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Residents in Seattle, WA Report Differential Use of Free-Floating Bikeshare by Age, Gender, Race, and Location

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Bikesharing may have numerous urban health, sustainability, and mobility benefits. Bikesharing systems that do not require stations (i.e., "dockless," or "free-floating" bikeshare) launched in North America in 2017. While this novel model may enhance access to and use of bikeshare by diverse populations, to date no work has examined equity in free-floating bikeshare use. This brief report uses a web-based panel survey ($n = 601$) to provide sociodemographic characteristics of adult Seattle residents reporting bikeshare use during the first 6 months of a pilot free-floating program. One-third of Seattle adults surveyed reported trying free-floating bikeshare. These users were disproportionately young, male, White, resided closer to the city center, and already more likely to have or use a bicycle. Safety, social, spatial access, physical size, operation, technology, and cost barriers remained, particularly for males and non-White respondents. Almost half of non-users were open to trying free-floating bikeshare. However, these respondents hold limited potential to diversify the user population: while more likely to be female, like current riders, they were young and already using bicycles. If cities, researchers, and operators work together in the rapidly-shifting mobility landscape, they may be able to remove inequitably distributed barriers to transportation technology.

Keywords: bike share, dockless, equity, ridership, demographics

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INTRODUCTION

Implementation of a bikesharing system—public use of a fleet of bicycles—has been used around the world to increase mobility and recreation. Increases in bicycling from introduction of bikeshare may help cities reach transportation, environmental, and population health goals. The deployment of smartphone-operated, non-station-based bicycle fleets, sometimes called "dockless," "free-floating," or "flexible" bikeshare, heralds in a new generation of bikesharing. These systems allow users to locate bikes using Global Positioning Systems (GPS), and then lock bikes in place at their destination (ITDP, 2018). In 2017, free-floating bikeshare made its appearance in North America, expanding rapidly to operate roughly 44,000 bikes (~44% of all share bikes) within the US by the end of 2017 (National Association of City Transportation Officials, 2018). The free-floating

bikeshare landscape is dynamic with new companies, technologies, and cities rapidly changing the number, type, and reach of these systems.

Uptake of traditional station-based bikesharing systems, which operate in nearly every city in the US with more than 500,000 residents (National Association of City Transportation Officials, 2018), has not been equitable across sociodemographic or economic groups. Previous work has shown bikeshare users to be predominantly male, higher socioeconomic status, and from areas with high existing cycling prevalence (Shaheen et al., 2013; Ricci, 2015; Fishman, 2016). While in many North American cities, bikeshare docking stations tend to be located in more advantaged neighborhoods (Smith et al., 2015; Ursaki and Aultman-Hall, 2016; Hosford and Winters, 2018), this source of inequity is mitigated by free-floating systems' flexibility to place bicycles in more locations within a service area. Despite this mitigation, no research to date has examined free-floating bikeshare usage or differences in barriers to uptake by sociodemographic and economic characteristics.

In July 2017, the City of Seattle, Washington was the first North American city to launch a pilot free-floating bikeshare program. In this brief report, we use results from a web survey of Seattle residents to examine whether reported free-floating bikeshare use or barriers to use were equitably distributed across sociodemographic groups during the first 6 months of this pilot program. These results can inform efforts to make free-floating bikeshare available to all.

METHODS

Setting and Pilot

Seattle, a city with about 700,000 residents in the Northwest United States, has a robust bicycling community and is among the top American cities for bicycling to work (McKenzie, 2014). In Summer 2017, Seattle Department of Transportation (SDOT) allowed three operators (LimeBike, Spin, and Ofo) to launch bikeshare programs. Operators offered smartphone applications ("apps") through which users rented bicycles for $1–2/h (costs varied by provider and each offered new riders incentives). Within 6 months of launching, 10,000 bikes were available (City of Seattle, 2018b).

Survey

In 2018, SDOT commissioned EMC Research (www.emcresearch.com) to perform a web survey of adult (18+ years) Seattle residents. Invitations were sent to a random sample of qualified respondents from *Research Now*, a recruit-only panel database of individuals recruited to participate in research studies. Multiple methods were used to ensure quality responses including participation limits and removal of those who sped through questions. Demographics were monitored to ensure a representative sample with minimal weighting adjustments; additional invitations were sent to specific demographic subgroups, as needed, to achieve a final sample that was demographically, and geographically representative of Seattle adults. The survey was conducted February 13-24, 2018, resulting in a total of 601 completed responses citywide.

Sociodemographics

Age, gender, race/ethnicity, car access, bicycle access, and ZIPcode were obtained from respondents. Age was dichotomized as 18–44 and 45+. Race/Ethnicity categories were combined to ensure enough respondents within each: (1) White; (2) Asian; (3) Other (including Hispanic and African American). Because the small sample size ($n = 601$) precluded more granular analysis, ZIPcode ($n = 28$) was classified (see **Supplementary Table**) into North Seattle, Central Seattle, and South Seattle.

