

1 **Perceived Safety and Separated Bike Lanes in the Midwest: Results from a Roadway Design**  
2 **Survey in Michigan**

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1 **ABSTRACT**

2 This article presents the results of an address-based sample survey (n=351) conducted in the fall of  
3 2016 for the Michigan Department of Transportation (MDOT) as part of an effort to provide  
4 guidance for building sidepaths. The survey investigated attitudes toward bicycling among drivers  
5 and bicyclists, bicycling habits, barriers to bicycling, and roadway design preferences regarding  
6 bicycle infrastructure in Michigan. In particular, this survey explored design preferences while  
7 bicycling with children, bicycling by oneself, and driving.

8 Safety emerged as a key barrier to cycling, as did distance, weather, and the difficulty of carrying  
9 things or traveling with others. Roadway design preferences were clearly weighted toward greater  
10 separation when sharing the roadway whether as a bicyclist or a driver, and this trend was most  
11 pronounced ( $p<0.001$ ) when considering bicycling with children. In all cases, ratings for one-way  
12 separated bike lanes were similar to those for sidepaths, suggesting that separated bike lanes could  
13 be a key part of addressing safety and comfort concerns of more cautious riders. Preferences for  
14 separation were strongly associated with perceived safety as a barrier. These results were even  
15 stronger for non-transport cyclists, although all groups, regardless of frequency or type of cycling,  
16 preferred more separation.

17 These results corroborate past research and add compelling evidence for separated facilities as a key  
18 part of expanding the potential for bicycling trips in general, and particularly with children. The  
19 survey findings will inform guidance about sidepath design for MDOT.

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## 1. INTRODUCTION

The last two decades have seen tremendous growth in bicycling in the U.S. In the last decade alone, major U.S. cities have experienced an average 47 percent increase in bike commuting (1). In some cities, such as Lexington, Kentucky, and Portland, Oregon, the percentage of bike commuters has grown over 300 percent since 2000, and many other U.S. cities have seen growth in excess of 100-200 percent (2). This trend toward increased cycling has led to a need to better understand how to accommodate bicyclists into streets historically designed for the car. Additionally, cities attempting to encourage bicycling are exploring ways to make cycling more attractive for the “interested but concerned” cyclists, which many see as key to increasing cycling mode share (3).

This paper presents findings from research examining roadway design preferences when bicycling with children, bicycling alone, and driving on multi-lane, commercial streets. The findings are based on results from a recent survey exploring attitudes toward driving and bicycling, bicycling habits, barriers to bicycling, and roadway design preferences among Michigan residents. The results corroborate past research findings on bicyclists’ and drivers’ roadway design preferences, and contribute a new understanding of design preferences for bicyclists specifically traveling with children. These findings also clearly tie perceived safety to preferences, and support an alignment between roadway users for design preferences, with both drivers and cyclists—regardless of cycling frequency or type of bicycling—preferring greater separation on the roadway.

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## 2. LITERATURE REVIEW

### 2.1 Barriers to Bicycling

Research on barriers to bicycling in North America has documented strong desires for additional bicycle facilities. For example, in their 2009 online survey of 1,605 Texas cyclists, Sener, Uluru, and Bhat found that nearly 80 percent of respondents characterized the overall quality of bicycle facilities in their communities as “inadequate” or “very inadequate” (4). Similarly, Dill and Voros conducted a telephone survey of 566 Portland residents, and found that 37 percent of those who wanted to bicycle more reported that there were not enough bike lanes or trails near where they wanted to go (5). In their adaptive stated preference survey of 167 University of Minnesota employees, Tilahun, Levinson, and Krizek found that the presence of a bicycle lane had a much greater impact on the odds of choosing a facility than did the elimination of on-street parking or the presence of an off-road facility (6). This pattern was magnified among women, and was not significantly tied to cycling experience.

### 2.2 Bicyclists’ Roadway Design Preferences

More recent research has focused specifically on roadway design preferences. In their survey of 1,402 Vancouver cyclists (all experience levels, including potential cyclists), Winters and Teschke found that off-street paths were the most preferred by all cyclist types, while major city streets without bicycle facilities were the least preferred. Barrier-separated cycle paths next to major streets were the fourth-ranked option for potential and occasional cyclists, and ranked second and third, respectively, for regular and frequent cyclists (7). A telephone survey of 908 residents from Portland, Oregon, found similarly strong preferences—particularly among potential cyclists and women—for separated bicycle facilities (8). These results were corroborated by a more recent

1 survey of nearly 2,300 residents in five major U.S. cities (9). A separate national study of 3,000  
2 people in 50 major U.S. cities found that the “interested but concerned” group of cyclists strongly  
3 preferred separation in the form of a path or trail over a major street with a striped bike lane (3).

4 Research on route choice supports these preferences. Winters et al. examined the routes of 74  
5 participants to determine the distance people detour from the shortest path to use a bicycle facility  
6 (10). They found that bike trips were significantly more likely to occur along routes with enhanced  
7 bicycle facilities including traffic calming, stencils, and signage; while only 21 percent of trips  
8 would be along designated bike routes in a shortest path scenario, on average, 49 percent of actual  
9 trip distance took place along a bike route. Broach, Dill and Gliebe used GPS monitors to gather  
10 data on the routes of 164 cyclists over several days in Portland, Oregon. After modeling the results  
11 to account for trade-offs in topography, traffic volumes, and street network characteristics, they  
12 found that cyclists travel out of their way to reach bicycle infrastructure, and particularly bicycle  
13 boulevards (11).

### 14 *2.3 Gap in the Literature*

15 Knowing cyclists’ roadway design preferences is critical to encouraging more cycling, but research  
16 has not always examined these preferences in a nuanced way. For example, a person may prefer the  
17 most direct route when commuting, but may prioritize roads with low-stress bicycle facilities when  
18 riding with children. Furthermore, given the needs of practitioners to plan for all modes, they also  
19 need to know how motorists who share the road with bicyclists view various design options. Few  
20 studies have examined drivers’ design preferences, although Sanders (12) found strong preferences  
21 for separation among both drivers and bicyclists in the SF Bay Area. The research presented in this  
22 paper strengthens the findings about drivers’ roadway design preferences and contributes to a  
23 nuanced understanding of bicyclists’ design preferences, including how they differ when bicycling  
24 by oneself versus with children.

25

## 26 **3. METHODOLOGY**

### 27 *3.1 Survey Construction and Recruitment*

28 The findings presented in this paper are based on research conducted as part of a larger project to  
29 develop design guidance for sidepaths for the Michigan Department of Transportation (MDOT).  
30 The survey was developed based on past research on attitudes, behavior, and roadway design  
31 preferences (3, 12) and was designed to take 10-15 minutes to complete. The survey focused on  
32 drivers and bicyclists in order to capture as wide of an audience as possible, and because conflicts  
33 on sidepaths often involve motor vehicles. An effort was made to collaborate with related national  
34 research (NCHRP 08-102), and the Michigan survey modeled the NHCRP survey where feasible. In  
35 particular, the survey graphics were almost all developed by the NCHRP team (13). This  
36 collaboration will allow for certain responses to be compared to a larger sample from around the  
37 country, which may ultimately enhance the reach of the end-user tool. More detail about the entire  
38 project, including a copy of the survey, can be found in the related MDOT report (14).

