Bike Share's Impact on COVID-19 Transmission and Bike Share's Responses to COVID-19: A case study of Washington DC

Beigi, Pedram\textsuperscript{1,3}, Haque, Mohaiminul\textsuperscript{1}, Rajabi, Mohammad Sadra\textsuperscript{1}, Hamdar, Samer \textsuperscript{2}
\textsuperscript{1} PhD Student, Department of Civil and Environmental Engineering, The George Washington University, Washington DC, United States
\textsuperscript{2} Associate Professor, Department of Civil and Environmental Engineering, The George Washington University, Washington DC, United States
\textsuperscript{3} beigi@gwu.edu

\textbf{Abstract:} Due to the wide-ranging travel restrictions and lock downs applied to limit the diffusion of the SARS-CoV2 virus, the coronavirus disease of 2019 (COVID-19) pandemic has had an immediate and significant effect on human mobility at the global, national, and local levels. At the local level, bike-sharing played a significant role in urban transport during the pandemic since riders could travel outdoors with reduced infection risk. However, based on different data resources, this non-motorized mode of transportation was still negatively affected by the pandemic (i.e., relative reduction in ridership). This study has two objectives: 1) to investigate the impact of the COVID-19 pandemic on the numbers and duration of trips conducted through a bike-sharing system – the Capital Bikeshare in Washington, DC, USA; and 2) to explore whether land use and household income in the nation's capital influence the spatial variation of ridership during the pandemic. Towards realizing these objectives, this research looks at the relationship between bike sharing and COVID-19 transmission as a two-directional relationship rather than a one-directional causal relationship. Accordingly, this study models i) the impact of COVID-19 infection numbers and rates on the use of the Capital Bikeshare system and ii) the risk of COVID-19 transmission among individual bike-sharing users. In other words, we examine i) the cyclist's behavior as a function of the COVID-19 transmission evolution in an urban environment and ii) the possible relationship between the bike share usage and the COVID-19 transmission through adopting a probabilistic contagion model. The findings show the risk of using a bike-sharing system during the pandemic and whether bike sharing remains a healthier alternative mode of transportation in terms of infection risk.

\textbf{Keywords:} Bike Sharing, Contagion, Covid-19, Infection Rate, Transmission Risk
5. CONCLUSION

In this paper, the impact of Covid-19 on the D.C. bike-share system as well as the bike-share usage impact on disease transmission is explored. D.C.’s Capital Bikeshare program lost around 10,000 daily users at the beginning of the Pandemic in March of 2020. Later on, the ridership numbers increased, but the Capital Bikeshare services are still below their daily averages from earlier years by an estimated 9,000 trips per day. The data reveals continued growth in the average trip duration from 13 minutes to 19 minutes. This could mean that people prefer short trips on foot instead of cycling as before the pandemic. Moreover, the stations with the lowest ratio of ridership after to before the pandemic were focused around downtown D.C. The office employment density is a significant factor in bike ridership. While it is reasonable to assume that the upper class of the society use personal vehicles during the COVID-19 and that bicycle riding declines in these areas while the opposite is true in low-income communities, regression analysis shows that there is no significant relationship between wealth, population density and bicycle ridership before and after the pandemic. However, it has been shown that land use plays an essential role in bike-sharing ridership, which it reduced more significantly in commercial and office areas in downtown D.C.

With such usage, to analyze the impact of bike-sharing on the dynamics of the Covid-19 reported case, the transmission process is classified into two types: i) Human-to-human transmission and ii) Human-to-surface-to-human transmission. A probabilistic contagion model is used to represent the first form of transmission. Transmission from one person to another would be infrequent. It’s exceedingly improbable that two strangers at a station will come into close proximity at the same time. On the other hand, the second type is more likely to happen, and it will be anticipated using the average number of trips per bike throughout the study interval and the corresponding duration during which the virus remains stable on a given surface.

The numerical analysis indicated that one infected person could infect a maximum of 5 persons, and three infected persons can infect a maximum of 28 persons during a 3-day interval (ignoring the possible infections beyond the bikers' community). The peak value of the 7-day moving average of infected persons is 194.

The findings show that bike-sharing has a minor impact on the Covid-19 infection rate, and that the government and decision-makers should consider it as a safe mode of transportation that should be maintained because it can encourage people to use it instead of the subway or bus. In comparison to other modes of public transit, bike-share remains a relatively healthier option.

The limitation is that there does not appear to be any real-world assessment of how bike-share users interact at stations. Also, for future studies, given the more specific data sets (i.e., the trip history dataset with a user identification number, socio-economic characteristics in a given location, datasets provided at this stage with routing information), the interaction of users at a station can be modeled much more realistic. Moreover, with the travel paths data complemented by pedestrian density information along some routes, we can predict the total impact of bike-share services at the origins, destinations, and in between the origin-destination (O.D.) pairs.

