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'On the buses': evaluating the impact of introducing free bus travel for young people on the public health

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'On the buses': evaluating the impact of introducing free bus travel for young people on the public health

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1. Summary for general audience

This study aims to assess the impact of free bus travel for young people on the health of the public. We will focus particularly on the effects on young people, but also intend to look at the consequent effects on other population groups for some outcomes.

In London, young people aged under 16 have been able to access free bus and tram travel since September 2005. This was extended to under 18 year olds in education, work or training in September 2006. One incentive for this policy was to decrease 'transport exclusion', and ensure that access to goods, services, education and training opportunities were not denied to some young people because of transport poverty. We would expect that this would increase health, as transport access is linked to well-being. However, there will be other health effects of free bus travel. These might include: young people walking less often or less far, and thus taking less exercise, or being more exposed to minor crime and assault as they travel further for longer distances. Free bus travel for young people might also reduce access other age groups have to transport if, for instance, the buses become too full, or older people are intimidated. Like other complex public policies, there are likely to be both health promoting and health damaging effects.

To assess these effects, we will begin with qualitative research talking young people and older citizens from a range of backgrounds to find out how they experience transport, and the ways in which they feel that access and use influences their health, and the broader determinants of health (eg: access to safe places to play and leisure facilities; opportunities for independent travel). An important element of this component of the project is to understand better how transport interventions can have differential effects on different population groups (eg by ethnicity, or deprivation).

This study then aims to measure as robustly as possible the overall impact on population health of this transport intervention. We will do this by first looking in detail at travel diary data to measure whether there have been any changes in the amount of bus and other kinds of transport undertaken by young people and others before and after the introduction of free bus travel. This will allow us to estimate the effect on access to transport, and on the amount of healthier 'active transport' (walking and cycling). Using comparisons between different age groups (with and without access to free travel) and national data will allow us to estimate how much of the change is due to the policy, and how much due to general changes in people's transport use. We will then look at the impact on injuries, both road traffic injuries and assaults, by using police records of traffic incidents and other available data sets (eg bus incident reports). Again, comparing these with national data and other cities, and comparing different age groups affected and not affected by the intervention will allow us to estimate how far changes identified are due to the intervention itself, and how far they reflect general background trends in, for instance, changes in the amount of walking or rates of injuries.

The need for public policy to be developed in the light of evidence is increasingly recognised, and we also aim to develop methods for developing this evidence base. This is a challenge, as transport interventions occur at the same time as other changes, and we need to develop methods to assess how far they have caused the effects we are measuring. Finally, we will draw on the transport studies literature on evaluating the costs and benefits of transport strategies to investigate the costs and benefits of this policy, from the perspectives of the economy, environment and society.

2. Background

The extension of free bus (and tram) travel in London to under 16 year olds in September 2005 and under 18 year olds in September 2006 provides a unique and timely opportunity to evaluate a large scale intervention in public health. The retrospective evaluation of interventions in complex systems using before-and-after experimental designs has well-known limitations for causal inference. However, although complex interventions of this kind are often not susceptible to 'hard' evaluations, they have traditionally been implemented, and will continue to be implemented, without evaluation, and an urgent need has been identified to build an evidence base (Ogilvie et al 2006, Petticrew et al 2005). This is consistent with the approach outlined in the recent MRC Complex Interventions guidance (2008) which underlines the need to evaluate even when randomised trials are not possible, using the best available methods. Notwithstanding the inevitable methodological limitations, we believe that this particular case study offers a significant opportunity to test the strengths and otherwise of a natural experiment in an area with a range of important public health impacts including injury, crime, social exclusion and sustainable development. The strengths of this particular case study in terms of the potential for maximising our faith in causal attributions include:

1) The intervention was introduced in a two step process (under 16 year olds, then under 18 year olds a year later), providing scope for internal comparisons;
2) Using London as our case study enables us to use more robust injury data sets, and more detailed travel diary data (including socio-economic indicators), than available elsewhere, with relatively long series of before and after data providing sufficient power for interrupted time series analyses, sub-group analyses and sensitivity analyses.
3) For key health outcomes, we have comparable national data to enable us to estimate background trends.

A significant thrust behind the decision of Transport for London (TfL) to extend free bus and tram travel to under 16s and then to 16-17 year olds in full time education or unwaged training was to reduce *social exclusion* by reducing 'transport poverty' and thus impact on a key determinant of health by improving the access of young people to education and training (SEU 2003). The extension of free bus travel was also part of a broader environmental strategy with health implications, aiming to increase bus travel in order to reduce private car use in London, thus impacting on *pollution levels* and *road injury*. Extending access to bus travel is also likely to have a range of other direct and indirect effects on public health. It may change the amount of *active transport* (walking and cycling) undertaken by young people, either through increasing the number of trips made, or by replacing other modes (such as walking or car occupancy). There may be consequent impacts on other population groups, if more bus transport by young people reduces willingness to travel by bus by others, particularly older citizens, thus exacerbating inequalities in transport access. As a public health intervention, therefore, the extension of free bus travel to young people is likely to have a number of positive and negative effects on health, the determinants

of health and health inequalities. To date, there is little robust evidence on which to assess the overall impact of such large scale interventions for the public health.

There are real challenges in evaluating these impacts, not least because they affect very different types of health outcome. The problems are suggested by Watkiss et al's (2000) comments on comparing the relative contributions of road accidents and pollution to fatalities in London for a health impact assessment. Although both outcomes can be quantified and compared, the causal links for pollution are less direct than for injuries, and the population groups affected differ in some respects. In the proposed study, there will be similar challenges. The benefits of increased access to educational opportunities have long term (but difficult to measure) advantages for health, but there are possible damaging effects on cardiovascular health from decreased time spent walking, although these may bring lower risks of being injured on the road. Evaluating these positive and negative effects on immediate health, the determinants of health and health inequalities, is difficult for three reasons. First, the causal pathways by which transport interventions might affect transport mode choice and therefore health are as yet poorly understood. There are likely to be complex interactions with, for instance, transport mode choices changing over time in response to the behaviour of other travellers (if, for instance, bus travel becomes more or less attractive). Second, we do not yet have sufficient evidence to quantify the risks and benefits of many of the known but distal effects of transport policy, such as the effect of reducing transport poverty (Watkiss et al 2000). Third, we know very little about the differential impact of transport mode choices on health across population groups, and thus the potential effect on health inequalities. For instance, using 'active' modes such as walking may have very different impacts on mental health (and even physical health) for those for whom it is a choice than for those who have no alternatives: we cannot assume that active transport is necessarily, for all groups, always a benefit for health.

