

Factors influencing bike share among underserved populations: Evidence from three U.S. cities

Jennifer Dill^{a,b,*}, Jiahui Ma^a, Nathan McNeil^b, Joseph Broach^b, John MacArthur^b

^a Nohad A. Toulon School of Urban Studies and Planning, Portland State University, PO Box 751, Portland, OR 97207-0751, United States

^b Transportation Research and Education Center, Portland State University, PO Box 751, Portland, OR 97207-0751, United States

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ABSTRACT

There is evidence that lower-income and people of color (POC) in the U.S. do not use bike share as much as higher-income and white people. Using data from residents living near stations in New York, Chicago, and Philadelphia, our analysis examines reasons for these disparities. While smaller shares of POC are members (vs higher-income white people), large shares of POC are interested in bike share. Among POC, having positive attitudes about bicycling and having family and friends that use bike share are strong predictors of interest in bike share. POC are also motivated to use bike share for recreational reasons. Receiving information from interactive sources may be effective at increasing bike share use and interest, though it is not clear whether these efforts have affected POC. Cost is a barrier for people who have tried bike share and are interested in using it in the future but are not members.

1. Introduction

Bike share systems have the potential to increase bicycling among people who face barriers to owning and maintaining a personal bicycle and to expand mobility options for lower-income people. Some demographic groups, including people of color and low-income people, have lower rates of physical activity, lower access to physical activity options, and higher rates of health outcomes linked to inactivity (Hawes et al., 2019; Lee et al., 2021; Levine, 2011). Bike share provides a form of physical activity that can help improve health through increased physical activity (Otero et al., 2018). However, evidence to date often shows that, particularly in the U.S., lower-income people and people of color are less likely to have access to bike share or to use bike share when it is available (Dill and McNeil, 2021). While there have been increased efforts to consider equity when siting bike share stations (Howland et al., 2017), it is unlikely that physical access alone will overcome disparities in use (Kodransky and Lewenstein, 2014; Stewart et al., 2013).

The objective of this paper is to understand what factors influence the use of and interest in bike share among traditionally underserved populations in the U.S. and how these factors vary by race/ethnicity and income. We use data from a random sample of residents living near bike share stations in neighborhoods in Brooklyn, New York, Chicago, Illinois, and Philadelphia, Pennsylvania. These three U.S. cities were part of the Better Bike Share Partnership (BBSP), which aimed to make bike share systems more equitable. The cities undertook various activities, including ambassador programs, group rides, bike riding classes, targeted advertising, discounts for lower-income residents, and cash payment options (Chicago and Philadelphia only). Our sample (n = 955) is a majority

* Corresponding author at: Nohad A. Toulon School of Urban Studies and Planning, Portland State University, PO Box 751, Portland, OR 97207-0751, United States.

E-mail addresses: jdill@pdx.edu (J. Dill), jiahma@pdx.edu (J. Ma), nmcneil@pdx.edu (N. McNeil), jbroach@pdx.edu (J. Broach), jhmcart@pdx.edu (J. MacArthur).

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people of color, which provides insights that build on and add to previous research that has largely been qualitative or based on data from only users. Our work is grounded in the U.S. context, which has a long history of racial discrimination and disparities with respect to transportation (Bullard and Johnson, 1997; Sanchez et al., 2018), including bicycling (Golub et al., 2016; Lugo, 2018). Racial, ethnic, and socioeconomic differences in bicycling in the U.S. are linked to patterns of segregation and other factors (Martens, Golub & Hamre, 2021). Our focus on race/ethnicity is between non-Hispanic white people and people of another race or ethnicity (referred to here as “people of color”), who have and continue to be harmed by racism and inequities in the U.S. transport system.

2. Literature review

Our review of the existing research is limited to research related to race/ethnicity and/or income and bike share or bicycling more broadly. More general research on factors influencing bicycling behavior is covered in several review papers (Buehler & Dill, 2016; Heinen et al., 2010; Heinen & Buehler, 2019; Muñoz et al., 2016; Piatkowski & Bopp, 2021; Pucher et al., 2010; Yang et al., 2019). A 2021 review of equity and bicycling research identified 33 papers, about two-thirds of which examined equitable access to bicycle infrastructure, either bike lanes or bike share (Jahanshahi et al., 2021). Few studies examined factors beyond access to infrastructure. The authors identified understanding population needs, usage behavior and perceived safety as a research gap, along with barriers to implementing equity policies.

Despite the growth of bike share systems in the U.S., there is evidence that certain demographic groups are using and benefitting from this transportation option at lower rates than others. A review of research related to equity and vehicle sharing found that people of color and lower-income residents use bike share less, and that this is explained in part by a lack of physical access (Dill & McNeil, 2021). Lower-income and racially diverse neighborhoods are often less likely to have bike share available (Barajas, 2018; Chen et al., 2019; Niemeier & Qian, 2018; Ogilvie & Goodman, 2012; Ursaki & Aultman-Hall, 2016). Disparities in access may be less significant for dockless bike share (A. Brown, 2021; Clewlow et al., 2018; Mooney et al., 2019; Qian et al., 2020).

Physical access does not completely explain these disparities. There is evidence that even when bike share is located nearby, lower-income people and people of color do not use it as much (Bachand-Marleau et al., 2012; Barbour et al., 2019; Biehl et al., 2018; Caspi & Noland, 2019; Chavis et al., 2018; Crossa et al., 2021; Daddio, 2012; Gavin et al., 2016; Hoe, 2015b; Oates et al., 2017; Rixey, 2013; Shaheen et al., 2014; Soto et al., 2021; Wang & Lindsey, 2019). However, some North American research has found higher levels of use by lower-income people after considering station access (Barbour et al., 2019; Oates et al., 2017; Reilly et al., 2020; Wang & Lindsey, 2019; Winters et al., 2019). A study of dockless bike share in Boston suburbs found lower access in areas with higher concentrations of African American residents, but where the dockless bikes were available more trips were generated in such areas (Gehrke et al., 2021). Research has also found that lower-income people and people of color are more likely to be casual users and not members (Buck et al., 2013; Hoe, 2015a; Kaviti & Venigalla, 2019; Qian & Jaller, 2019; Shaheen et al., 2015; Virginia Tech University, 2011). One limitation of some of this research is that it is based on anonymous use data, such as trips by station, with racial or economic disparities assessed using census data for the area around the station (Biehl et al., 2018; Caspi & Noland, 2019; Clewlow et al., 2018; Daddio, 2012; Gehrke et al., 2021; Mooney et al., 2019; Oates et al., 2017; Ogilvie & Goodman, 2012; Qian & Jaller, 2019; Rixey, 2013; Soto et al., 2021; Wang & Lindsey, 2019; Winters et al., 2019).

There is more limited research explaining the reasons for racial and economic disparities in bike share use beyond physical access. Our previous bivariate analysis of the data used for this paper found that people of color were more concerned about cost, liability issues, and using a credit card and had lower levels of knowledge about bike share (McNeil, et al., 2017b). Focus groups of lower-income Philadelphia residents conducted before the system was installed identified concerns related to cost, theft and liability, crime, age restrictions, and the time limit for rides (Hoe & Kaloustian, 2014). Similarly, qualitative research in Minneapolis identified cost, awareness, knowledge and self-efficacy as barriers to using bike share among lower income residents near stations (Stewart et al., 2013). A survey of New York public housing residents living near bike share stations found that 80 % did not know about the discounted memberships for which they were eligible. Some of the primary reasons for not using bike share included traffic safety and cost. In addition, many respondents were used to their normal routine, already owned a bike, or felt that the system was not intended for them. Of the few (14 %) who had used bike share, over 60 % indicated they did for fun and/or exercise (Stead, 2015). Access to credit cards, smart phones, and the internet are often cited as potential barriers to bike share use among lower-income people (Kodransky et al., 2014; Shaheen et al., 2014). Stead (2015) found that only 11 % of the public housing residents surveyed had a credit or debit card. A study of non-members in Baltimore found that POC were more likely to be concerned about not being able to ride with children or carry things, the only barrier that was cited significantly more by people of color than white respondents (Hull Grasso et al., 2020).

