Transportation Research Interdisciplinary Perspectives 10 (2021) 100353

Contents lists available at ScienceDirect

Transportation Research Interdisciplinary Perspectives

journal homepage: www.elsevier.com/locate/trip

Bike share responses to COVID-19

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ARTICLE INFO

Keywords:
COVID-19
Urban transportation
Bike share
Survey
Mixed methods

ABSTRACT

Bike sharing can leverage its physical distancing advantages for responding to the COVID-19 pandemic, but system management and communication are essential to support healthy transportation. This study addresses the need to understand the range of bike share systems' responses to the pandemic by reviewing bike share system cases in the United States and reports survey responses from bike share users in San Antonio (TX). Five out of eleven bike share systems communicated their responses to the pandemic online at the time of review. 43% of survey respondents who were unemployed due to the pandemic reported increasing use of the bike share system, whereas 36% of employed respondents decreased ridership. Most respondents were unaware of the bike share operator's steps to control the spread of COVID-19 for users. Moderate-frequency riders (1–2 times per month) may increase bike sharing the most after Coronavirus restrictions are lifted, from 22% of respondents to 34%. Based on our findings, we suggest bike share operators should expand communication efforts about policies and actions to support community health, explore how to serve unemployed and low-income communities best, and prepare for the equitable expansion of ridership following the pandemic.

1. Introduction

The global COVID-19 pandemic has managed to affect most, if not all, facets of daily life. Implementing policies such as face masks and social distancing mandates, closing schools and non-essential businesses, and work from home protocols have changed how many citizens live. A survey conducted by RTI. International in early March of 2020 found that more than 80% of 1,021 survey respondents supported the notion of suspending visitation to places in their communities such as grocery stores, churches, restaurants, and shopping malls (RTI International, 2020). Overcrowding and proximity of infected persons in enclosed spaces correlate with COVID-19 transmission, though an early analysis suggests metropolitan population size and connectivity are more critical than county-level density (Hamidi et al., 2020). Previous research shows that transportation systems' management can support the control of disease outbreaks (Chen et al., 2017). As many citizens choose to adapt to a socially distanced lifestyle, aspects of public activity such as transportation are likely to undergo considerable changes. This study focuses on bike sharing changes by reviewing bike share entities' response to COVID-19 in major U.S. cities and survey results from San Antonio, Texas.

1.1. COVID-19 and travel patterns

Personal travel is implicated as one of the causes of community spread of COVID-19, and contributes to the risk of overcrowding health care facilities (Oum and Wang, 2020). Modeling suggests that individualize do not "internalize the external cost of infection risks they impose on others…when making their own travel decisions", implying a need for a policy response to reduce transmission through transportation systems (Oum and Wang, 2020). Micromobility systems such as bike sharing can provide an alternate transportation mode that alleviates the public health fear of crowded public transit systems. Relieving crowded public transit could also allow the proper implementation of social distancing measures. The Centers for Disease Control has recommended incentives for using "forms of transportation that minimize close contact with others," such as biking (Centers for Disease Control and Prevention, 2020). Bike sharing allows socially distant transit while providing healthy, low-impact exercise for its users in addition to curbing emissions and mitigating traffic congestion (Bullock et al., 2017; Fishman et al., 2014; Marshall and Ferenchak, 2019; Nehme and Kohl, 2014). However, substituting public transit trips with bike sharing may impact efficacy for longer trips that leverage bike share access to public transit and final destinations (Tarpin-Pitre and Morency, 2020).

