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

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 14699 (SD=5390) while the mean trip duration was 18.5 minutes (SD=3.7). Significant increases in daily trip rate were observed following strike 1 (3864: 95% CI 125 to 7604) and strike 2 (11293: 95% CI 5169 to 17416).

Conclusions—Brief interventions that greatly constrain the primary motorised mode of transportation for a population may have short-term effects on travel behaviour. Repeated brief interventions at frequent intervals could contribute to increasing population levels of physical activity by promoting the use of active modes of transportation.

Interventions to increase physical activity in the population have been described as the ‘best buy’ for improving public health, but have tended to focus on individual behaviour change programs and encouragement to participate in formal sports and leisure activities.[1-3] In recent years the promotion of walking and cycling for transportation (active travel) as an alternative to motorised transportation has been proposed as a way of increasing population physical activity. Cycling in particular has the potential to increase heart rate sufficiently to deliver cardiorespiratory benefits and has been associated with improved health outcomes in both children and adults.[4-6] A recent systematic review has found some evidence for the potential of interventions to promote cycling, but robust evaluative studies are rare.[7]

A key challenge in the field is to demonstrate whether changes in transportation systems can bring about a shift from motorised to active travel. Researchers increasingly aspire to use ‘natural experiments’ to examine the impacts of transportation-related interventions,[8-10] for example whether congestion charging increases physical activity and reduces air pollution[11, 12] or whether implementing new public transportation systems increases physical activity.[13] However, there are relatively few published evaluations of interventions specifically intended to promote cycling for transportation.[14]

London, with a population of 7.6 million, has one of the largest and most complex transportation systems in the world, with an average of 24 million trips per day in 2007.[15] 40% of all trips in London are made by public transportation (which includes a comprehensive underground train system, overground trains, buses and river taxis), 38% by private motor vehicle, 21% on foot and 1.8% by bicycle.[15] London’s transportation strategy aims to reduce private motor vehicle travel and increase the use of public transportation,

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cycling and walking.[16] As part of this strategy, London implemented a public bicycle share program — colloquially known as 'Boris bikes' after the Mayor of London, Boris Johnson — which began operating on July 30th 2010. Such programs increase population access to bicycles by providing bicycles at docking stations around a city for a minimal fee.[17] They have shown to be well adopted in cities such as Montreal,[18] but considering that they have been implemented in over 100 cities worldwide, studies of their effects are uncommon.

In 2010, train drivers on the London Underground (the 'Tube') voted in support of two 24 hour strikes on September 6th and October 4th. 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 the opportunity presented by 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. We first investigate the immediate effect of the Tube strikes on use of the bicycle share program and then assess whether any initial increase in use of the program was sustained.

METHOD

Design

An interrupted time series design was used. This quasi-experimental design allows for the effects of interventions to be evaluated using longitudinal data while controlling a number of threats to internal validity.[19, 20] 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. Anonymous data for all trips made using 'Boris bikes' are freely available online from Transport for London.[21] 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 the mean trip duration per day. In segmented regression analysis variables are created to estimate and compare the intercepts and slopes of the regression lines for each segment. To estimate the intercepts for the pre-strike, strike 1 and strike 2 periods three dichotomous variables were created. These variables were set to 1 on the days of the relevant period and zero on all other days. For example, the variable that estimated the intercept for strike 1 was set to 1 from September 6th to October 3rd and zero on all other days. To estimate the slopes for the pre-strike, strike 1 and strike 2 periods three continuous time variables were created. The time variable used to estimate the slope of the pre-strike period indicated the time elapsed in days from the start of the study period (i.e. from 1 to 95 days). The time variables used to estimate the slope of the strike 1 and strike 2 periods indicated the number of days elapsed after strikes 1 and 2 respectively.

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.

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RESULTS

The mean total number of trips per day over the whole study period was 14699 (SD=5390) while the mean trip duration was 18.5 minutes (SD=3.7). Durbin-Watson statistics for both trip rate (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 rate and mean trip duration are given in Table 1 and Figure 1. For ease of interpretation, results are described with reference to Figure 1, with regression parameters from Table 1 in brackets. Table 2 shows the total number of trips for the four days before and after each strike as well as on the day of each strike.

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 period. The difference between the pre-strike and strike 1 intercepts is shown by a line representing strike 1 on September 6th. Compared to the pre-strike period, a significant increase in daily trip rate 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 rate occurred after strike 2 (11293: 95% CI 5169 to 17416). 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 min/day: 95% CI −0.28 to −0.12). The Tube strikes did not have a significant effect on mean trip duration.

