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Health impacts of free bus travel for young people: evaluation of a natural experiment in London

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Abstract

Background: We used the introduction of free bus travel for young people in London in 2005 as a natural experiment with which to assess its effects on active travel, car use, road traffic injuries, assaults, and on one measure of social inclusion, total number of trips made.

Methods: A controlled before-after analysis was conducted. We estimated trips by mode and distances travelled in the pre- and post-introduction periods using data from London Travel Demand Surveys. We estimated rates of road traffic injury and assault in each period using STATS19 data and Hospital Episode Statistics, respectively. We estimated the ratio of change in the target age-group (12-17 years) to the change in adults (ages 25-59 years), with 95% confidence intervals.

Results: The proportion of short trips travelled by bus by young people increased post-introduction. There was no evidence for an increase in the total number of bus trips or distance travelled by bus by young people attributable to the intervention. The proportion of short trips by walking decreased, but there was no evidence for any change to total distance walked. Car trips declined in both age groups, although distance travelled by car decreased more in young people. Road casualty rates declined, but the pre-post ratio of change was greater in young people than adults (ratio of ratios 0.84; 95% CI 0.82 to 0.87). Assaults increased and the ratio of change was greater in young people (1.20; 1.13 to 1.27). The frequency of all trips by young people was unchanged, both in absolute terms, and relative to adults.

Conclusion: The introduction of free bus travel for young people had little impact on active travel overall and shifted some travel from car to buses that could help broader environmental objectives.

Keywords: Natural experiment, Bus travel, Active travel, Road injuries, Social inclusion

What is already known on this subject?

- Improved access to public transport can increase population levels of physical activity through increases in the amounts of walking to public transport
- Increased access to public transport can help to reduce levels of obesity
- Free bus travel provides a benefit for the health of older people in the UK

What this study adds?

- A natural experiment of free bus travel for young people was found to encourage greater use of buses for shorter trips in place of walking, without reducing overall walking distances
- The evaluation found no negative effects of this policy on use of buses by older people
- Free bus travel can help to promote broader environmental objectives by shifting some travel by car to public transport.

Introduction

Urban transport policies may have direct impacts on the health of the population,[1-3] as well as on the economy,[4] and on the environment.[5] Modest gains in health can be achieved by switching short trips by motorised transport to more active modes, such as walking and cycling,[6] or by promoting public transport, due to increases in walking to bus stops or train stations.[7]

We used the introduction of free bus travel for young people in London as a natural experiment with which to evaluate its public health impacts. Theoretically, risks and benefits to health from provision of free public transport are likely to accrue both from increased access to transport, as well as from changes to travel modes used. In England, UK, free bus travel has been identified as providing a benefit for the health of older people.[8, 9] However, it is possible that in cities such as London, where dependence on private cars for travel is generally lower than in other cities, improving access to affordable public transport might actually reduce the amount of active travel, if it is used to replace walking or cycling, rather than to replace car use.

Shifts in modes of transport are also likely to change road traffic injury rates in the population, as risk of injury varies by transport mode.[10] Young people are particularly at risk of assault,[11] and greater access to public transport potentially increases this risk (e.g. by facilitating trips to distant or unfamiliar areas, possibly increasing confrontation with gangs). More tangential benefits that may result from increased access to public transport for young people include increased social inclusion and potentially decreased future reliance on car travel. In addition to benefits or costs for young people, there may also be consequent effects for older people, possibly displaced from buses.

The introduction of free bus travel for young people in London was not primarily aimed at public health, but it did aim to reduce social exclusion through reducing transport poverty, one determinant of health and well-being.[12] Its introduction is a natural experiment that presents a number of challenges for evaluation, both in analytical design, and in terms of attributing causal effects.[13] In this paper, we assess its effects on active travel, road traffic injuries, assaults, one measure of social inclusion (total number of trips made) and one measure of environmental impact (car use).

Methods

Intervention

Transport for London, the local government body responsible for London's transportation system, introduced free bus travel for young people aged 12 to 16 years in September 2005. Provision was extended in 2006 to people aged 17 years, if in full-time education or unwaged training.