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https://doi.org/10.1016/j.trip.2021.100353
Received 27 December 2020; Revised 10 March 2021; Accepted 13 March 2021
Available online 19 March 2021

While many citizens can work from home, those who must still commute are looking for safe means of transit, and those stuck at home are looking for activities that allow social distancing. Many cities saw extreme drops in bike share ridership as the pandemic initially struck but experienced increases when cities began reopening phases (Freeman, 2020; Padmanabhan et al., 2021). Public survey results from Sydney, Australia, suggest a rapid increase in bicycling trips and an increased need for improving bicycle infrastructure in response (Lock, 2020). The US Bureau of Transportation Statistics reports bike share ridership to have decreased by 44% in March, April, and May 2020 compared with the same months in 2019 (Bureau of Transportation Statistics, 2020). Ridership data from New York City in 2020 shows that bike share decreased less (71%) than subway trips (90%) as compared with February and March of the previous year (Teixeira and Lopes, 2020). The average bike share trip distance increased from 13 min to 19 min, providing further evidence of modal substitution during COVID-19, and can "support the transition to a post-coronavirus society" (Teixeira and Lopes, 2020). Bike sharing is still a relatively new form of transportation, and observation of bike share trips may induce new riders through social diffusion (Schoner et al., 2016). However, shared use of equipment may cause concerns, which this article quantifies for an established San Antonio, Texas system.

1.2. Urban transportation system responses to COVID-19

The pandemic caused major shifts in transportation to minimize infection, and cities responded with innovative solutions to maintain health and mobility, despite declining revenue. Nineteen out of 20 large cities in the United States reduced public transit service, while 14 of them shifted to fare-free service (Hamidi and Porter, 2020). In New York City, bike share trips fell less than subway trips (71% and 90%, respectively), as COVID-19 infections rose quickly during March 2020 (Teixeira and Lopes, 2020). The New York context showed modal conversion from the subway to bike share during this period, demonstrating bike sharing's resilience during the pandemic (Teixeira and Lopes, 2020). Transit reductions have particularly impacted people with disabilities (Cochran, 2020). Recognizing a need to provide safe alternatives to crowded transit systems, Bogotá, Columbia, added 13 miles of bike lanes overnight on March 17th with traffic cones and increased the network to 47 miles in a few days (Miketa and Sun, 2020). In the United States, New York added similar pop-up bicycle lanes, Oakland created a Slow Streets program, and Lyft created a free and reduced-fare program for bike share customers in Boston and Chicago (Miketa and Sun, 2020). Houston, New Orleans, and Atlanta suspended bike sharing and e-scooter services, whereas Detroit made their bike sharing program free to users (Hamidi and Porter, 2020). In Seattle, Uber's ridership dropped between 60 and 70 percent (Hamidi and Porter, 2020).

Rapid responses to the pandemic have in some ways shortchanged the planning process, leading to challenges from equity standpoints. Low-income communities suffer disproportionately from reduced access to basic needs following transit changes (Al Mamun and Lownes, 2011; Griffin and Sener, 2016; Karner and Golub, 2015; NAACP, 2020; Reddy et al., 2010). Inequitable access to bike sharing may be mitigated by supporting annual bike share memberships (Qian and Jaller, 2020) and incorporating dockless services (Qian et al., 2020). The Untokening Collective developed a guide for mobility justice responses to COVID-19, with 12 specific recommendations that emphasize centering vulnerable communities and equitable participation before planning projects (The Untokening, 2020). Some cities in the United Kingdom have implemented a Rapid Cycleway Prioritization Tool, providing a relatively transparent, GIS-driven process that has been combined with interactive websites for quick public engagement (Lovelace et al., 2020). Public transit and bike share services in our focus city of San Antonio have remained open throughout the pandemic with measures to minimize spread, despite some transit operators testing positive for COVID-19 (VIA, 2020). Shifts in living and working represent an opportunity to develop new transportation habits (Bonham and Wilson, 2012; Chatterjee et al., 2013), potentially supporting safety and health through bike sharing (Fishman and Schepers, 2016).