Despite a growing research literature on the links between particular transport modes and health outcomes (eg on road traffic injuries) there is a relatively weak evidence base on how transport policies relate to health and wellbeing in the broadest sense (Ogilvie et al 2006), and how these relate to inequalities in health outcomes. The proposed study aims first to map the salient health benefits of transport access for key population groups, using qualitative methods to investigate the ways in which transport mode choices (and the recent and expected interventions affecting these) may influence health outcomes. We will identify, and evaluate the utility of, sources of evidence on the outcomes identified. Second, we aim to produce a robust evaluation of the impact of free bus travel on important direct health outcomes for which we have good evidence (proportion of time spent in active transport and alternative motorised modes; road injury), and to examine whether the effects on these outcomes differ across the population. Third, we aim to develop and apply a method for conducting an economic evaluation of these health impacts.

2.1 Existing research

Transport policies and systems are increasingly accepted to have the potential to be both health promoting and harmful to health, and to contribute to the maintenance of health inequalities (Exworthy et al 2003, SEU 2003). However, the evidence base in this area, although relatively stronger on the transport policy side, is weaker in relation to the health related outcomes of changes to transport policies (Killoran et al 2006). Evaluations of concessionary or free bus travel provide useful background for mapping the potential range of impacts, but few of these have utilised robust designs or been published in peer reviewed journals. An evaluation of national concessionary travel in Scotland, for instance, identified some modal shift from private car use and an increase in active travel, but could not determine how far this was the result of

free bus travel provision, given limitations in the study design (Halcrow Group Limited 2009). The proposed study aims to build on such 'grey literature' evaluations by drawing on: the relatively small, but developing, body of research on methodological approaches to studying interventions in complex system in the absence of RCT evidence; the (generally) qualitative literature that contributes to understanding the likely implications of transport interventions for inequalities in health; and the economic literature on the costs and benefits of transport systems and transport mode change. An initial conceptual model (see diagram in appendix) of how this intervention is hypothesised to affect the public health draws on a growing body of literature addressing elements of the likely causal pathways. This evidence is summarised below, under headings starting with the most immediate and direct effects of transport policies – injury – and ending with the more distal and difficult to measure.

Injury Injuries are the health outcomes most obviously associated with transport. Although attributing injury rate changes to transport policy is challenging, our previous research has developed methodological approaches for strengthening the credibility of causal attribution, through for instance using multiple interrupted time series analyses for evaluating the impact of 20mph zones on road safety. In the UK, despite falling rates of road traffic injury in young people, stark inequalities remain in the risk of being injured on the road, with those in more deprived areas and those in some minority ethnic groups at highest risk (Edwards et al 2006a, 2006b, Steinbach et al 2008). A major contributor to this risk, and to inequalities in risk, is exposure. Given that in the UK risks of road injury remain higher for pedestrians and cyclists (Sonkin et al 2006), the greater likelihood of those in lower income groups to be walking rather than being driven puts them at greater risk. Drawing on the evidence on exposure and injury, we hypothesise that injury risk and inequalities in injury risk will decrease if bus transport displaces those modes more exposed to road danger (ie walking and cycling), but increase if it displaces private car use.

Pollution Subsidising bus travel has long been seen as a potential strategy to reduce private car use (Quarmby 1967), and has attracted more recent interest as a key element in reducing pollution and global warming. The immediate health impacts from pollution reduction of any modal shifts resulting from this intervention are likely to be too modest to assess quantitatively within the proposed study (Tonne et al 2008). However, research suggests that short term interventions can have lasting changes on transport mode choice (see eg Fujii & Kitamura 2003), and we will qualitatively explore the potential for future modal shifts resulting from changing perceptions of the acceptability of bus travel for young people.

Public transport and active transport There is a growing body of international evidence demonstrating associations between 'active' commuting and lower risks for overweight (see eg Gordon-Larsen et al 2005, Oja et al 1998), with a systematic review estimated that active commuting was associated with an 11% reduction in cardio-vascular risk (Hamer & Chida 2007). These gains are also seen for adolescents cycling or walking to school (Cooper et al 2008, Oja et al 1998). In addition to the direct health gain for the individual, increasing the proportion of active transport compared with private car transport has been linked with rather ambitious public health gains, such as reduced global warming and increased social cohesion and community safety (DfT 2004a).

The role of public transport in encouraging active transport is poorly understood for the UK. Evidence from the US suggests that increasing access to public transport can increase the amount of active transport undertaken enough to have a public health impact on obesity, particularly for men (Zheng 2008, Besser & Donneberg

2005, Edwards 2008). In addition to walking to transport, there may be a gain from walking within transit systems (see eg a study from Paris on the proportion of walking done within transport systems (Julien & Carré 2002). In contexts such as London, with less private car use and better public transport provision, improving access to affordable public transport may have very different effects, and *reduce* the amounts of active transport undertaken, if it simply replaces walking. However, given the suggestive evidence from Scotland that concessionary fares can stimulate trip making (Halcrow Group 2009), the overall impact could be an increase in levels of active transport.

Transport interventions and inequality Ogilvie et al (2004) noted that in general we know relatively little about the social distribution of health impacts of transport interventions. International comparisons suggest that the distribution of active transport depends on inter-relationships between transport systems and social structure: for young people, for instance, active modes of travel to school or college were more likely in high income groups in the United States (Gordon-Larsen et al 2005) but less likely for immigrants and high income groups in Canada (Pabayo & Gauvin 2007). In single settings, the impact of policies such as free bus travel may well have differential impacts on different population groups over time, as the *social meaning* of bus travel, or walking, changes. Whereas active transport may have health benefits for those who *choose* it, qualitative evidence suggests negative health effects for those for whom it is a compulsory form of transport (Bostock 2001). Given the suggestion that *perceived* health benefits may be an important determinant of whether activity does benefit health or not (Crum & Langer 2007), and evidence that views on the role of transport vary by socio-economic status (Brunton et al 2006, SEU 2003), how people *understand* the role of transport (particularly active transport) and health will be key to unpacking potential pathways linking transport policy and health inequalities.