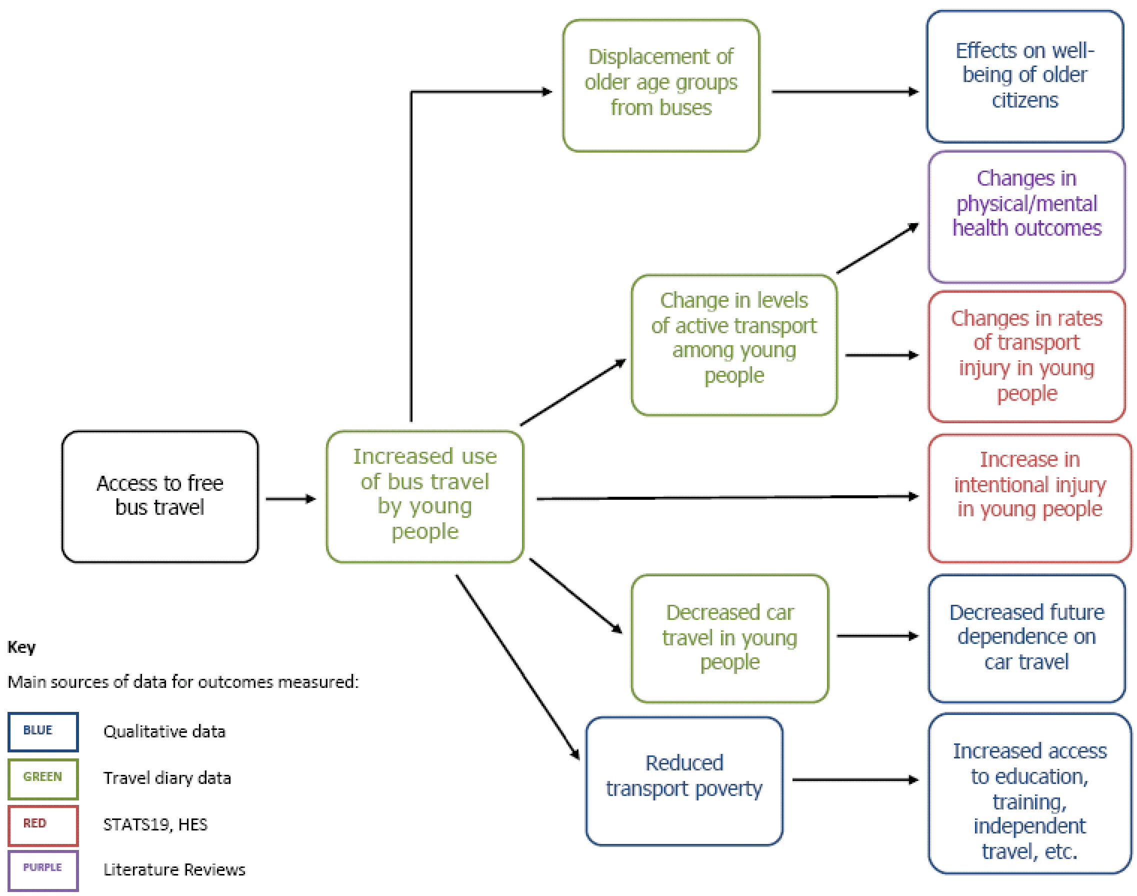
Hypotheses and outcomes

In line with recommendations for increasing confidence in causal attributions,[13-15] we pre-specified our hypotheses and expected directions of change.[16] We hypothesised that introduction of free bus travel for young people would be associated with:

- increased bus travel by young people and reduced walking, cycling and car travel;
- reduced bus use and fewer short bus trips (<1 km) by older people (60+ years), especially when children travel after school;
- fewer road traffic injuries to young people;
- more injuries to young people due to assaults.

The hypothesised direct and indirect effects are summarised in figure 1.

Figure 1 Hypothesised pathways linking free bus travel for young people to health outcomes.



Data sources

Travel surveys

We estimated distances travelled by mode in the pre-intervention period (2001-2004) using data from the 2001 London Area Transport Survey (LATS), and in the post-intervention period (2006-2009) using data from the London Travel Demand Surveys (LTDS).[17,18] LATS and LTDS used comparable survey methods to sample households and to collect data from every person aged over 5 years using travel diaries. Journey distances are estimated using the start-point, interchange and end-point of each trip made per person. Trips were defined by the main mode of transport used (e.g. a bus trip is a journey where bus is the main mode used for that journey). Although the data provided define each trip by the main mode of travel used, we calculated total distance travelled by mode by disaggregating the individual stages of each trip made. LATS sampled travel on weekdays during school term only and so our analysis is based on school term-time only. Missing journey distances (0.2% of trip stage distances were missing) were estimated using the median distance for each age group and travel mode. Information is collected on the age, ethnicity, household income and census Lower Super Output Area (LSOA) of residence of each participant. Ethnicity was coded using four categories: 'White', 'Black', 'Asian', and other. Household income was categorised as: <£15,000, £15,000 to £49,999, and £50,000 or more. Using data from the 2004 Index of Multiple Deprivation (IMD) available at LSOA level we assigned to each individual an area deprivation score based on the LSOA of their residence. We also used LSOA of residence to assign inner/outer London status to each individual. Survey weights (adjusted for non-response and scaled to mid-2007 population projections for the LTDS) were used to ensure that the sample was representative of the London population.