Free-Floating Bikeshare Use and Barriers

The survey obtained four dimensions of bikeshare use and uptake: (1) familiarity with the programs, (2) use in the previous 6 months, (3) barriers or drawbacks and (4) openness to future use (see **Supplementary Table**). Familiarity was dichotomized as Very/Somewhat familiar. Use in the previous 6 months was collapsed into "Users" (11+ times), "Low users" (1–10 times), "Open Non-users" (have not used bikeshare but open to it), and "Closed Non-users" (have not used bikeshare, do not plan to use). Those who responded "Strongly Agree" or "Somewhat Agree" with a particular barrier or drawbacks were classified as "Agree."

Equity

For this work, we conceptualized equity according to Rawls's distributive justice principles (Rawls, 2009). Specifically, we aimed to identify whether bikeshares were minimally accessible to all groups, and whether barriers to bikeshare use were distributed such that more socially disadvantaged groups also encountered more barriers (Pereira et al., 2017).

Analyses

Descriptive statistics of sociodemographic and travel behavior were calculated for the sample and by reported bikeshare program use. Cross-tabulations of frequencies and percentages of agreement with different barriers were reported across select sociodemographic characteristics (use, gender, race/ethnicity, and age). Data were weighted (using R package *anesrake*) to reflect the overall demographic makeup of adult residents of Seattle based on gender, age, race/ethnicity, and city region. All other analyses were completed in 2018 using SPSS.

RESULTS

Sample

Of the 601 web survey respondents, over half were younger (57%) and half were female (50%) (**Table 1**). Sixty-one percent identified as white, 15% as Asian, and 24% as Other. This broadly reflects 2016 American Community Survey Estimates for Seattle Adults (U.S. Census Bureau, 2016). The respondents had high rates of bicycling, including for transport, and high access to a working bicycle (54%) and a motor vehicle or car sharing service (e.g., car2go) (90%).

Familiarity With the Free-Floating Bikeshare Programs

Overall, 70% of Seattle adult residents surveyed reported being very or somewhat familiar with free-floating bikeshare

TABLE 1 | Characteristics of all adult Seattle survey respondents overall ($n = 601$) and by reported level of free-floating bikeshare use (February 2018).

	Overall	User[a]	Low User[a]	Open non-user[a]	Closed non-user[a]
	Percent %	Percent %	Percent %	Percent %	Percent %
n	601	66	133	185	217
AGE					
18-24	12	17%	20	11	7
25-34	26	35	40	26	15
35-44	19	41	24	15	13
45-54	15	6	11	18	17
55-64	13	1	4	17	19
65+	15	0	2	12	30
AGE (2-AGE SPLIT)					
18-44	57	93	83	52	34
45+	43	7	17	48	66
GENDER					
Male	49	66	53	42	48
Female	50	34	45	57	52
Non-binary	1	0	2	1	1
RACE/ETHNICITY					
White	61	72	53	60	64
Hispanic, African American, Other	24	22	28	24	21
Asian	15	7	18	16	15
REGION					
North Seattle	41	31	34	44	46
Central Seattle	36	54	41	35	28
South Seattle	23	15	25	21	26
Ever ride a bicycle in Seattle (for any reason)	54	96	89	48	24
FREQUENCY RIDING ANY BICYCLE IN THE LAST 6 MONTHS					
1 to 10 times	34	27	77	31	12
11+ times	19	73	23	14	5
Have not biked	47	—	—	55	83
Use bicycle for transportation (own bicycle or bikeshare)	11	38	12	7	6
Have access to a working bicycle	54	80	72	55	35
Have access to a motor vehicle or car sharing service	90	90	91	91	88
Very/Somewhat familiar with free-floating bikeshare in Seattle	70	97	95	66	50
Favorable opinion of free-floating bikeshare programs in Seattle	74	92	94	86	45

[a] *Use of free-floating bikeshare in the last 6 months classified by frequency and openness to try the bikes: User (used bikeshare 11+ times), Low user (used bikeshare 1 to 10 times), Open Non-user (have not used bikeshare, but open to it), Closed Non-user (have not used bikeshare, do not plan to use).*

in Seattle (**Table 1**). This was highest among users of the free-floating programs in the previous 6 months (97 and 95% for Users and Low Users, respectively). Similarly, 74% reported they had favorable opinions of free-floating bikeshare. Again, favorable opinion was highest among those who used the programs (92 and 94% for Users and Low Users, respectively).