'Transport poverty' and social exclusion The Social Exclusion Unit (SEU 2003) reviewed literature and case studies on the ways in which poor access to transport can reinforce social exclusion, documenting how the cost of transport can be a barrier for 16-18 year olds undertaking education or training. Free bus travel for young people was intended to address such social exclusion due to transport poverty through, for instance, increasing access to education, training, and recreation. Access to transport is also likely to have health benefits for independent mobility for young people, which has been identified as important for increasing self-esteem and an essential factor in inequalities for young people. These are important outcomes, but there is in general less evidence on such wider social and health effects of different transportation choices (Watkiss et al 2000), and little robust research evidence to draw on. As Preston (2009) has noted, 'social exclusion' has proved difficult to operationalise, and more work is needed on quantifying health benefits beyond those of mortality reduction.

Transport for London commissioned some limited evaluative work on the impact of free bus travel on these outcomes (Synovate Ltd 2006, 2007), based on surveys of users and non-users of the scheme. As the samples were not representative of the population, no firm conclusions can be drawn from these about the impact on access to education, training or independent mobility, but 14-15 years olds reported that access to free bus travel had increased access to sports and other recreational opportunities (Synovate Ltd 2006), and the majority of 16-17 year olds 'strongly felt' that the scheme had increased their likelihood of staying in full time education, particularly in lower income and minority ethnic groups (Synovate Ltd 2007).

Updates of reviews The literature review will be updated at project start, drawing on the wide range of health, transport and methodological expertise of the applicants, and including reviews using an appropriate search strategy to search the transport databases TRIS (Transport Research Information Service), IRRD (International Road Research Documentation), and TRANSDOC and relevant web sites of the road safety organizations.

2.2 Risks and benefits

The introduction of free bus travel is, then, likely to have had a range of direct and indirect effects on public health and health equity, anticipated and unanticipated, positive and negative. Both risks and benefits are likely to have resulted from both the *increased availability* of transport to young people, and changes in the share of *modes* of transport used (eg, from walking to bus travel) by young people and others. We have reasonable evidence on which to hypothesise the direction of some of these effects, but rather weaker evidence for others, for which we will produce robust evidence for direction of effect where possible. The literature summarised above suggests a conceptual model of key causal pathways linking the intervention and health outcomes (see appendix), which would include the following major components:

Impact on the determinants of health for young people. These are likely to result from increased access to transport. Hypothesised benefits to wellbeing from reductions in 'transport poverty' accrue from increased access to education, training opportunities, social support, recreation and independent travel. Many of these outcomes are under-researched, and there are no data providing direct measures on potential benefits for health. However, for 2005-06, the Active People Survey has data on the activity patterns (periods per week of moderate physical activity) of a little over 1500 16 to 18 year olds in London, and data will soon to be available from the second survey. Such evidence will provide useful data as background to the qualitative analyses, which we propose to use *to map the impact of free bus travel on the broader determinants of health. We will also investigate potential sources of evidence on outcomes such as increased access to education post-16 and increased participation in active recreation.*

Impact on the amount of active transport undertaken by young people. Although the Synovate Ltd (2006, 2007) surveys identified reported lower use of car transport for school journeys, they also identified that bus travel had replaced some walking. Reduced active transport may exacerbate the rise in overweight, obesity and other cardio-vascular risks (Frank et al 2004, Gordon-Larsen et al 2005, Hamer and Chida et al 2008). While active transport is being encouraged as both a route to reducing pollution in urban areas and increasing the health status of the population (TSO 2004, DfT 2004, TfL 2006), as suggested in the literature review above, it is as yet unclear how far the provision of public transport influences the amount of active transport undertaken in the UK. We hypothesise that extending free bus travel has reduced the amount of active transport undertaken by young people. However, given that in other settings, increased public transport access has increased levels of walking, it is possible that this intervention has stimulated trip taking, and had an overall positive impact on the levels of active walking. London has relatively good and detailed travel diary data, which will allow us to look at changes in transport mode use before and after the intervention and at differences across population groups. *We aim to measure the impact of the introduction of free bus travel on travel mode share, thus evaluating the impact of extending free bus travel to young people on active transport levels.*

Impact on injury rates in young people. In terms of potential direct effects on health, both increased access and change of mode are also likely to change young people's *exposure to the risks of road traffic injury*, and (through potentially increasing the duration and range of their journeys) to assaults. We will explore the use of Bus Incident reports as a source of data on change over time in assaults, using methods that minimize the influence of potential variations in reporting practice. Injuries continue to be a key contributor to morbidity, mortality and inequalities in this age group (Edwards et al 2006, Edwards et al 2008). The effects of increasing access to transport in general and the effects of changes in mode of travel are likely to be bi-directional. Increasing access to and use of bus transport may lead to greater exposure over larger geographical distances, thus increasing risks of road injury or assault. However, changes in mode of travel, from walking or cycling to bus travel, may decrease exposure to road injury, given the evidence that (currently) in the UK, walking or cycling pose greater risks than other modes (Sonkin et al 2006). *We aim to measure the changes in road traffic injury and assaults following the introduction of free bus travel.*

Determinants of health for older age groups Changes to young people's travel behaviour could be hypothesised to have consequent effects on health and the determinants of health for other population groups. If larger numbers of young people are using buses, this may reduce willingness to travel for other users, either through direct exclusion (if buses are too full) or through 'fear-based exclusion', with elderly people in particular reported to be concerned about personal safety and security (DfT 1999). The extension of free travel to under 18 year olds has exacerbated public concern about criminal damage, anti-social behaviour and assaults on buses, although it has been difficult to identify whether incidents have actually increased (London Assembly 2008). Concerns about young people and their contribution to 'fear based exclusion' are certainly not new (DfT 1999), but it is unclear whether extending free travel for young people has contributed to reductions in wider population use of the bus network. *Using travel diary data, we will examine transport modal shifts in other age groups to identify trends over time in active transport. Qualitative research with older citizens will explore their accounts of links between young people's access and their own bus use.*

2.3 Rationale for current study

Need for research Wanless (2004) and others (Ogilvie et al 2006) have suggested that opportunities to learn more about the effects of policies (such as transport and other social policies) on public health need to be seized if the public health evidence base is to develop. The introduction of free bus travel to young people in London provides a unique opportunity to understand the health promoting and health damaging effects of a policy intervention and to contribute to methodological development in relation to evaluating the public health impact of interventions in complex settings. A key challenge is to develop methods for assessing health impact in the absence of RCT evidence. In many cases, **natural experiments** are likely to provide the best available evidence despite problems of confounding (Craig et al 2008). Such opportunities arise rarely.