Road traffic injuries

We estimated road traffic injury rates by mode in the pre- and post- intervention periods using STATS19, the official dataset of injuries from road traffic collisions on public highways in the UK. The STATS19 data include information on age and ethnicity of casualties, which were used to create similar categories as described above. STATS19 also include coordinates of the location of collisions which were linked geographically to a LSOA, and through the LSOA code to both an IMD deprivation score and inner/outer London status.

Assaults

We estimated rates of assaults in the pre- and post- intervention periods using an extract of Hospital Episode Statistics data for England. We identified London and non-London residents using LSOA code of residence. Hospital admissions due to assaults were identified by the International Classification of Diseases (10th Revision) external cause of injury codes X85-Y09. Hospital Episode Statistics data include age and ethnicity; they were also linked to a deprivation score and inner/outer London status using LSOA.

Statistical analysis

We used change-on-change analysis to compare change in the outcomes in young people (the targets of the policy) with change in the outcomes in adults aged 25-59 years (i.e. those adults old enough to never have experienced free bus travel, and young enough not to qualify for an older citizens' free bus pass). This method controls for the effects of other changes to transport provision within the study area which might be expected to have affected use of modes by all age groups (e.g., congestion charging; expansion of the bus network).[19]

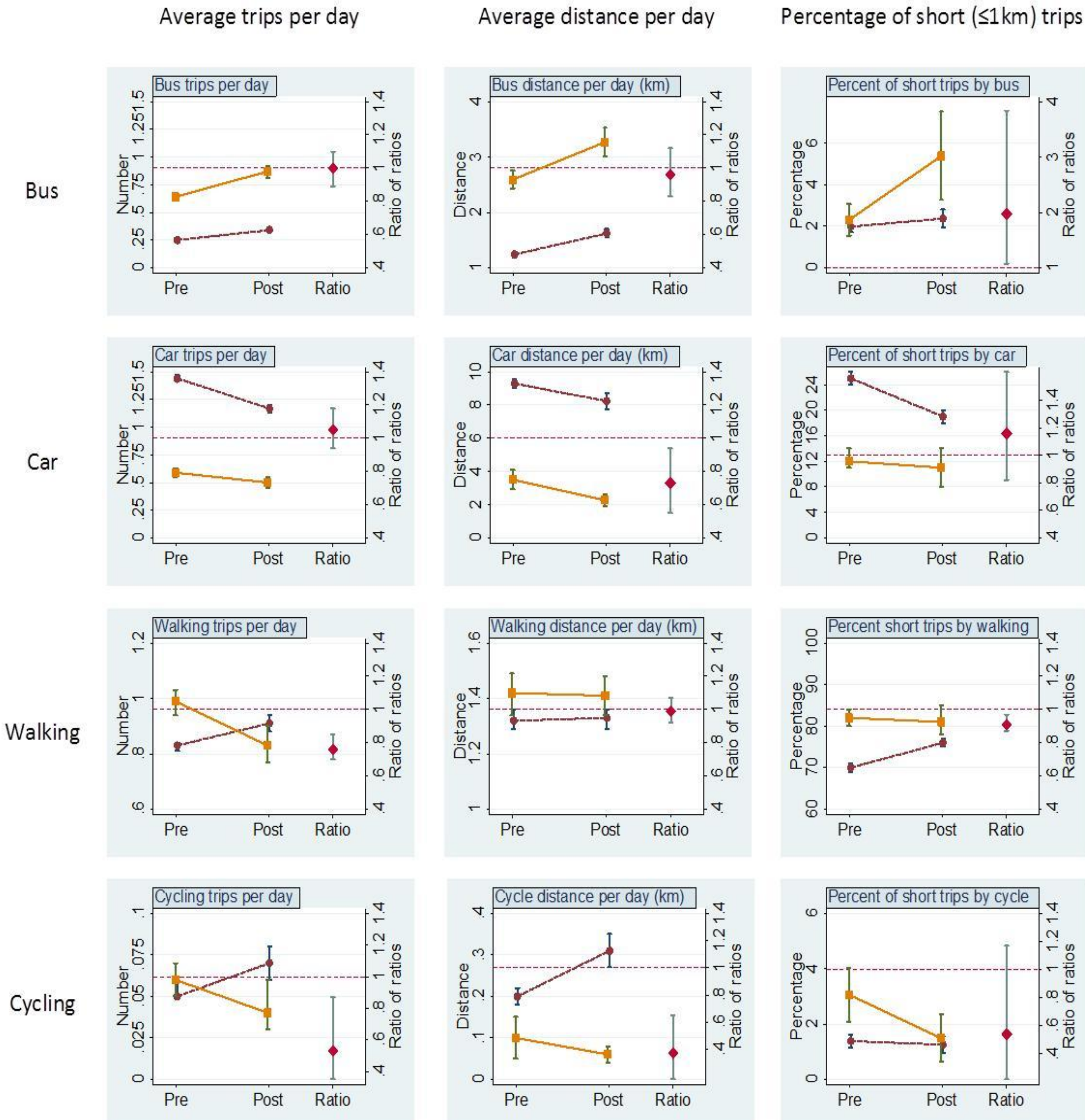
We estimated the ratio of the pre-post intervention change in the target age-group (ages 12-17 years) to that seen in adults (ages 25-59 years) and estimated 95% confidence intervals for the ratio using bootstrap methods implemented in Stata statistical software (StataCorp, Texas 77845 USA). We conducted subgroup analyses according to: Area (inner vs. outer London; high take-up vs. low take-up boroughs), Deprivation (most deprived population quintile vs. least deprived 80%), Household income (<£15k per year versus > £50k per year; possible for travel patterns only), and Ethnicity ('White', 'Black', 'Asian', other). To explore whether people aged 60+ years were displaced from buses we compared the pre-post change in older peoples' travel during school commuting hours versus travel at other times. We also used STATS19 data and Hospital Episode Statistics data for people aged 12-17 years living in England as a further control with which to assess changes in road injuries and assaults in young people after introduction of the scheme in London.