1.3. San Antonio bike share

The city of San Antonio grew around Spanish colonial missions along the San Antonio River and is home to the first bike share system in the state of Texas, launched in 2011 (Sherwood and Murphy, 2014). The San Antonio Bike Share has grown from 140 bicycles and 14 bike share stations to 600 + bicycles and 60 + strategically placed bike share stations in critical locations within the central city and along popular bike paths. Anchored by the Alamo, San Antonio is a major tourism destination for the nation, with recent restoration and expansion of active transportation paths along 13 miles of the San Antonio River (Doganer, 2017). An early survey of San Antonio Bike Share (SA Bike Share) system users suggested participants' bicycling increased after becoming members of the system, replacing personal car trips (36%), walking (32%), inducing new trips (13%), and replacing bus trips (10%) (Sherwood and Murphy, 2014). A later study of bike share trips showed that the top six stations by ridership are located along the city's extended Riverwalk trail, and suggested that the north–south alignment of the bike share system along the river, along with a lack of high-comfort bikeways throughout the city makes "using the system for point-to-point utilitarian travel inconvenient and uncomfortable" (Alcorn and Jiao, 2019). However, planning the bike share system with tourism as a major focus may not support paid memberships at a sustainable level if the pandemic continues to impact the city. The primary share of bike share stations and existing bike networks are currently constricted to the downtown area and surrounding neighborhoods surrounded by less bike friendly roadways. San Antonio's well-known sprawling land use patterns could prove a hindrance to creating a more integral bike network throughout the metro area to further support the bike share system in place. Therefore, SA Bike Share expressed interest in understanding local user needs better, particularly during the pandemic challenges.

SA Bike share implemented and communicated seven key measures to prevent spread of COVID-19, including "cleaning bikes with a germ-killing disinfectant, disinfecting frequently touched areas of stations, sanitizing all equipment and tools, wearing gloves when touching bike and station equipment, enforcing strict personal hygiene practices among SA BikeShare personnel, encouraging SA BikeShare riders to wash hands before and after riding and to use the BCycle app to check out bikes when possible, and continuing to monitor the latest updates from public health officials" (San Antonio Bike Share, 2020). As a proactive effort, SA Bike Share Executive Director J.D. Simpson reached out to the second author to co-develop and rapidly disseminate a survey of local users to better understand their use of the system and needs during and after the pandemic. Results of this study may be beneficial to other cities planning transportation through and beyond pandemics.

1.4. Study objectives

A review of previous studies shows gaps in research on individual's use of bike sharing in southwestern cities and a lack of structured research on bike share systems' responses to the pandemic. This paper aims to determine the current and future impacts of COVID-19 on bike share systems by reviewing bike share system responses in major cities and the results of a survey disseminated by San Antonio Bike Share to its local users. Specifically, we wish to understand responses of bike share systems and users to the pandemic, how San Antonio Bike Share users' understanding of actions to reduce infection risk, variation in

stated needs by income level, and anticipated use of bike sharing following the pandemic. We expected bike share systems to offer a mixed response to the pandemic, especially given the limited knowledge of infection risk due to bike share or systematic federal guidance for bike sharing systems. We anticipated individual bike share use would reduce to avoid infection, especially considering the widespread availability of automobiles in the San Antonio area. After examining results, we provide recommendations for bike share operators regarding plans of action for COVID-19, and future research.

2. Survey and case methods

We surveyed local users in San Antonio, Texas, in May 2020, and collected data on eleven bike share systems' responses to COVID-19 in June and July 2020. We begin with a description of a desktop analysis of bike share systems located in major U.S. cities, then proceed into San Antonio-specific results. In addition to descriptive statistics, we employ a sequential mixed-methods approach to understanding the needs of bike share users by income.

We reviewed COVID-19 responses by other bike share entities in major U.S. cities. These cities include New York City, Los Angeles, Chicago, Houston, Phoenix, Philadelphia, San Antonio, Washington D.C., Boston, Austin, and Portland, in addition to our focus on San Antonio. To qualify for analysis, the bike share entity had to have an official partnership with a host city. Private micromobility companies were not included in this analysis.