In this case study, we have the opportunity to exploit relatively robust data sets (for instance, more detailed travel diary data than available for the rest of the country, and more complete road traffic injury data) in order first to address some key empirical questions that are currently underexplored. These include whether extending public transport provision in a UK setting increases or decreases active transport. In this context of increasing policy interest in the health effects of transport interventions, this is an important issue. Second, this team brings together an

established group that have been working on methods for evaluating public health interventions in complex systems with an internationally recognised group of transport economists, drawing on the well-developed methods for evaluating the economic costs and benefits of transport policies. This provides a significant opportunity to strengthen the health economic evaluation of such interventions.

The setting London is unique in its transport systems, with a faster growth in bus transport than other parts of the UK, and lower levels of car ownership. It also has a unique regional governance of the system (through the Mayor of London's duty to develop transport policies). The policy and infrastructure context (co-interventions, policy imperatives, bus availability) of the intervention will be carefully described in our outputs. Although, as with all single case studies, the specific empirical findings are likely to have limited generalisability in a narrow sense, there are good grounds for assuming a high degree of conceptual generalisability from this study. First, single case studies can demonstrate the possible. The Report from the Committee of the Social Determinants of Health (WHO 2008), for instance, cited the London congestion charge as an example of a transport policy with public health benefits. Second, lessons learnt from London are likely to be closely followed by other urban centres on issues such as the potential implications of policies that aim to increase bus travel. Third, methodologically, this case study will generate considerable knowledge of the strengths and weaknesses of secondary sources for evaluating public health outcomes; methods for integrating data to strengthen the credibility of causal pathways; and designs for strengthening causal inference through appropriate internal comparisons.

3. Research objectives

To develop our understanding of how travel access affects the indirect or **broader determinants of health**, we aim to explore the likely effects through qualitative work mapping young people's and older citizens' experiences and views. Integrated with the quantitative findings, this will contribute to identifying plausible causal pathways that link transport to health.

To assess the public health impact of free bus travel we need first to identify changes in travel behaviour, to estimate the impact on a key **determinant of health** (active transport) and on potential travel exclusion for both young people themselves, and for other age groups in the population. Second, we need to identify changes to injury rates for 12-15 and 16-17 year olds before and after Sept 2005 and 2006 respectively in order to estimate the impact on **direct health outcomes** for these age groups. We then need to account as far as possible for confounders through appropriate population, place and time comparisons. With robust estimates of the effects on injury and active transport, we can then develop methods for economic evaluation. The objectives of the study are therefore to:

1. Determine the causal pathways that plausibly link transport interventions and young people's health;
2. Identify the ways in which young people and older citizens understand the role of bus and other transport mode access in facilitating and constraining their wellbeing;
3. Assess the impact of free bus travel for 12-17 year olds on their use of bus and other transport modes;
4. Assess the impact of free bus travel for 12-17 year olds on the use of bus and other transport modes by older age population groups;
5. Identify changes in the incidence of injury in young people after they had access to free bus travel;

6. Investigate, develop and apply a method for conducting an economic evaluation of the health impacts from introducing free bus travel for young people in London and other similar social interventions.

4. Research design

4.1 General design issues

This mixed-methods study will essentially track a natural experiment (Petticrew et al 2005). It aims to integrate a range of data sources and methods of analysis within a quasi-experimental design in order to evaluate the impact on public health of the introduction of free bus travel for young people in London. In order to develop a detailed causal pathway model, and evaluate the positive and negative impacts on health, we will use a combination of methods. First, qualitative research will be used to explore young people's and older citizens' perspectives. Second, secondary analysis of existing data sets will be used to determine the impact of the intervention on travel behaviour (modes of transport used) and active recreation to identify the likely impact on active transport. Third, secondary analysis of police data and Hospital Episode Statistics will be used to assess the impact of free bus travel on injury outcomes (transport injuries and assaults). Working with our advisory group, these data sources will be integrated to develop plausible causal pathways linking transport and the broader determinants of health. Finally, we will draw on the growing body of evidence on monetary values for health effects (eg injuries, assaults and changes to levels of active transport) to develop and conduct an economic evaluation of the key health outcomes identified by this case study.

The general design of this evaluation equates to an untreated control group design with pre- and post-test in Cook and Campbell's terminology, which they note is the most frequently-used interpretable quasi-experimental design. However, within each aim (see below) we propose methods to increase the credibility of causal inference. These will utilise best practice in the design and analysis of observational studies to minimise threats from confounding, and increase the credibility of causal attribution. We will examine aspects of internal consistency of evidence (whether intervention effects are similar in different age groups, and across more than one outcome); specificity (facilitated by comparison of changes in London with other cities and in London taking account of national background trends); and coherence (addressed through cross-reference to existing studies and knowledge of the determinants of active travel, and through the new qualitative data). Evidence for some outcomes (eg injuries) will be stronger, given there is sufficient data to conduct interrupted time series analyses. Causality is also determined by the observed strength of association which will be assessed at the analysis stage. Glasziou (2007) and others for example provide guidance on the interpretation of effect size data from observational studies when RCTs are not possible. The examination of Dose-Response relationships will strengthen the credibility of interpretation, and these will be estimated by the use of proxy measures of bus access, such as SOA level Public Transport Accessibility Levels. Qualitative data derived from a range of stakeholders will also permit examination of "local history" explanations for any observed differences. GIS methods will be used to describe in detail the transport environment across the study area.

4.2.Methods

4.2.1 Methods - Aim 1

To determine the causal pathways that may plausibly link transport interventions and young people's health.