Some reasons for not using bike share among people of color and lower-income people may also be related to reasons for not bicycling, generally. Concerns about traffic safety have been cited as a top barrier to bicycling in studies focusing on people of color and lower-income people (C. Brown, 2016; Community Cycling Center, 2012; Hoffman, 2015), though it is not clear if this is more or less of a concern compared to white or higher-income people. A Milwaukee, WI survey found that people living in a low-income neighborhood were more concerned about traffic safety for bicycling, though there were no differences by the respondent's race (Schneider et al., 2022). In Baltimore, traffic safety was the top bike share barrier among all categories of non-users, regardless of race or income (Hull Grasso et al., 2020). There is some evidence of racial disparities related to personal safety concerns. The Milwaukee survey found the Black and Hispanic respondents were more concerned about personal security, including things such as theft, violent crime, drug dealing, and harassment (Schneider et al., 2022). In one focus group study Black participants were concerned about being stopped by police, while Hispanic participants expressed concern over being victims of crime while biking (C. Brown & Sinclair, 2017). A lack of trust in the police was prevalent in more recent focus groups held in 10 U.S. cities (C. Brown et al., 2021). Focus groups in Portland, OR

found that people of color were also concerned about racial profiling and police violence, as well as racial microaggressions from other road users and gentrification (Lubitow et al., 2019). Data from Chicago indicates that citations for bicycling-related traffic infractions were disproportionately issued in Black and Latino neighborhoods and that this was not correlated with traffic safety problems (Barajas, 2021).

Another barrier to bicycling linked to race/ethnicity and/or income involves perceptions of it as a stigmatizing or negative activity. Some Black/African American and Hispanic/Latino participants in focus groups held in 10 U.S. cities said that their family might not support them bicycling because the activity is associated with whiteness. The study also found that many participants' perception of a typical bicyclist was a white male wearing spandex (C. Brown et al., 2021). One study found that some African-Americans perceived bicycles as toys for children, or associated them with drug dealers, while others viewed them as symbols of gentrification (Community Cycling Center, 2012). Another focus group study found some Black and Hispanic participants thought that riding a bicycle would suggest they could not afford a car or that their car was inoperable (C. Brown & Sinclair, 2017). Social stigma was identified as a potential barrier to bike share among current and former members of the system in Birmingham, Alabama, though the study participants were primarily white, non-Hispanic (Bateman et al., 2021).

3. Data and methods

3.1. Conceptual model

Based on the existing research reviewed above, we developed a conceptual model to test the various factors that could influence the decision to use bike sharing (Fig. 1). The model distinguishes between interest in using bike share and actually using bike share, similar to including both intentions and behavior in models based on the theory of planned behavior (Ajzen, 1991; Bezirgani et al., 2019; Rahman & Sciara, 2022). This is also an element of the Transtheoretical Model (TTM) of behavior change, which typically includes five stages of change: (1) Precontemplation; (2) Contemplation, where a person considers a change possible in the next six months; (3) Preparation, where the person plans to make a change in the next month and is taking steps to make that change; (4) Action, where the person has made the change recently; and (5) Maintenance, where they have engaged in the new behavior for more than six months (Friman et al., 2017). One application of this theory to bike sharing found that low-income people were more likely to be in a combined Action-Maintenance stage and that people of color were less likely to be in the contemplation stage (Biehl et al., 2019).

In this model, we use the term “attitudes” broadly. We include attitudes and perceptions of bicycling and bike share at two domains: (1) the personal level, e.g., a person liking to ride a bicycle or thinking that using bike share may be a useful way for them to get around; and (2) the community or societal level, e.g., a person thinking that more people bicycling is good for the environment or that the bike share system is good for the city. Finally, we include perceived barriers that apply to bicycling generally, such as concerns about traffic while bicycling, as well as with using a personal bicycle, such as not having a safe place to store a bike at home. Other barriers are specific to bike share, such as membership cost.

Using a bike share system requires specific knowledge, such as how to sign up, how to check out a bicycle, how and where to return it, time limits, etc. With such knowledge or with incorrect knowledge (e.g., thinking a helmet is required to use the system), people are less likely to use bike share. Demographic factors may influence interest and use directly, though we also believe, based on other research, that certain demographic characteristics may have a stronger relationship with attitudes which then influence interest and behavior. We are not sure if the same relationship exists with respect to bike share knowledge, as that has not been examined in the existing research. We also include social norms, such as seeing people “like me” using bike share. Finally, the model includes the bicycle infrastructure available. The diagram of the model shows the relationships between the factors and outcomes as unidirectional.

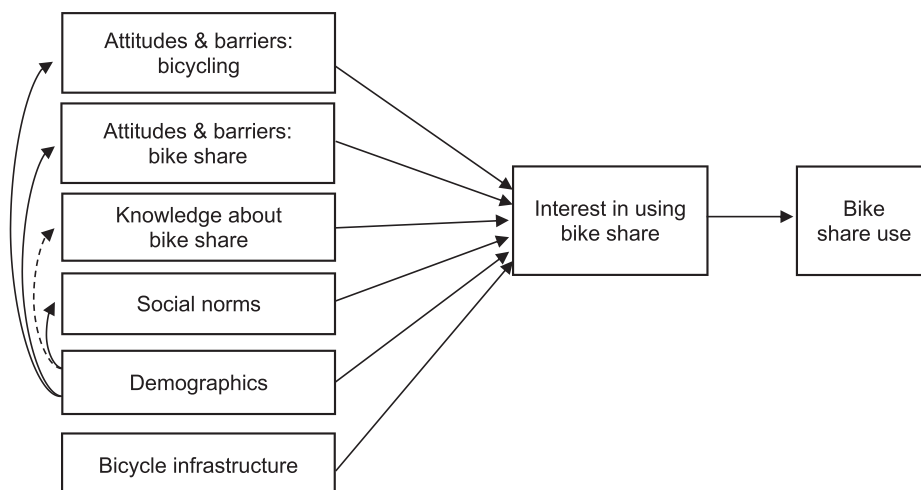


Fig. 1. Conceptual model.

Based on existing research, we think the directions shown are the most probable or strongest, though it is likely that many of the relationships are bidirectional. Our measures of each of the elements of this model are described in more detail in [Section 3.5](#).

3.2. Study locations

The study took place in the Brooklyn borough of New York City, NY, Chicago, IL, and Philadelphia, PA. These cities were participants in the Better Bike Share Partnership (BBSP) effort to improve the equity outcomes of their bike share systems (For more information about BBSP see <https://betterbikeshare.org/> and [McNeil et al., 2017b](#)). In addition to placing bike share stations in traditionally underserved neighborhoods—those with higher proportions of residents with lower-incomes and who are people of color—the effort included the ability to pay membership fees using cash (Philadelphia and Chicago only), discounted memberships, targeted education and marketing, ambassador programs, and outreach events such as organized rides.

The study areas are shown in [Fig. 2](#). We first selected study areas within the neighborhoods that were part of the BBSP effort. We selected the study areas to be within about one-quarter mile of a bike share station and to not include predominantly white, higher-income, or college student populations. In Chicago and Brooklyn, we also included nearby areas with similar demographics and new bike share stations but that were not receiving BBSP-related place-based outreach, such as organized rides and events. The intent was to provide a control area to test the effectiveness of those outreach efforts. These control neighborhoods did receive elements of citywide outreach, could participate in events held within the target areas, and were eligible for discount programs. Relative to residential areas in the three cities, all of the areas are close to the city's downtown, in areas with a dense grid street pattern, and have high population densities ([Table 1](#)). They are also similar in most characteristics, except that the Brooklyn study areas are much denser.

3.3. Survey administration

Our data collection occurred in 2016, about one year after the stations were installed in the neighborhoods. For Philadelphia, this was at the same time the entire system was launched. The systems in Chicago (Divvy) and New York (Citi Bike) launched in 2013. The