San Antonio Bike Share staff co-designed a survey instrument with the second author of this study to quantify local system users' understanding of the use and preferences during and after the COVID-19 pandemic. San Antonio Bike Share invited local users (defined as those who purchased a membership or joined the system's newsletter list) to complete an online survey administered through Qualtrics. The survey went to a total of 2,633 email addresses via Newsletter Email List (n = 1,583, 813 opens and 104 clicked on the link), Summer Club Members (n = 39, 21 opened, 13 clicked), Monthly Members (n = 96 members, 86 opened, 16 clicked), and Day Passes n = 915, 588 opened, 64 clicked). A complimentary guest day pass was offered as an incentive for completing the survey. One hundred twenty-five bike share users responded between May 5th and May 16th, 2020; 8.3 percent of the 1,508 we could verify received and opened the invitation. The time frame of our survey is just over one month after a previous analysis of Citi Bike in New York City (Teixeira and Lopes, 2020), and overlaps an analysis of bike sharing in Boston, Chicago, and New York City (Padmanabhan et al., 2021).

This article focuses on questions that inquired about bike usage during the COVID-19 pandemic, including changes in the frequency of use, understanding about the bike share operators' actions to reduce the chance of infection, respondents' plans for bike share use, and open-ended responses on bike share needs. We analyzed descriptive statistics from the survey and framed results in the larger US context by reviewing other systems' responses to the pandemic.

Demographics, including gender, race, and annual income measured in the survey, were compared with the 2018 American Community Survey results for San Antonio to evaluate survey representativeness. Table 1 shows that the survey skewed non-Hispanic/Latino, white, and female, compared with the American Community Survey statistics across San Antonio. However, household income ranges are somewhat representative of the community, with three income bands varying less than one percent from the broader population.

Demographic trends among survey respondents trended similarly to a study with similar survey distribution methods conducted in the Washington DC area (Buck et al., 2013). Similarities include approximately 80% percent of users identifying as White and a disproportionately smaller percentage, approximately 5% identifying as Black or African American. However, approximately 36% of respondents to the survey distributed by SA Bike Share identified as Hispanic/Latino, versus approximately 5% identifying as Hispanic/Latino from the Washington DC area. In terms of income, similar trends include either a quarter or more of respondents identifying as having an annual income of $50,000 or less. 24% of the San Antonio Bike Share survey respondents reported an annual income between $60,000 and $100,000 compared to 36% of respondents to the DC survey reporting an annual income between $50,000 and $100,000 (Buck et al., 2013). As shared micro-mobility systems such as bike sharing may become more popular soon, it will be necessary to implement policies and precautions to impede the spread of COVID-19.

Table 1
Demographics of Survey Respondents and the City of San Antonio, Texas.

	SA Bike Share Survey	San Antonio[a]
Hispanic/Latino		
Yes	36%	61%
No	64%	37%
Race		
White	81%	67%
Black or African American	5%	11%
American Indian or Alaska Native	1%	2%
Asian	3%	2%
Native Hawaiian or Pacific Islander	2%	0%
Other	8%	17%
Sex		
Male	38%	49%
Female	61%	51%
Household Annual Income		
Less than $10 K	4%	8%
$10 K-$19999	6%	11%
$20 K-$29999	10%	11%
$30 K-$39999	6%	10%
$40 K-$49999	9%	9%
$50 K-$59999	9%	9%
$60 K-$99999	24%	22%
$100 K-$149999	19%	12%
$150 K+	13%	8%

[a] American Community Survey 2018 data for the City of San Antonio

To understand how bike share users' needs vary by household income level, we use a mixed-method approach known as extreme case sampling (Creamer, 2018). Since San Antonio's median income was $50,980 in 2014–2018 (U.S. Census Bureau, 2020), we separated groups into extremes of at least $30,000 under and over the median, rounding to the group sizes dictated by the broad question ranges. We then compare responses to the open-ended question "What can SA Bike Share do to support your biking more often?" for respondents reporting household income below $30,000 and above $100,000. To contribute to qualitative findings' reliability, we repeated the respondents' wording to support 'thick description' of individual experience (Morse, 2015). Further, our triangulation of findings through mixed methods (quantitative and qualitative survey results) contributes to internal and external validity (Creamer, 2018). Taken together, our mixed-methods approach to analyzing the impact of COVID-19 on bike sharing seeks to maximize the descriptive power of a limited sample size for timely impact to practice and research from the COVID-19 pandemic.

