Can Protected Bike Lanes Help Close the Gender Gap in Cycling? Lessons from Five Cities

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ABSTRACT

Even in areas with increased levels of bicycling, there remains a significant "gender gap" in bicycling in the United States, in contrast to many other countries with high rates of bicycling. The primary objective of this paper was to explore whether protected bike lanes could help reduce the gender gap. To do so, we used survey data from a comprehensive evaluation of protected bike lanes in five large U.S. cities (Austin, TX, Chicago, IL, Portland, OR, San Francisco, CA, and Washington, DC) that included survey responses of 1,111 intercepted bicyclists and 2,283 residents. Both men and women overwhelmingly felt that the lanes increased their safety while riding in them. On several measures of safety and comfort, women bicyclists using the lanes did have significantly more positive associations with the protected lanes than men. A survey of residents, which included people who do and do not bicycle, revealed that women generally feel less comfortable than men bicycling on roadways, though the addition of some physical separation to a striped bike lane, does increase stated levels of comfort to a level that might increase rates of bicycling. Overall, women were also more likely to indicate that the new protected lane had increased their overall levels of bicycling. Analysis of the demographics of the intercepted bicyclists revealed differences between men and women that point to the challenge of increasing women's rates of bicycling, primarily that the women intercepted bicycling were much less likely than men to have children.

INTRODUCTION

Cities are increasingly investing in and promoting bicycle use for transportation as a way to address pollution, public health concerns, lack of roadway capacity, and diminishing transportation funding. More positively, investment in bicycling is seen as a way to attract the young "creative class" into dense urban downtowns, provide lower-stress transportation options, increase transportation equity, and build community (*6*). As a result, bicycling for transportation has increased in some communities in the United States, although rates remain low, particularly in suburban areas and the South (*7*). Even in areas with increased levels of bicycling, however, there remains a significant "gender gap" in bicycling in the United States, with men outnumbering women bicyclists by two or three to one (*1*). In addition, although men's utilitarian (i.e. non-recreational) bicycle travel increased slightly from 2001 to 2009, women's bicycle travel actually decreased between the 2001 and 2009 National Household Travel Survey (*7*). This gap is problematic not only because women should have equal access to bicycling for transportation and greater numbers of female bicyclists are associated with higher numbers of bicyclists overall (*8*), but also because we know the gap is not inevitable – in countries with high levels of bicycling, like the Netherlands, Germany, and Denmark, women constitute an equal or greater share of bicyclists (*1; 6; 9; 10*).

To understand why this gap persists in the United States, we need to understand what is different about women's attitudes, preferences, perceptions, and behaviors with respect to bicycling (*2*). The numbers of women bicycling in other countries is evidence that this gap is not biologically driven. In addition, the cycling gap cannot strictly be seen as a matter of the gendered pressures that women face in the U.S., such as household roles or workplace and wage gaps, as women in many other Westernized countries face these same issues (*11*), but still bicycle in numbers equal to men. One potential explanation of these cross-cultural differences in mode share is the role of infrastructure (*2-5*), particularly separated facilities found much more frequently in other countries. Recent years have seen an increase in US installations of separated facilities, protected bike lanes in particular, (*12*) with the goal of attracting people onto bikes who may be "interested but concerned" (*13; 14*). We use the terms "protected bike lanes" and "protected bikeways" to describe bicycle facilities that separate bicycle and automobile traffic, using paint, bollards, planters, parked cars, raised paving, or other methods of separation. While "cycle tracks" and "separated bikeways" are common terms, the term "protected bike lanes" is a widely-used term.

The primary objective of this paper is to explore whether these protected bike lanes could help reduce the gender gap in bicycling in large U.S. cities. To do so, we use survey data from a comprehensive evaluation (*12*) of protected bike lanes in five large U.S. cities.

BACKGROUND AND LITERATURE REVIEW

Bicycle-related gender differences appeared the moment that women first got on two wheels (*15*). Early fears about bicycling's impacts on women often revolved around women's health and safety, and whether the "gentler sex" should be bicycling at all. Fast forwarding to modern day, most research prior to the mid-2000s focused on the medical effects or crash-involvement likelihood of female bicyclists, without reference to involving more women in bicycling. A shift in focus to understanding bicycling for transportation, rather than recreation, resulted in researchers examining the "gender gap" in bicycling in earnest starting around 2004. Initial studies of secondary data focused on gender differences in bicycling behavior and preferences for different facility types. The patterns for women's overall travel behavior with respect to men's has held fairly steady in that ten years. Women's trips are significantly shorter than their male counterparts, and despite more trip-chaining than men, women travel fewer annual miles, regardless of mode (*2*). Despite the potential for bicycles to serve these shorter trips made by women, females make only one-quarter to one-third of all bicycle trips (*1*).

Consistent with psychological and sociological literature, concerns about safety affect women's travel preferences and choices at higher rates than men (*16*). Women consistently rate traffic concerns, aggressive driving, and personal security (i.e. fear of assault) among their significant travel-related concerns (*8*). Data show that, controlling for exposure, women are less likely than men to be injured in

traffic while bicycling, and less likely for injuries to be severe. Yet "higher perceptions of risk may be as important as actual risks" *(4, pg 223*) when looking at women's bicycling preferences and behaviors. Women have been shown to ride more cautiously than men (*17*) and to choose their routes to avoid "hidden dangers" to personal safety (*18*). Women are less likely to prefer off-street paths than men, ostensibly because despite the lack of danger from automobiles, there are heightened personal security concerns (*1*).

