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## Preventive Medicine

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## Brief Original Report

## The impact of public transportation strikes on use of a bicycle share program in London: Interrupted time series design

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## ARTICLE INFO

## Article history:

Received 8 June 2011

Received in revised form 6 September 2011

Accepted 11 September 2011

Available online 14 October 2011

## Keywords:

Interventions studies

Transportation

Physical activity

## ABSTRACT

**Objective.** To investigate the immediate and sustained effects of two London Underground strikes on use of a public bicycle share program.

**Methods.** An interrupted time series design was used to examine the impact of two 24 hour strikes on the total number of trips per day and mean trip duration per day on the London public bicycle share program. The strikes occurred on September 6th and October 4th 2010 and limited service on the London Underground.

**Results.** The mean total number of trips per day over the whole study period was 14,699 (SD = 5390) while the mean trip duration was 18.5 minutes (SD = 3.7). Significant increases in daily trip count were observed following strike 1 (3864; 95% CI 125 to 7604) and strike 2 (11,293; 95% CI 5169 to 17,416).

**Conclusions.** Events that greatly constrain the primary motorised mode of transportation for a population may have unintended short-term effects on travel behaviour. These findings suggest that limiting transportation options may have the potential to increase population levels of physical activity by promoting the use of cycling.

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Interventions to increase physical activity in the population have been described as the 'best buy' for improving public health (Morris, 1994). Cycling in particular has been associated with improved health outcomes in both children and adults (Cooper et al., 2008; von Huth Smith et al., 2007; Wagner et al., 2001). A recent systematic review has found some evidence for the potential of interventions to promote cycling, but robust evaluative studies are rare (Yang et al., 2010).

Researchers increasingly aspire to use 'natural experiments' to examine the impacts of transportation-related interventions, (Ogilvie et al., 2010, 2011; Petticrew et al., 2005) for example whether congestion charging increases physical activity and reduces air pollution (Beavers and Carslaw, 2005; Bergman et al., 2010). However, there are few published evaluations of interventions specifically intended to promote cycling for transportation (Cavill and Rutter, 2010; Yang et al., 2010).

With a population of 7.6 million, and an average of 24 million trips per day in 2007, 40% of all trips in London are made by public transportation, 38% by private motor vehicle, 21% on foot and 1.8% by

bicycle (Transport for London, 2009). London's transportation strategy aims to reduce private motor vehicle travel. As part of this strategy, London implemented a public bicycle share program (colloquially known as the 'Boris bikes'). Such programs provide bicycles at docking stations around a city for a minimal fee (Shaheen et al., 2010). They have shown to be well adopted but considering that they have been implemented in over 100 cities worldwide, studies of their effects are uncommon (Fuller et al., 2011).

In 2010, train drivers on the London Underground (the 'Tube') voted in support of two 24 hour strikes. These strikes constrained use of the mode of transportation most frequently used by London commuters while leaving the bicycle share program unaffected. In this paper, we use this 'natural experiment' to evaluate whether constraining the use of the Tube system was associated with an increase in use of the public bicycle share program.

## Method

An interrupted time series design was used (further reading in Shadish et al., 2002, pp. 171–206). The time series comprised 95 days between July 30th (the opening date for the bicycle share program) and November 1st 2010. Data were limited to this period because a third Tube strike occurred on November 2nd and data were unavailable to model the effect of this strike.

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**Table 1**

Regression parameters from segmented regression model predicting total number of trips per day and average trip duration on the London 'Boris bikes' between 30 July and 1 November 2010.

	Total trips per day			Average trip duration		
	Coefficient	P-value	95% CI	Coefficient	P-value	95% CI
Pre-strike intercept	5889.7	0.01	3424.2; 8355.2	25.1	0.01	23.3; 26.9
Pre-strike slope	254.7	0.01	144.5; 364.9	-0.2	0.01	-0.3; -0.1
Strike 1—intercept change	3864.5	0.04	124.7; 7604.2	1.2	0.40	-1.6; 3.9
Strike 1—slope change	-465.1	0.01	-671.4; -258.9	0.1	0.18	-0.1; 0.3
Strike 2—intercept change	11292.7	0.01	5169.2; 17416.2	2.9	0.19	-1.5; 7.5
Strike 2—slope change	-22.2	0.86	-262.5; 218.0	0.0	0.68	-0.1; 0.2

Anonymous data for all trips made using 'Boris bikes' are freely available online from Transport for London (Transport for London, 2010). No ethical approval was required. Individual trip data for each bicycle were aggregated by day. Segment points in the regression were defined by the 24 hour Tube strikes occurring on September 6th and October 4th. Data and Stata syntax used for all analyses are available in the online supplement.