To assess impact of the scheme on social inclusion we fitted a regression model of distance travelled according to journey purpose on deprivation (IMD as continuous variable) and tested for interaction with pre-post intervention status (i.e. change of slope with IMD). To strengthen any causal inference we used rate of uptake of free bus travel at borough level as a proxy for 'dose', with which to explore changes in outcome. To explore differential effects across the population, we examined differences in travel modes used according to level of household income and by ethnicity. Sample sizes for each data source analysed are summarized in the Web Appendix Table A1.

Results

We present our results under five headings: bus use, active travel, safety, social inclusion, and environmental impact. Results for travel mode are summarised in figure 2, safety in figure 3, and socio-economic gradients in travel patterns by journey purpose in figure 4. Pre- and post-intervention changes in people aged 60+ years are presented in Web Appendix Table A2.

Figure 2 Pre-post changes to travel by mode: young people (orange) and adults (red) with ratio of pre-post changes comparing young people with adults.



Footnote: Vertical bars show 95% confidence intervals. Horizontal dotted line indicates ratio=1 (i.e. no relative change).

Figure 3 Annual rates of road traffic injuries and assaults in London (young people, black; adults, grey).

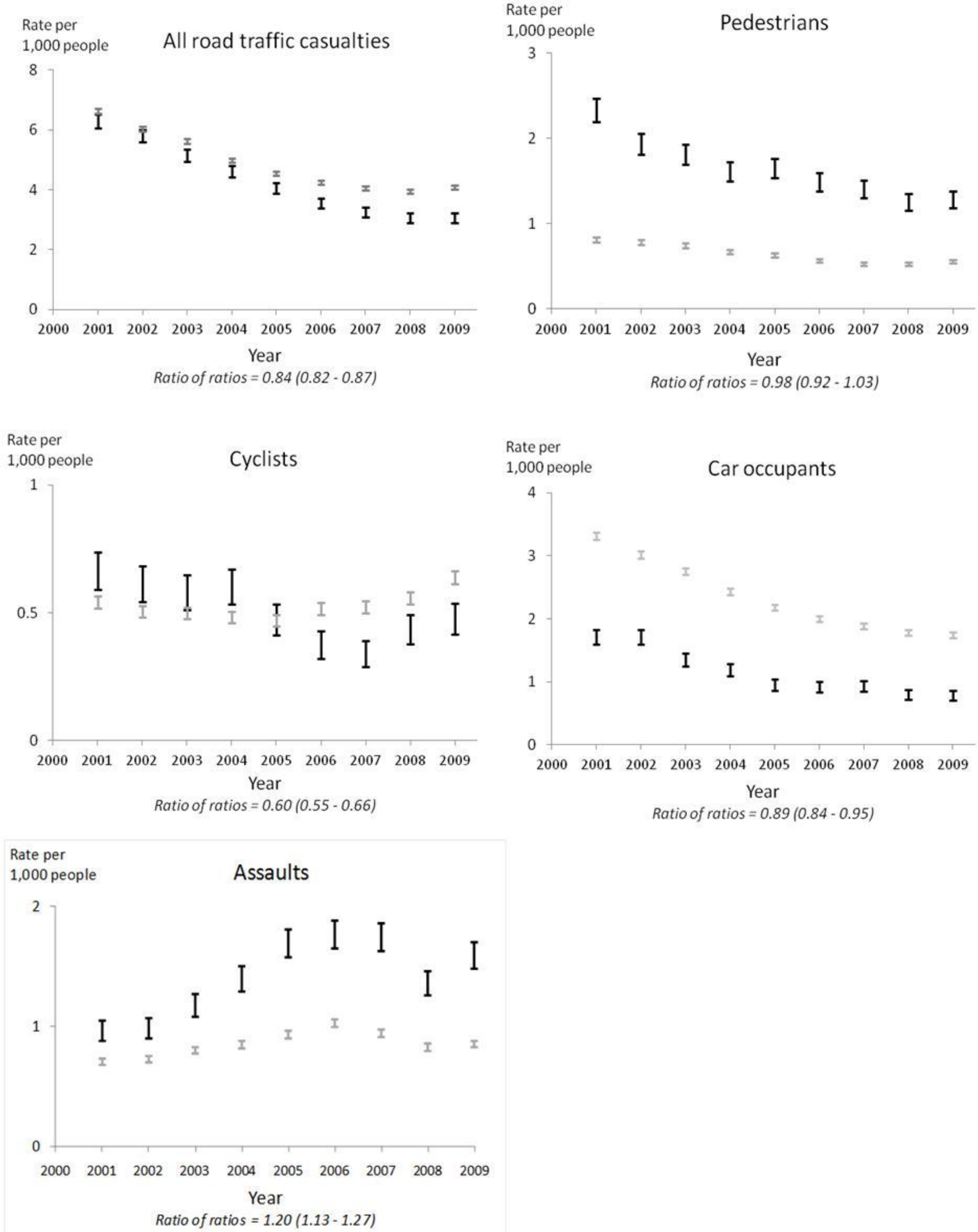
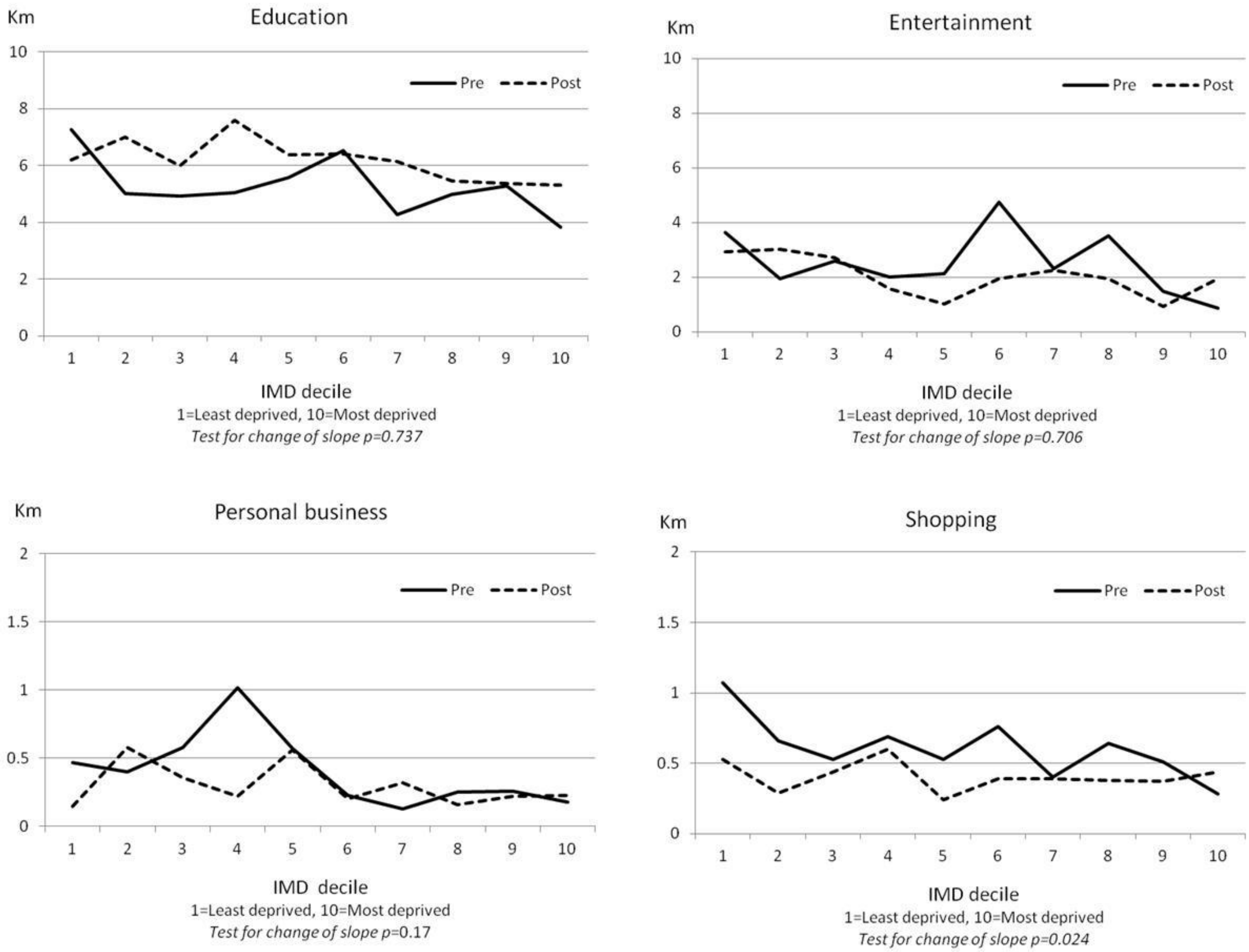


Figure 4 Distances travelled by young people according to journey purpose by decile of Index of Multiple Deprivation (IMD), pre and post introduction of free bus travel.