Reflecting the safety concerns about traffic and aggressive drivers, women consistently favor, both in stated and revealed preferences, dedicated bicycle facilities and lower volume streets (*1; 2; 4; 19*). Women are more likely than men to tolerate a travel-time trade-off to access these lower-stress routes (*20*). Still, even in US cities with significant lane-miles of neighborhood greenways, bike lanes, and low-volume streets, women are not bicycling in equal numbers to men like their European counterparts (*5*). This has led researchers and practitioners alike to hypothesize that more robust separation of drivers and bicyclists, like that found in "high-cycling" countries, may be required to achieve greater mode shares of all bicyclists, and female bicyclists in particular (*21*).

Observations of bicyclists show that women are more likely than men to prefer maximum separation from automobile traffic (*3*). Installation of a separated bikeway has been shown to increase the comfort and perceptions of safety of users, particularly women (*22*). These existing studies, however, have relied on secondary data or small sample sizes, or focused on one geographical area. Targeted survey design and instruments, and a large sample size can help address some of the limitations of these studies, and improve our existing understanding of the role of fully-separated bicycle facilities on women's bicycling preferences and behavior. This study provides a unique multi-city evaluation of protected bike lanes that facilitates examination of gender differences in both stated and revealed preferences for separated bicycle facilities.

METHODOLOGY

Study Overview

The study included nine new protected bike lanes in five large U.S. cities: Austin, TX; Chicago, IL; Portland, OR; San Francisco, CA; and Washington, D.C. These five cities participated in the inaugural "Green Lane Project" sponsored by People for Bikes. The projects were completed between spring 2012 and summer 2013 (Table 1). The overall research project was designed to gather information and data about a number of relevant questions related to protected bike lanes. The project is the first in the U.S. that evaluates protected bike lanes in multiple cities and contexts, employing a consistent methodology and timeframe, using observations of use and both bicyclist and resident perceptions. More details on the project and findings are available in the final report (*12*) and online at http://trec.pdx.edu/research/project/583/. This paper uses data from surveys conducted in each of the cities.

TABLE 1 Features of the Protected Bike Lanes in the Study

City	Facility Studied	Type of Protected Lane	Length	Buffer type
Washington, D.C.	L Street	One-way on a one-way street	1.12-mile	3' striped buffer zone with flexposts
Austin, TX	Bluebonnet Lane	Two-way on a two-way street	0.7 mile	2' buffer with flexposts
	Barton Springs Road	One-way on the south side of the road (other direction is shared use path)	0.5 mile	1.5' buffer with flexposts
	Rio Grande Street	Two-way on one-way street	0.5 mile	4' buffer with flexposts
San Francisco, CA	Oak /Fell Streets	Couplet of one-way lanes on one-way streets	0.3 miles each	5' buffers and flexposts
Chicago, IL	N/S Dearborn Street	Two-way on one-way street	1.2 miles	parking, flexposts, and a 3' buffer zone
	N Milwaukee Avenue	One-way on either side of a two-way street	0.8 mile	mix of a 2-3' painted buffers with posts and parking protected areas
Portland, OR	NE Multnomah Street	One-way on either side of a two-way street	0.8 miles	mix of parking, painted buffers, flexible bollards, and/or planters

User Surveys

Two types of surveys were conducted in each city: 1) intercept surveys of bicyclists riding on the facilities and 2) surveys of residents living nearby the facility. Certain questions are consistent between these two surveys, including a number of questions about general perceptions of bicycling and comfort on various facilities, along with demographic questions. The two surveys differ in their intended audience and level of detail. The resident survey is intended to gather information from individuals living near the protected lane, including those that bike, drive, or walk on the street that it was built on. The bicyclist survey was administered to bicyclists only and attempts to collect more detailed data about their experiences riding in the protected lanes.

In a few circumstances, either the resident or the bicyclist survey was not completed due to a failure to generate enough responses for analysis:

- A bicyclist intercept survey on Bluebonnet Lane in Austin resulted in only two completed responses after only about nine postcards were distributed. This reflected the low use of the facility during the survey period (during the summer, outside of the school year).
- We did not conduct a resident mail-out survey for Rio Grande because the nearby population, dominated by student housing at the University of Texas, had already entered summer break at the time of data collection. An email survey was distributed through the local neighborhood association, but yielded only five completed responses.

Resident Surveys

The resident surveys contained around 50 questions covering a range of topics. The first section of the survey is about the respondent's travel habits and opinions, including their attitudes about bicycling and other travel modes and their level of (theoretical) comfort under different bicycling scenarios. The next section asked all respondents (regardless of how they use the street) about their opinion of the impact the facility has had on their neighborhood, the safety of the street, and the effectiveness of its design in accomplishing its objectives (e.g., clear and adequate separation of bicyclists from motor vehicles). Following this overall section, respondents were asked questions related to their experiences driving, bicycling, or walking on the street since the cycle track was built. Respondents were instructed to skip sections that are not relevant to them (e.g., if they have not bicycled on the cycle track since it was built,

they were instructed to skip the bicycling section). The goal of these sections was to discern the impacts and benefits the protected lane has had on users of various modes of transportation. The questions for residents who had bicycled on the new lane were a subset of the questions from the bicyclist survey. The survey concluded with demographic questions that were standardized across all surveys.