3. Findings

3.1. Bike sharing during and after COVID-19

Table 2 examines bike share organizations' COVID-19 responses posted on the organizations' official websites in 11 major US cities. Only 5 of the 11 cities had directly posted their response to COVID-19, including measures taken to keep users safe and reduce the spread of COVID-19. Three of them included Centers for Disease Control

Table 2
Bike Share System Response to COVID-19 and Changes in Bicycling by Metro Area.

City	Bike Share Entity	Posted Response	CDC Guidelines Present	Change in Bicycle Miles Traveled, May 2020 vs. May 2019 (Grogan and Hise, 2020)
Boston, MA	BlueBikes	Direct Response	Yes	0% to −35%
Chicago, IL	Divvy	None	N/A	0% to −35%
New York City, NY	Citi Bike	Direct Response	Yes	0% to −35%
Philadelphia, PA	Indego	Link to City Response	No	0% to −35%
Portland, OR	Biketown	None	N/A	0% to −35%
Washington DC.	Capital BikeShare	None	N/A	0% to −35%
Austin, TX	Austin BCycle	Direct Response	Mentioned	+ 1 to 19%
Los Angeles, CA	Metro Bike Share	None	N/A	+ 1% to 19%
Houston, TX	BCycle	Direct Response	Yes	+ 50% to 89%
Phoenix, AZ	Grid Bikes	None	N/A	+ 50% to 89%
San Antonio, TX	San Antonio Bike Share	Direct Response	Mentioned	+ 50% to 89%

(CDC) guidelines for using bike share and had simply mentioned following CDC guidelines to improve user safety. The contrasting responses (or lack thereof) between different major cities reflect different policy implementations regarding health and safety ordinance for COVID-19 prevention. As the pandemic continues, one could anticipate that city bike share entities' responses and safety measures will eventually be implemented but should be as soon as possible to ensure their staff and local users' safety.

The last column in Table 2 shows changes in bicycling at the combined metropolitan statistical area, as detected through a big data service from Streetlight that aggregates mobile device positions and algorithmically infers travel mode (Grogan and Hise, 2020). This form of big data is a valuable resource for rapid and large-scale analysis, but one that includes biases in sampling, measurement, and aggregation (Griffin et al., 2020). Cities with an apparent decrease in vehicle miles traveled include places that already have high bicycle ridership. The analysts also noted that the same big data tool shows that bicycling reduced less than car travel in these locations (Grogan and Hise, 2020). However, this analysis level does not show a relationship between bike share system actions and ridership responses. Therefore, we delve into results from the local survey in San Antonio.

Table 3 illustrates the results of the survey question, “how has the Coronavirus outbreak impacted your use of San Antonio Bike Share?” across respondents’ employment status. Overall, almost half indicated that COVID-19 had not impacted their usage of the bike share system. Over a quarter of responses reported increasing San Antonio Bike Share ridership during the COVID-19 outbreak, with the highest response from those no longer working due to the Coronavirus. Less than a quarter of respondents reported stopping or decreasing ridership during the outbreak. Chi-square testing showed these relationships could be coincidental nearly three out of four times ($p = 0.242$). Bucketing the two working categories (paid employee and self-employed) against the four not working categories (due to Coronavirus, retirement, disability, and other) also showed similar significance ($p = 0.225$). The sample size of 109 valid responses to both employment status and the outbreak impact on SA Bike Share limited the generalizability of this finding, however.

Fig. 1 combines two separate survey questions: “currently, how often do you use SA Bike Share?” and “after Coronavirus restrictions are lifted, how often do you plan to use SA Bike Share?” Moderate ridership of 1–2 times monthly may increase the most. More than one in five plan to ride six times a month or more after Coronavirus restrictions are removed. Independence testing of this question pair with 115 responses shows a strong effect size of lifting Coronavirus restrictions (*Cramér’s* $V = 0.554$, $p < 0.001$).

