

Accepted Manuscript

Who are the ‘super-users’ of public bike share? An analysis of public bike share members in Vancouver, BC

Meghan Winters, Kate Hosford, Sana Javaheri



PII: S2211-3355(19)30120-2
DOI: <https://doi.org/10.1016/j.pmedr.2019.100946>
Article Number: 100946
Reference: PMEDR 100946
To appear in: *Preventive Medicine Reports*
Received date: 13 March 2019
Revised date: 29 May 2019
Accepted date: 4 July 2019

Please cite this article as: M. Winters, K. Hosford and S. Javaheri, Who are the ‘super-users’ of public bike share? An analysis of public bike share members in Vancouver, BC, Preventive Medicine Reports, <https://doi.org/10.1016/j.pmedr.2019.100946>

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Who are the ‘super-users’ of public bike share? An analysis of public bike share members in Vancouver, BC

Authors: Meghan Winters^{1,2}, Kate Hosford^{1,2}, Sana Javaheri³,

Affiliations:

¹ Faculty of Health Sciences, Simon Fraser University, 8888 University Drive, Burnaby, BC, Canada V5A1S6

² Centre for Hip Health and Mobility, 2635 Laurel Street, Vancouver, BC, Canada V5Z 1M9

³ School of Population and Public Health, University of British Columbia, 2206 East Mall, Vancouver, BC, Canada V6T 1Z3

Corresponding Author:

Meghan Winters
mwinters@sfu.ca
604-315-0484

Abstract: 248 words

Main text: 1952 words, 1 figure, 1 table

ABSTRACT

Public bike share programs have been critiqued for serving those who already bicycle, or more well-off individuals who already have a multitude of transportation options. While substantial research focuses on characteristics of public bike share members, it often overlooks their intensity of use which may relate more directly to transport and health gains. In this study we link system data with member survey data to characterize “super-users” of Vancouver’s public bike share system. We used system data from September 1, 2016-August 31, 2017 to calculate member-specific trip rates (trips/month). We linked system data to demographic and travel data for members who completed an online survey in 2017 (1232 members who had made 89,945 trips). We defined super-users as those who made 20 or more trips/month. We used a logistic regression to model demographic and travel characteristics associated with super-users as compared to regular users. Of the 1232 members, 204 were super-users. Super-users made 47% of the trips and had a median trip rate of 29.3 trips/month. In adjusted models, super-users were more likely to be young, male, have household incomes below \$75,000, and live and work near bike share docking stations. Super-users had fewer transportation options than regular users, with lower odds of having a personal bike or car share membership. Amongst members, we found a distinct demographic profile for super-users relative to regular users, suggesting that usage is an important consideration when quantifying transport and health gains, and the resulting equity implications of public bike share programs.

Keywords: Bicycling; Bicycle share; Active travel

1. INTRODUCTION

Public bike share systems facilitate access to bicycles and offer potential for greater mobility and health for users (Fishman, 2016; Shaheen et al., 2010). However, programs have been critiqued for serving those who already bicycle, or wealthy individuals who already have a multitude of transportation options (Fishman, 2016; Howland et al., 2017; Mcneil et al., 2017; Ricci, 2015). The literature comparing demographics of users with the underlying population has raised equity concerns, suggesting these programs largely profit advantaged populations (Hirsch et al., 2019; Hosford and Winters, 2017; Mcneil et al., 2017). Numerous studies suggest that in most North American cities, bike share members and casual users tend to be well-educated, younger, male, and have higher incomes (Fishman, 2016; McNeil et al., 2017; Shaheen, 2012).

However, membership does not equate use. For example, higher income populations with greater disposable income may readily purchase memberships, but then not put them to use. A handful of studies have incorporated intensity of use into their demographic comparisons (Chardon, 2019), which is more directly informative to understanding who stands to gain from transport opportunities and health benefits. For example, in London women made 18% of bike share trips despite accounting for 27% of all registered users (Ogilvie and Goodman, 2012). Studies of the bike share systems in New York and in Lyon, France have each found that a higher proportion of trips are made by men, and by members 20-40 years old (Vogel et al., 2014; Wang et al., 2018; Wang and Akar, 2019).

