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Impact of a public transit strike on public bicycle share use: An interrupted time series natural experiment study

Daniel Fuller[a,c,*], Hui Luan[b], Richard Buote[c], Amy H. Auchincloss[d]

[a] *School of Human Kinetics and Recreation, Memorial University of Newfoundland, Canada*
[b] *Department of Geography, University of Oregon, USA*
[c] *Division of Community Health and Humanities, Memorial University of Newfoundland, Canada*
[d] *Dornsife School of Public Health, Drexel University, USA*

ABSTRACT

Introduction: Promoting active transportation is an important public health objective. Limited research has examined the potential of interventions that highly constrain transportation and their potential impact on cycling. From November 1-7th, 2016, Philadelphia's transit workers went on strike, stopping all transit services in the city.
Methods: We used the strike event as a natural experiment to examine the impact of public transit strikes on use of Philadelphia's bicycle share program. We estimated the impact of the strike using two separate approaches, interrupted time series and Bayesian structural time series models. We estimated the impact of the intervention overall and stratified by membership type (members and non-members). Models controlled for the weather in Philadelphia (daily temperature and precipitation), and the rate of bicycle share use per 100,000 people in Washington, Boston, and Chicago.
Results: We estimate the strike caused an increase of between 86 and 92 trips per 100,000 population (57% increase in use) on average in Philadelphia during the strike period. After the strike ridership quickly returned to baseline, decreasing by 80 trips per 100,000 population after the strike. Similarly, members and non-member ridership increased by 41 and 49 trips per 100,000 population on average during the strike period and quickly returned to baseline, respectively.
Conclusions: Our results suggest that interventions that highly constrain transit can increase active transportation but the behavior may not be sustained after transit becomes available again.

1. Introduction

Philadelphia's Southeastern Pennsylvania Transportation Authority (SEPTA) is the public transit provider for the city of Philadelphia, U.S.A. Each day, about 800,000 people use the city's transit system (Simon, 2016). From November 1-7th, 2016, SEPTA's transit workers went on strike, thus stopping city bus, subway and trolley services. We used the strike event as a natural experiment to examine the impact of public transit strikes on use of Philadelphia's bicycle share program.

Active transportation (utilitarian walking and cycling) has become a growing area of research for public and population health researchers. Those who take part in more active travel have lower rates of chronic disease, and reductions in all-cause mortality (Mueller et al., 2015; Panter et al., 2018; Saunders et al., 2013). Interventions shown to promote active transportation include separated cycling infrastructure and promotional campaigns (Scheepers et al., 2014). Public bicycle share programs are another intervention with the potential to increase active transportation. Public bicycle share programs have been shown to increase cycling and cycling related physical activity in Montreal (Fuller et al., 2013) but not in Vancouver (Hosford et al., 2018). It is clear that more

* Corresponding author. School of Human Kinetics and Recreation Physical Education Building, Memorial University, St. John's, NL, A1C 5S7, Canada.

E-mail address: dfuller@mun.ca (D. Fuller).

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research is needed to better understand the potential health benefits of bicycle share programs (Bauman et al., 2017).

Limited research has examined the potential of interventions that highly constrain other modes of transportation and their potential impact on cycling (Pucher et al., 2010). Transit strikes offer insight into the potential of public bicycle share programs when transportation is highly constrained (Jäppinen et al., 2013). These natural experiments also provide the ability to improve our causal claims about the potential impact of bicycle program use, particularly when combined with publicly available bicycle share data (Médard de Chardon, 2016). Our previous work examined the impact of two Tube strikes in London, England on the use of public bicycle programs (Fuller et al., 2012). We showed that bike share trips increased by 3864 following the first strike and 11,293 per day following the second strike.

The purpose of our study was to examine the impact of a transit strike on public bicycle share trips in Philadelphia, Pennsylvania. We further stratified our analysis to examine whether changes differed by members or non-members of the program.

2. Materials and methods

Publicly available data from January to December 2016 were retrieved from the websites of four major bike share companies in US cities. The cities were the transit strike city, Philadelphia, and three control cities, Chicago, IL, Washington D.C., and Boston, MA. The control cities were chosen due to similarity with the transit strike city on population size, city infrastructure for public transit and biking, region (northeast-central USA), and climate.