Bus use

The introduction of the free bus travel scheme was associated with an increase in the proportion of short trips travelled by bus by young people, from around 2% to around 5% of short trips (figure 2). The proportion remained at around 2% pre- and post-intervention in the control group, so there was therefore evidence for a doubling (relative change 1.97; 95% CI 1.07 to 3.84) of the proportion of short trips by bus by young people attributable to the intervention. There was, however, no evidence of change to the number of bus trips, or distance travelled by bus, attributable to the intervention. There was a 35% (95% CI 25% to 47%) increase in the average number of bus trips per day by young people, and a 36% (95% CI 25% to 46%) increase in the control group (relative change 1.00; 0.89 to 1.10). There was a 26% (95% CI 13% to 41%) increase in average distance travelled by bus by young people, and a 31% (95% CI 19% to 42%) increase in the control group (relative change 0.96; 0.83 to 1.12).

Active travel

There was a decline in the number of walking trips per day by young people, both in absolute terms and especially relative to the change in adults. There was, however, no appreciable impact on the total distance walked, despite a decrease in the percentage of short trips made by walking – largely a substitution by bus trips. There was clear evidence for a decrease in cycle trips and distances cycled by young people, but the large estimated reduction in percentage of short trips by bicycle was not statistically significant. However, these changes occurred from a low baseline (e.g. mean distance cycled per person per day was under 0.1 km pre-intervention and the percentage of short trips was 3% pre-intervention).

Safety

Road traffic casualty rates continued to decline after introduction of the scheme, but at a greater rate in young people than adults (ratio of ratios 0.84; 95% CI 0.82 to 0.87). When compared with the change in young people nationally the relative change was greater (0.70; 0.68 to 0.73). The major contributors to this decline were reductions in car occupant casualties (ratio of ratios: 0.89; 0.84 to 0.95; and 0.65; 0.61 to 0.69, nationally) and cyclist casualties (ratio of ratios: 0.60; 0.55 to 0.66; and 0.81; 0.74 to 0.88, nationally). The change to pedestrian casualty rates was similar in young people and adults (ratio of ratios: 0.98; 0.92 to 1.03; and 0.93; 0.88 to 0.98, nationally). Hospital admission rates due to assaults had been rising in both age groups pre-2005 but reached a relatively higher peak in young people. Although the pre-post ratio of change in assaults was therefore greater in young people (ratio of ratios 1.20; 1.13 to 1.27), this reflects a larger increase in assaults in young people occurring before introduction of the scheme. When compared with the change in assaults to young people nationally, the relative change was marginally greater (ratio of ratios 1.32; 1.25 to 1.4).

Social inclusion

In the absence of direct markers of social inclusion we examined journeys to/from school and work and the socio-economic gradient in distance travelled (all modes) by journey purpose. The frequency of journeys to/from school or work in young people was higher after introduction of the scheme (relative change 1.09; 1.06 to 1.14), but was lower in adults. The ratio of change in young people compared with adults was 1.19 (95% CI 1.13 to 1.25). In contrast, the frequency of all journeys in young people was unchanged both in absolute terms and relative to that in adults (ratio of ratios 1.00; 0.97 to 1.04). Plots of distance travelled by journey purpose against decile of IMD (figure 4) show no clear evidence of diminution in socio-economic gradients following introduction of the scheme. Nevertheless, the patterns were suggestive of a flattening in the socio-economic gradient for travel 'for shopping' (a lower level post-intervention; p-value for change of slope with IMD was p=0.024).

Environmental impact

The introduction of free bus travel was associated with a reduction in number of car trips per day by young people (relative change 0.85, 0.77 to 0.95) and by adults (0.81; 0.77 to 0.85). There was also a reduction in the average distance travelled by car each day by young people (0.65; 0.49 to 0.84) and by adults (0.89; 0.84 to 0.94), but the reduction was greater in young people (relative change 0.73; 0.55 to 0.94).

Subgroup analyses

Subgroup analyses provided weak evidence that the pre-post reduction in total distance walked and cycled was greater in inner London compared with outer London, but less clear evidence that it varied with socio-economic deprivation, household income, ethnicity, or area-level uptake (table 1). Similarly, the relative reduction in road traffic injury was greater in inner London, but there was no clear evidence of variation in relation to other potential modifiers. The pre-post increase in assaults was higher in inner London, in the most deprived areas, in the 'Black' and 'White' populations relative to 'Asian', and higher in areas with a high level of uptake of free bus travel. There was no evidence that introduction of the scheme appreciably affected travel by those aged 60+ years, and specifically no indication of reduced bus use during peak times when young people travel home after school (weekdays 3-4 pm); see Web Appendix Table A2.