There is limited information about frequency of bike share use across demographic characteristics other than age and gender, as demographic data is not typically collected for members. Moreover, emerging evidence from publicly available open data suggests that a small proportion of members make a large proportion of all bike share trips in some cities (Chardon, 2019) – a group we refer to as ‘super-users’. In this study, we link bike share system data with member survey data to characterize the ‘super-users’ of Vancouver’s public bike share system.

2. METHODS

2.1. Context

The City of Vancouver (land area 115 km²) has over 320 km bikeways and a commuter cycling mode share of 6.1% (City of Vancouver, 2018; Statistics Canada, 2016). The *Mobi by Shaw Go* docked bike share system in Vancouver launched in 2016. As of October 2017, the system had over 1200 bicycles at 122 stations and a bike share service area of 17 km². Approximately 6400 memberships were purchased in the first year (City of Vancouver, 2017). The cost for unlimited 30-minute trips was \$9.75 (Canadian dollars) for a day pass, \$75 for a 3-month pass, and \$129 for an annual pass .

2.2. Data

2.2.1. System data

We used 1 year of *Mobi by Shaw Go* system data (member ID, trip distance, duration) from September 1, 2016 to August 31, 2017, obtained from the operator. This dataset included 498,693 trips, of which 367,812 were made by annual or monthly members (n=8376), and 130,881 by casual users (day-pass users). For each member, we calculated a member-specific trip rate as the total number of trips/total number of months as a member. The duration of the membership was taken as the time between the

member's first trip and the last bike share trip. Members who made no trips in the 1-year study period were not included in our analysis.

2.2.2. Survey data

We conducted a survey of all active monthly and yearly members as of September 19, 2017 (n=4762 members) in partnership with *Mobi by Shaw Go* and the City of Vancouver. The survey protocol was approved by the Simon Fraser University Research Ethics Board and respondents provided informed consent. We administered the survey via e-mail from September 22, 2017 to October 6, 2017 and gathered data from 1400 of 4762 members (response rate 29%). Members were incentivized to participate by a prize draw for one of ten \$50 gift cards upon survey completion. The survey collected information about demographics (age, gender, household income, education, employment status, born in Canada), transportation (drivers' license, bicycle ownership, car ownership, primary mode of transportation, car share membership, perceived safety of bicycling), and residential and work location (see Appendix A for survey questions). We used residential and work locations to categorize respondents according to whether they lived and/or worked within a 500 meter road network buffer of a bike share station. This represents a reasonable distance to walk to a docking station, and has been used in previous studies to define service areas (Fuller et al., 2013; Ursaki and Aultman-Hall, 2016).

2.2.3 Defining super-users

To assess the frequency of use across members, we created a Lorenz curve by calculating the number of trips made per member and graphing the cumulative distribution of trips by the cumulative proportion of members. The Lorenz curve showed that 9.5% of all members made 50% of all trips (Figure 1). This information informed our definition of "super-users" as members who made 20 or more trips per month, a point that approximately reflected members within the top 10th percentile of usage (n=876). All other members were considered "regular users" (<20 trips per month). Figure B.1. in Appendix B shows the distribution of monthly bike share trips made by super-users and regular users.