These results support the notion that shared-use micro-mobility systems such as bike shares could experience an increase in total usage during or post-pandemic. Whether the reports of increased usage are a result of commuting or leisure is unclear. The perception that is gaining clarity is that commuting patterns post-pandemic, at least in the immediate future, will undoubtedly be different. As people adapt to new isolated lifestyles and commuting patterns change, it will be imperative for shared micro-mobility systems to continue to meet the demand for alternative forms of transportation. The purpose of shared micro-mobility usage could be changing as well. As isolated lifestyles increase, the demand for delivery services has risen. Daily tasks such as eating out, grocery store visits, and retail shopping have citizens fearful due to health concerns. Providing transportation to support the essential workforce at a discounted or complimentary rate could be a viable method of increasing overall long-term usage.

3.2. Understanding of bike share actions to reduce infection risk

To evaluate whether users were aware of SA Bike Share’s protective actions, the survey asked “did you know that SA Bike Share has taken seven steps to protect the health and safety of employees and riders during the Coronavirus outbreak?” As described previously, these staff actions included rigorous approaches to cleaning bikes and station equipment, equipment and tools, wearing gloves, enforcing strict personal hygiene, encouraging riders to wash hands before and after

Table 3
Percent Coronavirus outbreak impacted use of bike share by working status.

	Total	Working, paid employee (n = 72)	Working, self-employed (n = 4)	Not working due to Coronavirus (n = 14)	Not working, retired (n = 12)	Not working, other (n = 6)
No—same use of San Antonio Bike Share during Coronavirus	48	53	50	36	33	50
Yes—increased bike share use during Coronavirus	26	24	25	43	25	17
Yes—decreased bike share use during Coronavirus	14	11	25	14	17	33
Yes, stopped bike share use during Coronavirus	8	10	0	0	8	0
Unsure	5	3	0	7	17	0

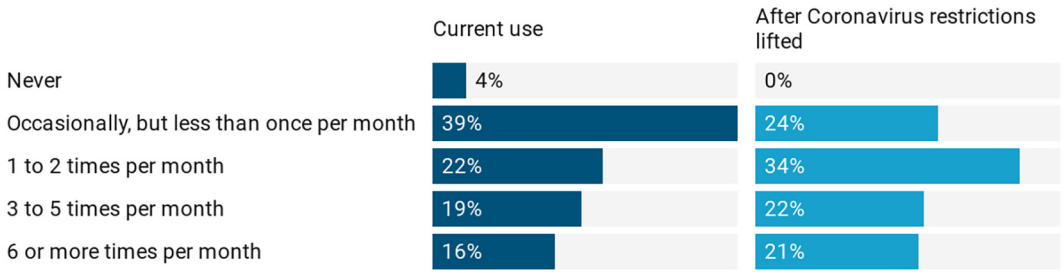

Fig. 1. Stated change in Bike Share Usage from COVID-19 Restrictions.

riding and to use the BCycle app to check out bikes when possible, and monitoring updates from public health officials. Out of the 120 responses to this question, 57% were unaware of the policies and precautions implemented by San Antonio Bike Share during the COVID-19 outbreak. 4.2% were at least partially unsure. Recognizing that respondents to the survey may be more engaged and knowledgeable than casual users of the system, this finding indicates a significant lack of knowledge regarding SA Bike Share's efforts to reduce the risk of infection associated with bike sharing. With recent developments in understanding COVID-19 transmission vectors by the CDC, primarily regarding less likely infection possibilities via contaminated surfaces versus airborne transmission, these response methods to COVID-19 may need to be revisited. Further efforts may need to be made to enforce the wearing of facial coverings by users to prevent airborne transmission while using bike share bicycles and while using possibly crowded bike share stations.