Paper copies of the resident survey were mailed to up to 2,000 resident addresses within a specific boundary (up to a quarter mile) of each study facility. The size of the boundary around each facility differed based on the density of the surrounding area and the resulting distance needed to achieve a sufficient sample size. Resident addresses are taken from the Reference USA database accessed through a PSU subscription service.

The paper surveys were printed in booklet form and ranged in size from 8-12 pages. In addition to the survey, each envelope included an invitation letter introducing the project, and a postage-paid return envelope. The packet also contained a slip of paper on which the respondent could record his or her contact information (the surveys themselves are anonymous) to be entered into a drawing for one of three $100 Amazon.com gift cards.

Survey recipients were given two options for completing the survey. They could fill out the paper copy of the survey and return it in the postage-paid envelope. Alternatively, they were given the option of completing an online version of the questionnaire. A reminder postcard was sent a few days after the first survey. A second copy of the survey was sent to households that had not responded to the original survey by the requested completed date (typically about two weeks from when it was mailed).

Response rates for the Resident survey ranged from a low of 13% near the L Street facility in Washington D.C., to a high of 34% near NE Multnomah Street in Portland (Table 2). The overall response rate for residents was 23%. Just over a third of all respondents (34%) opted to complete the web survey, demonstrating the value of having that option.

Details about the resident sample can be found in Lessons from the Green Lanes: Evaluating Protected Bike Lanes in the U.S. (*Monsere et al 2014*). Comparing the overall sample across the cities to Census data, resident survey respondents were considerably older, more likely to be homeowners, and more likely to have at least a four-year college degree. The survey sample contained a slightly higher percentage of respondents identifying as white than comparison tracts (81% compared to 76%), and slightly fewer identifying as black, Hispanic/Latino, or Asian (5-6% compared 8-9%). Respondents were also more likely to have children in the household and work from home. Although the combined group of respondents was only slightly more likely to be earning $100,000 or more, this group was in fact overrepresented in most individual localities.

Intercept Surveys of Bicyclists

The bicyclist survey was different from the resident survey in its overall intent in that it targeted a specific population (i.e., people who have bicycled on the cycle track). It included more detailed questions about the bicycling experience on the new lane and about the respondent's stated level of comfort bicycling under different scenarios. In this regard, it complemented the resident survey's broad reach to many user types and more general questions. Several questions were based on or identical to those from the resident survey, and the overall structure of this survey is similar to that of the resident survey. The bicyclist survey began with general questions about travel habits and opinions and questions about the trip they were making when they were intercepted for the survey. The next section included specific questions about their experience while bicycling in the new facility. These questions were more detailed than those in the bicyclist portion of the resident survey. In addition to the topics covered in the resident survey, respondents to the bicyclist survey were asked about obstacles they encounter in the cycle track and potentially dangerous situations they have encountered. They were asked the same set of demographic questions.

The bicyclist survey was designed as an intercept survey with riders receiving a postcard directing them to a web address to complete the survey electronically. Project team members, volunteers or city staff intercepted bicyclists along the study facility and handed them a postcard encouraging them to take an online survey. The postcard included a web address and unique code needed to access the

survey. The logistics of the intercept method were slightly different for each facility. Locations for survey distribution along each facility were typically at locations where bicyclists were already required to stop (i.e., stop-controlled or signalized intersections) so that the postcard distributors would not distract or endanger the bicyclists. While volunteers were able to provide some basic information to the bicyclists if they asked and encourage them to complete the survey, they were instructed not to discuss the project in detail or encourage the riders to respond in any particular way. The survey intercept times and days were determined based on ridership patterns along the route. Typically, the AM and PM commuter peak periods were surveyed, along with a possible midday or weekend period. To reduce the likelihood that an individual received more than one survey postcard, each time period was generally only surveyed once. Similar to the resident survey, respondents to the bicyclist survey were provided the option to enter a drawing for one of three $100 Amazon.com gift cards.

Response rates for the bicyclist intercept survey were calculated by dividing the number of responses by the number of postcards distributed; the number of people who declined to take a postcard was not recorded. Postcards were numbered but volunteers did not always diligently log starting and stopping numbers. The response rate ranged from 21% along Dearborn Street in Chicago to 56% along NE Multnomah Street in Portland, with an overall response rate of 33%.

Bicyclist survey respondents tended to be a relatively multimodal group, with at least two-thirds of respondents on each facility owning a car (73% overall average) and most having a transit pass (72% overall average). Over a quarter (28%) has a car-share membership. About a fifth of respondents in cities with bike-share systems were members at the time of the survey (19%). On average, respondents owned more bicycles (2.9 per household) than cars (1.2 per household).

In comparison to the resident respondents, the intercepted bicyclist respondents were more likely to be white (89% compared to 81%); male (68% vs 47%); work outside the home (90% vs. 66%); and make over $100,000 per year (48% vs. 41%). The bicyclist respondents were about as likely as resident respondents to possess a four-year degree (82%).