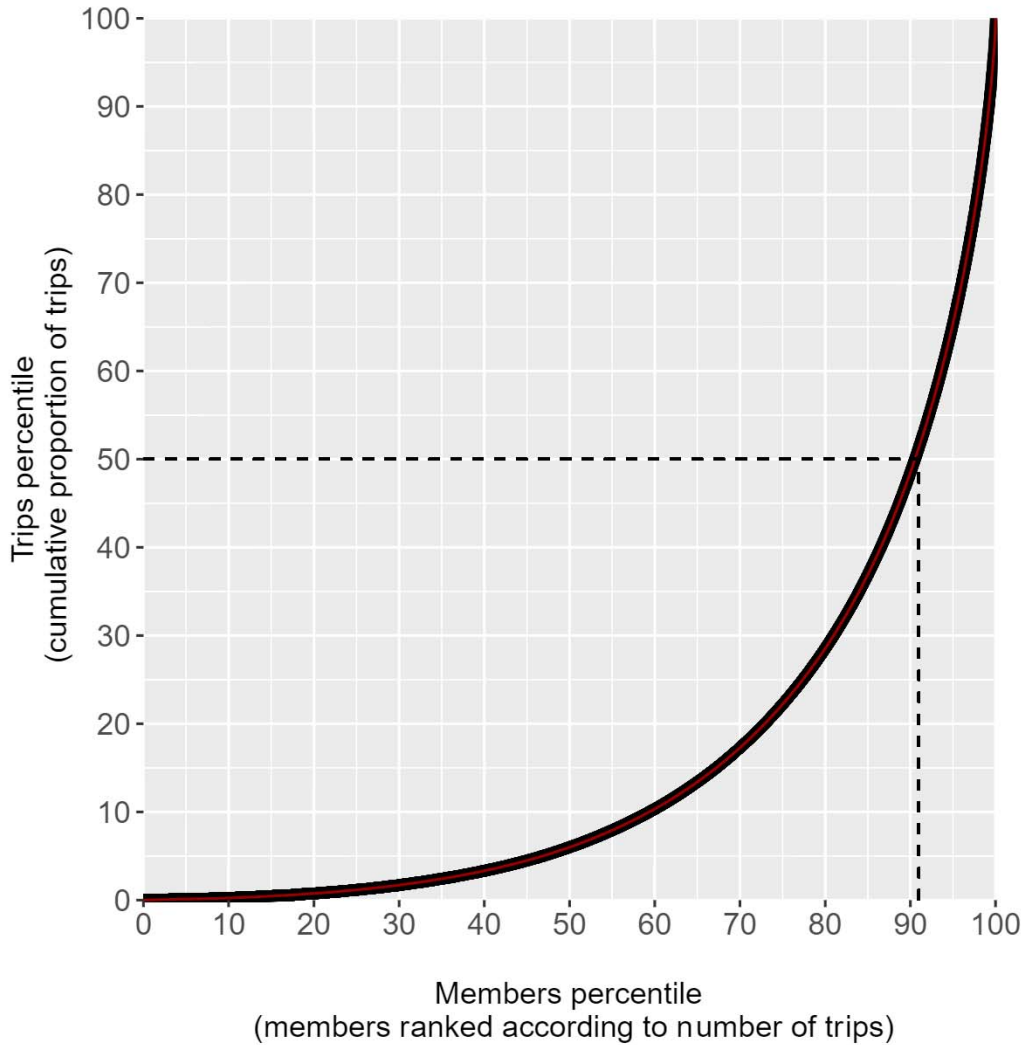


Figure 1. The distribution of trips made by *Mobi by Shaw Go* members (n=8376) from September 1, 2016 to August 31, 2017, Vancouver, BC.
Note. A perfect linear relationship would indicate that members made equal numbers of trips.

2.2.4. Linkage

The system data and survey data were linked by member ID and anonymized. Of the 1400 survey respondents, 87 were missing system data (no trips in the study period) and 81 were missing demographic data. The final analysis dataset comprised 1232 members, of which 204 who were super-users (20 or more trips/month) and 1028 were regular users (<20 trips/month).

2.3. Analysis

All statistical analyses were conducted using R 3.4.1. We compared usage for super-users and regular users, in terms of trip frequency and average weekly distance and minutes bicycling on bike share. We calculated the distribution across the independent variables listed in section 2.2.2 and used logistic regression to model the odds of being a super-user compared to a regular user. We included independent variables associated with the dependent variable in bivariate analysis at a significance level of $p < 0.10$ in multivariable logistic regression and used backward stepwise regression using the

Akaike Information Criterion (AIC) to construct a model with the lowest AIC value. Independent variables commonly associated with bicycling (age, gender, income) were retained even if not selected by the backward stepwise regression procedure. The fully adjusted model included age, gender, born in Canada, access to a personal bicycle, car share membership, primary mode of transportation, and home and work location relative to the bike share service area. In this paper we present the unadjusted results for all variables that were tested in bivariate analyses and adjusted results for all variables retained in the final model.

3. RESULTS

A total of 8376 members made 367,812 trips from September 1, 2016 to August 31, 2017. The median usage across all members is 4 trips per month (25th percentile: 1.8, 75th percentile: 9.6). We had both system data and survey data for 1232 *Mobi by Shaw Go* members active as of September 2017. These members made 89,945 trips and had a median usage of 5.8 trips per month (25th percentile: 2.6, 75th percentile: 14.2). In terms of contribution to total physical activity, members with linked survey data used bike share on average 57.6 minutes per week. Appendix C provides monthly trip data stratified by user type.