39 In October of 2016, approximately 5,000 letters printed in both English and Spanish were mailed to  
40 a random selection of Michigan residents who were in the telephone directory asking them to take

1 the survey. To increase the likelihood that recipients would open the letters, the research team hand-  
2 addressed each envelope and used first-class stamps. The letter explained the purpose of the survey  
3 and directed the recipients to the website [www.michdrivebike.org](http://www.michdrivebike.org), where there was a link to take  
4 the survey in either English or Spanish; recipients could also request a paper copy of the survey.  
5 The first 250 respondents were offered a \$5 “gourmet coffee” gift card upon completion of the  
6 survey; the remaining respondents were entered into a raffle for one of twenty \$5 gift cards.  
7 Respondents were given two weeks to respond to the survey, and two reminder postcards were sent  
8 out, approximately six days apart. To mitigate potential response bias, the letter requested that only  
9 the person in the household whose birthday was most recent and who was at least age 18 take the  
10 survey.

11 Seven pairs of duplicates were detected, after which one of each pair was randomly removed from  
12 the sample. The final cleaned sample contained 351 respondents, resulting in a 4.9 percent response  
13 rate. Guidance on surveys suggests that this percentage is well within the range of what one can  
14 expect from a mail survey (15).

### 15 *3.2 Respondent Cyclist Typology*

16 To facilitate analysis, respondents were categorized according to how often they bicycled for  
17 “work/school”, “transportation other than to work or school (e.g., errands)”, and recreation or  
18 exercise. The categories equated to the following:

19 **Frequent cyclist (n=116):** Respondent who reported bicycling at least once a week for any purpose  
20 (transportation, recreation, or exercise), and not being “absolutely limited” by not having a bike or  
21 not knowing how to ride a bike.

22 **Occasional cyclist (n=83):** Respondent who reported bicycling at least once a month (but less than  
23 once a week) for any purpose, or reported biking at least once a week but also reported being  
24 “absolutely limited” by not having a bike or not knowing how to bike.

25 **Rare cyclist (n=93):** Respondent who reported bicycling occasionally, but less than once a month  
26 for any purpose.

27 **Never cyclist (n=54):** Respondent who reported never bicycling for any purpose; or who did not  
28 indicate how often they bike for a particular purpose, but is either “absolutely limited” by not  
29 knowing how to ride a bike or not owning a bike, or indicated that they “cannot bike at all”.

30 Five respondents were unable to be classified because they did not indicate: 1) how often they biked  
31 for transportation, recreation, or exercise purposes, 2) whether they can ride a bike at all, or 3)  
32 whether they are limited by not having a bike or not knowing how to bike.

33 The findings in this paper focus on roadway design preferences. Respondents were asked to  
34 indicate their agreement or disagreement with comfort for 1) bicycling by oneself, 2) bicycling with  
35 children, and 3) driving on a series of seven multi-lane, commercial roadway designs (with one two-  
36 lane exception). Agreement was measured on a five-part Likert scale, with a neutral option and the  
37 modifier “completely” for the ends of the scale. The photos, displayed together in Figure 4 on p.  
38 14, were manipulated via photo-editing software to show a variation on the original roadway  
39 design. Respondents were presented with the photos one-by-one, and the photos were randomized

1 within each survey to control for ordering effects. Respondents did not know which designs the  
2 choice set contained.

3 The results were analyzed using Microsoft Excel and the statistical package STATA. Kruskal  
4 Wallis and Wilcoxon-Mann-Whitney tests, both of which are non-parametric versions of Anova  
5 appropriate for ordinal variables, were used to determine if differences in responses between  
6 different types of cyclists were statistically significant. These instances are noted where applicable  
7 in the text.

### 8 *3.3 Limitations*

9 Due the racial homogeneity of the sample, care should be taken when extending these conclusions  
10 to races and ethnicities other than White/Caucasian. However, recent research indicates that traffic  
11 safety is a large concern within Black and Latino cyclists, as well—albeit not the only safety  
12 concern (16). As with all surveys, there may be some bias because people are more likely to  
13 respond when interested in a subject. In addition, the seven roadway designs did not represent a  
14 complete set of designs available; there may be roadway designs that respondents would have  
15 preferred more or less than the ones discussed in this paper. It also cannot be guaranteed that all  
16 respondents held the same definition of “comfort” when answering the questions.

17

## 18 **4. Findings**

### 19 *4.1 Demographic Characteristics of Survey Participants*

20 The 351 respondents live in 65 different zip codes and more than 20 different cities across  
21 Michigan. They provided their race or ethnicity, age, gender, annual household income, household  
22 composition, and bicycle and vehicle ownership, as shown in Table 1. Not surprisingly given the  
23 demographics of the state, as well as response patterns to bicycling surveys, the majority of survey  
24 respondents identified as White or Caucasian (only); the racial distribution across the different  
25 cyclist types was relatively similar.

26 The median age range of respondents was 45 to 54. Somewhat unexpectedly, there were more  
27 respondents over age 65 than between the ages of 18 and 24, which may be due to the  
28 representation of those age groups in a telephone directory-based sample. Not surprisingly, seniors  
29 were overrepresented in the “never cyclist” category (33 percent, compared to less than 20 percent  
30 of the other categories).

31 Forty-one percent of respondents identified as female. The gender split was less balanced among  
32 frequent and occasional cyclists than among rare and never cyclists, fitting with past research on  
33 cycling demographics (3, 9). Of the approximately eighty percent of the sample who provided their  
34 annual household income, the responses indicate a significantly higher percentage earning \$50,001  
35 to \$75,000 compared to all other income groups, except those whose households earn more than  
36 \$125,000 ( $p < 0.02$ ). The highest income respondents are more common among the frequent and  
37 occasional cyclists than the rare and never cyclists.

38

1 **TABLE 1. Demographic Characteristics of Survey Participants by Cyclists Type**

Demographic Characteristics	Never Cyclists (n=54)	Rare Cyclists (n=93)	Occasional Cyclists (n=83)	Frequent Cyclists (n=116)	Total (n=351) <sup>1</sup>
<b>Age</b>					
18-24	4%	3%	0%	1%	2%
25-34	7%	22%	17%	14%	15%
35-44	11%	12%	24%	19%	17%
45-54	20%	23%	23%	22%	23%
55-64	22%	22%	23%	24%	23%
65+	33%	17%	12%	19%	18%
Unknown	2%	2%	1%	2%	2%
<i>Kruskal Wallis significant (p &lt; 0.05)</i>					
<b>Sex</b>					
Female	46%	52%	37%	31%	41%
Male	52%	46%	60%	68%	58%
Unknown	2%	2%	2%	1%	1%
<i>Kruskal Wallis significant (p &lt; 0.05)</i>					
<b>Race/Ethnicity</b>					
White or Caucasian (only)	85%	81%	83%	83%	83%
Hispanic or Latino	2%	2%	4%	1%	2%
Black or African American	4%	1%	5%	3%	3%
Asian or Pacific Islander	0%	3%	4%	2%	2%
American Indian or Alaskan Native	2%	0%	0%	0%	0%
Multiracial	0%	3%	0%	2%	1%
Unknown	7%	10%	5%	10%	9%
<i>Kruskal Wallis not significant</i>					
<b>Annual Household Income</b>					
\$30,000 or less	7%	10%	8%	3%	9%
\$30,001 to \$50,000	13%	13%	7%	15%	12%
\$50,000 to \$75,000	24%	20%	13%	20%	19%
\$75,001 to \$100,000	7%	15%	18%	9%	12%
\$100,001 to \$125,000	13%	14%	10%	12%	12%
More than \$125,000	9%	8%	24%	22%	17%
Unknown	26%	20%	19%	20%	21%
<i>Kruskal Wallis significant (p &lt; 0.05)</i>					
<b>Children ≤ Age 16 in Household</b>					
None	85%	73%	59%	73%	71%
At least one	15%	27%	40%	23%	27%
Unknown	0%	0%	1%	3%	2%
<i>Kruskal Wallis significant (p &lt; 0.01)</i>					

2 <sup>1</sup> Total includes five respondents unable to be classified in the cyclist typology.