TABLE 2 Survey Distribution and Response Rates

City	Route	Resident Survey					Bicyclist Survey		
		Mailed (not delivered)	Paper Responses	Web Responses	Total Responses	Response Rate	Distrib-uted*	Returned	Response Rate
Washington, D.C.	L Street	2,000 (168)	148	88	236	13%	763	300	39%
Austin, TX	Bluebonnet	1,661 (71)	304	135	439	28%	-	-	-
	Barton Springs	343 (10)	55	36	91	27%	73	18	25%
	Rio Grande	-			-	-	98	43	44%
San Francisco, CA	Oak /Fell	1,967 (32)	318	199	517	27%	900	278	31%
Chicago, IL	N/S Dearborn	1,200 (81)	121	76	197	18%	600	124	21%
	N Milwaukee	1,500 (30)	185	126	311	21%	775	236	30%
Portland, OR	NE Multnomah	1,550 (83)	368	124	492	34%	200	112	56%
Overall		**9,746**	**1,499**	**784**	**2,283**	**23%**	**3,409**	**1,111**	**33%**

Note: Response rate for resident survey calculated based upon number of mailed surveys not returned as undeliverable, "mailed" minus "not delivered."

*Estimated for San Francisco, Chicago, and Portland due to volunteer logging.

FINDINGS

Riding in the Protected Lanes

The evidence of whether the protected lanes have influenced the behavior of women differently than men in the initial year is mixed. Women represented 24-44% of the intercepted bicyclists who agreed to complete the survey. The gender split for the cyclists intercepted and surveyed on the protected lanes appears in Figure 1, along with the gender split for people reporting bicycling as their primary commuted mode in the American Community Survey (2010-2012 3-year estimate) for each city. When the margins of error for each data source are considered, any differences between the survey and the ACS data are not statistically significant.

While the gender split among intercepted bicyclists does not indicate significant behavior changes due to the new facilities, some of the survey responses do reveal potentially important differences. The women intercepted in the lanes were less likely to say that they used the same route to bicycle prior to the installation (63% of men vs. 56% of women), indicating some change in behavior. (Note: Unless stated otherwise, throughout this paper all stated differences are statistically significant at $p<0.05$.) Women were also more likely to strongly agree that they would go out of their way to ride on the street with the protected lane compared to other streets. In addition, women were significantly more likely to say that they had increased their *overall* amount of cycling *a lot* because of the protected lanes (Figure 2). The gender difference varied by city, with the largest differences seen in Austin, San Francisco, and Washington, D.C.

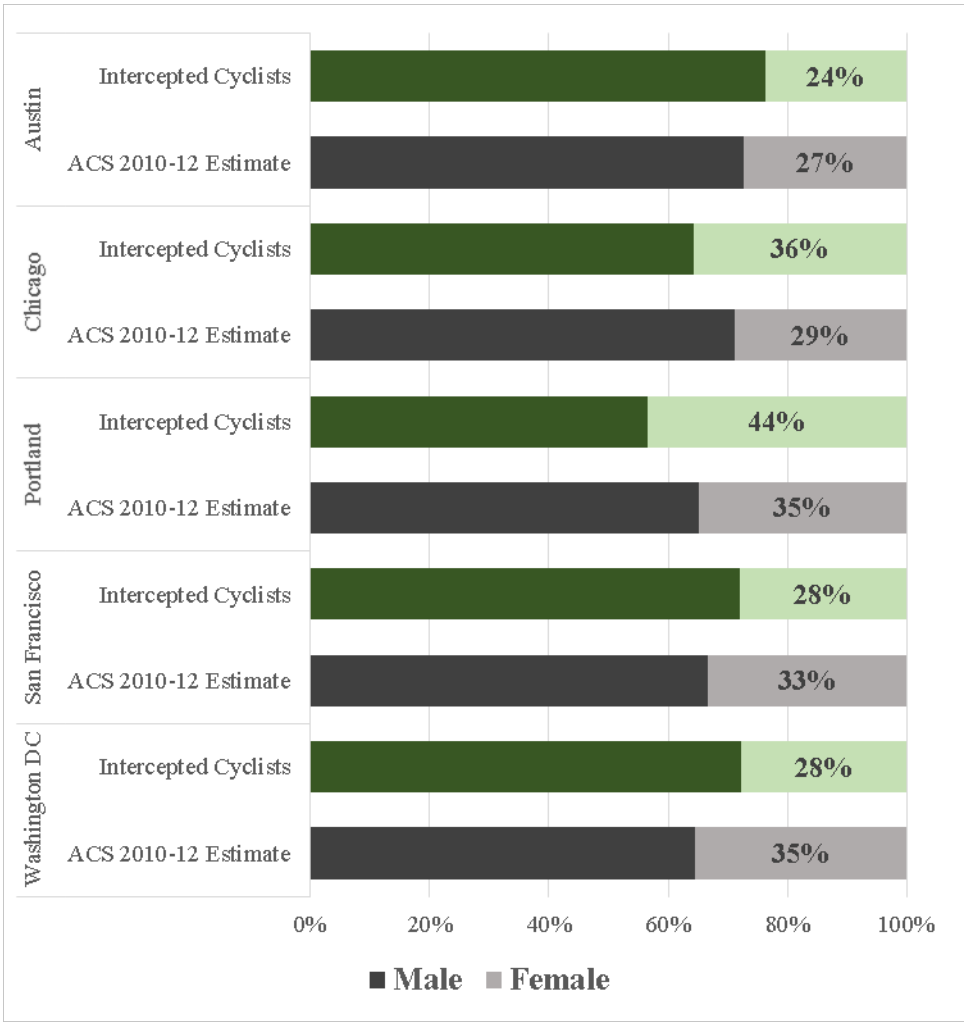


FIGURE 1 Bicyclist intercept survey respondents by gender, compared with gender of bicycle commuters from American Community Survey.