3.1. Who are the super-users?

Amongst the members surveyed, 204 were super-users. Super-users had a median usage more than 6 times that of regular users (29.3 compared to 4.5 trips/month), and were ten times as likely to bicycle \geq 150 minutes per week on bike share as compared to regular users (21.8% versus to 2.1%) (Appendix C). Table 1 shows the distribution of super-users and regular users across all covariates, and bivariate (unadjusted) and multivariable (adjusted) model results. Compared to regular users, super-users tended to be younger, men, and be born outside of Canada. In terms of socioeconomic status, people with lower incomes were more likely to be super-users, with a consistent trend across income categories. Education and employment were not associated with being a super-user in bivariate models. In terms of transportation, super-users had four times higher odds of using a bicycle as their primary transportation, as compared to the car. They had lower odds of owning their own bicycle or of belonging to a car share, indicating they may be more dependent on the bike share program specifically for their transportation needs. Compared with regular users, they were more likely to live and to work inside the bike share service area.

Table 1. Demographic and travel characteristics of public bike share members, and associations with being a superuser of bike share (n=1232 *Mobi by Shaw Go* members), Vancouver, BC, 2017.

	Regular Users n=1028	Super-users n=204	Unadjusted	Adjusted*
	%	%	OR (95% CI)	OR (95% CI)
Age				
16-34	37	54	1.00	1.00
35-54	51	39	0.52 (0.38, 0.71)	0.59 (0.42, 0.84)
55+	12	7	0.39 (0.21, 0.69)	0.44 (0.22, 0.83)
Gender				
Women	43	33	1.00	1.00
Men	57	67	1.55 (1.14, 2.15)	1.84 (1.32, 2.61)
Income				
<\$35,000	4	7	2.35 (1.15, 4.60)	2.58 (1.16, 5.52)
\$35,000-\$74,999	16	27	2.51 (1.60, 3.96)	1.91 (1.17, 3.16)
\$75,000-\$149,999	37	32	1.30 (0.85, 2.00)	1.06 (0.67, 1.67)
\$150,000+	29	19	1.00	1.00
No response	14	15	1.64 (0.98, 2.74)	1.57 (0.89, 2.75)
Education				
Post-secondary or less	65	65	1.00	
Graduate post-secondary	35	35	0.97 (0.71, 1.33)	
Employment status				
Unemployed/Other**	10	8	1.00	
Employed	90	92	1.25 (0.74, 2.25)	
Born in Canada (ref: No)				
Yes	66	51	0.56 (0.41, 0.75)	0.74 (0.53, 1.03)
Driver's license (ref: No)				
Yes	94	89	0.53 (0.33, 0.89)	
Access to a personal bicycle (ref: No)				
Yes	71	61	0.62 (0.46, 0.85)	0.73 (0.50, 1.05)
Access to a car (ref: No)				
Yes	66	55	0.62 (0.46, 0.84)	
Car share membership (ref: No)				
Yes	69	62	0.72 (0.53, 0.99)	0.69 (0.49, 0.98)
Primary mode of transportation				
Car	28	13	1.00	
Walk	30	27	1.92 (1.19, 3.20)	1.41 (0.84, 2.40)
Transit	25	18	1.55 (0.91, 2.66)	1.13 (0.64, 1.99)
Bicycle	18	43	5.23 (3.29, 8.57)	4.09 (2.50, 6.88)
Perceived safety of cycling				
Dangerous	13	15	1.00	
Neither safe nor unsafe	8	6	0.71 (0.34, 1.42)	
Safe	79	79	0.88 (0.58, 1.37)	
Home location relative to bike share service area				
Outside	21	9	1.00	1.00
Inside	65	73	2.64 (1.62, 4.55)	2.30 (1.36, 4.11)
No address provided	15	18	2.89 (1.60, 5.37)	2.57 (1.24, 5.44)
Work location relative to bike share service area				
Outside	21	12	1.00	1.00
Inside	52	61	2.10 (1.34, 3.41)	2.00 (1.22, 3.38)
Does not work or study	7	5	1.22 (0.53, 2.61)	1.08 (0.43, 2.56)
No address provided	20	22	1.91 (1.13, 3.29)	1.35 (0.70, 2.60)

* Multivariable model used backward stepwise regression using AIC. Age gender, and income were kept in the model even if not initially selected during the stepwise regression procedure.