Table 1. Ratios of relative change in the target age-group (12-17 years) to the change in adults (ages 25-59 years) by principal subgroups ('ratio of ratios').

Outcome	Potential modifier		Ratio of ratios (95% CI)	Test for interaction
Distance walking and cycling (km)	Area of London	Inner London	0.80 (0.66 - 0.97)	p =0.06
		Outer London	0.97 (0.87 - 1.05)	
	Deprivation	Most deprived fifth	0.82 (0.71 - 1.01)	p =0.29
		Least deprived 80%	0.92 (0.83 - 1.01)	
	Household income	<15k	0.98 (0.81 - 1.18)	p =0.65
		>50k	0.92 (0.77 - 1.09)	
	Ethnicity	White	0.89 (0.80 - 0.98)	p =0.92
		Black	0.85 (0.66 - 1.12)	
		Asian	0.84 (0.61 - 1.12)	
	Intervention take-up	High take up area	0.93 (0.82 - 1.05)	p =0.35
		Low take up area	0.85 (0.71 - 0.96)	
Road injuries	Area of London	Inner London	0.79 (0.75 - 0.83)	p <0.01
		Outer London	0.89 (0.85 - 0.92)	
	Deprivation group	Most deprived fifth	0.85 (0.80 - 0.91)	p =0.97
		Least deprived 80%	0.85 (0.82 - 0.88)	
	Ethnicity	White	0.88 (0.85 - 0.92)	p =0.11
		Black	0.93 (0.86 - 1.01)	
		Asian	0.81 (0.73 - 0.90)	
	Intervention take-up	High take up area	0.86 (0.82 - 0.90)	p =0.26
		Low take up area	0.83 (0.79 - 0.87)	
Assaults	Area of London	Inner London	1.40 (1.29 - 1.53)	p <0.01
		Outer London	1.05 (0.97 - 1.14)	
	Deprivation group	Most deprived fifth	1.46 (1.31 - 1.62)	p <0.01
		Least deprived 80%	1.12 (1.05 - 1.20)	
	Ethnicity	White	1.06 (0.96 - 1.17)	p <0.01
		Black	1.53 (1.33 - 1.78)	
		Asian	0.65 (0.53 - 0.80)	
	Intervention take-up	High take up area	1.26 (1.17 - 1.36)	p <0.01
		Low take up area	1.12 (1.02 - 1.23)	

Discussion

This is one of few studies that have attempted to evaluate the breadth of public health impacts of city-level transport policies. Our results suggest that the following occurred: higher use of bus travel by young people for short journeys, and lower car distances (among young people and overall); little reduction in active travel (fewer walking trips but no appreciable change in distance walked, reduction in cycling but from a low base); a reduction in road traffic injuries to car occupants and cyclists (but not pedestrians); an increase in assaults (which largely preceded the scheme); a modest overall increase in journeys; equivocal evidence of impact on socio-economic gradients in travel behaviour; no evidence of adverse impact on travel by people aged 60+ years; and shifts from car use to public transport that could help broader environmental objectives.

These changes are consistent with results of qualitative studies of young people about the scheme and their travel behaviour.[20] The findings suggest, unsurprisingly, a good uptake in use of buses for fulfilling travel needs, including for short journeys. One disadvantage appears to be some reduction in the proportion of short trips by walking, and in the (already) low level of cycling; these might be detrimental to the establishment of future travel habits bringing regular physical activity. On the other hand, the increase in use of public transport may help to establish travel behaviour for later life that entails some physical activity, as well as helping to reduce car use. The observed reduction in road traffic injuries, especially of cyclists, is consistent with the substitution of walking, cycling and car journeys with (relatively safe) bus travel, although other factors may also play a part in the selective improvement over time in road injuries among young people. Although the observed increase in assaults among young people may partly be a consequence of their increased use of bus travel, the temporal pattern of change might argue against it being a major causal factor.

Our evidence on social inclusion is indirect: the frequency of school or work journeys for young people was (relatively) higher after introduction of the scheme and there was weak evidence of a flattening in the socio-economic gradients in travel for shopping (but not for education, personal business or entertainment). While this is not strong evidence for a favourable influence on social inclusion, the patterns suggest a helpful direction of change. There was no suggestion of negative effects on bus use, or overall travel, by people aged 60+ years, indicating an absence of a detrimental effect on the social inclusion of this group.