In addition to adding to much needed evidence in the field of transport, this study will contribute to methodological development by: identifying and reviewing available and

robust sources of data that can be used to estimate public health gain; identify and assess methods for addressing known biases in observational studies (eg, setting out clear *a priori* hypotheses, using appropriate comparator data sets to address known confounders, use of multiple data sources) and develop understanding of causal attribution in non-RCT designs through integrating qualitative and other data sources.
The approach will involve using the qualitative data which describes (among other things) the choices young people make about transport, and the influences on their travel behaviour; observational data; interviews with other stakeholders; and quantitative data on the actual changes in transport behaviour. These will be integrated into a general model describing the relevant causal pathways and the specific mechanisms. This is consistent with recommendations from Shadish et al. (2002) on the use of qualitative and quantitative data to support the development of generalised causal inferences from experimental and quasi-experimental studies. They describe how observational/ethnographic methods and statistical models incorporating independent, dependent, mediating and moderating variables can be integrated (as we intend in this study), with the purpose of exploring potential explanations and pathways. While no study is in itself intrinsically generalisable to all settings, generalisations can be rendered more causally convincing if they explore detailed pathways, mechanisms, and outcomes, as we seek to do in this project. This applies as much to experimental as to non-experimental evaluative studies. However if this process of describing mechanisms is done thoroughly, then common underlying processes may be identified which may be relevant to similar interventions in other settings (such as other cities).

It can be argued that London is unique and the findings are not generalisable. However the same argument can be made about *any* evaluation of a social intervention, in any setting, randomised or otherwise. But while contexts, settings and indeed the intervention itself may vary, this does not mean we should not seek to learn about the processes and impacts of individual interventions. In short, each new evaluation then contributes to the wider public health evidence base – illustrating the range and size of positive and negative impacts, their social distribution and the potential mechanisms by which these were achieved; this information can then inform subsequent decision-making about similar types of intervention, and can inform the methods of future evaluations.

As we intend to use both descriptive (qualitative) and quantitative synthesis, we will use developing narrative synthesis methods to report results from diverse sources (Arai et al 2005).

4.2.2 Methods - Aim 2

To identify the ways in which young people and older citizens understand the role of bus and other transport mode access in facilitating and constraining their wellbeing.

The secondary data will provide a detailed analysis of changes in transport behaviour and injury outcomes in the London population, compared with others where appropriate, from which we can identify public health gains and losses. However, the pathways linking transport choices, transport behaviour and the determinants of health are complex and multi-directional. The **qualitative component**, which will inform and be informed by the quantitative analysis, aims to explore young people's accounts of the impact of the transport on the broader determinants of health, and identify (from analysis of those accounts and additional data from other users and key stakeholders) plausible pathways by which policy, access and behaviour interact to constrain and facilitate wellbeing. Understanding how young people's perceptions of risk and safety interact with other criteria (eg availability and cost of transport) in

their decisions about modes of transport is essential if we are to identify: barriers to active transport; how access to travel may change access to both healthy and unhealthy public spaces; exposure to risks of assault, injury or other harm. For young people, independent travel presents opportunities for: access to education, employment, goods and services; both health promoting and health damaging social networks and the development of autonomy and self-confidence. It also presents a set of risks to be managed, particularly in urban areas where the risks of assault or road danger are perceived as high.

Previous research has identified some of the constraints acting on young people's travel in urban areas; the complex strategies young people adopt both to maximise their own safety whilst travelling independently and to allay parental fears about their independent travel (Brunton et al 2006, Jones et al 2000); and has identified the need for more research on the structural determinants of risk exposure (Thomas et al 2007). The qualitative component of this study will use a combination of individual interviews, group interviews and observation to map how transport use is related to: opportunities for independent travel; social inclusion; health promoting activity and risks to health.

Although the primary focus of this study is on the public health implications for young people, we also aim to capture the potential impact on other population groups. The qualitative component will focus on older people, for two reasons. First, those aged over 60 also have access to free travel, through Freedom Pass issued by local authorities in London. Second, concerns have been expressed (although to our knowledge, these are not evidence-based) about the possible effects specifically on older people's access to bus travel resulting from increased access for young people (eg from over-crowded buses, or fear-based exclusion).

Sample The aims of the sampling strategy are to recruit a maximum variation sample (in terms of those variables likely to shape experiences and accounts, such as transport availability, gender, age, ethnicity, disability, area deprivation). We will do this by selecting four contrasting areas of London (selected to include 'bus rich'/'bus poor' areas of contrasting area deprivation from inner and outer London) and theoretically sampling young people within those areas. We aim to recruit young people to the research team via social networking web sites (eg FaceBook groups) who can help with recruitment for different population groups, as well as recruiting through conventional community networks (eg sports clubs, community organisations, supplementary schools), and through a young people's involvement project in an inner London borough. Drawing on 'theoretical sampling' techniques (in which early data analysis is used to suggest later sampling decisions, and where later data is used to 'test' emerging hypotheses) we plan to sample to the point of saturation (when additional data adds little to ongoing analysis), with an estimate of up to **50 young people** in individual (or pair, if participants prefer) interviews and **8 group interviews** (of around 5 participants, N=approx 40 participants) would achieve this. We aim to use both individual and group interviews, as individual interviews are more likely to generate detailed accounts of sensitive information around perceived risks and health impacts, whereas group interviews (particularly if using natural groups) access more normative accounts of behaviour and the ways in which participants' understanding of transport and health is socially generated.

Recruitment of **older citizens** in the same areas will also be carried out in ways designed to obtain a maximum variation sample include both 'younger' and 'older' over 60 year olds in outer and inner London boroughs likely to have been affected by bus use by other groups. Recruitment of individuals will be through community groups, and for those more socially isolated through 'park bench' approaches and on

buses. These approaches will be made by an experienced researcher (HR). Again, we will sample to saturation, with the expectation that this will be reached by including around 25 individuals.

Data generation and analysis Pilot work carried out as part of a study for TfL (Steinbach et al 2007) suggests that: well designed interviews are a productive way to generate data on young people's experiences and accounts of transport; that this was a topic of interest to them and that there were variations in accounts from those across London's diverse ethnic communities. Interviews will begin with narrative questions focusing on how young people manage transport within their daily lives. Later parts of the individual and group interviews will be more semi-structured, including questions related to how:

- Participants understand and manage the opportunities and risks posed by different transport modes;
- Accounts of risks and opportunities are related to the broader determinants of health;
- Access to free bus/tram travel in London affects reported travel behaviours and risk management strategies.