References

Ahangari, Samira, Celeste Chavis, and Mansoureh Jeihani. 2020. "Public transit ridership analysis during the COVID-19 pandemic." Medrxiv.

Aloi, Alfredo, Borja Alonso, Juan Benavente, Rubén Cordera, Eneko Echániz, Felipe González, Claudio Ladisa, Raquel Lezama-Romanelli, Álvaro López-Parra, and Vittorio Mazzei. 2020. "Effects of the COVID-19 lockdown on urban mobility: Empirical evidence from the city of Santander (Spain)." Sustainability 12.

Anzai, Asami, Tetsuro Kobayashi, Natalie M Linton, Ryo Kinoshita, Katsuma Hayashi, Ayako Suzuki, Yichi Yang, Sung-mok Jung, Takeshi Miyama, and Andrei R Akhmetzhanov. 2020. "Assessing the impact of reduced travel on exportation dynamics of novel coronavirus infection (COVID-19)." Journal of clinical medicine 9: 601.
Batty, Michael. 2020. "The Coronavirus crisis: What will the post-pandemic city look like?" Environment and Planning B: Urban Analytics and City Science 47: 547-552.

Beigi, Pedram, Michel Khoueiry, Mohammad Sadra Rajabi, and Samer Hamdar. 2022. "Station Reallocation and Rebalancing Strategy for Bike-Sharing Systems: A Case Study of Washington DC." arXiv.2204.07875.

Bucsky, Peter. 2020. "Modal share changes due to COVID-19: The case of Budapest." Transportation Research Interdisciplinary Perspectives 8.

Budd, Lucy, and Stephen Ison. 2020. "Responsible Transport: A post-COVID agenda for transport policy and practice." Transportation Research Interdisciplinary Perspectives 6.

Campisi, Tiziana, Giovanna Acampa, Giorgia Marino, and Giovanni Tesoriere. 2020. "Cycling master plans in Italy: The I-BIM feasibility tool for cost and safety assessments." Sustainability 12.

CapitalBikeshare. 2022. Capital Bikeshare System Data. https://capitalbikeshare.com/.

CDC. n.d. Ending Isolation and Precautions for People with COVID-19: Interim Guidance. Accessed 2022. https://www.cdc.gov/coronavirus/2019-ncov/hcp/duration-isolation.html.

Chai, Xinwei, Xian Guo, Jihua Xiao, and Jie Jiang. 2020. "Analysis of Spatial-temporal Behavior Pattern of the Share Bike Usage during COVID-19 Pandemic in Beijing." arXiv preprint arXiv:2004.12340.

Chartier, Y, and CL Pessoa-Silva. 2009. "Natural ventilation for infection control in health-care settings." World Health Organization.

Chinazzi, Matteo, Jessica T Davis, Marco Ajelli, Corrado Gioannini, Maria Litvinova, Stefano Merler, Ana Pastore y Piombini, Kunpeng Mu, Luca Rossi, and Kaiyuan Sun. 2020. "The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak." Science 368: 395-400.

de Haas, Mathijs, Roel Faber, and Marije Hamersma. 2020. "How COVID-19 and the Dutch 'intelligent lockdown' change activities, work and travel behaviour: Evidence from longitudinal data in the Netherlands." Transportation Research Interdisciplinary Perspectives 6.

De Vos, Jonas. 2020. "The effect of COVID-19 and subsequent social distancing on travel behavior." Transportation Research Interdisciplinary Perspectives 5.

Dindar, Amin, Shiva Ourang, and Erfan Gholami Ghadikola. 2022. "Development of a Communication-Assisted Adaptive Overcurrent Protection Scheme in Smart Distribution Networks in Presence of Wind and Solar Generation." SSRN.

Doucette, Mitchell L, Andrew Tucker, Marisa E Auguste, Amy Watkins, Christa Green, Flavia E Pereira, Kevin T Borrup, David Shapiro, and Garry Lapidus. 2021. "Initial impact of COVID-19’s stay-at-home order on motor vehicle traffic and crash patterns in Connecticut: an interrupted time series analysis." Injury prevention 3-9.

Erfani, Abdolmajid, Mehdi Tavakolan, Ali Hassandokht Mashhadi, and Pouria Mohammadi. 2021. "Heterogeneous or homogeneous? A modified decision-making approach in renewable energy investment projects." AIMS Energy 9: 558-580.

Field, Andy. 2013. Discovering statistics using IBM SPSS statistics. sage.

Gajendran, Natarajan. 2020. "Impact of novel Coronavirus (COVID-19) pandemic on travel pattern: A case study of India." Indian Jour-nal of Science and Technology 13: 2491-2501.

Huang, Jizhou, Haifeng Wang, Miao Fan, An Zhuo, Yibo Sun, and Ying Li. 2020. "Understanding the impact of the COVID-19 pandemic on transportation-related behaviors with human mobility data." Proceedings of the 26th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining.