DISCUSSION

This study took advantage of a ‘natural experiment’ to investigate the impact of Tube strikes on use of a public bicycle share program in London. The results suggest that a brief intervention 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 the effects of the intervention appeared to last at least four days, four times longer than the period of the intervention. Since the strikes occurred on Mondays, it is possible that people were prompted to use the bicycles as a result of the strikes, continued to do so for the rest of 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 at least one health-enhancing bout of physical activity during each trip sufficient to contribute half of their recommended daily total.[22] Increasing the total number of trips per day may be both more important and more realistic than increasing trip duration as a means of increasing population physical activity through urban cycling. While the effects of collisions and exposure to air pollution would need to be considered in an evaluation of the overall health impacts of a cycling promotion strategy, modelling studies strongly suggest that the health benefits of an increase in cycling would outweigh the risks.[23, 24]

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Strengths and limitations

Strengths of the study include the time series design and use of a natural experiment. Three important limitations of the analysis should be considered. It was not possible to identify how many unique and new users adopted the program as a result of the strikes or whether the users were already sufficiently physically active. This may be important because the health benefits of additional bicycle trips would be greatest among the most inactive members of the population. 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.[25] Finally, the pre-strike period of analysis represents the early implementation phase of the program. This may have confounded the effect of the first strike because the pre-strike slope was still increasing when the first strike occurred.

CONCLUSION

Brief interventions that greatly constrain the primary motorised mode of transportation for a population may have short-term effects on travel behaviour. Repeated brief interventions at frequent intervals could contribute to increasing population levels of physical activity by promoting the use of active modes of transportation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

References

1. Ogilvie D, Egan M, Hamilton M, Petticrew M. Promoting walking and cycling as an alternative to using cars: systematic review. BMJ. 2004; 329:763–767. [PubMed: 15385407]
2. Ogilvie D, Foster CE, Rothnie H, et al. Interventions to promote walking: Systematic review. BMJ. 2007; 334:1204–1214. [PubMed: 17540909]
3. Pucher J, Dill J, Handy S. Infrastructure, Programs, and Policies to Increase Bicycling: An International Review. Prev Med. 2009; 50(S1):S106–S125. [PubMed: 19765610]
4. Cooper AR, Wedderkopp N, Jago R, et al. Longitudinal associations of cycling to school with adolescent fittness. Prev Med. 2008; 47:324–328. [PubMed: 18602943]
5. von Huth Smith L, Borch-Johnsen K, Jørgensen T. Commuting physical activity is favorably associated with biological risk factors for cardiovascular disease. Euro J Epidemiol. 2007; 22(11): 771–779.
6. Wagner A, Simon C, Ducimetiere P, et al. Leisure-time physical activity and regular walking or cycling to work are associated with adiposity and 5y weight gain in middle-aged men: the PRIME study. Int J Obesity. 2001; 25:940–948.
7. Yang L, Sahlqvist S, McMinn A, Griffin SJ, Ogilvie D. Interventions to promote cycling: systematic review. BMJ. 2010; 341:c5293. [PubMed: 20959282]
8. Ogilvie D, Bull F, Powell J, et al. An applied ecological framework for evaluating infrastructure to promote walking and cycling: the iConnect study. Am J Public Health. 2011; 101(3):473–481. [PubMed: 21233429]
9. Ogilvie D, Griffin S, Jones A, et al. Commuting and health in Cambridge: a study of a 'natural experiment' in the provision of new transport infrastructure. BMC Public Health. 2010; 16(10)
10. Petticrew M, Cummins S, Ferrell C, et al. Natural experiements an underused tool for public health. Public Health. 2005; 119(751-757):751. [PubMed: 15913681]
11. Beevers SD, Carslaw DC. The impact of congestion charging on vehicle emissions in London. Atmospheric Environment. 2005; 39:1–5.
12. Bergman P, Grjibovski AM, Hagstromer M, Patterson E, Sjostrom M. Congestion road tax and physical activity. Am J Prev Med. 2010; 38(2):171–177. [PubMed: 20117573]

13. MacDonald JM, Stokes RJ, Cohen DA, Kofner A, Ridgeway GK. The effect of light rail transit on body mass index and physical activity. Am J Prev Med. 2010; 39(2):105–112. [PubMed: 20621257]

14. Cavill N, Rutter H. London cycle hire scheme: Will it do more harm than good? Student BMJ. 2010; 18:C5621.

15. Transport for London. Travel in London: Key trends and developments. 2009.

16. Mayor's Transport Strategy. [Accessed March 28 2011] Available at: http://www.london.gov.uk/publication/mayors-transport-strategy

17. Shaheen, SA.; Guzman, S.; Zhang, H. Bikesharing in Europe, the Americas, and Asia: Past, present and future. Transportation Research Board Annual Meeting; 2010.