The assembly, analysis and interpretation of data for this study, relating to a population-level intervention with multiple interconnected and often indirect effects, were inevitably complicated. A strength was availability of large datasets relating to a range of population-level outcomes that should demonstrate evidence of change, if the scheme did result in altered behaviours. On the other hand, its main weakness is attribution, as it is impossible to eliminate or take account of the influence of other factors that may have had a selective impact over time on some of the measured outcomes for young people, including regional transport-related interventions and national trends in travel modes and safety. A particular limitation with available travel survey data was that this was limited to a single year pre-intervention. These data also only included travel on weekdays during school term times. We attempted to minimise bias by comparing pre-post changes in young people to changes in adults, but this is not a perfect control for temporal changes that hypothetically have selective effects in young people. Furthermore, our subgroup analyses by level of take-up of the intervention did not find evidence that higher ‘dose’ was associated with a greater effect on most outcomes. Nonetheless, our results present a somewhat coherent picture that is supported by qualitative evidence.[20, 21] While not all observed effects may be attributable directly to the scheme, it seems probable that many of those effects were partly influenced by it.

The implication of our evaluation for policy depends upon the value assigned to the attainment of different objectives, and on the degree to which our results suggest causal influence. What seems clear is that the scheme brought about a shift in travel behaviour among young people in London, who now use buses more frequently in place of short walking trips and cycling, with reduced car use, and little overall reduction in active travel. On the one hand it might be argued that an increase in short journeys by bus should not necessarily be seen as a positive effect of the intervention on active travel, as most young people can easily walk or cycle these distances, some of whom might benefit from increased physical activity. On the other hand this shift probably has consequential reductions in road injuries and changes in traffic overall that are likely to be broadly positive from an environmental perspective. Beneficial effects on social inclusion are uncertain but suggested. By most parameters these would be judged broadly positive changes, not just for young people, but for the city as a whole.

Contributors

JG, PW, HR, MP, PE, RS conceived the study. PE is guarantor. PE, RS and PW obtained data sets and carried out the analyses. JG, PW, PE, and RS wrote the manuscript with contributions from HR, MP, CK, JN, AJ, and AG. The final version was approved by all authors.

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Competing Interest:

None

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Appendix

Table A1 Sample sizes available from each data source in the pre- and post-intervention periods

Data source			Age group		
	Intervention period	Time period	12-17 years	25-59 years	60+ years
London Area Transport Survey	Pre	2001	4,206	31,169	10,671
London Travel Demand Survey	Post	2006 to 2008	2,024	14,085	5,033
STATS19	Pre	2001 to 2004	11,221	89,661	13,337
	Post	2006 to 2009	6,657	65,542	9,283
Hospital Episode Statistics	Pre	2001 to 2004	2,321	11,829	905
	Post	2006 to 2009	3,322	14,641	959

Table A2. Pre-intervention (pre-2005) to post-intervention (2006 onwards) change in key outcome measures, 60+ years.

		Within travel from School hours (3-4 pm, Mon to Fri, in term time)			**Other times**			**Ratio of ratios**
		Pre-	Post-	Ratio	Pre-	Post-	Ratio	
Bus travel	Frequency	0.06 (0.06 - 0.07)	0.07 (0.06 - 0.08)	1.11 (0.92 - 1.32)	0.36 (0.34 - 0.37)	0.37 (0.35 - 0.4)	1.04 (0.94 - 1.18)	1.07 (0.91 - 1.21)
	Distance	0.26 (0.23- 0.29)	0.25 (0.21- 0.28)	0.95 (0.80- 1.13)	1.19 (1.11- 1.26)	1.19 (1.09- 1.29)	1.00 (0.89- 1.14)	0.95 (0.80-1.11)
	% of short distance trips by bus	7.09 (5.73 - 9.46)	8.42 (4.4 - 11.71)	1.19 (0.53 - 1.65)	7.33 (6.23 - 8.53)	7.03 (5.74 - 8.53)	0.96 (0.80 - 1.14)	1.24 (0.52 - 1.69)
All travel	Frequency	0.31 (0.29 - 0.32)	0.33 (0.31 - 0.35)	1.08 (0.97 - 1.17)	1.98 (1.94 - 2.02)	2.07 (2.01 - 2.13)	1.05 (0.99 - 1.12)	1.03 (0.94 - 1.10)
	Distance	1.62 (1.44- 1.80)	1.90 (1.40- 2.40)	1.17 (0.91- 1.60)	8.09 (7.70- 8.49)	9.29 (8.46- 10.12)	1.15 (1.03- 1.27)	1.02 (0.80-1.30)
	% of all trips which are short distance	30.12 (27.47 - 33.95)	29.52 (26.38 - 33.38)	0.98 (0.85 - 1.12)	36.20 (34.12 - 39.05)	35.67 (33.57 - 37.93)	0.99 (0.93 - 1.04)	0.99 (0.88 - 1.16)