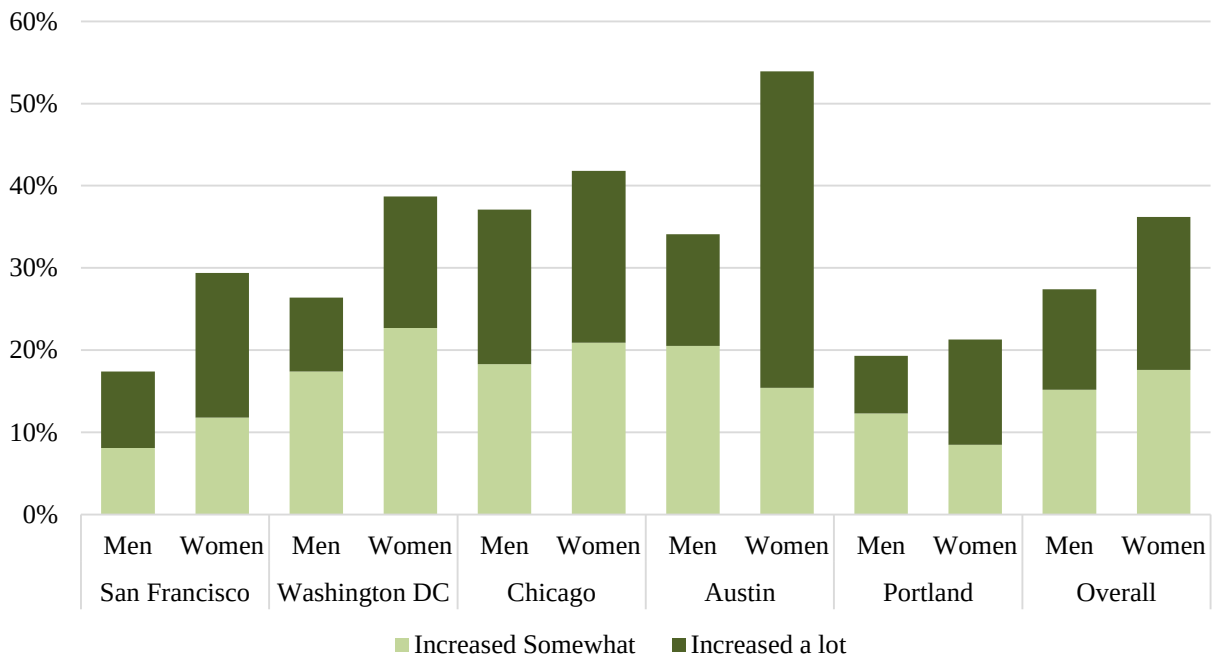


FIGURE 2 Increase in overall bicycling due to protected lanes, by gender (Bicyclist intercept Surveys).

There were some notable gender differences in the demographics of the intercepted bicyclists (Table 3). Women were more likely to live in a household without a motor vehicle and slightly more likely to be a member of a carsharing program. Women were more likely to live in a household without other adults and less likely to live in a household with two adults. Likely related to that, only 13% of the women were in household with children, compared to 31% of the men. Women were also more likely to have lower household incomes and be attending school, though only 11% were students. Women were, on average, younger than the male bicyclists intercepted. There were no difference in overall level of education; 91% of the women and 89% of the men had a four-year college degree.

TABLE 3 Significant Demographic Differences between Men and Women Bicyclists

Demographic Category	Women	Men
No motor vehicles in household	36%	25%
Member of carsharing program*	33%	27%
1-adult household	26%	20%
2-adult household	54%	64%
Child in household	13%	31%
Attend school	11%	7%
Average age	34	37
Income under $25,000	9%	4%
Income $25,000-49,999	19%	11%
Income $100,000-199,999	22%	33%
Income $200,000 or more	5%	14%
n	321	694