These data contained all trips taken over a given time period, the duration of a trip, the station where the trip began and ended, and the membership type (member and non-member). Membership type was used to proxy short-vs. longer-term commitment to using bicycle share. Members were 30-day or yearly members. Non-members were day users (walk-up users). In Philadelphia, at the time of this study, a 30-day membership could be purchased for $15/month (or $5/month with food-stamp card) and allowed unlimited 60-min rides, while the pay-per-trip day use option cost $4 per half hour. A third membership type called Indego-Flex ($10 yearly fee allowing for a pay-per-trip rate of $4 per hour) existed at the time of the study, but composed only 1% of the data and was not included in the analysis. Duration of membership was not available in the dataset (newer and older members were indistinguishable).

This project did not require ethical approval as data used were publicly available and anonymized.

2.1. Intervention

A categorical variable was created (1, 2, and 3) indicating pre-strike (Jan 1, 2016–Oct 31, 2016), strike (Nov 1, 2016–Nov 7, 2016), and post-strike (Nov 8, 2016–Dec 31, 2016) dates, respectively.

2.2. Measures

The primary outcome of interest was the number of trips on bike share per 100,000 population per day in Philadelphia.

Covariates included the average daily temperature and precipitation data for Philadelphia in 2016 (National Climatic Data Center, 2018) and the number of trips per 100,000 population per day for the control cities Chicago, IL, Washington D.C., and Boston, MA.

2.3. Analysis

We used two methods to estimate the potential impact of the public transit strike. In both analyses we aimed to estimate the causal impact of the intervention, which assumes that we can predict the hypothetical counterfactuals. First, how bike use would have evolved if there was no public transit strike. Second, whether the impact of the public transit strike on bike share use would have continued after the strike.

We used two analysis methods. First, we used an interrupted time series approach, which is a relatively common method for evaluating the impact of natural experiments (Lopez Bernal et al., 2017). The aim is to estimate immediate change and trend in change after the intervention. The parameters of interest are the strike intercept and the post-strike slope that assess the immediate and trend in change, respectively. Second, we used a recently developed Bayesian structural time series model implemented using the CausalImpact R package (Brodersen et al., 2015). This model estimates a counterfactual using a Bayesian approach and accounts for autocorrelation inherent in time series data. Results are presented for the pooled data and stratified by membership type. We provide all of the data and analysis R code on GitHub (https://github.com/walkabilly/Phillybikeshare).

3. Results

In 2006, Chicago had the highest average daily trips, 4737 (SD = 4230) followed by Washington (4605, SD = 3333.6), Boston (1688, SD = 1708), and finally Philadelphia (902, SD = 804), which was the newest program. Fig. 1 shows the total number of trips per day for each city between September 1, 2016 and December 31, 2016. The average temperature in Philadelphia was 58.7 °F (SD = 17.8 °F), while the average precipitation was 0.13 inches (SD = 0.43 inches). Table 1 shows the results from the interrupted time series and Bayesian structural time series analyses.