18. Fuller D, Gauvin L, Kestens Y, et al. Prevalence and correlates of use of a new public bicycle share program in Montreal, Canada. Am J Prev Med. In Press.

19. Shadish, WR.; Cook, TD.; Cambell, DT. Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin; Boston, MA: 2002.

20. West, SG.; Biesanz, JC.; Pitts, SC. Causal inference and generalization in field setting: Experimental and quasi-experimental designs. In: Reis, HT.; Judd, CM., editors. Handbook of research methods in personality and social psychology. Cambridge University Press; New York: 2000.

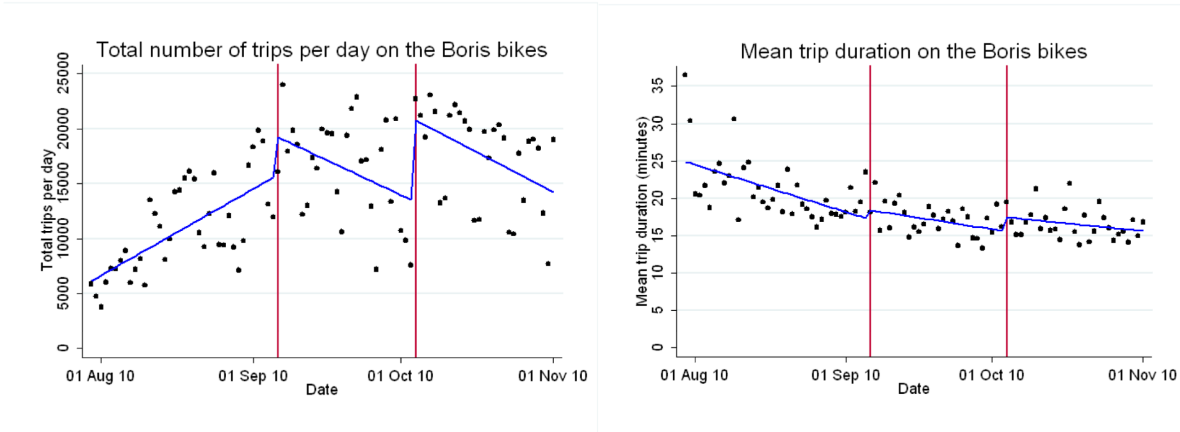
21. Transport for London. [Accessed March 28 2011] Barclay's cycle hire statistics. Available at: http://www.tfl.gov.uk/tfl/syndication/feeds/BarclaysCycleHireUsageStats.zip

22. Department of Health. [Accessed April 5 2011] At least five a week: Evidence on the impact of physical activity and its relationship to health. Available at: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGu idance/DH_4080994

23. de Hartog JJ, Boogaard H, Nijland H, Hoek G. Do the health benefits of cycling outweigh the risks? Environmental Health Perspectives. 2010; 118(8):1109–1116. [PubMed: 20587380]

24. Woodcock J, Banister D, Edwards P, Prentice AM, Roberts I. Energy and transport. Lancet. 2007; 370:1078–1088. [PubMed: 17868817]

25. Lachapelle U, Frank L, Saelens BE, Sallis JF, Conway TL. Commuting by public transit and physical activity: where you live, where you work, and how you get there. J Physical Activity and Health. 2011; 8(1):S72–82.



Vertical red lines=Tube strikes

Figure 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 1nd 2010

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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 ‘Boris bikes’ over time

	Total trips per day			Average trip duration		
	Coefficient	***P*-value**	**95% CI**	**Coefficient**	***P*-value**	**95% CI**
Pre-strike intercept	5889.73	0.001	3424.22; 8355.23	25.09	0.001	23.29; 26.88
Pre-strike slope	254.67	0.001	144.46; 364.88	−0.20	0.001	−0.28; −0.12
Strike 1 – Intercept change	3864.47	0.043	124.69; 7604.24	1.15	0.401	−1.57; 3.88
Strike 1 – Slope change	−465.14	0.001	−671.35; −258.93	0.10	0.182	−0.05; 0.25
Strike 2 – Intercept change	11292.73	0.001	5169.18; 17416.19	2.99	0.185	−1.46; 7.46
Strike 2 – Slope change	−22.23	0.855	−262.47; 218.01	0.04	0.677	−0.14; 0.21

Table 2

Total trips per day on the Boris public bicycle share program four days before and after each Tube strike

	−4 days	−3 days	−2 days	−1 days	Strike	+1 days	+2 days	+3 days	+4 days
Strike 1	19818	18873	13101	11924	16058	23988	17923	19818	18552
Strike 2	20876	10714	9818	7570	22712	21172	19193	23044	21556

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