** Other = Student, Retired, or Homemaker

4. DISCUSSION

We linked system data with member survey data for Vancouver's public bike share system to make a novel contribution toward understanding who is capitalizing on public bike share programs. Consistent with findings in Denver and London (Chardon, 2019), we found that about 10% of members make half of all trips. We compared these high volume "super-users" to less frequent users to understand who amongst members is realizing benefits, and found that the profile of a super-user is a young male who, notably, has a lower income than those who use the program less often. In terms of transportation, super-users emerge as people with fewer transportation options than regular users, as they are less likely to own a personal bicycle or belong to a car share program.

Considering usage when quantifying transport and health gains from bike share can provide a more nuanced understanding of the equity implications of these programs. Past studies have found that members tend to be young, male, educated, and have higher incomes (Fishman, 2016; McNeil et al., 2017; Shaheen, 2012). However, in our study, we found that the patterning varied for income across membership and usage. While members overall tended to have higher incomes compared to the general population, the super-users were more likely to have lower incomes than regular users. For other characteristics such as age and gender, both were correlated with membership and usage, but we found incorporating usage led to a more nuanced understanding of potential inequities. For example, there is a moderate gender gap amongst members (41% women), but this was more substantial when usage was taken into account, with women accounting for only 33% of super-users. Equity in spatial access has also received research attention, with studies finding that in most cities bike share disproportionately serves higher income areas (Hosford and Winters, 2017; Smith et al., 2015; Ursaki and Aultman-Hall, 2016). This study concurs that frequency of use is indeed higher amongst those who live and work within the service area.

This study uses a full year of data for the sole bike share system in the city. Our analysis sample included one in seven (14.7%, $n=1232/8376$) bike share members at the time. Unfortunately, no demographic data is collected at the time members join, limiting an assessment of representativeness. The system data suggested that survey respondents had a slightly higher frequency of use than the average member. Thus, the associations between super-users and regular users presented here may be conservative, as the least frequent users of bike share are underrepresented in the survey. Ongoing research calls into question the amount of health benefits bike share may offer (Bauman et al., 2017). We considered frequency of use, but do not have data on the frequency of riding personal bicycles or objective measures of overall physical activity (duration or intensity), which could provide a deeper understanding of health benefits attributable to bike share.

5. CONCLUSION

Super-users emerge as having a distinctive demographic profile from the typical bike share member. Analyses that incorporate frequency of use can provide greater nuance into some of the prevalent concerns about the equity of who these programs serve.

Funding: This work was supported by the Canadian Institutes for Health Research [Population Health Intervention Research Grant no. 120515]. MW was supported by a Michael Smith Foundation for Health Research Scholar Award, KH by a Simon Fraser University KEY Big Data Award, and SJ by a Social Science and Humanities Undergraduate Research Award.

Conflicts of interest: The authors declare there is no conflict of interest.

Acknowledgement: We want to acknowledge the assistance of *Mobi by Shaw Go* in facilitating the administration of the member survey in 2017, and in providing system data.