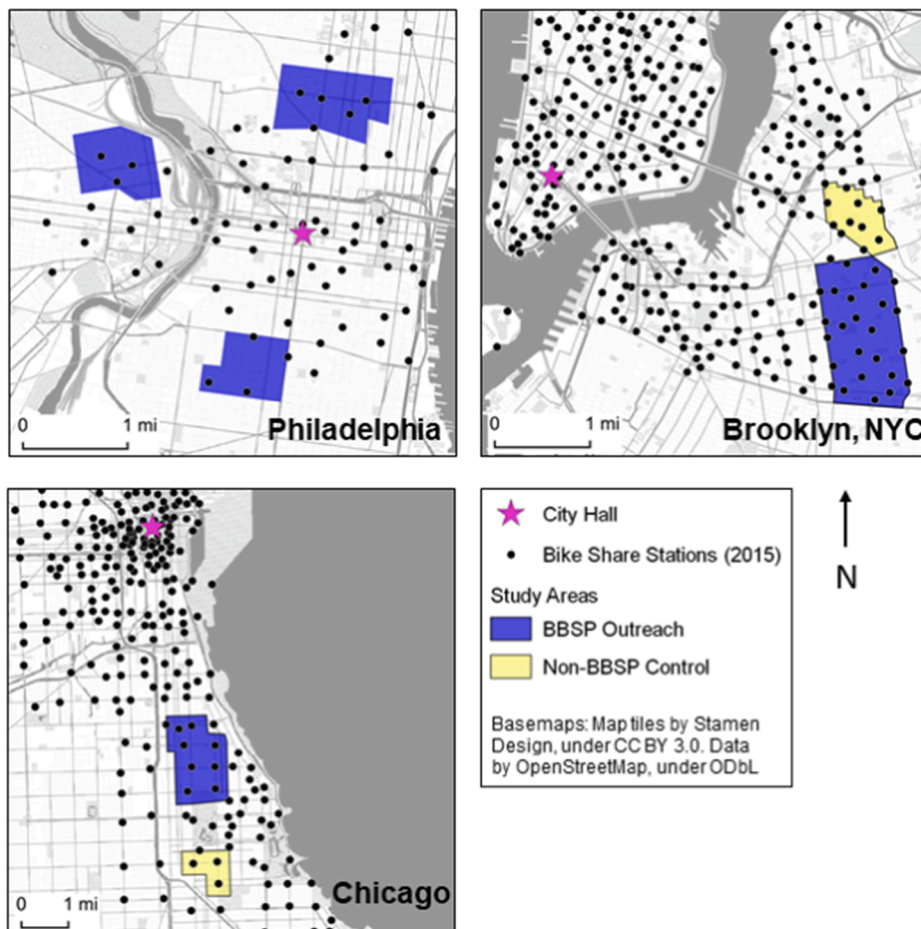


Fig. 2. Study Area Locations.

Table 1
Characteristics of the study areas.

	Brooklyn, NY (2 areas)	Chicago, IL (2 areas)	Philadelphia, PA (3 areas)
Population density (per square mile)	60,281 – 84,437	15,198 – 22,999	13,330 – 29,558
Street network density (miles per square mile)	25.5 – 32.7	19.3 – 22.7	28.8 – 43.1
Density of bike lanes and paths (miles per square mile)	2.8 – 3.3	1.6 – 2.1	1.7 – 6.7
Average distance to downtown city hall (miles)	3.1 – 3.6	5.1 – 7.2	1.2 – 1.8
% people of color	80 – 89 %	95 – 97 %	82 – 84 %
% below 300 % of poverty	67 – 73 %	67 – 82 %	67 – 83 %

survey was designed as a paper, mail out survey, and included the option of being mailed back or completed online. The surveys were generally identical, with only minor specifications/modifications based on the city or neighborhood. The survey included questions on: (1) their neighborhood and how they get around; (2) attitudes about bicycling, including barriers; (3) their experience with the bike share system, including sources of information and knowledge about how the system worked; (4) attitudes about the bike share system and motivations and barriers to using it; and (5) demographics. We made available a Spanish-language version of the survey, both on paper and on the web.

Our sampling frame included all non-duplicate residential addresses from InfoUSA (now known as Data Axle USA) within our study area boundaries. The InfoUSA database of residential addresses is compiled from a variety of sources and updated regularly, though it likely does not include 100 % of addresses within our study areas (Kennel and Li, 2009) and we do not know what bias this may introduce to the sample. We randomly selected 6,000 addresses for each city. Each survey packet included an invitation letter, a paper survey, a prepaid and preaddressed return envelope, a compensation/raffle drawing slip, and a brightly colored Spanish-language slip explaining the survey. The letter and survey included a URL address and code to complete the survey online. Every person who returned the completed survey and the slip would be mailed transit passes worth about \$5 in each city. The respondent could also opt in to a drawing for a \$250 Amazon gift card (one per city). Two days after the surveys were mailed, we sent a postcard reminder that included the survey URL and code. Of the 18,000 surveys sent, based on returned mail, 16,907 were delivered. There were 1,885 completed surveys (517 online and 1,368 by mail), for an 11 % overall response rate.

3.4. Sample used for analysis

We compared the respondents to demographic data from the American Community Survey 5-year estimates for 2011–2015 for the Census tracts with majority of area inside the survey sample boundary. With respect to race/ethnicity the respondents matched somewhat closely to their respective neighborhoods, with 65 % of both the respondents and ACS estimated population identifying as Black. There were differences for other race/ethnicity categories (respondents vs ACS): non-Hispanic white was 20 % vs 14 % and Hispanic was 9 % vs 17 %. The sample also matched well for income (vs ACS): under \$25,000 was 44 % vs 45 %, \$25,000–49,999 was 21 % vs 22 %. The survey sample was more female (70 % vs 56 %), older (44 % were 55 or older vs 29 % and 23 % were age 18–34 vs 38 %), and more educated (70 % had at least some college vs 51 %). It is unclear if this response bias is due to attitudes about or participation in bike share. To reduce such bias, the survey was branded as a “Neighborhood Transportation Survey” and the questions on the first page were not focused on bicycling or bike share. There is some evidence that higher educated people and women are more likely to respond to mail surveys (Green 1996).

For this analysis, we limited the sample to respondents who indicated that they were physically able to ride a bicycle and who were below the age of 65. The age limitation is based on our prior analysis of the data, which revealed that older adults are a very distinct population group with respect to bike sharing and should be analyzed separately (Howland et al., 2018; McNeil et al., 2017b). To answer our key research questions, we also created four groups based on race/ethnicity and income: lower-income people of color (POC); higher-income POC; lower-income white; and higher-income white. POC is defined as anyone identifying as a race other than white (including white plus another race) and/or as Hispanic. Income groups were based upon being below or at/above 300 % of the federal poverty threshold for their family size (U.S. Department of Health and Human Services, 2016). The sample for this analysis is therefore limited to respondents who provided data on age, ability to ride a bicycle, race/ethnicity, income, and family size ($n = 955$). The large majority (81 %) of the POC respondents identified as Black or African American; 13 % identified as being of Hispanic, Latino or Spanish origin, 7 % Asian, and 4 % American Indian or Alaska Native. Multiple responses were allowed.

3.5. Variables

3.5.1. Dependent variable

Our categorical dependent variable combines both interest in bike share and use of bike share. The groups somewhat emulate those that would be used in a stages of change model with bike share membership as the final behavior, except that we include a group of people who have tried bike share but are not interested in using it in the future (“Tried/Not Interested”). We are also not explicit about defining a preparation stage to become a bike share member. Preparing could involve getting information, which is included in our model as an independent variable. Trying bikeshare without being a member could be considered another preparation step, though it is not necessary. Table 2 shows how the five groups were created using three questions, where [BSS] was replaced with the name of the specific bike share system for the city.

Table 3 shows the group membership by the race/ethnicity and income categories. Consistent with existing research, higher-income white respondents are more likely to be members (11 %), compared to 5 % of higher income POC and 1 % of lower-income POC. Of note, however, is that 43 % of lower-income POC are interested compared to 33 % of higher-income white respondents. One key difference between the POC (both higher- and lower-income) and higher-income white people who are interested but not members is that the latter group is more likely to have tried bike share, indicating that they are perhaps further along a behavior change process that leads to membership.

3.5.2. Independent variables

Given the depth of the survey, we were able to test many measures of attitudes towards and barriers to bicycling and bike sharing. The variables for attitudes and barriers for bicycling appear in Table 4 and in Table 5 for bike sharing. We share all of the variables we tested here, even though some were not significant in the models. We discuss the relevance of insignificant variables in our findings and discussion.

The survey included questions described as “opinions about” bicycling and the bike share system for that city. These attitudinal questions used a four-point scale from strongly disagree (1) to strongly agree (4) with a “does not apply” option. There were separate questions about reasons for not bicycling or using the bike share system. These questions used a three-point scale of not a barrier (1), small barrier (2) and big barrier (3), with a “does not apply” option. For questions in these sections that had common themes, we created scale variables using the mean score. To reduce the omission of respondents due to item non-response, we created the scales allowing up to two missing items when there were four or more items. In addition, we coded “does not apply” as 2.5 for the attitude scales (1 to 4) and 1 for the barriers scales (1 to 3). There were also questions asking respondents to choose from a list of reasons they use or would consider using the bike share system. From these responses, we created two scales about bike share motivators, one with items related to fun and exercise and the other with items related to the utility of bike share (Table 5).

Another set of variables relates to knowledge and information and social norms. We have two measures of knowledge and one related to information sources (Table 6). The first is a scale of three items related to knowledge-based barriers to using bike share. The second is based on 13 statements for which respondents indicated whether the statement was definitely or probably true or false. These included statements such as whether a credit card or smart phone was needed to use the bike share system, the cost of membership, that membership was limited to customers of the sponsor of the system, and that helmets are required. Each correct answer (definitely or probably) was coded as 1 and the correct answers were summed to create a scale of factual knowledge. Another variable measured whether the respondent had received information about the system from an interactive source, such as talking to a representative of the system or one of the partner organizations at an event. The survey also collected data on whether the person received information from more passive sources, such as television, newspaper, and ads. Bivariate analysis did not find that these sources were correlated with our dependent variable. We tested three measures of social norms: whether the respondent’s friends or family have used the bike share system, whether they see people like them using the system in their neighborhood, and whether not wanting to be seen on a bike share bike is a barrier to using the system.