3.3. Stated needs of low and high-income groups

We expected the stated needs of relatively lower-income (<$30 k annual income) and wealthy bike share users (>$100 k annual income) to differ based on access to the system, but age was also a factor. High-income respondents lived closer to a San Antonio Bike Share station on average, 13.6 min by walking, as compared to an average 35.4 min walk to a station for low-income respondents ($p = 0.00429$) Low-income respondents were more likely young, with an average age of 34.3 years, compared to the high-income group's average age of 47.7 ($p = 0.002$). However, income groups did not significantly vary by reported ethnicity ($p = 0.0610$) or gender ($p = 0.550$).

Regarding stated needs, ranked ANOVA results showed that the system maintenance were most significant. Respondents with higher incomes valued system maintenance more, with ranked ANOVA showing a strong effect (*Cohen's* $f = 0.492$, $p = 0.005$). Income was more likely to be a coincidental factor in categories of ease-of-use of the station kiosks ($p = 0.315$) and smartphone app ($p = 0.340$), proximity to work/school ($p = 0.213$) or home ($p = 0.499$), and cleanliness of bikes and stations ($p = 0.207$). However, we deepen statistical generalizations with individual open-ended responses from extreme samples —at the highest and lowest ends of the income spectrum in our responses.

To add qualitative insights, we reviewed responses to the survey question "What can SA Bike Share do to support your biking more often?" (N = 98). Those who responded with a household income of less than $30,000 annually included practical insights (n = 16). "Make prices more accessible, and [provide] longer rent time" suggests that the pricing structure may restrict use to some, supported by another response to "increase this time to 2–3 hrs. Several responses like "add more docks," "more stations beyond the corridor" and "more stations in more parks" supports the previous study that pointed out limitations of a system planned to service tourism districts (Alcorn and Jiao, 2019). One respondent requested adding a baby seat to bikes, showing that the existing equipment may limit use by growing families, especially since the system requires riders to be 18 or older. Only one low-income respondent commented on a need for maintenance: "Keep up with the stations a little bit more and maintain the bikes a little bit better. I have found bicycles missing pieces and have gone back to the same station to find the same bicycle a few weeks in a row".

Responses to "What can SA Bike Share do to support your biking more often?" among those making more than $100,000 annually by household (n = 27), there was more emphasis on the broader bicycling system, ranging from bike lane networks to bicycle maintenance. Comments like "increase bike lanes throughout the city" and "improve bikes and trails" suggest a role for advocacy with city and state transportation departments. Many of the city's higher-income neighborhoods are located on the northern side of the city, and this group suggested locations "further north," "in Tobin Hill/Government Hill/Beacon Hill neighborhoods," and to "place stations in Monte Vista."]. Specific to the COVID-19 pandemic, a high-income respondent requested "sanitation supplies at the bike station." Tellingly, some high-income respondents also requested the service to be "more affordable" and to provide "discounts for people living downtown." Both income levels mentioned a need to improve the system's maintenance overall and increase the availability of e-bikes.

4. Discussion and conclusions

4.1. Controlling infectious disease

This study shows that bike share systems are sensitive to impacts during a pandemic. Public communication may impact the role that bike sharing serves to keep a population safe and healthy. At the time of this study, only five out of eleven studied bike share systems had communicated their steps to control the transmission of COVID online. Even in the case of San Antonio's system that proactively communicated their efforts, most were unaware that the bike share system had implemented additional health measures. Informing the public of these measures may increase ridership with appropriate cautions, but these efforts require resources. Financial support from governments or private foundations may help improve safety measures and public communication during a pandemic.

4.2. Bike sharing during the COVID-19 pandemic

This study suggests people unemployed by the pandemic are most likely to increase their use of bike share systems. Unemployed persons may restrict use of driving or public transit due to cost, and may have more time available for health-supporting bicycling. Therefore, this population may be a priority for information campaigns and services such as reduced cost bike share memberships. Information and support for bike sharing may be a valuable part of cities' responses to unemployment due to the pandemic, particularly if offered through broader response and education programs.