An essential element will be **observational ethnographic data**, generated by observation of transport behaviour in everyday life in public spaces, including bus travel (in and outside school hours) to capture what people do, as well as what they say they do, and informal interviews with other transport users, parents, and other stakeholders. Analysis of all qualitative data will use principles of the constant comparative method (Strauss 1987), including detailed use of open coding on early data, development of conceptual coding schemes and an iterative approach to hypothesis generation and testing. Our experience is that for policy orientated research, an approach which goes beyond thematic analysis is vital for generating both valid and useful theory for practice.

4.2.3 Methods. Quantitative analyses: Aims 3, 4 and 5

- *To assess the impact of free bus travel for 12-17 year olds on their use of bus and other transport modes (including active transport i.e. walking and cycling);*
- *To assess the impact of free bus travel for 12-17 year olds on bus transport and other transport modes by older age groups.*
- *To determine changes in the incidence of injury in young people after they had access to free bus travel*

Quantitative data series are available for London on use of transport, including walking and cycling (London Area Travel Survey (LATS), London Travel Demand Survey (LTDS)), and injuries (Stats19 road injury data, Hospital Episode Statistics (HES)). These allow analyses of change in important outcomes following the introduction of the free bus and tram travel scheme. The quantification of change will be based on before-after comparisons using two time points: (i) the introduction of free bus travel in London to children <16 years in September 2005 and (ii) its extension to those under 18 years in September 2006. To minimize possible bias arising from changes over time in the completeness of data recording, for most analyses we propose to compare the changes in the relevant outcomes in the under 18s (under 16s) with those observed at other ages: a *change-on-change* analysis. Although this carries some penalty in terms of statistical power, the comparatively large number of events at other ages means the penalty is modest, while achieving a gain of reduced potential for bias. We will examine the following outcomes:

- the frequency and distance of **active transport (i.e. walking and cycling)** in those aged 12–17 years ;
- the frequency of **bus use and the distance travelled by bus**, in those aged 12–15 and 16–17 years;
- the **frequency of bus travel** and the distance travelled by bus in other age groups;
- the **incidence of intentional and non-intentional injuries** in young people aged 12-17.

Table 1: Available sample sizes of main secondary data sets

	2001	2002	2003	2004	2005	2006	2007	2008
FREE BUS/TRAM SCHEME					<16s	<18s		
	Pre-intervention				Post-intervention periods			
London Area Travel Survey (LATS) [number of households]	30,000							
London Travel & Demand Survey (LTDS) [number of households]					5,000	8,000	8,000	8,000
National Travel Surveys (NTS) [number of households]	9,000	9,000	9,000	9,000	9,000	9,000	9,000	
Stats19 [persons] (percent in 12-17 years)	45,000 *(7%)*	41,000 *(7%)*	39,000 *(7%)*	35,000 *(7%)*	32,000 *(7%)*	29,000 *(6%)*	Not yet analysed	Not yet analysed
Hospital Episode Statistics (external cause admissions in London)	*100k (350)*	*100k (350)*	*100k (350)*	*100k (350)*	*100k (350)*	*100k (350)*	*100k (350)*	*100k (350)*

Travel patterns: LATS, LTDS. We will use data collected five years before the interventions in the 2001 London Area Transport Survey (LATS), and data from the 2005–2007 London Travel Demand Surveys (LTDS) for the post-interventions period. The LATS and LTDS surveys collect comparable travel data sets based on daily travel diaries, using comparable sampling designs. The 2001 LATS included 30,000 households and LTDS included 5,000 households in 2005, with a further 8,000 households annually since 2006. Every person aged over 5 years living in each household is asked to complete a one-day travel diary that records the starts, interchanges and ends of every trip made on that day. In 2001 LATS there were 360,389 interchanges (parts of trips) made by 67,252 individuals. With similar levels of travel in 2005–2008 we expect data to be available on over 250,000 travel interchanges made by 47,000 individuals. Journey times are collected in both LATS and LTDS. Journey distance is estimated using the start-point, interchange and end-point of each trip (these locations are geo-coded and 'crow-fly' distances are easily calculated). For the travel patterns, comparisons will also be made with data from the National Travel Survey (NTS, Department for Transport). This national survey includes samples of approximately 9,000 households each year, including

approximately 20,000 individuals, with data from seven day travel diaries for each individual. The inclusion of NTS data will enable us to assess whether trends in main travel modes nationally and in other urban areas differ to those used as main modes in London.

Travel-related injuries and assaults: Stats19, bus incident reports, HES. **STATS19 road injury data,** the official dataset of human death and personal injuries from road traffic crashes on the public highway in the UK**,** are available for each year of the study (to 2009). We will analyse casualties among young people travelling as pedestrians, cyclists, car occupants and bus occupants, and by severity of injury ('Fatal' or 'Serious' (hospital admission), and 'Slight' - minor injuries).

STATS19 data remain the richest source of information on road traffic injuries in England, and are an essential component of assessments of transport effects on injury events. Although there is recognised to be a degree of under-reporting in STATS19 data, the completeness in London is estimated to be around 87%, and the change-on-change analysis will help to minimize bias arising from year-to-year variations in completeness. Comparatively long series of Stats19 data are available and our experience has demonstrated the value of using these longer series, stratified by key factors, to derive more accurate estimates of the relevant trends and step effects. Differences in these between socio-demographic strata *within* London are likely to be an important element of the interpretation of the quantitative data. Published analyses of national data will be used to estimate national and urban area background trends in injury rates.

The utility of **bus incident reports** and other data sets will be examined for the potential to identify changes in assaults, if the known problems of reporting bias can be addressed. If feasible methods for evaluating transport interventions are to be developed, it is essential to generate knowledge about the uses and limitations of routine data sets for evaluating outcomes.

An extract of **Hospital Episode Statistics** (HES) will be obtained for England covering the period 2001 to 2009. We will identify all London residents using census super output area (SOA) code of residence. We will analyse hospital admissions due to all ICD external causes of injury, and specifically those external causes directly influenced by transport access (e.g. transport injuries, assaults). Comparisons will be made with admissions for other external causes that are not plausibly linked to transport policy change (e.g. poisoning, falls, self-harm). We will include all admissions, given that restricting our case definition by injury severity will greatly reduce the sample size available, but will conduct a sensitivity analysis using only severe injury admissions to test whether differential admission rates by external cause over time may have introduced bias (e.g. due to differences in admissions policy) .