Using GIS data provided by each city at the time of our data collection, we calculated the number of miles of bicycle infrastructure within a 0.5-mile buffer of each respondent’s home address. Bicycle infrastructure included striped bike lanes and protected or separated bike lanes. The mean and standard deviation of this variable for each city was: Brooklyn, 3.00 (0.81); Chicago 2.77 (1.10); and Philadelphia 2.68 (1.87).

3.6. Analysis approach

We estimated multinomial logit (MNL) models using our user-interest dependent variable. The base (reference) was Non-user/Not Interested. Some analyses using a traditional stages of change dependent variable might use an ordinal model. However, there is no clear order for all of the categories in our dependent variable, so MNL is more appropriate. In the first step to developing the models, we tested each independent variable separately in a model with a constant. Variables that were not significant were dropped from further analysis. We then estimated the MNL in three stages: demographics, bicycling attitudes and barriers (Table 4) and bicycle infrastructure; and bike share attitudes, barriers, knowledge and norms (Table 5 and Table 6). We also included dummy variables for the cities in the first stage. After the first and second stages, we removed variables where $p > 0.15$. For the final model, we only retained variables where $p < 0.10$. In our findings, we share a model (Model 1) with just the demographic and city dummy variables to show

Table 2
Explanation of use-interest group dependent variable.

Group	Interest In the next 6 months, how likely are you to ride a [BSS] bike?	Non-user vs Tried Have you ridden a [BSS] bike?	Current Member Are you currently a member of [BSS]?
Non-user/Not interested (n = 511)	Not at all likely/Not likely	No or not sure	No or not sure
Non-user/Interested (n = 287)	Somewhat likely/Very Likely	No or not sure	No or not sure
Tried/Not interested (n = 31)	Not at all likely/Not likely	Yes	No or not sure
Tried/Interested (n = 83)	Somewhat likely/Very Likely	Yes	No or not sure
Current member (n = 43)	–	–	Yes

Note: On each survey [BSS] was replaced with the name of that city’s bike share system.

Table 3

Use-Interest group membership by race/ethnicity and income category.

	Lower-Income POC	Higher-Income POC	Lower-Income White	Higher-Income White	Total
Non-user/Not interested	54 %	53 %	55 %	52 %	54 %
Non-user/Interested	37 %	29 %	31 %	19 %	30 %
Tried/Not interested	1 %	5 %	6 %	4 %	3 %
Tried/Interested	6 %	8 %	6 %	14 %	9 %
Current member	1 %	5 %	2 %	11 %	4 %
Total	100 %	100 %	100 %	100 %	100 %
n	428	252	49	226	955

Table 4

Independent variables measuring attitudes and barriers about bicycling.

Variable	Description	Statistics
Bicycling Attitudes: Personal (5 items, Strongly disagree to strongly agree)	I would like to ride a bicycle (for transportation) more than I currently do Riding a bike would make me more independent in getting around Riding a bike would help me spend less on transportation Riding a bike would be a good way for me to get exercise Riding a bike would be a good way for me to spend time with friends or family	Mean: 2.813 sd: 0.568 Range: 1.0–4.0 Cronbach's Alpha: 0.77
Bicycling Attitudes: Community Benefits (4 items, Strongly disagree to strongly agree)	Getting more people to ride bikes is good for the environment Getting more people to ride bikes will help make the community healthier [City] should invest in projects (such as bike lanes) that make riding bikes safer and easier Riding a bike is a convenient way for people to get places in [City]	Mean: 3.240 sd: 0.603 Range: 1.0–4.0 Cronbach's Alpha: 0.85
Bicycling Attitudes: Community Nuisances (3 items, Strongly agree to strongly disagree)	People on bikes make roads less safe for others Bike lanes make it harder to get around my neighborhood [BSS] stations take up street and sidewalk space that would be better used for other things	Mean: 2.805 sd: 0.703 Range: 1.0–4.0 Cronbach's Alpha: 0.72
Bicycling Barrier: traffic (Not a barrier to big barrier)	Traffic makes riding a bike in my neighborhood feel dangerous	Mean: 2.083 sd: 0.869 Range: 1.0–3.0
Bicycling Barrier: Police attention (Not a barrier to big barrier)	Riding a bike could make me a target for police attention	Mean: 1.181 sd: 0.504 Range: 1.0–3.0
Bicycling Barrier: crime (Not a barrier to big barrier)	Riding a bike could cause me to be harassed or a victim of crime	Mean: 1.505 sd: 0.724 Range: 1.0–3.0
Bicycling Barrier: Gear & Logistics (4 items, Not a barrier to big barrier)	I don't have a bike or related gear (such as helmet / lock / lights) It is too expensive to buy a bike or related gear I don't have a safe place to store a bike at home I don't know a good place for me to get a bike fixed	Mean: 1.603 sd: 0.613 Range: 1.0–3.0 Cronbach's Alpha: 0.76
Bicycling Barrier: Appearance & Comfort (3 items, Not a barrier to big barrier)	Riding a bike could mess up my hair or appearance The clothes I wear are not appropriate for biking Riding a bike could make me sweaty	Mean: 1.422 sd: 0.566 Range: 1.0–3.0 Cronbach's Alpha: 0.81

Note: On each survey [BSS] was replaced with the name of that city's bike share system.

how the inclusion of variables representing other parts of our conceptual model alter (or not) the effects of demographics (Model 1). The analysis was conducted using IBM SPSS Statistics 28.

Because our primary objective is to understand lower-income and people of color, we also estimated separate models for three of our four race/ethnicity and income groups: lower-income POC, higher-income POC, and higher-income white respondents. However, because there were few POC in some of the five groups in our original user-interest dependent variable, we collapsed the variable to interested or not, omitting current members. Therefore, these models explain factors associated with interest in bike share among non-members. For these models, we started with the same independent variables in our final MNL model and then tested adding variables that had been dropped from those models. As a result, one variable was added to these models – bicycle infrastructure – which was not significant in the MNL models. In addition, including the variable indicating utility as a reason for using bike share in the MNL models

Table 5
Independent variables measuring attitudes and barriers about bike share.

Variable	Description	Statistics
Bikeshare Attitudes: Personal (4 items, Strongly agree to strongly disagree)	[BSS] is useful for people like me Using [BSS] is a good way to spend less money on transportation Using [BSS] is a good alternative to using public transportation [BSS] is a good way to get to public transportation	Mean: 2.845 sd: 0.542 Range: 1.0–4.0 Cronbach's Alpha: 0.77
Bikeshare Attitudes: Neighborhood (2 items, Strongly agree to strongly disagree)	There is a focused effort to make [BSS] better for all residents in my neighborhood Over time, the [BSS] program is getting better at serving the needs of people like me	Mean: 2.658 sd: 0.529 Range: 1.0–4.0 Cronbach's Alpha: 0.76
Bikeshare Attitudes: Community Benefits (3 items, Strongly agree to strongly disagree)	I consider [BSS] to be a part of the city's public transportation system Overall, [BSS] is good for the city Overall, [BSS] is good for my neighborhood	Mean: 2.947 sd: 0.598 Range: 1.0–4.0 Cronbach's Alpha: 0.79
Bikeshare Barriers: Accessibility (3 items, Not a barrier to big barrier)	There aren't [BSS] stations near where I want to go There aren't [BSS] stations near my home I don't know where other stations are to drop off a bike	Mean: 1.378 sd: 0.541 Range: 1.0–3.0 Cronbach's Alpha: 0.76
Bikeshare Barriers: Complexity (2 items, Not a barrier to big barrier)	Signing up for [BSS] is too complicated Checking out and returning [BSS] bikes is too complicated	Mean: 1.270 sd: 0.511 Range: 1.0–3.0 Cronbach's Alpha: 0.81
Bikeshare Barriers: Cost (Not a barrier to big barrier)	Membership or use costs are too high	Mean: 1.806 sd: 0.858 Range: (1–3)
Bikeshare Barriers: Credit Card	Credit card is a barrier to use bike share <i>and</i> Does not have a credit card Credit card is a barrier to use bike share <i>and</i> Has a credit card Credit card is not a barrier to use bike share	16 % 18 % 66 %
Bikeshare Barriers: Smartphone (Not a barrier to big barrier)	I don't have a smartphone (indicated as a barrier to using bike share)	9 % big barrier 5 % small barrier
Reasons for using bike share: fun/exercise (4 items, yes or no)	To get exercise For fun To ride with friends/family Want to try biking	Mean: 0.46 sd: 0.35 Range: 0.0–1.0 Cronbach's Alpha: 0.71
Reasons for using bike share: utility (4 items, yes or no)	Saves me money compared to other transportation options Saves me time compared to other transportation options It's an easy way to get around Stations are near my home/work/school	Mean: 0.32 sd: 0.34 Range: 0.0–1.0 Cronbach's Alpha: 0.73

Note: On each survey [BSS] was replaced with the name of that city's bike share system.

resulted in an over-specified model, but it was included in the interest model. Finally, to provide additional insights into what might be done to motivate these interested respondents to become members or ride more often, we analyze responses to questions about what changes would make them more likely to use the bike share system.