1 Nearly 72 percent of respondents reported having no children under age 16 in their household.  
2 Never cyclists were the least likely to report having children under age 16, likely related to the  
3 higher percentage of senior citizens in this group. Forty percent of occasional cyclists have at least  
4 one child in their household, suggesting the potential to make cycling easier for children may be  
5 welcomed in this group. In terms of vehicle and bicycle ownership, only 2 percent of respondents  
6 represented zero-vehicle households, 24 percent had one vehicle, and 74 percent had two or more  
7 vehicles. Similarly, 14 percent of respondents had no bicycles in their households, 19 percent had  
8 one bicycle, and 65 percent had two or more bicycles.

9 Respondents were also asked about their commute habits and how often they bicycle for  
10 “transportation other than to work or school”, fun/recreation/leisure, and exercise/fitness. Nearly 90  
11 percent of the sample drives alone to work or school at least once a week. However, the sample  
12 also includes a fair amount of walking and bicycling, with approximately 26 percent walking to  
13 work or school at least once a week, and approximately 14 percent bicycling at least once a week  
14 for the same purpose. These numbers may indicate a bias toward walking and bicycling within the  
15 sample population, given that the American Community Survey indicates that only 0.5 percent of  
16 Michiganders bicycle to work on average, but they may also reflect the multi-modal nature of  
17 commuting that is difficult to capture via the American Community Survey (17).

18 Nearly one-quarter of respondents bicycle for transportation other than to work or school at least  
19 once a month, while approximately half of respondents bicycle primarily for fun/recreation/leisure  
20 or exercise/fitness purposes at least once a month. These findings reveal a fair amount of bicycling  
21 within the sample, and support the need to understand bicycling desires and patterns via research  
22 like this.

#### 23 *4.2 Views on Transportation*

24 To gain a deeper understanding of respondents’ attitudes toward cycling, they were asked to choose  
25 how strongly they agreed or disagreed (on a five-point Likert scale) with several statements about  
26 their lifestyles and travel habits. Figure 1 presents the distribution of responses from all respondents  
27 for statements about attitudes toward driving, bicycling, walking, and exercise. While the general  
28 trends between the four groups are relatively similar, there are a few significant differences, as  
29 indicated by asterisks in the chart.

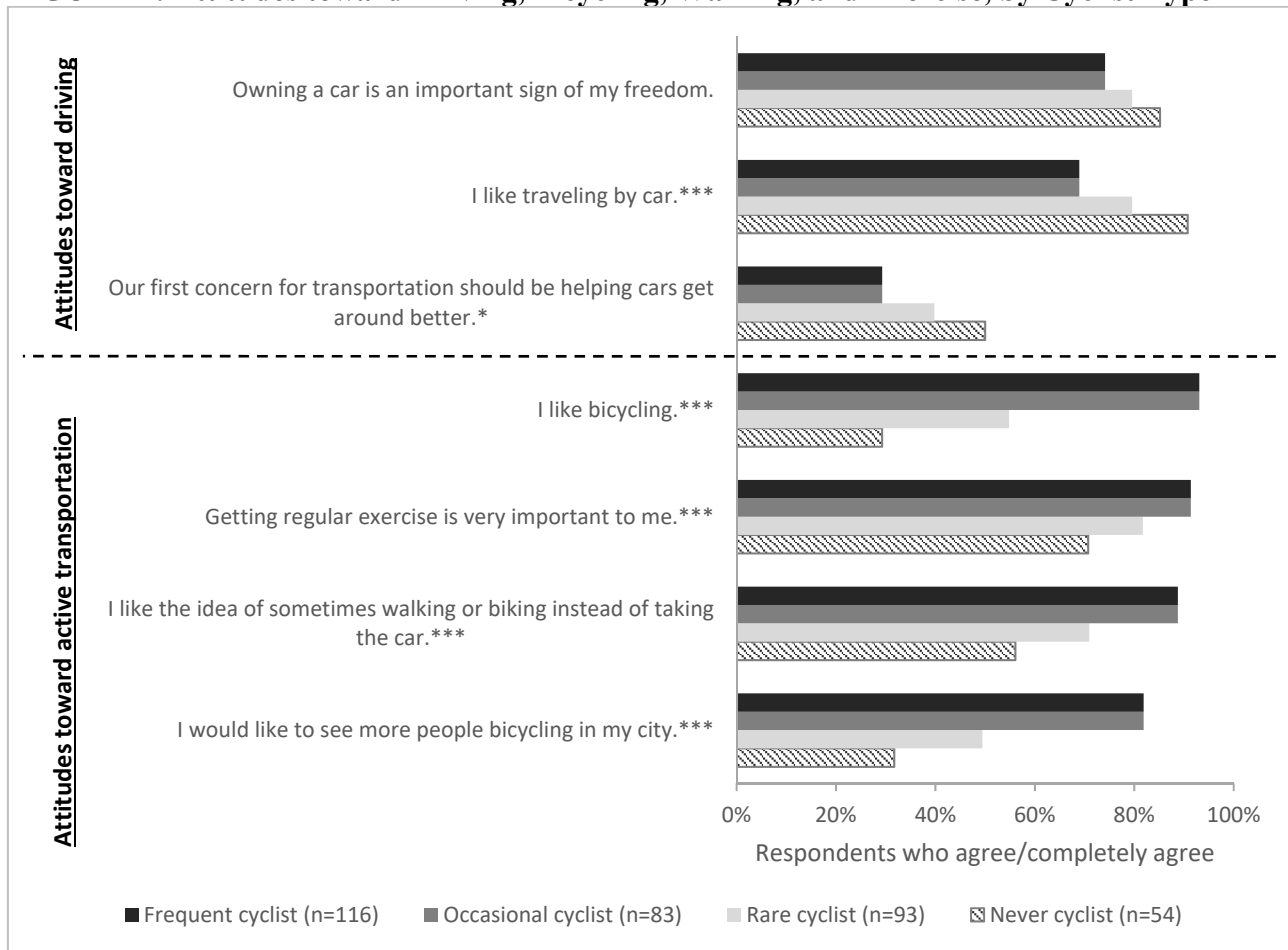
30 The majority of survey respondents hold generally positive attitudes toward driving, but feel less  
31 uniformly positive toward active transportation. A large majority of each group agreed or strongly  
32 agreed that “owning a car is an important sign of (their) freedom” and that they “like traveling by  
33 car.” Despite this clear appreciation for cars, a much smaller percentage of all groups agreed or  
34 strongly agreed that helping cars to get around better should be a top transportation concern. As  
35 might be expected, frequent and occasional cyclists were significantly less likely ( $p < 0.05$ ) to agree  
36 with the latter two statements than rare or never cyclists.