ACCEPTED MANUSCRIPT

REFERENCES

- Bauman, A., Crane, M., Drayton, B.A., Titze, S., 2017. The unrealised potential of bike share schemes to influence population physical activity levels – a narrative review. *Prev. Med.* 103, S7–S14. <https://doi.org/10.1016/j.ypmed.2017.02.015>.
- City of Vancouver, 2017. Archived – celebrating one year of public bike share in Vancouver. <http://vancouver.ca/news-calendar/celebrating-one-year-of-public-bikeshare-in-vancouver.aspx>, Accessed date: 2 February 2018.
- City of Vancouver, 2018. Open Data Catalogue – bikeways data. <http://data.vancouver.ca/datacatalogue/bikeways.html>, Accessed date: 1 February 2018.
- Chardon, C.M. De, 2019. The contradictions of bike-share benefits, purposes and outcomes. *Transp. Res. Part A* 121, 401–419. <https://doi.org/10.1016/j.tra.2019.01.031>
- Fishman, E., 2016. Bikeshare: A review of recent literature. *Transport Reviews*, 36(1), pp.92-113. <https://doi.org/10.1080/01441647.2015.1033036>
- Fuller, D., Gauvin, L., Kestens, Y., Daniel, M., Fournier, M., Morency, P., Drouin, L., 2013. Impact evaluation of a public bicycle share program on cycling: A case example of BIXI in Montreal, Quebec. *Am. J. Public Health* 103, 85–92. <https://doi.org/10.2105/AJPH.2012.300917>
- Hirsch, J.A., Stewart, I., Ziegler, S., Richter, B., Mooney, S.J., 2019. Residents in Seattle, WA report differential use of free-floating bikeshare by age, gender, race, and location. *Frontiers in Built Environment*. 5. <https://doi.org/10.3389/fbuil.2019.00017>
- Hosford, K., Winters, M., 2018. Who Are Public Bike Share Programs Serving? an Evaluation of the Equity of Spatial Access To Bike Share Service Areas in Canadian Cities. *Transp. Res. Rec.* 2672, 42-50. <https://doi.org/10.1177/0361198118783107>
- Howland, S., McNeil, N., MacArthur, J., 2017. Current Efforts to Make Bike Share More Equitable: A Survey of System Owners and Operators. *Transp. Res. Rec.* 2662, 160–167. <https://doi.org/10.3141/2662-18>
- Mcneil, N., Dill, J., Macarthur, J., Broach, J., Howland, S., 2017. Breaking Barriers to Bike Share: Insights from Residents of Traditionally Underserved Neighborhoods. https://pdxscholar.library.pdx.edu/trec_reports/138/. Accessed date: 1 February 2019.
- Ogilvie, F., Goodman, A., 2012. Inequalities in usage of a public bicycle sharing scheme: Socio-demographic predictors of uptake and usage of the London (UK) cycle hire scheme. *Prev. Med.* 55, 40–45. <https://doi.org/10.1016/j.ypmed.2012.05.002>
- Ricci, M., 2015. Bike sharing: A review of evidence on impacts and processes of implementation and operation. *Res. Transp. Bus. Manag.* 15, 28–38. <https://doi.org/10.1016/j.rtbm.2015.03.003>
- Shaheen, S., Guzman, S., Zhang, H., 2010. Bikesharing in Europe, the Americas, and Asia. *Transp. Res. Rec.* 2143, 159–167. <https://doi.org/10.3141/2143-20>
- Shaheen, S.A., 2012. Public bikesharing in North America: Early operator and user understanding, MTI Report 11-19, Mineta Transportation Institute Publications. <https://transweb.sjsu.edu/research/public-bikesharing-north-america-early-operator-and-user-understanding>. Accessed date: 1 February 2019.

- Smith, C.S., Oh, J., Lei, C., 2015. Exploring the Equity Dimensions of US Bicycle Sharing Systems. TRCLC 14-01. Transportation Research Center for Livable Communities (TRCLC) https://wmich.edu/sites/default/files/attachments/u428/2015/TRCLC_RR_14_01.pdf. Accessed date: 1 February 2019.
- Statistics Canada, 2016. Vancouver, CY [Census subdivision], British Columbia and Greater Vancouver, RD [Census division], British Columbia (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. <http://www12.statcan.gc.ca/census-recensement/2016/dp>.
- Ursaki, J., Aultman-Hall, L., 2016. Quantifying the equity of bikeshare access in US cities, in: 95th Annual Meeting of the Transportation Research Board, Washington, DC.
- Vogel, M., Hamon, R., Lozenguez, G., Merchez, L., Abry, P., Barnier, J., Borgnat, P., Flandrin, P., Mallon, I., Robardet, C., 2014. From bicycle sharing system movements to users : a typology of Vélo ' v cyclists in Lyon based on large-scale behavioural dataset. *J. Transp. Geogr.* 41, 280–291. <https://doi.org/10.1016/j.jtrangeo.2014.07.005>
- Wang, K., Akar, G., 2019. Gender gap generators for bike share ridership: Evidence from Citi Bike system in New York City. *J. Transp. Geogr.* 76, 1–9. <https://doi.org/10.1016/j.jtrangeo.2019.02.003>
- Wang, K., Akar, G., Chen, Y.-J., 2018. Bike sharing differences among Millennials, Gen Xers, and Baby Boomers: Lessons learnt from New York City's bike share. *Transp. Res. Part A Policy Pract.* 116, 1–14. <https://doi.org/10.1016/J.TRA.2018.06.001>