4. Results

4.1. Characteristics of the sample

Sociodemographic characteristics of the respondents are shown in Table 7. Most of our sample does have access to items that make use of bike share feasible or easier: a smartphone, credit or debit card, and reliable internet access. However, lower-income POC respondents were less likely to have these items. The data show signs of the gentrification occurring in some of the neighborhoods, with

Table 6
Independent variables measuring knowledge of bike share and social norms.

Variable	Description	Statistics
Bikeshare Barriers: Knowledge (3 items, Not a barrier to big barrier)	I worry that I'll have to pay for the bike if anything happens to it I don't know enough about how to use it I worry that the [BSS] bikes wouldn't adjust to fit me	Mean: 1.61 sd: 0.61 Range: 1.0–3.0 Cronbach's Alpha: 0.72
Factual knowledge	Number of incorrect answers for 13 True/False questions about the bike share service.	Mean: 6.83 sd: 3.86 Range: 0–13
Received interactive sources of information	Choosing Yes to any one of the following: Where have you gotten information about [BSS]? Talked to someone at an event Where have you gotten information about [BSS]? Talked to someone from the [Local Partner] Have you ever talked to someone who works with [BSS]? Have you attended special events related to [BSS]?	22 %
Friends or family have used BSS	Have any of your friends or family used [BSS]?"	54 %
Social norms (Strongly disagree to strongly agree)	I see people like me using [BSS] in my neighborhood	Mean: 2.81 sd: 0.75 Range: 1–4
Social Stigma (Not a barrier to big barrier)	I don't want to be seen on a [BSS] bike	Mean: 1.16 sd: 0.46 Range: 1–3

Note: On each survey [BSS] was replaced with the name of that city's bike share system.

35–43 % of the white respondents having lived in the neighborhood two years or less and over half of the lower-income POC respondents having lived in their neighborhood for 11 or more years. The white respondents are also younger, less likely to have children in the household, and more likely to be male. A large share (33 %) of the lower-income white respondents are full-time students. Because of this, and the sample size ($n = 49$), our analysis does not focus on this group.

4.2. Models of factors associated with group membership

The MNL models of user-interest group membership are shown in Table 8. As expected, the full model (Model 2) has higher explanatory power than the model with only demographics and the city dummies (Model 1), and the significance of the demographic variables changes some when the other factors are included. All of the components of our conceptual model are represented in Model 2 except for bicycle infrastructure, which was not significant.

4.2.1. Demographic factors

Of particular interest for our research objective is the role of race/ethnicity and income. In Model 1 lower-income people of color are far less likely to be a bike share member (base is higher-income white respondents). However, in Model 2 there are no significant correlations for this group, likely indicating that the other components of our conceptual model are more important. In contrast, being a lower-income white person is marginally significant in both models and is associated with lower odds of bike share membership. Having at least a bachelor's degree increases the odds of being Tried/Not Interested in both models, but reduces the odds of being a member in Model 2.

While a higher age is associated with lower odds of having tried bike share or being a member in Model 1, it is only significantly associated with lower odds of being in the Tried/Interested group in Model 2. In Model 2, being male increases the odds of being in the Non-user/Interested group and has no effect on membership. The Brooklyn respondents are less likely to be in the Tried/Not Interested and Non-user/Interested groups. Being in Philadelphia was not significantly different than being in Brooklyn in any of the models. Only in Model 2 is having a car available significant; those with a car are much less likely to be members or to be Tried/Not Interested. Respondents with a bicycle are less likely to be Tried/Not Interested or Non-user/Interested.

4.2.2. Attitudes and barriers

Only one of the attitude or barrier variables related to bicycling (not bike share) is significant in Model 2. Respondents who were more positive about the personal benefits of bicycling are more likely to be interested in bike share (non-users and tried). Attitudes about bicycling at the community level are not significant and not included in the model. While 42 % of our respondents indicated that a big barrier to bicycling was that traffic makes riding a bicycle in their neighborhood dangerous, this is not a significant factor associated with interest, use, or membership. Concerns about police attention, harassment, and crime are also not significant, nor are barriers related to appearance and comfort or gear and logistics for bicycling.

Table 7

Sociodemographic characteristics of the respondents by race/ethnicity and income groups.

	All	Lower-Income POC	Higher-Income POC	Lower-Income White	Higher-Income White
<i>Household income</i>					
Under \$50,000	54 %	93 %	19 %	90 %	12 %
\$50-\$99,999	27 %	7 %	51 %	10 %	42 %
\$100,000+	19 %	0 %	30 %	0 %	46 %
<i>Access to banking and technology</i>					
Smartphone	81 %	66 %	91 %	84 %	97 %
Credit card	69 %	42 %	88 %	78 %	98 %
Debit card	83 %	69 %	92 %	86 %	96 %
Reliable internet access	75 %	54 %	87 %	86 %	100 %
<i>Housing</i>					
Owns home	36 %	15 %	58 %	19 %	51 %
Rents home (not subsidized)	43 %	40 %	37 %	71 %	48 %
Lives in subsidized rental housing	18 %	37 %	4 %	8 %	0 %
Has lived in current neighborhood					
...0-2 years	23 %	15 %	19 %	43 %	35 %
...2.1-5 years	20 %	12 %	22 %	28 %	31 %
...6-10 years	19 %	20 %	18 %	17 %	20 %
...11 + years	38 %	53 %	40 %	11 %	14 %
<i>Transportation</i>					
Driver's license	73 %	48 %	91 %	82 %	96 %
Transit pass	47 %	44 %	56 %	35 %	44 %
Car available for use	49 %	30 %	70 %	49 %	62 %
Carshare membership	9 %	3 %	8 %	14 %	19 %
Working bicycle	32 %	15 %	35 %	35 %	58 %
<i>Other demographics</i>					
Age 18-34	35 %	22 %	28 %	65 %	60 %
Age 35-54	42 %	45 %	49 %	29 %	34 %
Age 55-64	23 %	33 %	23 %	6 %	6 %
Female	67 %	74 %	68 %	65 %	53 %
Employed	77 %	57 %	94 %	71 %	96 %
Full-time student	10 %	9 %	9 %	33 %	8 %
Has bachelor's degree or higher	52 %	19 %	67 %	67 %	92 %
Children in the household	34 %	47 %	26 %	35 %	16 %
<i>City</i>					
Chicago, IL	32 %	39 %	44 %	8 %	9 %
Philadelphia, PA	39 %	30 %	32 %	67 %	57 %
Brooklyn, NY	30 %	32 %	25 %	24 %	34 %
n	955	426	252	49	226

Note: For some characteristics, the sample size may be smaller due to question non-response.

Several of the variables measuring attitudes and barriers related to bike sharing are significant in Model 2. Positive personal attitudes related to bike share are significantly associated with being a member, as are positive views of the community-related benefits of bike share. Positive bike share attitudes are also associated with being Tried/Interested. Respondents who agreed that the bike share system was serving people in the neighborhood are more likely to be Non-user/Interested and less likely to be Tried/Not Interested or a member. Cost being a barrier to bike share is associated with being Tried/Interested. The bike share barriers that are not significant are station accessibility, system complexity, and credit card and smartphone access. People who are motivated to use bike share for fun, exercise and social reasons are more likely to be interested (non-user and tried). This factor is not associated with membership.

4.2.3. Knowledge and social norms

Respondents who indicated knowledge-related barriers to bike share use are less likely to be Tried/Interested or members, and those with more accurate factual knowledge are more likely to have tried bike share or are members. People who received more interactive sources of information are more likely to be in all of these groups, relative to having not tried nor being interested in bike share. The size of the coefficients indicates that this has a lower effect on increasing the odds of being Non-user/Interested.

Having friends and family that have used bike share is associated with being interested, particularly Tried/Interested, and being a member. If respondents agreed that they see people like them using bike share they are more likely to be Non-user/Interested. This measure of a social norm is not correlated with having tried bike share or being a member. Our measure of social stigma (not wanting to be seen on a bike share bike) was not significant.