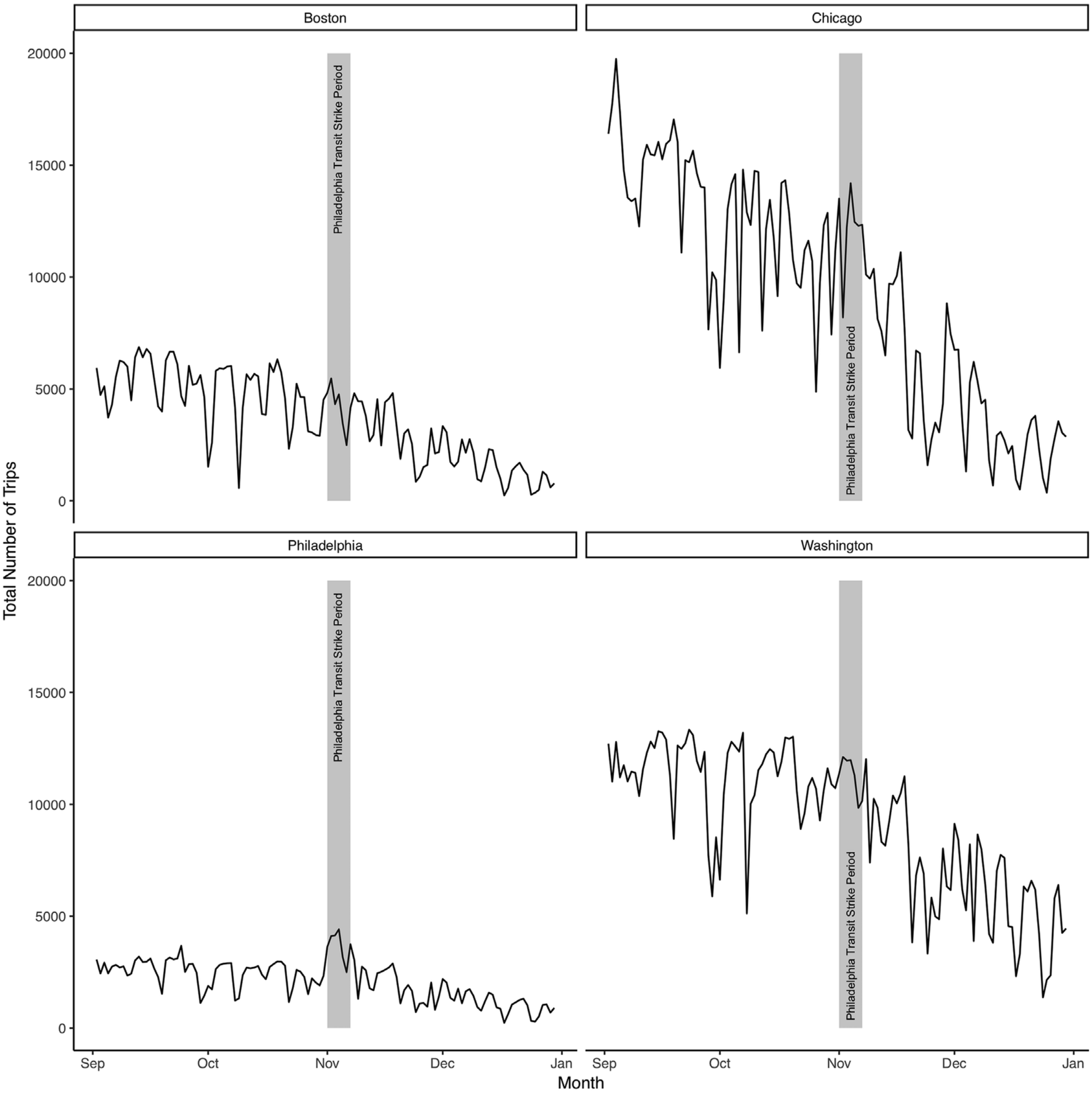

Fig. 1. Total number of bicycle share trips between September 1, 2016 and December 31, 2016 in Philadelphia, Boston, Chicago, and Washington.

Table 1
Interrupted time series and Bayesian structural time series analysis estimating number of trips per 100,000 bike share users in Philadelphia.

Parameters	All Users Coefficient (95% CI or 95% CrI)	Members Coefficient (95% CI or 95% CrI)	Non-Members Coefficient (95% CI or 95% CrI)
Interrupted Time Series			
Strike Intercept	92.5 (CI: 67.9 to117.8)	41.4 (CI: 20.9 to 61.8)	49.3 (CI: 39.0 to 59.5)
Post-strike Slope	−80.2 (CI: −106.0 to −54.4)	−34.1 (CI: −55.2 to −13.0)	−45.3 (CI: −55.8 to −43.8)
Bayesian Structural Time Series			
Strike Intercept	86 (CrI: 73 to 99)	49 (CrI: 38 to 60)	34 (CrI: 29 to 39)
Post-strike Slope	−62 (CrI: −265 to 161)	−42 (CrI: −183 to 91)	−38 (CrI: −71 to −3.1)

Notes. 1. All models control for daily temperature in Philadelphia, daily precipitation in Philadelphia, and the bikeshare use per 100,000 people in Washington, Boston, and Chicago. 2. Pre-strike period = Jan 1, 2016–Oct 31, 2016, strike period = Nov 1, 2016–Nov 7, 2016, post-strike period = Nov 8, 2016–Dec 31, 2016. CI = Confidence Interval. CrI = Credible Interval.