Use of the Free-Floating Bikeshare Programs in the Previous 6 Months

Across all Seattle adult residents surveyed, in the previous 6 months 11% were Users (11+ times) and 22% were Low Users (**Table 1**). Users were younger (aged 18–44), male, White, and resided in Central Seattle. They were more likely to report using a bicycle for transportation, having access to a working bicycle, and reporting a higher bicycle riding frequency. Similar, albeit less-pronounced, sociodemographic patterns emerged among Low Users.

Barriers or Drawbacks to Free-Floating Bikeshare

Safety and social issues were the most commonly reported barriers and drawbacks (**Table 2**). These included bikeshares in places they didn't belong (e.g., blocking sidewalks/curb cuts), riders without helmets, lack of trails or protected lanes, and safety in traffic or up hills. Spatial access, physical barriers (about bicycle

TABLE 2 | Prevalence of reported downsides or barriers to free-floating bikeshare use among Seattle residents surveyed February 2018 ($n = 601$).

		Overall	Users	Open non-users	Closed non-users	Male	Female	White	Asian	Other	18–44	45
		n	199	185	217	294[a]	301[a]	368	143	90	343	258
Domain	**Downside/ Barrier**	**% Agree**	**% Agree**	**% Agree**	**% Agree**	**% Agree**	**% Agree**	**% Agree**	**% Agree**	**% Agree**	**% Agree**	**% Agree**
Spatial access	There are too few bikeshares near me when I need one (Spatial Access Barrier)	36	54	31	23	43	29	33	36	42	43	26
Environmental barrier; Safety barrier	There aren't enough bike trails or protected bike lanes where I want to go	56	65	59	45	61	52	57	52	57	58	54
Safety barrier	Too many bikeshare users ride without helmets	62	68	58	60	65	59	61	64	62	64	60
Safety barrier; Physical Barrier	The weight of the bikeshares makes them difficult to use safely in traffic or going up hills	39	56	28	33	46	32	39	44	37	41	37
Physical barrier	The bikeshares don't fit my size or physical needs	29	45	14	27	35	23	29	21	34	29	28
Operational barrier	The companies that operate the bikeshares don't respond quickly enough to requests	26	50	12	16	33	20	27	20	27	30	20
Operational barrier	The bikeshares aren't well-maintained	34	49	19	33	42	26	33	39	34	38	29
Technology barrier	The bikeshare apps are difficult to use, or don't work reliably	23	40	11	17	29	17	21	30	23	29	16
Cost barrier	Bikeshares are too expensive for me to use them frequently	29	44	20	23	33	25	29	23	33	34	22
Social barrier	Bikeshares are often parked in the middle of sidewalks or blocking curb ramps, making it more difficult for those with visual and physical disabilities to get around the city	60	55	55	68	64	55	61	62	53	54	67
Social barrier	Too many bikeshares wind up toppled over, littered in parks, dumped in ditches, and left in other places where they don't belong	67	62	66	73	71	64	70	68	60	60	77

[a] *Total not equal to the full sample (n = 601) since some participants identified as "Non-binary," falling in neither Male nor Female category. Non-binary not shown due to small sample size (n = 6).*

size/weight), operation barriers (about companies/maintenance), technology barriers (about apps), and cost barriers were also reported.

Males were more likely to identify barriers. Respondents who did not report White or Asian race were more likely to identify geographic access, bicycle size, or cost as barriers. Older respondents were more likely to identify bikeshare parking and sidewalk accessibility as drawbacks. Compared to users, Non-users were less likely to report barriers, except for social barriers. Generally, Closed Non-users reported more barriers than Open Non-users.

Openness to Future Use of Free-Floating Bikeshare

Of the 67% who did not use bikeshare in the previous 6 months, just under half (46%) could be classified as Open Non-users. Compared to the Closed Non-users, Open Non-users were younger and female (**Table 1**). They had greater access to a working bicycle, higher rates of ever bicycling in Seattle, and higher rates of riding any bicycle in the previous 6 months. They also reported more familiarity, a more favorable opinion of the free-floating bikeshare programs, and fewer barriers (**Table 2**) than Closed Non-users.

DISCUSSION

This brief report examined personal characteristics of those reporting use of free-floating bikeshare in Seattle, WA during the first 6 months of operation. Uptake within adult Seattle residents surveyed was high (33%). However, use of the free-floating bikeshare was still unequal: users were younger, male, White, resided closer to the city center, and already more likely to have or use a bicycle. Downsides or barriers remained, with differences in the reporting of these barriers by subgroups. Some of these differences, including that access and cost were more of a barrier for members of disadvantaged minority groups, raise equity concerns.

Results confirm existing findings from station-based systems across North America that bikeshare users tend to be male, White, and higher socioeconomic status than the general population (Shaheen et al., 2013; Ricci, 2015; Fishman, 2016). They also align with international evidence showing free-floating bikeshare users in China to be younger, better-educated, and have higher incomes (Xin et al., 2018). Similar to station-based systems, differences in use may result partially from inequity in spatial access (Ursaki and Aultman-Hall, 2016; Hosford and Winters, 2018). Since free-floating systems do not anchor bicycles to stations, users may ride to neighborhoods reflecting their sociodemographic characteristics, resulting in less equitable geographic coverage.