37  
38 Figure 1 also shows the significant variation ( $p < 0.001$ ) in the degree to which the four types of  
39 cyclists feel positively about bicycling, walking and exercise. The majority of frequent and  
40 occasional cyclists agreed or strongly agreed with all four statements about bicycling, walking and  
41 exercise, whereas the majority of never cyclists agreed or strongly agreed with only the two



1 statements that did not focus on bicycling. Note the similarity in responses between enjoyment of  
 2 bicycling and wanting to “see more people bicycling in (their) city.”

3  
 4 **FIGURE 1. Attitudes toward Driving, Bicycling, Walking, and Exercise, by Cyclist Type**



5  
 6 \*=  $p < 0.05$ , \*\*=  $p < 0.01$ , and \*\*\*=  $p < 0.001$

7  
 8 **4.3 General Barriers to Bicycling**

9 Respondents were also asked about general barriers to bicycling. Forty-three percent of respondents  
 10 agreed or strongly agreed that they would bicycle more if their friends or family came with them;  
 11 this seemed to be particularly salient for occasional cyclists. Only 38 percent of respondents agreed  
 12 or strongly agreed that they are often accompanied by children or older adults when they travel, but  
 13 more occasional cyclists (46 percent) expressed agreement with this statement than other groups.  
 14 Even fewer respondents (34 percent) agreed or strongly agreed that they live too far away from  
 15 things to walk or bicycle, although never cyclists were significantly more likely ( $p < 0.001$ ) to agree  
 16 with this statement. The respondents clearly rejected the idea that bicycling was “odd” or a sign of  
 17 low income.

18 Respondents were also asked about concerns about bicycling, particularly with regard to safety.  
 19 Less than fifteen percent of each cyclist type agreed or strongly agreed that they would discourage  
 20 others from bicycling to work or school, although never cyclists were significantly more likely ( $p <$   
 21 0.02) to agree with this statement than frequent cyclists. However, over forty percent of the sample

1 agreed or strongly agreed with the statement that “many bicyclists appear to have little regard for  
2 their personal safety,” suggesting that behavioral trends may need to be further explored in  
3 Michigan. Unsurprisingly, agreement differed by cycling frequency (45 percent of never cyclists as  
4 compared to 29 percent of frequent cyclists). Moreover, the large majority (73 percent) of the  
5 sample agreed or strongly agreed with the idea that “many drivers don’t seem to notice bicyclists,”  
6 suggesting that people may not feel safe driving due to driver behavior. Interestingly, frequent  
7 cyclists (65 percent agreement) were the least likely to agree with this statement.

#### 8 *4.4 Barriers to Bicycling to Work or School*

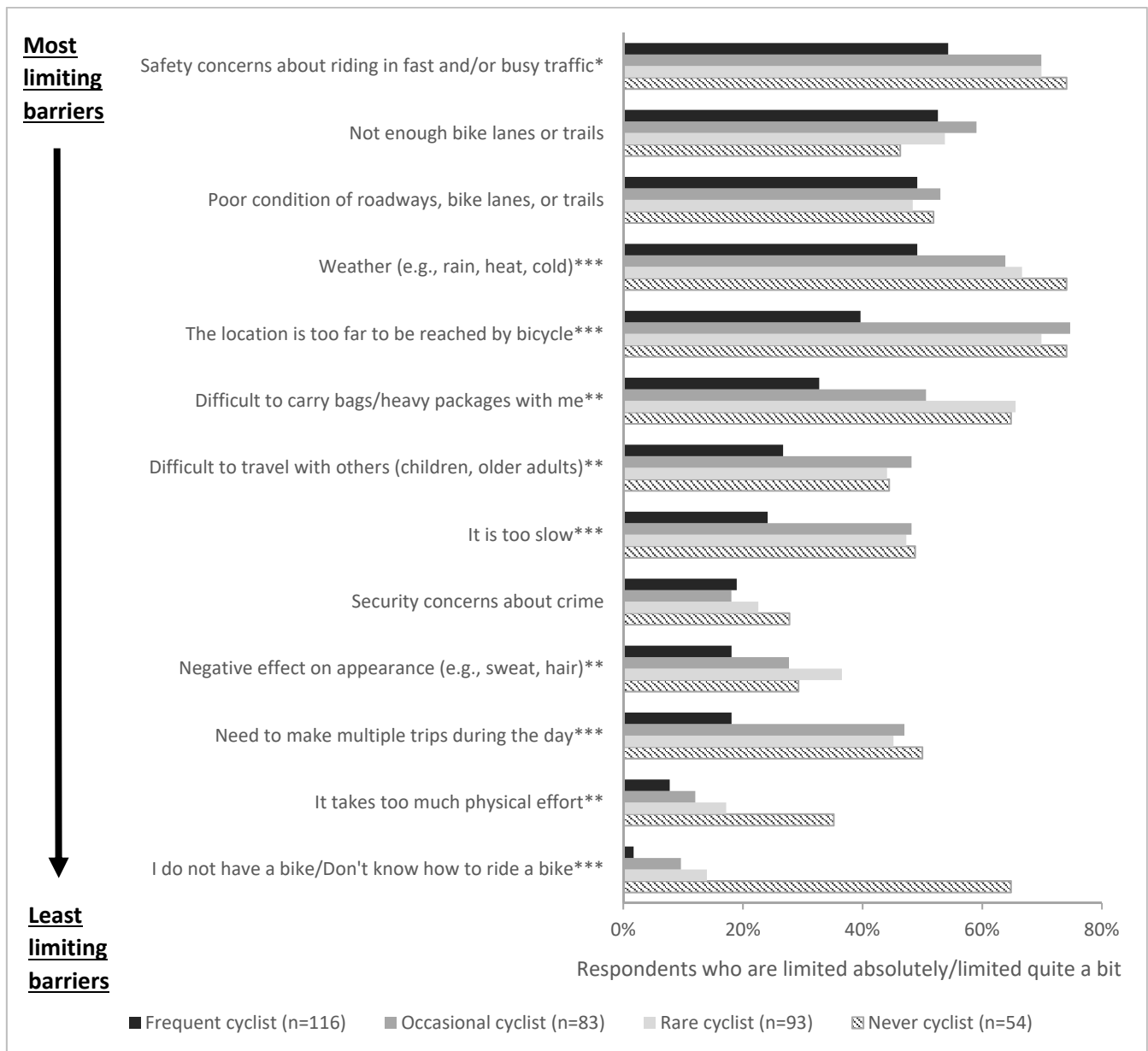
9 Participants were also asked how much various factors limited their ability to bicycle to work or  
10 school (options were “absolutely limits”, “limits quite a bit”, “limits somewhat”, or “does not  
11 limit”). Figure 2 shows the percentage of each cyclist group that is limited “quite a bit” or  
12 “absolutely” from biking to work or school by each barrier. The data indicate that safety, distance,  
13 and weather concerns topped the list for occasional, rare, and never cyclists, while frequent cyclists  
14 seemed more focused on safety and roadway/infrastructure conditions. In all instances, frequent  
15 cyclists were the least likely to indicate being limited by the barriers, while never cyclists were  
16 generally the most likely to indicate a higher level of limitation. However, other barriers are as  
17 limiting to occasional or rare cyclists as they are to never cyclists, again suggesting that addressing  
18 these barriers (e.g., building more high-quality infrastructure, teaching people how to dress for and  
19 be safe while cycling in inclement weather) may encourage cycling within certain groups to  
20 different degrees. Note that more cyclists of each type indicated that safety concerns were a barrier  
21 than that a lack of bike lanes or trails was a barrier, although the difference between the two  
22 diminishes with increasing cycling frequency. These findings suggest that the provision of bike  
23 lanes and trails should be accompanied by more general traffic calming strategies where possible.  
24 For example, bicycle boulevards—traffic-calmed neighborhood streets that prioritize bicycle  
25 traffic—offer a potential solution to simultaneously address both barriers.