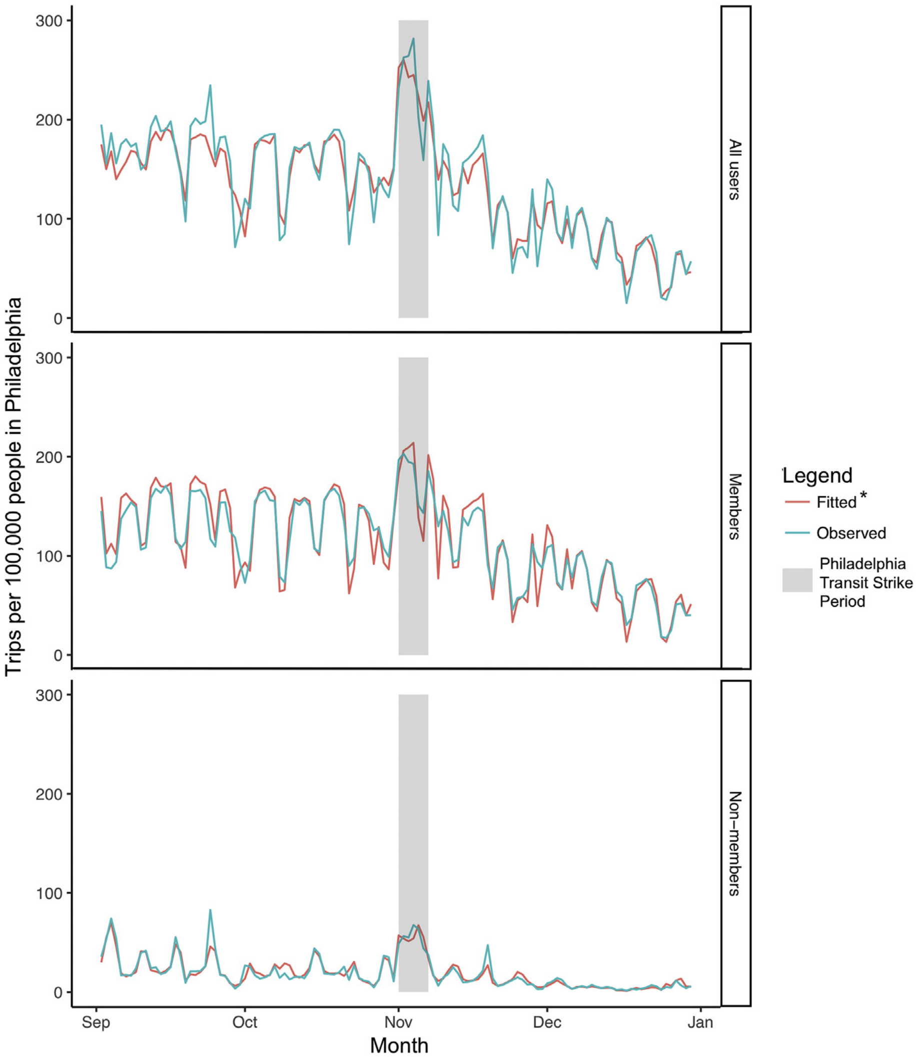

Fig. 2. Observed and fitted bicycle share trips per 100,000 population between September 1, 2016 and December 31, 2016 in Philadelphia, Boston, Chicago, and Washington. * Model fit using interrupted time series analysis including strike periods, average daily temperature and precipitation data for Philadelphia, and the number of trips per 100,000 population per day for the control cities Chicago, IL, Washington D.C., and Boston, MA.

3.1. Interrupted time series analysis

Interrupted time series analysis was performed to compare differences in public bike share use between pre-strike and strike and between strike and post-strike periods, using Philadelphia weather and each city as controls.