Note: All differences significant at $p<0.05$ except noted by *, $p<0.10$

Sense of Safety and Comfort

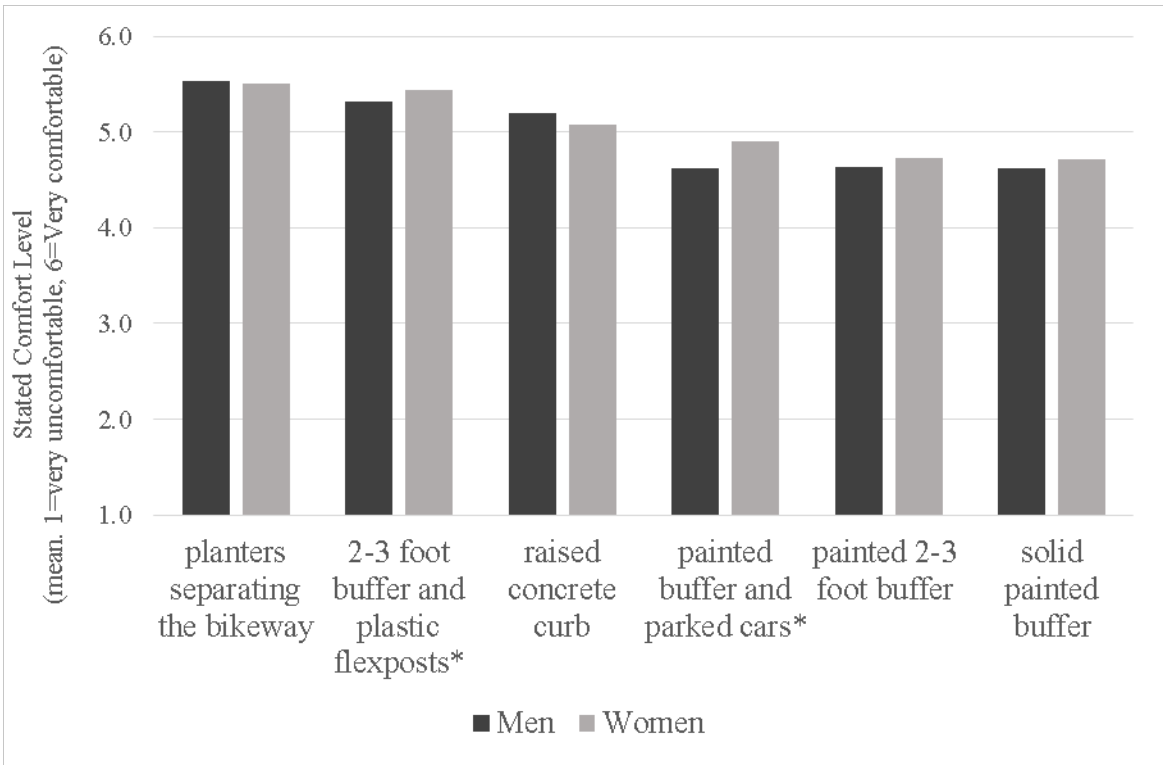
Overall, the protected lanes received favorable responses from both men and women who were intercepted bicycling in the lanes, though there were a few gender differences. Men and women overwhelmingly, and equally, felt that the safety of bicycling on the street had increased (95% of men and 97% of women). However, women were more likely to agree that the "bikeway" is safer than other "bikeways" in the city (93% of women vs. 87% of men). Where there are differences between men and women, it is sometimes because women's *level* of agreement is stronger than men's. For example, a larger share of women (58% vs. 48% of men) *strongly* agreed that the buffers with the plastic flexposts made them feel safe, while there was no significant difference in the shares that *somewhat* agreed. Similarly, women were more likely to state that the usefulness of the street to getting to places they want to go had increased *a lot* (51% of women vs. 40% of men), though more men than women said that it had increased *somewhat* (35% or men v.s 27% of women).

Safety and comfort are related, but different concepts. Women were more likely to state that how comfortable they feel when bicycling on the street had increased *a lot* (66% or women vs. 58% of men), though when the "increased somewhat" responses are included, there are no gender differences. The higher level of comfort may be because women were more likely to feel that drivers' awareness of people biking on the street had increased either a lot or somewhat (88% of women vs. 80% of men). Women were more likely to agree (strongly or somewhat) that the signals, signs, and streets markings made it clear who has the right of way at intersections (81% of women vs. 74% of men).

There were several questions about other aspects of the protected lanes where there were no significant differences between men and women (for individuals responses or when combined, e.g. a lot combined with somewhat):

- The time it takes to bicycle on the street
- Drivers' speeds on the street
- Difficulty of navigating around turning motor vehicles
- Difficulty of navigating around pedestrians
- The buffer section with parked cars makes me feel safe (only asked on lanes with such buffers)
- Leaves and debris in the lane are worse than other places I ride
- Puddles and standing water are worse than other places I ride
- The lane is wide enough for me to ride comfortably
- The lane is wide enough for one bicyclist to pass another
- The lane is wide enough for two people to comfortably ride side-by-side
- The lane makes it clear where cars can be and where the designated bicycle lanes are
- The buffer effectively separates bikes from cars
- The buffer does a good job of protecting bikes from cars
- The lanes makes drivers and bicyclists more predictable
- The lane makes it clear where pedestrians and bicyclists should be
- The lane design effectively separates bicyclists from pedestrians

A major objective of the overall evaluation of the protected lanes was to assess different design options, including the type of buffer used. Because most of the lanes only used one type of buffer, and some buffer types were not used in any of the cities, we included a question on the intercept survey to gauge bicyclists' comfort with different buffer designs. Each design had text and an illustration; illustrations were used to control as many unrelated streetscape elements as possible. Overall, the intercepted bicyclists are comfortable with all of the buffer types (Figure 3). There were two gender differences. Women were more comfortable than men with the 2-3 foot buffered with plastic flexposts and the painted buffer with parked cars. While the differences were statistically significant, they are only one-tenth and three-tenths of a point, respectively, which may not be a meaningful difference.