26 For the less limiting barriers in Figure 2, responses between groups varied significantly except  
27 regarding security concerns about crime. Occasional cyclists were the most likely to indicate a  
28 strong limitation in the case of negative effect on appearance and difficulty traveling with others,  
29 but occasional and rare cyclists tend to feel similarly; a one-way ANOVA confirmed that there were  
30 no significant differences between the responses of occasional and rare cyclists for any of the  
31 barriers listed.

32 Note that the barrier of not having a bike/not knowing how to ride a bike was cited by some  
33 respondents of each group, but overwhelmingly so by never cyclists. Only 20 percent of never  
34 cyclists indicated via an earlier question that they cannot ride a bike, suggesting that this barrier  
35 refers to not having a bicycle for the majority of never cyclists.

36  
37  
38  
39  
40

1 **FIGURE 2. Strength of Barriers to Biking to Work/School, by Cyclist Type**



2  
3 \*=  $p < 0.05$ , \*\* =  $p < 0.01$ , and \*\*\* =  $p < 0.001$

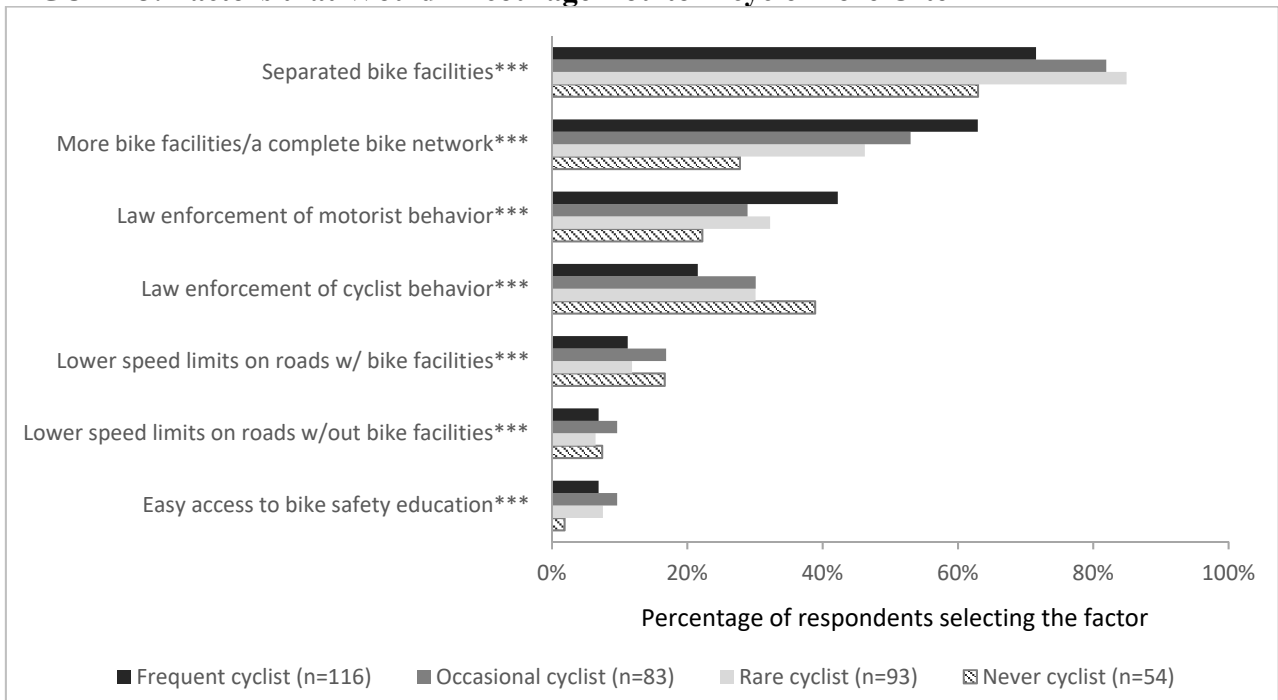
4  
5 **4.5 Factors that Would Encourage More Cycling**

6 Participants were also asked to choose three changes that would encourage them to bicycle more in  
7 their community (Figure 3). Seventy-five percent of all respondents indicated that the installation of  
8 separated bicycle facilities would encourage them to bicycle more. Interestingly, rare cyclists were  
9 more likely to choose this response than occasional cyclists, possibly corroborating past research  
10 findings that a lack of perceived cycling comfort and safety is a critical barrier to increasing cycling  
11 (5,12,18). The fact that about 72 percent of frequent cyclists also chose separated bike facilities  
12 suggests that this lack of comfort and safety is experienced even by those who currently bicycle.  
13 This connection between increased cycling and increased perceived safety and comfort is

1 underscored by the clear difference in the percentage of people who chose separated bike facilities  
 2 as compared to more bike facilities. This choice seems to be particularly salient for never and rare  
 3 cyclists, with almost twice as many choosing separated bike facilities over more facilities in  
 4 general.

5 In comparison, about half of respondents indicated that adding more bicycle facilities or a complete  
 6 bicycle network would encourage them to bicycle more, while a minority suggested that improved  
 7 law enforcement of motorist and cyclist behavior, respectively, would encourage them to bicycle  
 8 more. Increased law enforcement, easier access to education, and lower speed limits were unpopular  
 9 generally. As might be expected, never cyclists were more likely to choose increased law  
 10 enforcement of bicyclists over that of motorists, while frequent cyclists were much more likely to  
 11 choose the opposite. Overall, these findings indicate a clear preference for infrastructure in the form  
 12 of separated bike facilities and a complete bicycle network to encourage the sample population to  
 13 bicycle more often.

14 **FIGURE 3. Factors that Would Encourage You to Bicycle More Often**



15  
 16 \*\*\* $p < 0.001$

17 Notes: Separated bicycle facilities include those that provide increased separation from traffic (e.g., median, landscape  
 18 buffer, etc.). Percentages do not add up to 100 because respondents could choose up to three factors.

19  
 20 **4.6 Confidence while Bicycling**

21 Respondents were also asked how confident they felt riding a bicycle. Unsurprisingly, the majority  
 22 of frequent cyclists and occasional cyclists feel “very confident” riding a bicycle. Interestingly, 89  
 23 percent of rare cyclists feel at least “somewhat confident” riding a bicycle, as do 59 percent of never  
 24 cyclists, although the split between “very” and “somewhat” confident was much more even for  
 25 these two groups. Never cyclists were also much more likely to report not feeling confident than  
 26 the other cyclist types (41 percent not confident or cannot ride a bike at all, as compared to only 11  
 27 percent of rare cyclists not feeling confident). While cycling frequency is not solely explained by

1 the ability to ride a bike, there is clearly a connection between the two ( $p < 0.001$ ). Additionally,  
2 being “somewhat confident” may be a barrier to more riding in itself, or it may be the result of not  
3 being able to bicycle frequently due to other barriers.