4.3. Interest in bike sharing by race/ethnicity and income groups

The segmented models of interest in bike share among non-members are shown in Table 9. Several of the variables that are significant in MNL Model 2 are not significant in these models, particularly attitudes and barriers related to bike share. As noted in Section 3.6, bicycle infrastructure is significant in one of these models. Among higher-income POC, a higher density of bicycle infrastructure is

Table 8
Multinomial logit models of group membership.

	Tried/ Not Interested		Non-user/ Interested		Tried/ Interested		Current member	
	B	p	B	p	B	p	B	p
<i>Model 1</i>								
Constant ^a	-1.61	0.20	-0.42	0.36	-0.08	0.91	0.95	0.36
Age (years, 18–64)	-0.05	0.02	-0.01	0.18	-0.04	<0.01	-0.04	0.02
Male	0.70	0.15	0.22	0.21	-0.47	0.07	-0.60	0.08
Has Bachelor's degree or higher	1.47	0.02	-0.01	0.98	0.43	0.21	-0.43	0.35
Lower-income person of color ^a	-0.57	0.42	0.44	0.11	-0.01	0.97	-1.96	<0.01
Higher-income person of color ^a	0.42	0.40	0.21	0.42	0.02	0.96	-0.54	0.23
Lower-income white ^a	-0.23	0.78	0.20	0.59	-0.88	0.18	-1.80	0.09
Philadelphia ^b	-0.52	0.30	0.01	0.96	0.29	0.37	-0.38	0.45
Brooklyn ^b	-1.05	0.06	-0.56	0.01	-0.62	0.11	-0.06	0.91
Has car available for use	-0.64	0.15	0.27	0.12	-0.16	0.57	-0.54	0.17
Has a working bicycle	-0.13	0.76	-0.71	<0.01	0.16	0.56	0.22	0.55
<i>Model 2</i>								
Constant	-4.77	0.04	-7.32	<0.01	-9.13	<0.01	-15.86	<0.01
Age (years, 18–64)	-0.03	0.27	-0.01	0.35	-0.03	0.03	<0.01	0.99
Male	0.82	0.11	0.47	0.02	-0.24	0.44	-0.03	0.95
Has Bachelor's degree or higher	1.34	0.05	-0.06	0.79	0.24	0.56	-1.22	0.09
Lower-income person of color ^a	-0.01	0.99	0.24	0.46	0.43	0.39	-1.41	0.18
Higher-income person of color ^a	0.65	0.26	0.38	0.21	0.59	0.16	0.16	0.81
Lower-income white ^a	-0.40	0.66	-0.01	0.98	-0.66	0.35	-2.58	0.07
Philadelphia ^b	-0.39	0.49	0.01	0.96	0.49	0.23	-0.20	0.80
Brooklyn ^b	-1.41	0.03	-0.63	0.01	-0.75	0.10	0.19	0.82
Has car available for use	-1.13	0.02	0.19	0.38	-0.10	0.76	-1.44	0.01
Has a working bicycle	-0.87	0.10	-0.94	<0.01	-0.51	0.15	-0.90	0.14
Bicycling attitudes: personal	0.50	0.27	0.90	<0.01	0.81	0.01	0.52	0.37
Bike share attitudes: personal	-0.19	0.75	0.34	0.15	0.75	0.05	3.73	<0.01
Bike share attitudes: neighborhood	-1.20	0.02	0.38	0.10	0.33	0.37	-1.47	0.01
Bike share attitudes: community benefits	0.46	0.36	-0.12	0.60	-0.03	0.95	1.48	0.04
Bike share barrier: cost	0.22	0.46	0.08	0.55	0.65	<0.01	-0.73	0.09
Reason for using bike share: fun/exercise	0.70	0.33	1.76	<0.01	1.88	<0.01	1.30	0.15
Bike share barrier: knowledge	-0.51	0.31	0.26	0.17	-1.03	0.01	-2.98	<0.01
Factual knowledge	0.36	<0.01	-0.12	0.52	0.09	0.09	0.46	<0.01
Received Interactive sources of info	1.30	0.01	0.47	0.05	1.18	<0.01	1.54	0.01
Friends or family have used [BSS]	0.65	0.17	0.53	0.01	2.18	<0.01	1.89	0.01
I see people like me using [BSS] in my neighborhood	-0.02	0.96	0.38	0.01	0.06	0.82	-0.10	0.83

Dependent variable reference category is Non-User/Not Interested.

Bold indicates significance $p \leq 0.10$.

Model 1 statistics: $n = 926$; $-2 \text{ Log Likelihood}$, Intercept only = 1962.88; Final = 1811.28; Chi-Square = 151.60; McFadden pseudo $R^2 = 0.08$.

Model 2 statistics: $n = 846$; $-2 \text{ Log Likelihood}$, Intercept only = 1984.37; Final = 1378.01; Chi-Square = 606.36; McFadden pseudo $R^2 = 0.31$.

^a Reference category is Higher-income white.

^b Reference category is Chicago.

associated with higher likelihood of being interested in bike share.

Among lower-income people of color, having positive personal attitudes about bicycling, being motivated to use bike share for fun, exercise, and social reasons, and having friends and family who have ridden bike share all increase the odds of being interested in using bike share. For this same group, a higher age, bachelor's degree, and living in Brooklyn decrease the odds of being interested. Among the higher-income POC, in addition to bicycle infrastructure, living in Philadelphia, having a car available, having positive personal attitudes about bicycling, being motivated to use bike share for fun, exercise, and social reasons, and having friends and family who have ridden bike share all increase the odds of being interested in using bike share.

The factors associated with interest among the higher-income white respondents were somewhat different than for POC. While those who were motivated by fun, exercise, and social reasons are similarly more interested, the utilitarian motivations are a stronger predictor of interest for this group. (Note that this variable was not included in the MNL model due to over-specification.) The higher-income white respondents who had received bike share information from interactive sources are more likely to be interested, though those with more accurate factual information are less likely to be interested. Having friends and family who have used bike share is associated with interest for the higher-income white residents. Higher-income white residents with bicycles also have very low odds of being interested in bike share.

There are also some significant differences between these three sociodemographic groups with respect to what changes might motivate them to use bike share. Table 10 shows the share of non-members who are interested in bike share who would be "much more likely" to use bike share if certain changes were made. The most popular changes are having more short-term membership and pass options, discounted membership and use options and free transfers between public transit and bike share. There were no significant differences among the three groups for these changes. Compared to higher-income white respondents, POC (both lower- and higher-

Table 9

Binomial logit models of interest in bike sharing among non-members, by race/ethnicity and income groups.

	Lower-income person of color		Higher-income person of color		Higher-income white	
	B	p	B	p	B	p
Constant	-4.82	<0.01	-8.81	<0.01	-10.77	<0.01
Age (years, 18–64)	-0.02	0.05	-0.01	0.70	<0.01	0.98
Male	0.16	0.61	0.26	0.51	0.17	0.71
Has a Bachelor's degree or higher	-0.61	0.06	0.16	0.70	1.42	0.13
Philadelphia ^a	-0.43	0.18	1.15	0.02	0.08	0.92
Brooklyn ^a	-0.84	0.01	0.08	0.87	-0.87	0.35
Has car available for use	0.13	0.65	0.92	0.05	0.80	0.17
Has a working bicycle	-0.60	0.11	-0.77	0.11	-2.04	<0.01
Bicycling attitudes: personal	0.98	<0.01	1.00	0.01	0.80	0.12
Bicycle infrastructure	-0.15	0.16	0.42	0.01	0.19	0.18
Bike share attitudes: personal	0.17	0.62	0.54	0.22	0.86	0.21
Bike share attitudes: neighborhood	0.39	0.22	0.25	0.58	0.61	0.36
Bike share attitudes: community benefits	-0.19	0.58	-0.59	0.14	0.73	0.20
Bike share barrier: cost	-0.01	0.95	0.18	0.46	0.54	0.13
Reason for using bike share: fun/exercise	1.50	<0.01	1.46	0.02	1.68	0.03
Reason for using bike share: utility	0.49	0.29	0.87	0.17	2.33	<0.01
Bike share barrier: knowledge	0.26	0.28	0.11	0.77	-0.93	0.13
Factual knowledge	0.04	0.30	<0.01	0.96	-0.27	0.01
Received interactive sources of info	-0.09	0.78	0.58	0.18	1.34	0.02
Friends or family have used [BSS]	0.60	0.03	0.96	0.02	1.43	0.01
I see people like me using [BSS] in my neighborhood	0.29	0.15	0.44	0.11	-0.06	0.88
n	359		212		189	
McFadden pseudo R ²	0.23		0.29		0.43	

Dependent variable reference category is Not interested.