Results indicate that the public transit strike contributed to increased bike share use for the entire population, members, and non-members in Philadelphia. The strike intercept shows that on average per 100,000 population, Philadelphia bikeshare trips increased by 92 (95% CI: 67.89 to 117.82) overall, and among members and non-members the usage increased by 41 (95% CI: 20.94 to 61.84) and 49 (95% CI: 39.03 to 59.50) trips, respectively. However, after the strike was over, trips declined by a similar amount. The post-strike slope shows that bikeshare trips per 100,000 decreased by 80 trips (95% CI: −106.00 to −54.41) overall, 34 member trips (95% CI: −55.21 to −13.03), and 45 non-member trips (95% CI: −55.83 to −43.77).

Fig. 2 shows the observed data versus fitted data for Philadelphia, members, and non-members data using interrupted time series analysis, respectively.

3.2. Bayesian structural time series analysis

Results from the Bayesian structural time series models were similar to the findings from the interrupted time series analysis. The strike intercept showed that per 100,000 population, there was an increase of 86 trips per 100,000 overall (95% CrI: 73 to 99) and an increase of 49 (95% CrI: 38 to 60) and 34 (95% CrI: 29 to 39) trips per 100,000 by members and non-members, respectively.

However, after the strike was over, bikeshare use returned to normal indicating no lasting effect of the strike on bikeshare use. The post-strike slope shows that over and above the seasonal decline, there may be a decrease in bikeshare trips; however, with the exception of non-members, there were very wide credible intervals which indicated high uncertainty. Overall trips declined 62 per 100,000 (95% CrI: −265 to 161). For members and non-members trips per 100,000 decrease by 42 (95% CrI: −183 to 91) and 38 (95% CrI: −71 to −3.1) respectively.

4. Discussion

The objective of this study was to estimate the impact of a public transit strike on public bicycle share program use. The public transit strike caused a short-term increase in public bicycle share program use in Philadelphia. However, the effect was short lived and quickly returned to the weekly and seasonal trend once the strike was over. This study extends our previous work examining the impact of transit strikes on public bike share use (Fuller et al., 2012). It provides further evidence that in the face of a major transportation constraint, large scale adoption of cycling as a transportation mode can occur. Overall the adoption of bicycle share appeared short-lived. Despite an eventual decrease back to baseline, non-members may have sustained their bicycle share use for slightly longer than members. This suggest the potential for new adoption of bicycle share program use among less frequent users as a result of the public transit strike. Based on the previous literature, this may suggest increases in physical activity are plausible but short lived (Fuller et al., 2013; Hosford et al., 2018).

It is unknown why ridership was not sustained after the strike was over. One plausible explanations is traffic congestion (Fox 29 News, 2016). Extreme rush-hour traffic congestion is common during transit strikes (Lo and Hall, 2006) meaning that users were cycling in high traffic stress conditions and the bicycle share program operator had difficulty rebalancing bicycles. This may have negatively impacted new user satisfaction.

From a practical perspective, there are other instances were mobility is constrained. For example, lines or routes being shut down due to planned maintenance or major road construction. Our analysis approach could be used to examine the potential effects of other types of mobility constraints on bike share use. Agencies could promote bike share use during events that constrain mobility.

Generalizability of this study's results is limited by the fact that the strike occurred as weather was becoming cooler (end of fall/beginning of winter) thus the post-strike season was brief. The long-lasting effect of the strike may have been stronger if the strike occurred in spring or summer; new users may have been willing to continue using bike share after the strike was over which could have reinforced cycling. An additional study limitation is that we are unable to determine whether there was an increase in unique users of the bike share service, although we were able to separate users by membership status. Data on physical activity levels of users were not available, so it is not possible to determine whether the increase in bike share use we observed caused a change in physical activity, as users may already be achieving recommended activity levels or may replace their leisure time activity with transportation activity (Brondeel et al., 2017).

5. Conclusion

A transit strike in Philadelphia caused a large increase in bikeshare use for bikeshare members and non-members during the strike period. This suggests that both people who cycle regularly and people who do not cycle regularly can adopt cycling in the face of major transportation constraint. After the strike, however, bike share use reverted to expected levels, which suggests that more cycling incentives are needed to encourage people who adopt cycling during a transit strike to continue.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jth.2019.03.018.

Declaration of interest

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