Adaptations made during the COVID-19 pandemic are imperative to mitigating the virus's spread and preparing for other possible imminent health crises. While many now live more socially distanced lifestyles and have reduced overall mobility, efficient transportation and mobility in cities are still crucial in connecting people to the city. Social distancing is more than a trend, and shared use micromobility systems provide citizens the opportunity to use transit in a safe and healthy way that caters to their comforts. As cities eventually reopen, bike share policies and users' knowledge of the actions may impact willingness to choose this mode. Ensuring the health and safety of users during the time of increased demand will be crucial. Implementing guidelines informed by organizations such as the Center for Disease Control is a good starting point for all bike share operators. Operators can keep all stations operational for essential workers and those looking to avoid crowded public transit systems. Informing users of precautionary guidelines will be key to ensure proper compliance. With these recommendations, bike share operators can ensure users' health and safety and continue to provide bike sharing as a healthy travel option during the COVID −19 pandemic.

4.3. Bike share changes after Coronavirus restrictions are lifted

Survey results from San Antonio suggest a significant increase in bike share use after Coronavirus restrictions are lifted. However, our survey cannot directly link respondents' reasons for stating they would use bike share more. Based on previous research, open stations' locations, perception of safety, available time, including the continuation of employer teleworking policies, and pricing policies will likely be important factors. The San Antonio Bike Share survey suggests moderate-frequency bike share users may be most likely to increase bike share usage after the Coronavirus restrictions are lifted. People who already use the system on occasion could be more sensitive to information about bike share operations changes and could be an efficient target for advertising or other public communication methods. Where possible, governments and non-profit organizations should partner to support healthy and safe transportation options during the pandemic and again as cities emerge from Coronavirus restrictions.

To realize benefits to community health and mobility in addition to bike share system efficiency, operators should partner with other organizations to extend communication about COVID safety and their sanitation and maintenance practices that may change as government restrictions are lifted. Our analysis of systems' communication of COVID policies and practices and the general lack of knowledge among local bike share users at our study site show improving communication may be vital to realizing the stated latent demand for bike sharing.

Income status poses a challenge to equity for bike sharing, but this study suggests several opportunities to improve low-income communities' service. Many bike share systems are designed around downtown amenities and destinations, which our study shows are likely to be less accessible to low-income communities. This finding triangulates in the present study through the higher walking distances for low-income communities and written descriptions of the need for more stations to their communities in open-ended responses. Pricing policies such as discounted passes for low-income system users may also be a necessary part of equitable growth in bike sharing after governments lift Coronavirus restrictions. These findings corroborate previous studies on bike sharing equity in general. However, the few existing studies on bike share equity do not report solutions are exhausted—more policy and technical innovations should be evaluated to improve equity.

4.4. Limitations and future research

The limited scope of case cities and small survey from San Antonio bike share users are generalizable to a limited set of cases. Additional research is needed across systems that complement characteristics found in San Antonio to deepen insights on improving bike share responses to the pandemic. Cities with stronger control of the outbreak may have differing impacts on bicycle ridership. With the primary period of analysis of bike ridership changes taking place during May of 2020, additional analysis of months in the next phase of the pandemic could provide insights to changes in bike share usage and overall mobility during the pandemic. Women's bicycling rates may be more responsive to infrastructure changes (Wang and Akar, 2019), warranting attention to how policies impact gender equity. Further, in-depth case studies are needed to deepen understanding of major transportation policy decisions' local and political actions, including funding for improving connections between modes, such as public transit and micromobility.

CRediT authorship contribution statement

Jeffrey Jobe: Writing - original draft, Formal analysis, Writing - review & editing. **Greg P. Griffin:** Conceptualization, Methodology, Formal analysis, Visualization, Resources, Writing - review & editing.

Acknowledgements

The authors appreciate the contributions of J.D. Simpson, Executive Director of San Antonio Bike Share, who co-developed the survey instrument, disseminated the survey, and provided data on response rates.

This work was supported by the United States National Science Foundation (NSF) under award number 2016717.

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