Analysis. For all outcomes, the principal analysis will be the comparison of the change before and after September 2005 (for those aged 12-15), and before and after September 2006 (for those aged 16–17 years). These changes will be compared with similarly-defined change at other ages. Where relevant, appropriate denominator populations (ONS population projections) will be used to allow for differences between years in the number of young people at risk. Robust standard errors will be calculated, clustering on borough to allow for similarities of outcome at that geographical level. We will also explore the use of other multi-level modelling methods to allow for other forms of data hierarchy relating to spatial variation in bus service provision.

To assess the impact of the interventions on transport (including active transport) we will compare mean times and distances, as well as the percentage of short distance trips travelled by the relevant mode (walking, cycling, bus, car). We will also estimate changes in amounts of travel on journeys to work or school in people aged under 18 years (to assess potential increased access to education).

For all outcomes, we will investigate evidence for variations by socio-economic group or household income and, where possible, by ethnicity (to address questions of impact on inequalities), although power will be limited for most such sub-group analyses.

Sample size *Example of power to detect changes in distance of trips made by bus and walking*
Provisional 2001 estimates of the distances of trips made by young people by bus and by walking are shown below. With 3,000 young people in the sample before and after the intervention, the study will have 80% power to detect a 10% reduction in the average daily distances walked by young people (from an average 0.91 km per day to 0.82 km per day) at a 5% significance level. Similarly, the study would have 98% power to detect a 10% increase in the distance of bus travel from an average of 4.33 km per day to an average 4.76 km per day. For transport-related injury, the study would have 80% power to detect a 10% change, or 90% power to detect a 12% change significant at the 5% level. Statistical power is inevitably more limited for subgroup analyses, but for example there is 90% power to detect a 15% change in average distance travelled by bus by young people *within the most deprived quartile*.

Table 2: Average distances by mode for Londoners aged 12-17 years (LATS 2001)

	12–15 years	*16–17 years*	*Total*
Number in sample	3,150	2,300	5,450
Average distance per bus trip (km) [SD]	4.19 [4.4]	4.51 [3.8]	4.33 [4.1]
Average distance per walking trip (km) [SD]	0.87 [1.2]	0.95 [1.35]	0.91[1.26]

4.2.5 Methods - Aim 6

Investigate, develop and apply a method for conducting an economic evaluation of the health impacts from introducing free bus travel for young people in London and other similar social interventions.

In the field of transport there is a strong body of literature focusing on evaluating the costs and benefits of transport strategies and interventions from the perspective of the economy, environment and social aspects. In terms of evaluating the range of impacts on health from an intervention the literature is less focused, but increasing. The aim of this task will be to develop and apply an evaluation method that will allow policy makers to evaluate the impact on health and injury from this intervention. Firstly, a background review will be conducted focusing on how health has been included in the evaluation of transport policy interventions (including WHO (2008), Bickel et al (2006) and DfT (2004b)) to identify the main methodological options and recommend an approach for this study.

The evaluation will draw on the well established literature on values associated with slight, serious and fatal injuries (DfT, 2009a), Home Office (2005) values used for crime (including assault) and the emerging literature on the health effects from changes to walking and cycling (DfT, 2009b). The quantitative work in aim 5 (incidence of injury) and 3 and 4 (changes in active transport) will be used as key inputs into the evaluation. This will be combined with an assessment of the cost that has been incurred by TfL as a result of introducing concessionary fares (eg from lost

revenue, from administration of the scheme), as part of a value for money assessment. Given the focus on young people, particular attention will be applied to the appropriate use of economic values for the target age group concerned based on the existing literature. It will not be possible to value all the impacts identified between health and transport in the causal pathway exercise. A qualitative, and where possible quantitative, assessment of these impacts will be implemented where appropriate. There will therefore be scope to extend this assessment in the future.

This evaluation methodology will allow the research team to assess whether the policy has had an overall positive economic impact when compared with the costs and benefits based on the inputs that can be monetised for public health. It will then, in combination with the qualitative and quantitative assessments, provide an impact assessment of the policy with regard to public health. This approach of combining both a value for money assessment alongside other impacts that are assessed either qualitatively or quantitatively is common practice in transport policy evaluation (DfT 2005c), and this study provides an opportunity to identify the utility of this approach within public health evaluations.

5. Study population

The primary study population is residents of London aged 12-17 years old. However, as other groups will be affected by the intervention, the wider study population is all residents of London aged over 12. Populations for specific objectives are detailed above (Section 4.2).

6. The intervention

The intervention is the introduction of free bus travel for young people under 16 years old in September 2005 and those under 18 years old (in full time education or unwaged training) in September 2006.

7. Outcome measures

Key outcome measures investigated in this study are:

- reported health benefits and risks of access to bus travel for young people and older citizens;
- change in the time and distance of active transport (walking, cycling) undertaken by young people and older age groups;
- change in road transport injuries in young people;
- change in assault injuries in young people.

In addition, our review of the literature and available evidence will identify existing evidence on the following outcome measures:

- Changes in access to education and training for 16-18 year olds;
- Changes in active recreational activity;
- Changes in bus incidents.

These are detailed in the methods section (4.2) above.

8 – 10. Assessment and follow up; sample sizes; statistical analysis

Assessment of outcomes, sample sizes and analyses are all detailed under methods for specific components, above (Section 4.2)

11. Ethical arrangements

The study will be conducted in accordance with MRC guidelines, those of LSHTM and good practice for social research (the ESRC ethical framework). Approval from

LSHTM Ethics Committee will be sought. All confidential data will be stored on the secure server of LSHTM. Access to data files on this server is traced using the 'LT auditor plus' software. Our Information Security and Management Policy is compliant with BS7799. Qualitative data (MP3 files, transcripts) will be kept securely, with only coded identifiers. As the data sets accessed directly in this study (STATS19, HES, LATS/LTDS) are the property of DfT, DoH and TfL respectively, they will be destroyed at project-end according to conditions determined by the data providers. Our Records Management policy requires primary data generated to be kept securely for at least 10 years post the study end date.