Javadinasr, Mohammadjavad, Tassio B Magassy, Ehsan Rahimi, Amir Davatgari, Deborah Salon, Matthew Wigginton Bhagat-Conway, Rishabh Singh Chauhan, Ram M Pendyala, Sybil Derrible, and Sara Khoeini. 2021. "The Enduring Effects of COVID-19 on Travel Behavior in the United States: A Panel Study on Observed and Expected Changes in Telecommuting, Mode Choice, Online Shopping and Air Travel." arXiv preprint arXiv:2109.07988.

Krishnakumari, Panchamy. 2020. "Virus spreading in public transport networks: the alarming consequences of the business as usual scenario."

Lauer, Stephen A, Kyra H Grantz, Qifang Bi, Forrest K Jones, Qulu Zheng, Hannah R Meredith, Andrew S Azman, Nicholas G Reich, and Justin Lessler. 2020. "The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: estimation and application." Annals of internal medicine 172: 577-582.
Linka, Kevin, Mathias Peirlinck, Francisco Sahli Costabal, and Ellen Kuhl. 2020. "Outbreak dynamics of COVID-19 in Europe and the effect of travel restrictions." Computer methods in biomechanics and biomedical engineering 23: 710-717.

Megahed, Naglaa A, and Ehab M Ghoneim. 2020. "Antivirus-built environment: Lessons learned from Covid-19 pandemic." Sustainable cities and society 61.

Mogaji, Emmanuel. 2020. "Impact of COVID-19 on transportation in Lagos, Nigeria." Transportation Research Interdisciplinary Perspectives 6.

Musselwhite, Charles, Erel Avineri, and Yusak Susilo. 2020. "Editorial JTH 16--The Coronavirus Disease COVID-19 and implications for transport and health." Journal of transport & health 16.

National Institutes of Health. 2020. "New coronavirus stable for hours on surfaces." URL: https://www.nih.gov/news-events/news-releases/new-coronavirus-stable-hours-surfaces. Access Date: March 23.

Oztig, Lacin Idil, and Oykum Esra Askin. 2020. "Human mobility and coronavirus disease 2019 (COVID-19): a negative binomial regression analysis." Public health 185: 364-367.

Razavi, Moein, Hamed Alikhani, Vahid Janfaza, Benyamin Sadeghi, and Ehsan Alikhani. 2022. "An automatic system to monitor the physical distance and face mask wearing of construction workers in covid-19 pandemic." SN computer science 1: 1-8.

Saberi, Meead, Mehrnaz Ghamami, Yi Gu, Mohammad Hossein Sam Shojaei, and Elliot Fishman. 2018. "Understanding the impacts of a public transit disruption on bicycle sharing mobility patterns: A case of Tube strike in London." Journal of Transport Geography 66: 154-166.

Shakerian, Mohammad, Mohammad Sadra Rajabi, Mohammad Tajik, and Hosein Taghaddos. 2022. "Hybrid Simulation-based Resource Planning and Constructability Analysis of RCC Pavement Projects." arXiv preprint arXiv:2204.05659.

Shang, Wen-Long, Jinyu Chen, Huibo Bi, Yi Sui, Yanyan Chen, and Haitao Yu. 2021. "Impacts of COVID-19 pandemic on user behaviors and environmental benefits of bike sharing: A big-data analysis." Applied Energy 285.

Stadnytskyi, Valentyn, Christina E Bax, Adriaan Bax, and Philip Anfinrud. 2020. "The airborne lifetime of small speech droplets and their potential importance in SARS-CoV-2 transmission." Proceedings of the National Academy of Sciences 117: 11875-11877.

Sun, Xiaojian, Sebastian Wandelt, and Anming Zhang. 2020. "How did COVID-19 impact air transportation? A first peek through the lens of complex networks." Journal of Air Transport Management 89.

Tian, Xuelin, Chunjiang An, Zhikun Chen, and Zhiqiang Tian. 2021. "Assessing the impact of COVID-19 pandemic on urban transportation and air quality in Canada." Science of the Total Environment 765.

Van Doremalen, Neeltje, Trenton Bushmaker, Dylan H Morris, Myndi G Holbrook, Amandine Gamble, Brandi N Williamson, Azali Tamin, Jennifer L Harcourt, Natalie J Thornburg, and Susan I Gerber. 2020. "Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1." New England journal of medicine 382: 1564-1567.

WHO, World Health Organization. 2022. WHO Coronavirus (COVID-19) Dashboard. Accessed 2022. https://covid19.who.int/.

Zargari, Faraz, Nima Aminpour, Mohammad Amir Ahmadian, Amir Samimi, and Saeid Sayedi. 2022. "Impact of mobility on COVID-19 spread--A time series analysis." Transportation Research Interdisciplinary Perspectives 13.