*Measures*

The outcome variables were the total number of trips per day and (as a proxy for the dose of physical activity associated with the trips) the mean trip duration. Variables were created to estimate and compare the intercepts and slopes of the regression lines for each segment. A complete description of the variables is provided in the supplement.

*Analysis*

Separate segmented regression models were estimated for the relationship between the strikes and the number of trips per day and the trip duration. Durbin-Watson statistics were computed to test potential autocorrelation within the data.

**Results**

The mean total number of trips per day over the whole study period was 14,699 (SD= 5390) while the mean trip duration was 18.5 minutes (SD=3.7). Durbin-Watson statistics for both trip count (Durbin-Watson(6, 95)=1.43) and trip duration (Durbin-Watson(6, 95)=1.69) models showed limited autocorrelation and no corrections were made. Results from the segmented regression models predicting daily trip count and mean trip duration are given in Table 1 and Fig. 1.

For total trips per day, the pre-strike intercept was 5890 (95% CI 3424 to 8355). The pre-strike slope shows that the number of trips increased by an estimated 255 (95% CI 144 to 365) per day over the pre-

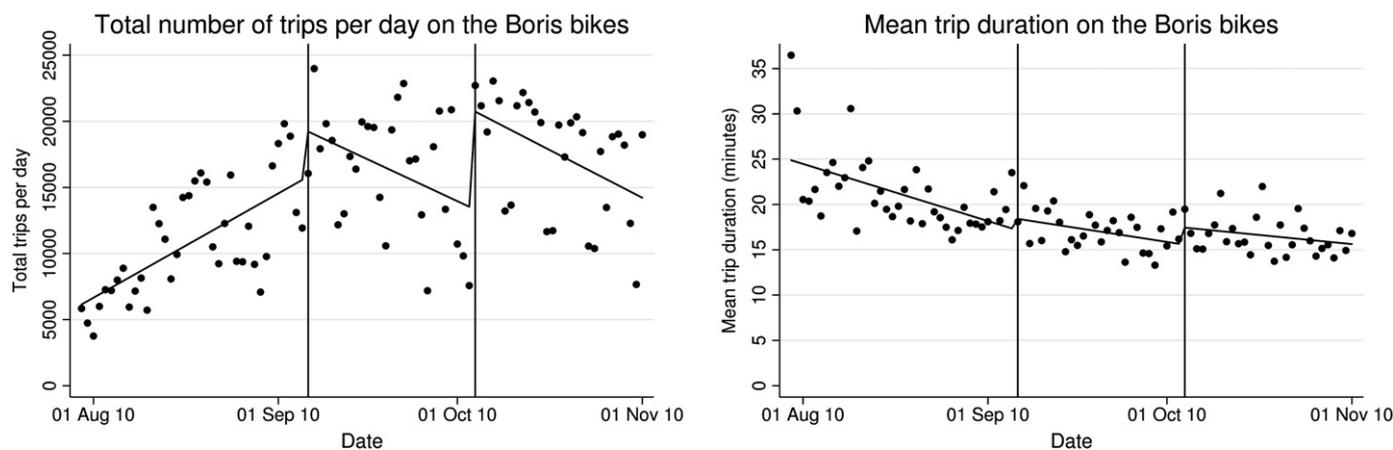
strike period. The difference between the pre-strike and strike 1 intercepts is shown by a line representing strike 1 on 6 September. Compared to the pre-strike period, a significant increase in daily trip count occurred after strike 1 (3864; 95% CI 125 to 7604). After this initial increase in bicycle use, the significantly declining slope compared to the pre-strike period indicates a return to use similar to the period before strike 1 (-465; 95% CI -671 to -259). Similar results were observed for strike 2. A significant increase in mean daily trip count occurred after strike 2 (11,293; 95% CI 5169 to 17,416). Following this, a decreasing slope not significantly different from that observed after strike 1 suggests a return to use similar to the period before strike 1 (-22; 95% CI -262 to 218).