In addition to the usual ethical issues of maintaining confidentiality and considering representation, there are additional ethical concerns in working with young people, including those of ensuring adequate consent to inclusion, and minimizing the exclusion of marginalized young people. Our recruitment strategy is designed to maximize inclusion, and young people participating will be deemed competent to make their own decisions (MRC *Ethics Guide: Medical Research Involving Children*); ie those under 16 years will not be excluded if parental consent cannot be obtained. Interview protocols will be developed to cover disclosures of harm. Consent is a process rather than a one-off event, and participants will be involved in discussing consent as the work progresses. Observational studies of public behaviour (such as behaviour on public transport) raise ethical issues around inability to secure consent; as the ESRC guidelines note, informed consent is 'impracticable and meaningless' in such situations (ESRC http://www.esrc.ac.uk/ESRCInfoCentre/Images/ESRC_Re_Ethics_Frame_tcm6-11291.pdf p21), and it would be impossible to secure consent from, say, all bus passengers to note- taking by research staff. However, we believe that observational data on how travellers do behave is an essential adjunct to the data we will generate on how they say they behave. Any observational data in the form of field notes will be anonymised, with confidentiality ensured through coded use of contextual identifiers, and accounts written with respect for participants.

12. Research governance

The sponsor of this project will be LSHTM. We will establish a study steering committee to: advise on the primary qualitative study; facilitate access to key stakeholders; assist with knowledge translation. We will therefore include representatives from Policy Analysis and Surface Transport at Transport for London (as the intervention provider), a member of the Public Health Centre for Excellence at NICE (as the key provider of public health guidance)**;** a user of routine data on transport; a member of a local authority scrutiny committee with responsibility for health. We would also hope to include colleagues from Canada and Australia working on complex interventions who are part of the CIHR funded International Collaboration on complex interventions of which Petticrew and Roberts are members. This steering committee will also include the applicants and collaborators (including Suzanne Lutchman representing an NHS public health department). There will in addition be seminars and regular, minuted meetings of the investigators, employed researcher(s) and collaborators.

We do not feel that this piece of work requires a data monitoring and ethics committee, but will discuss emerging results with the Study Steering Committee. End point users will be involved in the work in ways which use their lay expertise but outwith the steering group.

13. Timetable and milestones

13.1 *Summary Timetable*

	Year 1: 2010/11						Year 2: 2011/12						Year 3: 2012		
	M/A	M/J	J/A	S/O	N/D	J/F	M/A	M/J	J/A	S/O	N/D	J/F	M/A	M/J	J/A
Recruitment / ethics approval															
Update literature review															
Access and prepare quantitative data sets															
Review of additional data sources															
Quantitative analysis															
Recruit participants															
Qualitative fieldwork															
Qualitative analysis															
Develop economic evaluation methodology															
Complete economic evaluation															
Seminars-Collaborators															
Workshops/conferences															
Writing up															

13.2 *Key Milestones*

Year 1

- Complete ethical approval — June 2010
- First investigators' seminar –develop conceptual model — April 2010
- Access required data sets for quantitative components — Aug 2010
- Complete review of additional data sets — Feb 2011

Year 2

- Complete interviews and focus groups — Aug 2011
- Complete qualitative analysis — Oct 2011
- Complete quantitative analysis — Aug 2011
- Circulate working paper on casual pathways — Sept 2011
- Complete economic evaluation — Feb 2012

Year 3

- Hold workshop for stakeholders — May 2012
- Complete draft papers on empirical findings, implications for public health, economic evaluation, methodology — July 2012
- Final report to funders — Aug 2012

14. Expertise

This proposal arises from the ongoing work at LSHTM and IoE on transport and health, on methods to evaluate public health interventions, on understanding complex interventions, and on direct work with children and young people, and from the ITS at Leeds on the evaluation of transport policy. The research team has a proven track record, with peer-reviewed output in areas including: secondary analysis of transport and health data; the evaluation of complex interventions (including transport interventions); qualitative research with young people and on the use and synthesis of mixed-methods in public health research. Recent and ongoing grants from DH and TfL have included studies of inequalities in road injury, from ESRC on methodological work, from the Canadian Institutes for Health Research on complex interventions, and from WHO on the injuries report for the Commission on the Social

Determinants of Health. Members of the team have collaborated successfully on a large number of previous grants and publications, completed to time and to budget, and have engaged in knowledge translation through scientific and stakeholder publications and engagement with policy makers, end point users of services and practitioners.

The applicants benefit from the institutional base of large multi-disciplinary departments of Public Health at LSHTM, social science at IOE, and the Institute for Transport Studies at Leeds, one of the world's leading academic centres of transport research. The team have excellent links with relevant stakeholders (including TfL, DfT, and the Wellcome convened workshop on Environmental Determinants of Physical Activity). The Transport and Health group at LSHTM is a collaboration that has developed considerable experience of working together on mixed methods studies, and draws on expertise more broadly across LSHTM, and ITS at Leeds has an internationally recognised record of collaborative work on transport policy and appraisal.

15. Members of the public

This study is likely to be of direct interest to the public, not only in London, but also those in cities worldwide who are following with interest the ways in which transport policies in London impact on health, social cohesion, congestion and air quality. Our policy (and practice to date) is to share information in a timely manner. We will do this through briefings to colleagues in TfL, the establishment of an 'On the buses' website which will link to internet networking sites, and short items in mainstream news services generated by young people (http://www.headliners.org/). Young people's input will aid in identifying dissemination opportunities.

Apart from peer-reviewed journal articles on public health, economic evaluation and methodological findings, this research is likely to generate findings useful for policy makers, in particular identifying the range of positive and negative impacts which need to be taken into account when planning new transport policies. This work is therefore likely to be of value in future health impact assessments of transport interventions, including modeling work on likely health impact. In the shorter term, we will ensure that learning in both directions (policy and practice to research and vice versa) will be facilitated through the advisory group, including key stakeholders (London Health Commission representatives, a young people's participation worker; TfL representatives) in a process of integrated knowledge exchange, recognizing the importance of stakeholders to the process of knowledge production. We will publish in stakeholder publications, including those aimed at transport policy makers and public health practitioners. Petticrew and Roberts are part of an international collaboration on complex interventions funded by the Canadian Institutes for Health Research, which provides an opportunity to disseminate the methodological work internationally.

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