Bold indicates significance $p \leq 0.10$.^a Reference category is Chicago.**Table 10**

Changes that would make interested non-members much more likely to use bike sharing, by race/ethnicity and income groups.

Would the following changes make you more likely to use [BSS]?	% answering "much more likely"			
	Lower-income people of color	Higher-income people of color	Higher-income white	All Interested Non-members ^a
More short-term membership or pass options (e.g. daily, weekly, or monthly instead of yearly)	52 % (45–59 %)	56 % (46–66 %)	53 % (41–64 %)	53 % (48–58 %)
Discounted membership or use options	49 % (42–57 %)	54 % (44–65 %)	57 % (45–68 %)	52 % (47–57 %)
Free transfers between public transportation and [BSS]	49 % (42–57 %)	51 % (40–61 %)	61 % (50–72 %)	52 % (47–57 %)
Access to free or low-cost helmets and other gear	45 % (37–52 %)	37 % (27–47 %)	26 % (16–36 %)	38 % (33–43 %)
Option to sign up or buy passes at a store instead of online	42 % (35–50 %)	27 % (18–36 %)	7 % (1–13 %)	31 % (26–36 %)
Help finding safe ways to get where I need to go	42 % (35–49 %)	36 % (26–45 %)	38 % (27–50 %)	39 % (34–44 %)
If more of my friends or family could use [BSS] with me	40 % (33–47 %)	36 % (26–45 %)	12 % (5–20 %)	31 % (27–36 %)
Easier way to pay with cash	39 % (32–46 %)	27 % (18–36 %)	9 % (3–16 %)	29 % (25–34 %)
More [BSS] stations where I want to go	38 % (31–45 %)	38 % (28–48 %)	54 % (43–65 %)	42 % (37–47 %)
Organized rides for people like me	37 % (30–44 %)	22 % (14–31 %)	11 % (4–18 %)	26 % (22–31 %)
More [BSS] stations close together	35 % (28–42 %)	32 % (23–42 %)	33 % (22–44 %)	34 % (29–39 %)
If [BSS] users were more diverse	21 % (15–27 %)	16 % (9–24 %)	3 % (-1–6 %)	16 % (12–19 %)
n ^b	174–180	90–92	73–74	355–362

Boldface indicates significant difference (two-tailed z-test, $p < 0.05$) from higher-income white respondents.

95% confidence interval shown in parentheses.

^a Includes low-income white respondents, $n = 19$.^b n varies due to item non-response.

income) are more responsive to having an option to sign up or buy passes at a store, having more of their friends and family use bike share with them, having easier ways to pay with cash, and if bike share users were more diverse, though the last factor was only a strong motivator for 21 % and 16 % of the POC (lower- and higher-income, respectively). POC are less motivated by having more stations where they need to go. Lower-income POC are more motivated than higher-income white respondents by having access to free or low-cost helmets or other gear and having organized rides for people like them.

5. Discussion

Overall, our analysis confirms most aspects of our conceptual model, and indicates that some factors are likely more important than others, and that factors vary by race/ethnicity and income. Of the main components of our model, bicycle infrastructure appears to have a relatively weak relationship with interest and use of bike share. A higher density of bike lanes is associated with greater interest in bike share among higher-income POC non-members, but it was not associated with other outcomes. This could be due to low variance in this variable, particularly in Brooklyn and Chicago, or that for most respondents there is enough bike infrastructure that it is not a factor in decision making. In addition, these neighborhoods all had a well-connected gridded street network, resulting in options to ride on lower-traffic streets, at least for shorter trips. Research has found that such an environment can be associated with higher cycling rates, even without bike lanes (Dill et al., 2014).

Similar to much recent travel behavior research, we found that attitudes, broadly defined, play an important role in interest and use of bike share. Having positive attitudes about personal benefits of bicycling generally (not specific to bike share), is a strongly associated with interest in bike share among non-members, particularly for POC. Many bicycling attitudes and barriers did not play a role in bike share interest, use, or membership. Perhaps most surprising is that concerns about traffic safety while bicycling do not appear to influence interest or behavior. Nearly half (45 %) of our sample indicated this was a big barrier to bicycling. It may be that the more general personal attitudes about bicycling are stronger factors. Concerns about police attention, harassment or crime while bicycling were also not associated with bike share interest, use or membership, even for our segmented interest models. As noted in our literature review, these factors have been identified as barriers in several qualitative studies. Our survey did find that lower-income POC cited police attention as a big barrier to bicycling at a significantly higher rate (14 %) than higher-income white respondents (4 %) did. Similarly, 25 % of lower-income POC cited concerns about harassment and crime as a big barrier to bicycling compared to only 12 % of higher-income white respondents. However, POC rated other items as big barriers at a much higher rate, indicating that police attention, harassment and crime are barriers, but that they are not among the most important barriers for a large share of lower-income POC. It may also be that these barriers do not apply equally to using bike share.

While having positive attitudes about bicycling is not associated with bike share membership, having positive attitudes about the personal and community-level benefits of bike share is. Positive attitudes about the personal benefits of bike share are also associated with higher odds of being Tried/Interested. It is possible that bike share members had positive attitudes about bike share prior to becoming a member and these attitudes strengthened over time. This would be consistent with theory and research that people's travel behavior reinforces attitudes (Kroesen & Handy, 2014). In addition, it may be that non-members, particularly those who have not tried it yet, have not yet formed strong or specific attitudes about bike share.

The variable measuring neighborhood-level bike share attitudes is an indicator that respondents think that the bike share system is making an effort to serve people in their neighborhood and getting better at serving people like them. Stronger agreement with these statements is associated with people being interested in bike share, though not having tried it yet. This may indicate that some residents are noticing the efforts of all three systems to address equity-related concerns, including adding stations in their neighborhood and activities associated with the Better Bike Share Partnership, such as discounts and cash payment options. Inadequate community involvement in planning and operating bike share systems has been identified as one reason for disparate outcomes in underserved communities (Hannig, 2016). However, stronger agreement with this attitude is associated with lower odds of being a member or being Tried/Not interested. The former finding may indicate that members are more cognizant of shortcomings of the system in their neighborhood. The latter may indicate that some residents tried bike share but did not see enough personal benefit and are no longer interested. Perceptions that the system was not serving their neighborhood may have contributed to a decision not to become a member. It is important to note that only 3 % of our sample are in this group (Tired/Not interested), indicating that there is not a large trend of people trying bike share and losing interest.

The findings indicate that the recreational potential of bike share may drive interest in riding, particularly for POC, who do not appear to be motivated by the utility of bike share. In contrast, bike share members have discovered and/or were motivated by the utilitarian aspects of the system. People who listed fun, exercise and social reasons as reasons for using bike share are much more likely to be interested in using bike share, whether or not they had tried it. This is consistent with findings from Bateman et al. (2021). This relationship is consistent across the race/ethnicity and income groups. However, these reasons did not motivate respondents who are bike share members.

The existing research has identified cost as a barrier to bike share use, particularly for lower-income people, and our findings support this. Specifically, people who have tried bike share and are still be interested (Tried/Interested) are more likely to say that cost is a barrier to using bike share. The fact that this barrier is such a significant predictor for being in the Tried/Interested group and not the Tried/Not interested group is notable. It may indicate that cost is not the reason people in the latter group lost interest, but that it is a barrier to overcome to move Tried/Interested people to become members. Why this barrier is not a significant factor in predicting interest in our segmented models is unclear. We would expect it to be a factor particularly for lower-income respondents. It may be that combining the Non-user/Interested and Tried/Interested into a single group for the segmented models negated the relationship.

Knowledge and interactive sources of information are also associated with bike share interest, use, and membership. Having higher

levels of factual knowledge is associated with having tried bike share and being a member. This makes sense since a certain level of knowledge is necessary to use the system and using it will likely convey additional knowledge. Factual knowledge is not a factor associated with interest among non-member POC (lower- and higher-income). This may indicate that people in these groups, while interested, have not yet sought out information about how to use the system, a key step in the TTM stages of change. Respondents who indicated knowledge-related barriers to using bike share are less likely to be Tried/Interested. This indicates that people who have tried the system and are still interested have likely overcome such concerns, or never had them to begin with.

Outreach efforts in these neighborhoods may be having an effect on encouraging people to try bike share and become members. Having received information about bike share from interactive sources, which are typically in-person, is associated with much higher odds of being a member and having tried bike share and somewhat higher odds of being Non-user/Interested. Taken together, this indicates that getting information from interactive sources is likely part of the preparation stage before trying bike share or becoming a member. It is concerning that for higher-income white non-members, receiving information from interactive sources significantly increased the odds of being interested in bike share, but there was no association for lower- or higher-income POC.