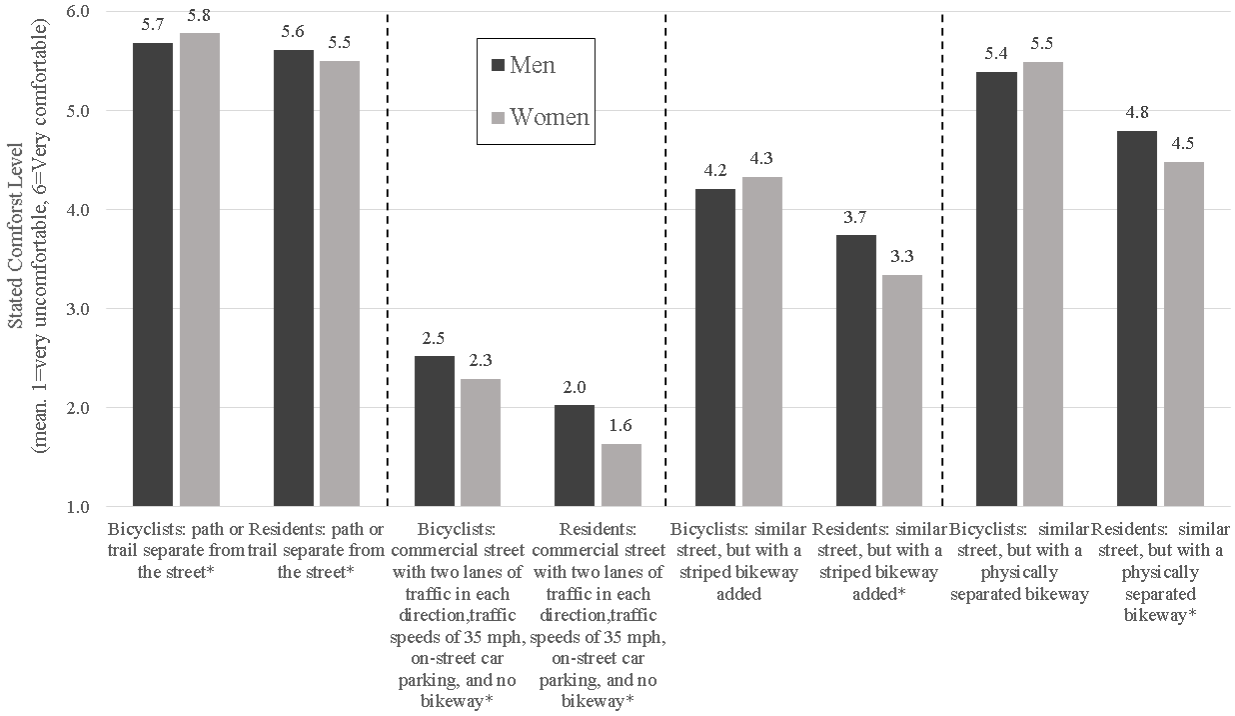


**Significant difference, p<0.05*

FIGURE 3 Bicyclists' stated comfort with different hypothetical buffer designs, by gender.

Both the bicyclist intercept survey and the resident survey included questions about respondents' stated level of comfort bicycling in different environments. Because the resident survey included people who do and do not bicycle, it is expected that their levels of comfort would be lower than the intercepted bicyclists, and that is shown in Figure 4. Among the intercepted bicyclists, women were slightly more comfortable than men on paths or trails separated from the street and less comfortable on commerical streets without bike lanes. They were equally comfortable when a striped bike lane or a physically separated bike lane was added to the street. Moreover, the stated levels of comfort for the physically separated lane on the commercial street were nearly equal to those on a separate path or trail.

In contrast, amoung the residents, women were less comfortable than men in every environment. The physically separated lanes did increase comfort levels to an average of 4.5 on the 1-6 scale, 1=very uncomfortable, 6=very comfortable. Note that the gender differences can be attributed to the residents who currently do not make trips on bicycle. When the analysis is done with only residents who make some or most of their commute or other trips on bicycle, there are only gender differences on the street without a bike lane.



**Significant difference between men and women, p<0.05*

FIGURE 4 Levels of comfort in different bicycling environments, intercepted bicyclists and residents.

The potential for protected lanes to improve comfort levels and therefore increase bicycling among women is explored more in Figure 5. The figure shows the stated comfort levels for the women residents who stated that they were interested in bicycling more for transportation and divides those women between those who make some or most of their commute or other trips by bicycle currently ("utilitarian bicyclists") and those who do not. Therefore, the group of women labeled as non-utilitarian bicyclists in this figure could be considered a target market—they currently do not bicycle for transportation, but want to. For those women, changing a striped bike lane to a protected bike lane increases their average level of stated comfort from 3.2 to 4.6. In a separate question, residents were asked whether they would be more likely to ride a bicycle if motor vehicles and bicycles were physically separated by a barrier. Among the residents who were interested in bicycling more for transportation, 87% of the women and 82% of the men agreed, a statistically significant difference between genders.

