an adult, cycling for fun or to other destinations as a child was. If planners and advocates hope that increasing cycling among children will lead to more cycling among adults as they age, this finding indicates that efforts need to focus on cycling for all purposes as a child, not just to school. However, people's recollections of their childhood behavior may be influenced by other factors and may not be accurate. The survey also found that people who lived in households with other adults that cycled regularly, had co-workers who cycled to work, or who saw adults cycling on their street frequently were more likely to be regular cyclists themselves. These findings could be interpreted in different ways. On the one hand, having the social support and cues about cycling may promote more cycling. However, cyclists may just be more aware of the cycling behavior of those around them. In addition, the level of cycling at work may be a function of the work site location, facilities as work (e.g. lockers and showers), and/or type of employer.

The survey revealed some relationships between the built environment, measured both objectively and subjectively, and cycling. There was no relationship between the number of miles of bike lanes within one-quarter mile of the respondent's home and levels of cycling. This finding conflicts with other research at the aggregate level, but not the Seattle survey of adults (11). This could indicate that either bike lanes do not increase levels of cycling or that the relationship is just not revealed using the variables as they were defined here. Further analysis should be conducted with different measures of bike lane infrastructure, perhaps a measure of the connectivity of the bike lane network. In addition, different dependent variables may reveal different relationships. A dependent variable that better distinguishes between people who take their bike in their vehicle to cycle on trails elsewhere versus people who cycle in their neighborhood, for example, would be worth exploring. Respondents who lived in neighborhoods closer to downtown and with higher levels of street connectivity were more likely to have made a utilitarian bike trip in the past summer. This may indicate that street networks that provide shorter distances to destinations may increase cycling for non-recreation purposes. However, as with the findings for most of the variables examined, a multivariate analysis is necessary to more fully understand the relationship. For example, street connectivity may be positively correlated with a greater mix of land uses, and therefore, destinations.

There is a relationship between regular cycling and positive perceptions of a neighborhood for cycling. Respondents who agreed that there were bike lanes in their neighborhood that were easy to get to and connected to places they needed to go and that there were quiet streets that connected to places were more likely to be regular or utilitarian cyclists. It is difficult to know the direction of the relationship between positive neighborhood perceptions and cycling, however. Do cyclists think their neighborhood is better for cycling because they cycle and are more aware, or do their perceptions reflect the characteristics of the neighborhood and encourage them to cycle more? In addition, the lack of consistency between the findings with respect to the objective versus subjective measures of bike lane infrastructure should be explored further. How well do people's perceptions of their environment match the objective measures? If they do not match well, what might cause the difference? The findings so far indicate that current cycling behavior may influence perceptions. But, if an objective is to increase cycling among irregular and non-cyclists, it will be useful to understand what influences their perceptions. This could lead to policy responses, such as improved signage.

The survey also revealed some clear relationships between attitudes towards various travel modes and levels of cycling. Attitudes towards bicycling, driving, and the environment relate to levels of cycling. The question remains as to the relative role of attitudes compared to the other factors, including the built environment. This question must be explored using multivariate analysis.

Finally, a majority of respondents indicated that they wanted to cycle more. The most common environmental barrier keeping them from cycling more was "too much traffic," cited by 56% of those who wanted to cycle more. Not having bike lanes or trails was a barrier for 37% of the respondents who wanted to cycle more. Further analysis of the data revealed that people citing this as a barrier did have significantly fewer bike lanes within a mile of their home. Further analysis of this data may help identify appropriate responses to increase cycling rates.

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