The social aspects of bike share are also important in our findings. People who have family and friends that have used bike share are much more likely to be Tried/Interested or a current member, and somewhat more likely to be a Non-user/Interested. This is also a positive factor associated with interest among all non-member groups, though it is stronger for higher-income white non-members than POC non-members, particularly lower-income non-members. This may reflect lower levels of use and interest in these groups. Seeing people who looked like them using bike share is associated with higher odds of being a Non-user/Interested, but not with being interested in the non-member segmented models. In addition, our measure of social stigma was not significant in any of the models. These findings may indicate that bike share use among closer ties (family and friends) is a more important aspect of social norms. In addition, this finding complements our findings that non-members are particularly motivated by the fun and social reasons for using bike share.

Sociodemographic characteristics, as well as factors related to the city, are also important, though mediated by attitudes and other factors. In particular, being a lower-income POC only decreased the odds of being a bike share member when not controlling for attitudes, knowledge and social norms. In addition, age is only a factor associated with Tried/Interested in the full model, while it is also associated with membership and Tried/Not Interested in the model without all the factors. These findings imply that it is likely that differences in attitudes, knowledge, and/or social norms for some demographic groups are driving some of the demographic differences in bike share use. Notably, gender does not appear to be a factor influencing the likelihood of being a member or being Tried/Interested, after controlling for all other factors. However, men are more likely to be Non-user/Interested. Since this latter group is large (30 % of our sample), this is concerning if these systems aim to increase interest and use among all genders.

6. Conclusions

Using data from residents of neighborhoods traditionally underserved by bike share systems, our analysis helps explain the racial and income disparities found in the existing research. While smaller shares of the people of color in our sample are bike share members compared to higher-income white people – consistent with most of the existing research – large shares of both lower-income and higher-income POC are interested in using bike share. Among POC non-members, having positive attitudes about the personal benefits of bicycling and having family and friends that use bike share are strong factors associated with interest in using bike share. In addition, POC non-members are motivated to use bike share for fun, exercise, and social reasons. This is in contrast to higher-income white non-members who also value the utility of bike share. Having bike lanes nearby also appears to motivate interest among higher-income POC non-members. We also identified factors that may explain why some people become members while others are perhaps at stages leading to membership, based on interest and whether they have tried bike share. These factors and related policy and programmatic actions are discussed below and summarized in [Table 11](#).

Interested non-members, unlike members, appear to be motivated to use bike share for fun, exercise, or social reasons. Bike share systems could develop outreach and marketing programs that promote these aspects of bike share, though additional efforts may be necessary. For example, most bike share systems do not allow children, particularly those under 16 years old, to use the system.

Table 11
Key findings and related policy and programmatic actions.

Key Finding	Potential policy or programmatic actions
Interested non-members, including POC, are motivated to use bike share for fun, recreation, and social reasons	Marketing that focuses on recreation Family memberships Bicycles that accommodate children More casual use options, such as longer rental times and seasonal memberships
Knowledge of bike share and receiving information from interactive sources are associated with bike share use	Increased interactive marketing efforts, particularly addressing concerns and motivators of POC Group rides in underserved neighborhoods to introduce bike share
Cost is a barrier for people who are interested in using bike share	Discounted memberships, with significant outreach efforts to ensure knowledge of the discounts Short-term membership options (vs annual) Free transfers between bike share and transit Options to purchase memberships at stores and with cash

Compared to higher-income white people, a greater share of interested non-member POC indicated that they would be much more likely to use bike share if more of their friends and family could use it with them. Research of non-users in Baltimore also found that being able to carry items or ride with children was a barrier for POC (Hull Grasso et al., 2020). Offering family or household memberships might encourage more use, as could bikes that could carry children (e.g. cargo bikes) or smaller bikes that children could ride. There are a handful of examples internationally of such programs (Merchant, 2019). Potential users that are focused on recreational use might also benefit from more casual use options (e.g. longer time limits) or seasonal memberships.

People who know more about bike share are more likely to have tried it, indicating that knowledge plays a role in the process. A person's knowledge and attitudes could be influenced through information sources, and we found that receiving information from interactive sources may be particularly effective at getting people to try bike share, as well as increasing interest in bike share without trying it, though to a lesser extent. Implementing more personal "hands on" outreach programs appears to be effective at increasing use of bike share. However, among non-members we found that it was only a factor associated with interest among higher-income white people and not POC. We did find that lower-income POC may be particularly motivated to use bike share if there were organized rides with "people like me." Bike share systems in the U.S. have undertaken a number of outreach activities with an equity focus, including ambassador programs, enrollment assistance, classes, prescribe-a-bike, and organized rides (McNeil et al., 2019). Our finding suggest that these programs may need to improve to ensure the efforts are reaching POC and speak to their concerns and motivators.

Membership cost appears to be a barrier for people who have tried bike share and are interested in using it in the future but are not members. The most popular actions that our interested non-members indicated would make them much more likely to use bike share were more short-term membership or pass options, discounts, and free transfers between bike share and transit. At the time of our study, Chicago and Philadelphia offered income-based discount memberships and New York offered discounted memberships to public housing residents. Unfortunately, only 25 % our lower-income POC respondents knew that these discounts were available, indicating that more outreach about discount programs is likely necessary. More research is likely needed on what level of discounts is effective at increasing bike share use among lower-income people. A separate survey conducted as part of this same research project found that among members who had taken advantage of the discounted memberships the most common reason for joining was the discount, though the sample size was relatively small ($n = 70$) (McNeil, et al., 2017a).

While we did not find that credit card or smartphone access influenced interest, use or membership in our models, the interested non-members who are POC are more likely than higher-income white interested non-members to state that obtaining passes at a store rather than online or having an easier way to pay with cash would make them much more likely to use bike share. Expanding these options may be an effective action. In addition, lower-income POC were more interested in free or low-cost helmets or other gear, which could also be part of an equity-focused outreach program.

As with most cross-sectional, survey-based research, our study has limitations. Our findings suggest that attitudes and knowledge may change as people try and become bike share members. Our cross-sectional data limits our ability to fully understand the direction of the relationship, along with other causal mechanisms. Future research using our conceptual model should test the bidirectional relationship for factors such as attitudes and knowledge, ideally using longitudinal data. While our sample included many lower-income and POC, women, older adults, and more educated adults were over-represented. Our models did control for these characteristics. We did not have enough lower-income white respondents to make findings about that particular group. In addition, because of the low rates of membership among POC, we were unable to model factors that contribute to POC becoming bike share members. The POC in our sample are also predominantly Black or African American. Hispanic people were underrepresented in our sample, and our study areas had small numbers of other races. It would be better to have a large enough sample to examine different racial and ethnic groups separately, rather than combining them into a single POC group. For example, there is evidence that bike share membership disparities in New York City vary by racial groups, with Asian/Pacific Islanders more likely to be bike share members compared to their rates of cycling in the city (Crossa et al., 2021).

Our study also only examined station-based bike share. It is not clear whether these same factors would apply to a dockless system and more research on this would be useful. As discussed in our literature review, there is limited and mixed evidence about whether low-income or POC use dockless systems more than station-based bike share. We would expect that some factors, such as attitudes about bicycling, knowledge, and reasons for using bike share would apply similarly to a dockless system. Barriers related to station access, which a dockless system might overcome, were not a factor in our analysis. In fact, POC were less likely than higher-income people to say that more stations where they wanted to go would motivate them to use bike share (among non-members interested in using bike share). That may be linked to POC being motivated to use bike share for recreation rather than utility. Of course, a dockless system may provide more flexibility for these types of trips as well.

We did not find that bicycle lanes or concerns about traffic safety while bicycling are significant factors in predicting bike share use or membership. This may be due, in part, to the characteristics of our study areas. We did find that bike lanes may be linked to increased interest in bike share among higher-income POC. Research in more varied environments and with larger samples could explore the role of infrastructure further. We also did not find that personal safety concerns, including police harassment, predicted interest, use, or membership. Qualitative research has found these to be important factors for POC. Our findings indicate that broader attitudes about bicycling may be better predictors in models, and that these personal safety concerns are still expressed by higher shares of POC as a barrier to bicycling. A structural modeling approach might be able to examine how personal safety concerns contribute to broader attitudes about bicycling and, therefore, bike share behavior.

CRedit authorship contribution statement

Jennifer Dill: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review &

editing, Supervision, Funding acquisition. **Jiahui Ma**: Formal analysis, Writing – review & editing. **Nathan McNeil**: Investigation, Writing – review & editing, Project administration, Funding acquisition. **Joseph Broach**: Investigation, Data curation, Visualization, Writing – review & editing. **John MacArthur**: Investigation, Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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