A significant decrease in mean trip duration was observed during the pre-strike period (-0.20 minutes/day; 95% CI -0.28 to -0.12). The Tube strikes did not have a significant effect on mean trip duration.

**Discussion**

The results suggest that an event which constrained the primary motorised transportation mode of the population was associated with an increase in use of the bicycle share program. Examining Table 2 suggests that because the strikes occurred on Mondays, people used the bicycles as a result of the strikes, continued to do so for the week and reverted to their usual mode of transportation the following week.

Trip duration decreased during the pre-strike period. This may reflect an adoption phase after the program commenced as users experimented with the system and learned to navigate better between docking stations. Although trip duration decreased, the mean trip duration (18.5 minutes) suggests that on average, users accrued one health-enhancing bout of physical activity during each trip sufficient to contribute half of their recommended daily total (UK Department of Health, 2010). The intervention strategy of limiting public transportation to increase bicycle share use may not be



**Fig. 1.** Segmented regression results for total number of trips per day and mean trip duration on the 'Boris bikes' from July 30th 2010 to November 1st 2010 in London. Vertical black lines = Tube strikes.

**Table 2**  
Total trips per day on the London Boris public bicycle share program 4 days before and after each Tube strike between 30 July and 1 November 2010.

	– 4 days	– 3 days	– 2 days	– 1 days	Strike	+ 1 days	+ 2 days	+ 3 days	+ 4 days
Strike 1	19,818	18,873	13,101	11,924	16,058	23,988	17,923	19,818	18,552
Strike 2	20,876	10,714	9818	7570	22,712	21,172	19,193	23,044	21,556

feasible. This study is a 'proof of concept' that interventions constraining the use of motorised transportation have the potential to increase utility cycling.

Strengths of the study include the time series design and use of a natural experiment. Four important limitations of the analysis should be considered. It was not possible to identify how many unique or new users adopted the program as a result of the strikes or whether the users were already sufficiently physically active. The analysis took no account of the physical activity content of journeys on public transportation, but several studies have shown that public transportation users tend to be more active than those who travel by car (Lachapelle et al., 2011). The pre-strike period of analysis represents the early implementation phase of the program. The fact that the pre-strike slope was positive when the first strike occurred may have heightened the apparent effect of the strikes; conversely, it is also possible that the strikes would have had a larger effect if they had occurred later, when there was greater public awareness and acceptance of the program. Finally, daily or seasonal weather fluctuations could have influenced the effect of the strikes, which took place in autumn; whether similar increases would have been seen at other times of year is unknown.

## Conclusion

The findings reported here suggest that events that greatly constrain the primary motorised mode of transportation for a population may lead to short-term increases in cycling. Though the effects of the strikes were unintended, these findings may be transferable as they suggest that the development of interventions which limit transportation options may have the potential to increase population levels of physical activity by promoting the use of utility cycling.

## Competing interest declaration

All authors have completed the Unified Competing Interest form at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) (available on request from the corresponding author) and declare no support from any organisation for the submitted work other than those listed in the Acknowledgments, no financial relationships with any organisations that might have an interest in the submitted work in the previous 3 years, and no other relationships or activities that could appear to have influenced the submitted work.

## Acknowledgments

The authors would thank Carol Desousa for assistance with data analysis. DF is supported by the Social Science and Humanities Research Council of Canada (SSHRC) and was co-hosted by the Healthy Environments Research Programme, School of Geography, Queen Mary University of London and the Centre for Diet and Activity

Research (CEDAR), a UKCRC Public Health Research Centre of Excellence. Funding for the latter from the British Heart Foundation, Economic and Social Research Council, Medical Research Council, National Institute for Health Research and the Wellcome Trust, under the auspices of the UK Clinical Research Collaboration, is gratefully acknowledged (<http://www.esrc.ac.uk/publichealthresearchcentres>). SC is funded by a Senior Fellowship supported by the National Institute of Health Research and DO is also supported by CEDAR. The views expressed in this publication are those of the authors and not necessarily those of the NHS, the National Institute of Health Research or the Department of Health.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at [doi:10.1016/j.ypmed.2011.09.021](https://doi.org/10.1016/j.ypmed.2011.09.021).

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