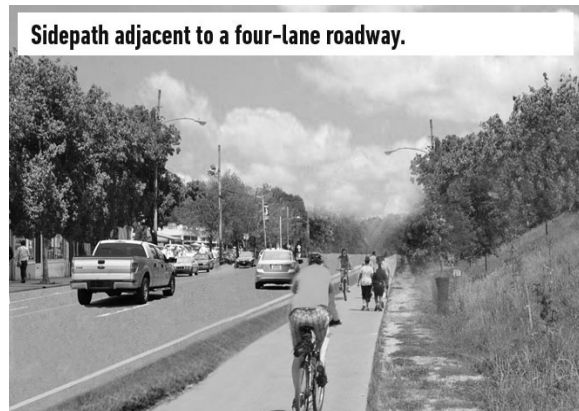
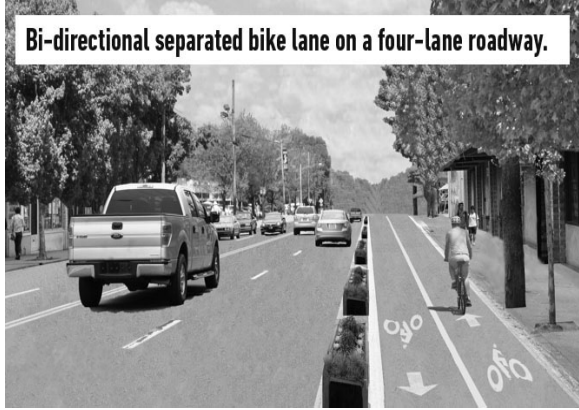
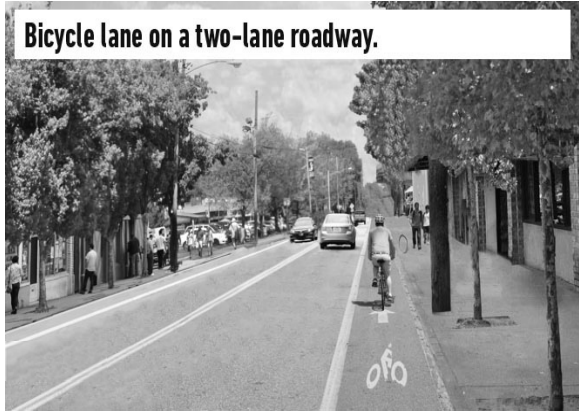
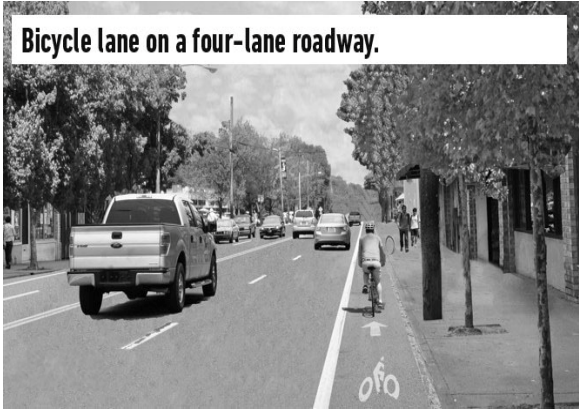
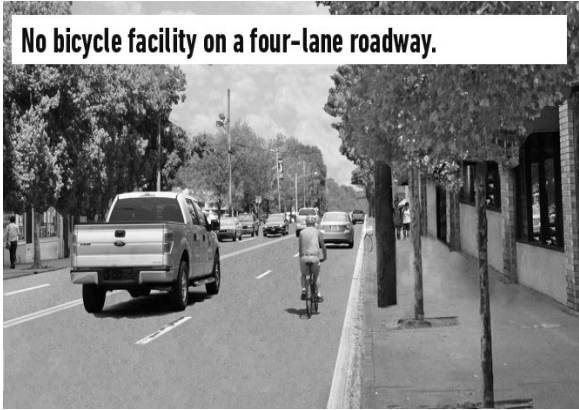
#### 4 *4.7 Roadway Design Preferences*

5 Respondents were then asked a series of questions about their level of comfort and experience  
6 riding and driving on seven different roadway designs (see Figure 4). The results indicate several  
7 key trends in respondents’ preferences for driving near bicyclists and bicycling near drivers.

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1 **FIGURE 4. Roadway Design Options**

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1 Figure 5 shows how comfortable respondents reported feeling when considering riding by  
2 themselves, riding with children, and driving on each of the seven roadway designs. The data show  
3 that respondents would be more comfortable with both bicycling by oneself and driving with  
4 increased separation, which research has found to be associated with perceived predictability on the  
5 roadway (12), although the majority of respondents would feel comfortable in most scenarios with  
6 some type of bicycle facility. Interestingly, a greater percentage of respondents would feel  
7 comfortable driving on a four-lane roadway with a bike lane than on a two-lane roadway with a bike  
8 lane—likely related to opportunities for drivers to further separate themselves from cyclists on the  
9 multi-lane roadway.

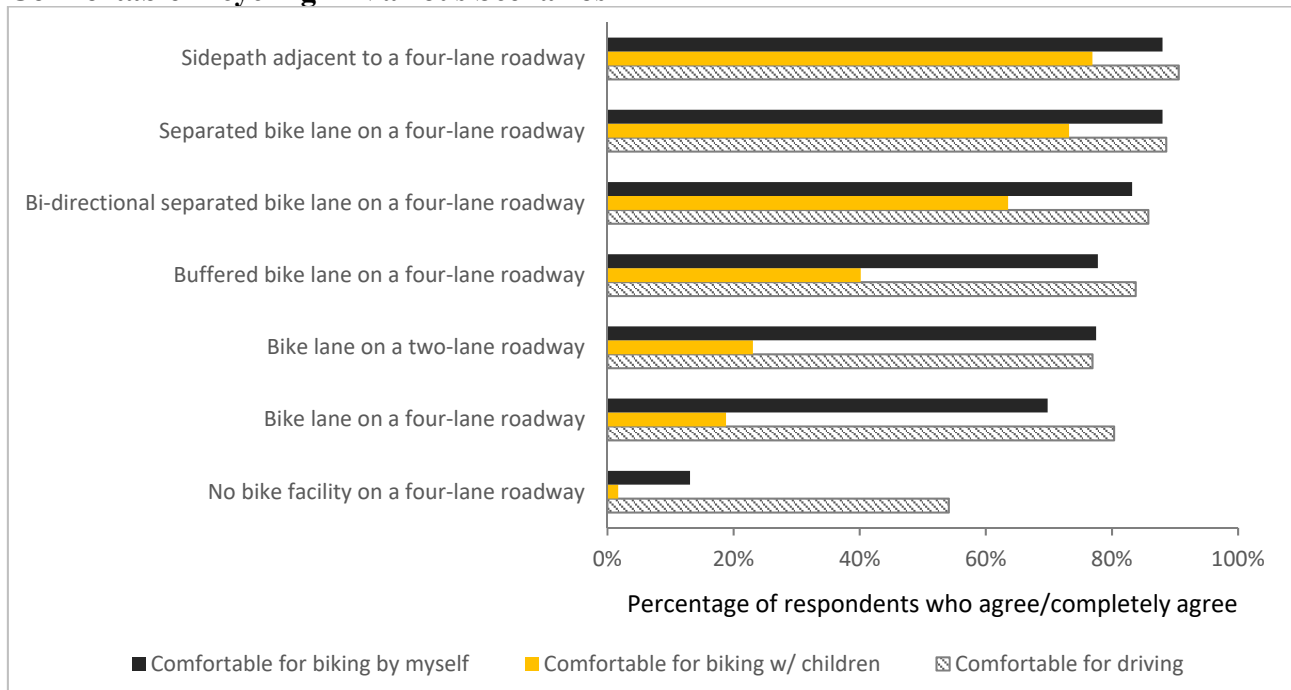
10 When considering bicycling with children, however, comfort declines rapidly without separation  
11 from cars: less than fifty percent of the sample would be comfortable in a buffered bicycle lane; less  
12 than twenty percent would be comfortable in a regular bicycle lane on a four-lane roadway; and less  
13 than two percent would be comfortable on a four-lane roadway with no bicycle facility. These  
14 findings underscore the increased perceived vulnerability of bicycling with children and the  
15 commensurate need for clear and strong separation from traffic for comfort. Note that sidepaths  
16 and separated bicycle lanes are approximately evenly comfortable for each purpose, with just a  
17 slight dip for bicycling with children. Given that paths have tended to be the gold standard for  
18 comfort, this finding is encouraging for cities aiming to use separated bike lanes to encourage more  
19 bicycling.