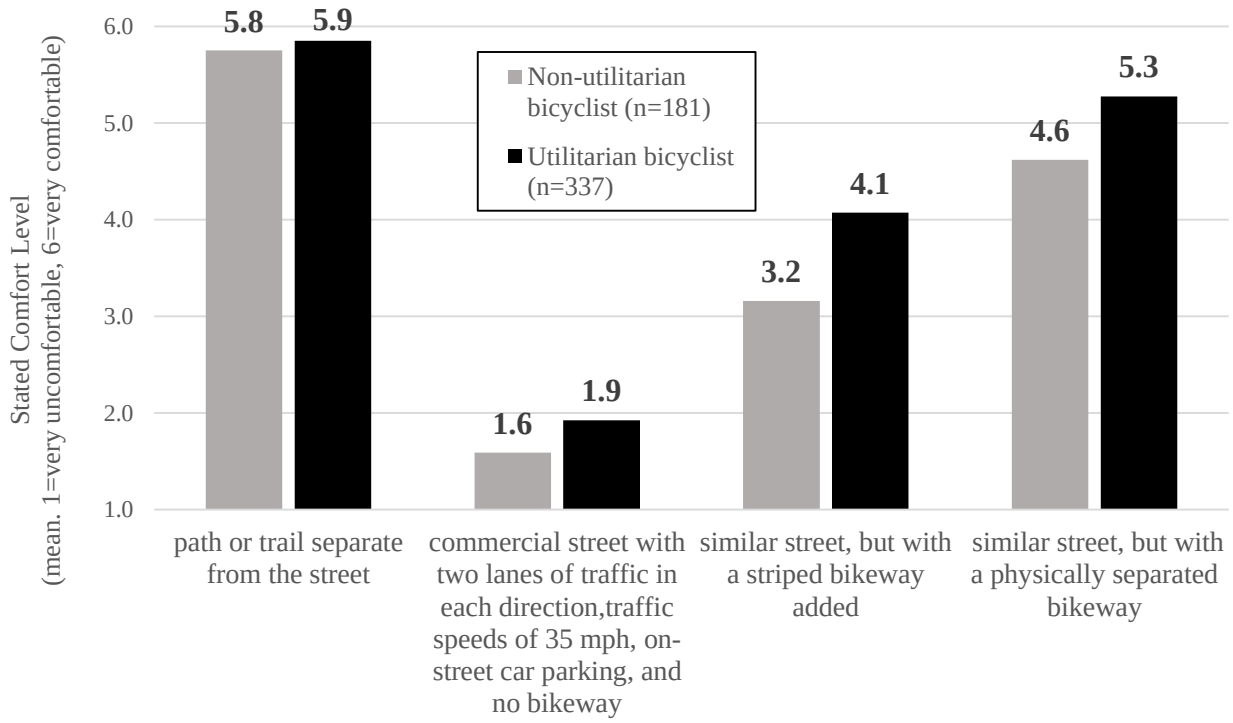


FIGURE 5 Levels of comfort in different bicycling environments: Women residents who are interested in bicycling more, by current bicycling behavior.

CONCLUSIONS

The primary objective of this paper was to explore whether these protected bike lanes could help reduce the gender gap in bicycling in large U.S. cities. To do so, we used survey data from a comprehensive evaluation of protected bike lanes in five large U.S. cities. Surveys of bicyclists riding on the new lanes soon after their installation reveals that women represent 24-44% of the riders, which is comparable to overall bicycle commuting rates in the cities. Any shift in the gender balance of bicyclists on the street is likely to take some time. Therefore, our analysis focused on indications from survey respondents that the lanes might provide higher levels of comfort and perceptions of safety, both factors that influence the decision to ride, particularly among women. Both men and women overwhelmingly felt that the lanes increased their safety while riding in them. On several measures of safety and comfort, women bicyclists using the lanes did have significantly more positive associations with the protected lanes than men. We know that women have more concerns than men about drivers, so it is encouraging the impact these facilities had on women bicyclists' perceptions of drivers' awareness of bicyclists and on the clarity of right-of-way at intersections.

The survey of residents, which included people who do and do not bicycle, revealed that women generally feel less comfortable than men bicycling on roadways, though the addition of some physical separation in addition to a striped bike lane does increase stated levels of comfort to a level that might increase rates of bicycling (4.5 on a 1-6 scale). For potential women bicyclists, protected lanes increase stated comfort levels significantly, though women still reported lower comfort levels than men. It is unknown what comfort level is high enough to get potential women bicyclists to start cycling, but their stated level of comfort on striped bike lanes (mean=3.2) doesn't seem high enough. More research is needed to correlate stated levels of comfort with actual behavior and behavior change.

The findings provide some indication that existing women bicyclists benefit more than men from the protected lanes and may increase their cycling overall more as a result. The intercepted women were less likely than men to have been riding on that street prior to the installation of the protected lane, indicating attractiveness of the facilities to women in particular. Overall, women were also more likely to

indicate that the new lane had increased their overall levels of bicycling a lot. This was particularly true in Austin, Washington DC and Chicago. It may be worth further research to understand the change in these cities relative to the others. Since we know that greater numbers of bicycling by women is associated with higher mode share overall, the overall impact of these facilities outside their direct impact is worth understanding.

Some of the lack of gender differences in attitudes about the design of the facilities are also encouraging from a design and engineering standpoint. The lack of differences on features (such as lane width and most buffer designs) may indicate that cities are not inadvertently implementing a "gendered design" that does not serve women as well as men, or at least that the designs do not affect women differentially.

The demographics of the intercepted bicyclists revealed differences between men and women that point to the challenge of increasing women's rates of bicycling. The women were much less likely than men to have children. Research on women's travel behavior demonstrates that women are more responsible for the taking children places and for household shopping (*23*), trips for which bicycling is a challenge. While protected lanes may provide a better environment for bicycling with children, they are unlikely to address all of the challenges facing mothers who may be interested in bicycling for transportation. With the exception of the Dearborn facility in Chicago, the design of the facilities still require interactions with turning cars at intersections; this additional risk could be important to bicyclists with children. Different bicycle technologies (e.g. electric assist bicycles and cargo bikes) may help, as would greater travel independence for older children (*8*) and a shift in household responsibilities.

Given that this research is based upon surveys, there are limitations, such as response bias and misinterpretations of question wording. However, if these factors are not differential with respect to gender, they may not affect the findings. While the cities in the study were diverse, they do not represent the full range of bicycling environments in U.S. cities. In particular, some of the environments were dense urban cores (Washington DC, Chicago and San Francisco) and none were suburban in nature. Research in these environments would be valuable. Finally, research designs that rely on stated preferences in hypothetical situations, as the resident survey did in some of the analysis here, may not accurately represent actual behavior.

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