Conversely, free-floating systems may provide more equitable access by not restricting bicycles to stations (often located inequitably) and distributing more bicycles compared to station-based programs. Indeed, in Seattle during the pilot, while bicycle availability varied greatly between neighborhoods, a large fleet size ensured no neighborhood was consistently denied access (Mooney et al., 2019). However, despite broad availability, socioeconomically privileged neighborhoods had more bikes per capita during the pilot (Mooney et al., 2019).

Safety, social, spatial access, physical size, operation, technology, and cost concerns remained, particularly for males and non-White respondents. This may reflect less experience using the system (higher percentage of "not sure" responses, not shown). However, these align with some established barriers such as cost, pricing structure and limited access to credit cards or smartphones, often required for registration (Smith et al., 2015; McNeil et al., 2018). Issues novel to free-floating systems, such as blocked sidewalks, may pose social barriers to use. Technology, including apps used to locate and unlock/lock bicycles, also represent a larger barrier for free-floating bikeshare. To address these issues, cities have used permitting to require implementation of low-income payment plans, payment systems for the unbanked, and non-smartphone options. Differences in reported barriers for subgroups suggest necessary tailoring to attract diverse riders. For example, since free-floating bicycles do not need to fit stations, operators could diversify fleets to accommodate different sizes and abilities. We found continued room for growth, with almost half of non-users open to trying free-floating bikeshare. In addition, non-users generally reported fewer barriers to use than users, potentially reflecting less experience with the system. This is consistent with previous work that those who report higher issues with transit have a higher percentage of trips made by this mode (Delbosc and Currie, 2011). Nonetheless, addressing the two largest barriers (social and environmental) may engage non-users. However, these respondents hold limited potential to diversify the user population: while more likely to be female, like current riders, they were young and already bicycling.

Results should be interpreted considering limitations. First, as a web panel, results only represent adults with internet access. While we did weight responses according to available demographic characteristics, future studies of barriers should incorporate results gathered using other survey methods (e.g., in-person interviews) to account for potential sampling artifacts. Second, Seattle results may not be generalizable to other cities. Familiarity, favorability, uptake, and barriers may differ within lower-cycling contexts. Third, assessment of barriers was structured; future work should elucidate obstacles using flexible qualitative methods. Fourth and finally, free-floating bikeshare programs are part of a fast-changing, small-scale mobility industry. Since the initial Seattle pilot launch, two of the three companies ceased operations and the industry is exploring new fleet types (e.g., electric bicycles and scooters). In parallel, cities are implementing new equity requirements to reduce barriers and increase access. For example, during their second permit cycle, Seattle, informed by the pilot, required distribution of bicycles in designated equity focus areas, low-barrier rental methods for those without smartphones or bank accounts, and language translation of documents (City of Seattle, 2018a). Future work should elucidate whether new city or industry initiatives shift use patterns.

Despite limitations, this work contributes in several key ways. First, it utilized a panel survey of adult Seattle residents rather

than a survey of riders. This allowed both assessment of use and barriers to use among non-users. Second, this is the first study to examine equity in bikeshare use within a free-floating system. Within an ever-emerging, rapidly-shifting mobility landscape, this work may shed light on paths forward for new, more equitable, transportation technology.

CONCLUSION

In conclusion, we report use and barriers to use of free-floating bikeshare during a pilot program in Seattle, WA. Similar to station-based bikeshare, we found users to be younger, male, White, and more experienced with bicycles. Barriers common to other bikeshare systems remained problematic, including safe city bicycling infrastructure. With almost half of non-users open to trying free-floating bikeshare, results suggest opportunities for increasing use. Data to understand distribution, rebalancing, and suitable fleet size for free-floating systems may be important for increasing spatial access. Outreach initiatives to reach low-income residents may increase access. Similarly, the introduction of diverse bicycle types may encourage use among different populations. If cities and operators work together to address current limitations, free-floating bikeshare or other small-scale mobility systems may increase urban health, equity, and sustainability.

DATA AVAILABILITY

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The analyses of these data were exempt because (1) they were performed on behalf of the City of Seattle (2) Data used were de-identified files and publicly available (due to #1) as they are open components of the pilot bikeshare evaluation.

AUTHOR CONTRIBUTIONS

JH and SM conceived the idea of the study. IS, SZ, and BR performed the computations. JH compiled the relevant data, drafted the manuscript, and produced the tables. All authors contributed to the reviewing of the final manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fbuil.2019.00017/full#supplementary-material

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.