20 Comfort was also examined by type of bicycling (non-transport cycling compared to all-purpose  
21 cycling). The same preference order was found for both groups, although non-transport cyclists  
22 were significantly less likely to feel comfortable bicycling alone or with children than all-purpose  
23 cyclists – with the exception of the sidepath and separated bike lane designs.

24 These data corroborate past research on roadway design preferences, indicating that most  
25 respondents felt considerably less comfortable riding on a roadway without a bicycle facility than  
26 riding on a roadway with any type of bike facility (12, 3). They also support findings presented  
27 earlier in the paper regarding cyclists' concerns about safety and their desire for more separated  
28 bike lanes.

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1 **FIGURE 5. Roadway Design Preferences by Percentage of Respondents who would Feel**  
 2 **Comfortable Bicycling in Various Scenarios**



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5 The survey also asked about respondents’ willingness to try bicycling on the various facilities.  
 6 Nearly 90 percent of respondents would be willing to try bicycling on a separated facility, while no  
 7 less than 68 percent would be willing to try even just a bicycle lane. In contrast, only 24 percent  
 8 indicated a willingness to try bicycling on a four-lane roadway without a bicycle facility.

9

10 **4.7.1 Roadway Design Preferences by Cyclist Type**

11 Comfort levels for each roadway design were also examined by the cyclist type (data not shown;  
 12 general patterns fit with Figure 5). In each case, “never cyclists” were the least comfortable with the  
 13 bicycle facilities, whether when cycling alone or with children. Comfort levels among frequent,  
 14 occasional, and rare cyclists were similar for all of the separated facilities, with rare cyclists slightly  
 15 lower in general, and the difference becoming more pronounced for non-separated facilities. The  
 16 percentage of respondents who indicated comfort bicycling by oneself without a bicycle facility on  
 17 a four-lane roadway was low for all groups (less than twenty percent), but particularly so for never  
 18 cyclists.

19 When considering riding with children, all cyclists felt less comfortable as separation decreased,  
 20 and dramatically so as the separation decreased to just a line (i.e., bike lane) and then no facility at  
 21 all. Comfort for driving was pretty consistently high, although less so for the bike lane on the two-  
 22 lane roadway and the no facility option, similar to Figure 5. For both of these design options,  
 23 comfort increased with cycling frequency.

24



1 Finally, most respondents indicated a willingness to try bicycling on the various street designs,  
2 although the willingness steadily decreased as separation decreased. Never cyclists were  
3 consistently the least likely to indicate a willingness, although over 70 percent of them indicated a  
4 willingness to try bicycling on a separated bike lane or a sidepath, potentially indicating an  
5 opportunity to make headway in a group of people traditionally left out of bicycle planning. The no  
6 bike facility option remained unpopular across all groups.  
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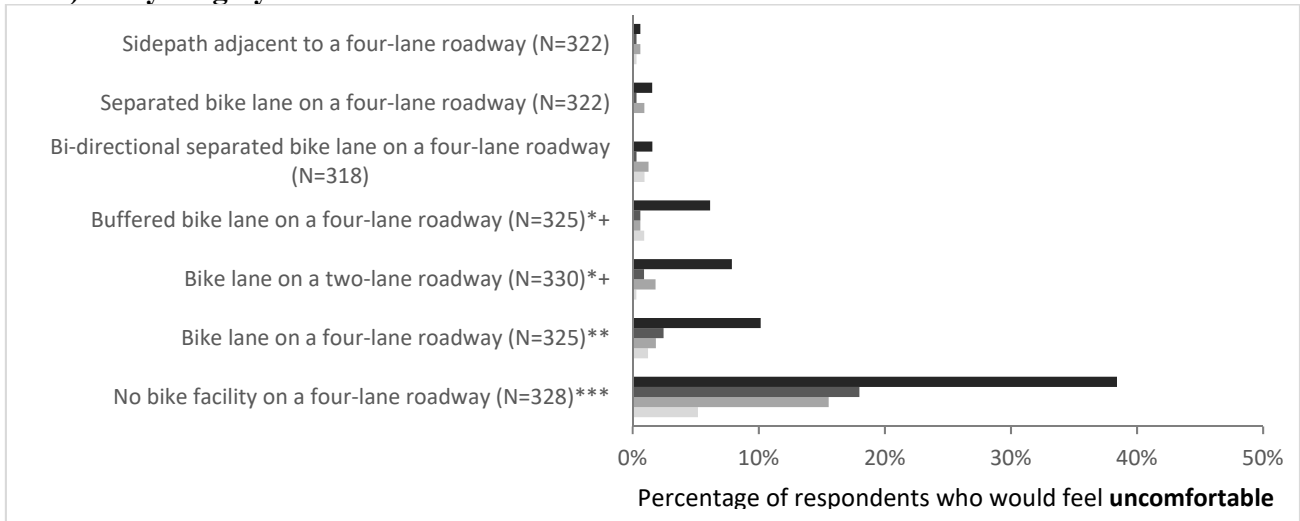
#### 8 **4.7.2 Roadway Design Preferences by Respondents Concerned about Safety**

9 Additional exploration was conducted to determine whether reported comfort levels on various  
10 roadway designs differed based on respondents' concerns about safety. In each case, respondents  
11 who were "absolutely" limited by concerns (i.e., "very concerned") about safety were significantly  
12 ( $p < 0.05$ ) less likely to indicate that they would be comfortable riding on various roadways. As  
13 seen in Figure 6, a significantly higher percentage of respondents who are very concerned about  
14 safety reported that they would feel uncomfortable riding by themselves on a roadway with no bike  
15 facilities compared to the rest of the respondents ( $p < 0.001$ ). However, when physical separation is  
16 present between drivers and bicyclists, very concerned cyclists feel a similar level of comfort to the  
17 rest of the respondents. Additionally, very concerned respondents were the most likely to be  
18 affected when a bicycle lane was added to the road.

19 In general, as the separation between drivers and cyclists increases, the percentage of respondents  
20 who are very concerned with their safety and would feel uncomfortable riding on a roadway  
21 decreases. Not surprisingly, the differences in the responses of those who are very concerned and  
22 those who are not concerned are even more pronounced when considering bicycling with children.  
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1 **Figure 6. Comfort Level for Bicycling by Level of Concern for Safety**

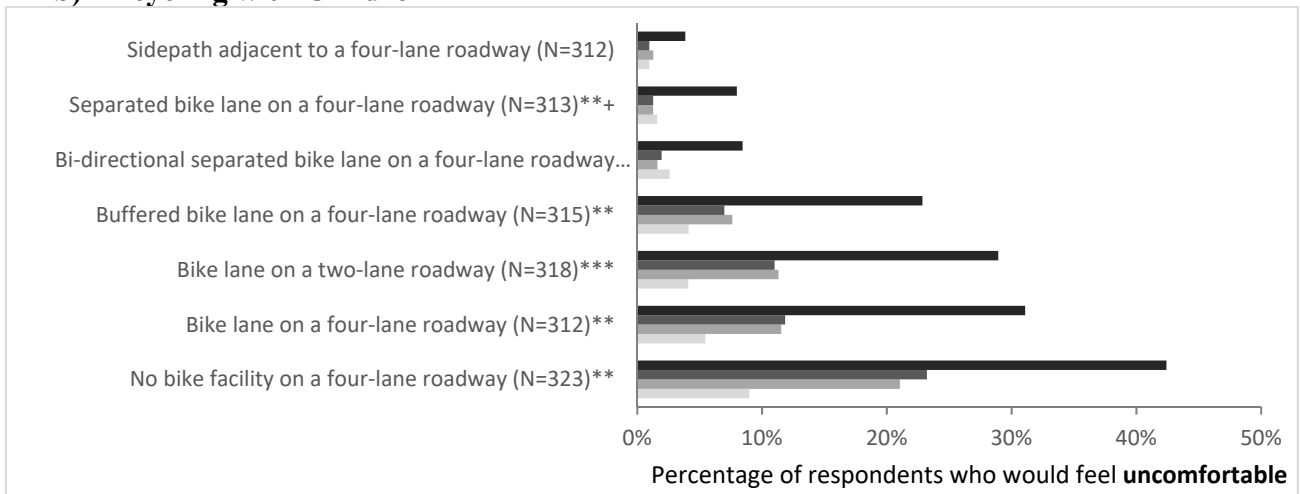
2 **a) Bicycling by Oneself**



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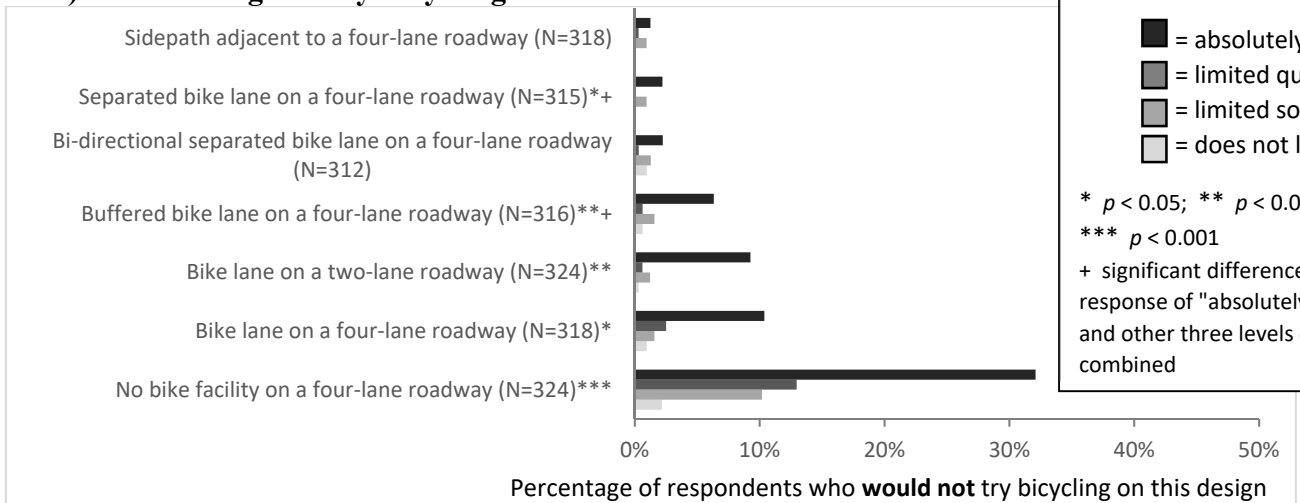
5 **b) Bicycling with Children**



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8 **c) "Something I'd Try Bicycling"**



**Legend**

- = absolutely limited
- = limited quite a bit
- = limited somewhat
- = does not limit

\*  $p < 0.05$ ; \*\*  $p < 0.01$   
 \*\*\*  $p < 0.001$   
 + significant difference between response of "absolutely limits" and other three levels of concern combined

9

## 1 5. CONCLUSIONS

2 The survey successfully captured a cross-section of Michigan residents to gain a more nuanced  
3 understanding of their attitudes toward bicycling and driving, bicycling habits, barriers to bicycling,  
4 and roadway design preferences. The findings overwhelmingly suggest a preference for more  
5 bicycle accommodations, and more separated facilities in particular. Seventy-five percent of all  
6 respondents indicated that the installation of separated bicycle facilities would encourage them to  
7 bicycle more, with almost twice as many rare cyclists choosing separated bike facilities over more  
8 facilities in general.

9 Relatedly, safety concerns, distance, and weather appeared to be the most limiting barriers for all  
10 cyclist types. Nearly 89 percent of respondents reported that safety concerns about riding in fast  
11 and/or busy traffic at least somewhat limited their ability to bike to work or school, with 68 percent  
12 saying that safety concerns limited them “quite a lot” or “absolutely.” As expected, frequent cyclists  
13 were less likely to indicate barriers than other cyclists.

14 The presence of bicycle facilities increases respondents’ comfort and willingness to try bicycling on  
15 a roadway. Most respondents felt considerably more comfortable bicycling on a roadway with any  
16 type of bike facility over one lacking a bicycle facility, and this preference was even stronger when  
17 the facility was separated from drivers by a physical barrier. Separation was even more important  
18 when considering cycling with children, with comfort levels declining rapidly without separation  
19 from cars when children are considered. Respondents were also more likely to indicate comfort  
20 while driving with greater separation from bicyclists.

21 These findings corroborate past research, clarify the nuance of bicycling considering trip  
22 companions, and show a clear pathway from safety as a barrier to bicycling to something that can  
23 be addressed through infrastructure. Ultimately, these findings will provide an important  
24 complement to the crash history when determining guidance for sidepath design.

25

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28 attempt to understand design preferences among Michigan residents. We also appreciate the help of  
29 Hannah Pritchard, Connor Cox, and our Wayne State partners for helping deploy the survey.

30

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