Transport, Physical Activity and Health:
Present knowledge and the way ahead

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Foreword

This document contains a review of the literature in the field of transport and physical activity. It was funded by the Department for Transport through the Short-Term Analysis Programme of the UK Transport Research Centre (UKTRC). The purpose of the project which led to this review was to bring together experts from the fields of transport and physical activity, and complementary fields, to share knowledge and exchange ideas through a series of workshops, to examine the evidence of the role of transport in influencing levels of physical activity and hence its possible contribution to the solution of the health problems caused by the decline in physical activity.

The following people were members of the group of experts:

- Professor Roger Mackett, Centre for Transport Studies, University College London (convenor of the group);
- Mrs Belinda Brown, Centre for Transport Studies, University College London (secretary of the group);
- Professor Fiona Bull, School of Sport and Exercise Science, University of Loughborough;
- Mr Nick Cavill, Cavill and Associates;
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- Professor Catharine Ward Thompson, OPENspace Research Centre, Edinburgh College of Art and University of Edinburgh;
- Mr Ben Watson, Policy Studies Institute, London.

Members of staff from the Department for Transport and other experts attended individual meetings and contributed to the discussions.

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ABSTRACT

The objective of this report is to consider the available evidence on the role of transport in increasing levels of physical activity, and so contribute to addressing the nation's health problems caused by low levels of physical activity. Evidence on the links between transport and physical activity is examined, followed by examination of the effects of individual behaviour on physical activity. Whilst research on this topic has had some impact, there are a number on concerns about the approach, in particular the lack of evidence on long-term effects. Modifications to the built environment to increase physical activity are discussed: these need to be supported by other measures to be fully effective. The key relationship is between car use and physical activity. In order to increase levels of physical activity, it is necessary to reduce use of the car. Because so many households have adopted lifestyles that revolve around the use of the car, it is important to recognise that any policies to reduce car use must provide as much, or close to as much, accessibility as the car does. One way to do this is to shift the method of accessing cars from individual household ownership to a more flexible system of hiring or sharing cars. There would need to be a variety of supporting policy actions affecting transport and land use. It would be very useful to have a wide debate about transport modelling to ensure that the models represent travel and locational behaviour effectively, including factors that represent physical activity; the discussion should include the cost effectiveness of making changes to the existing modelling system. The implementation of the approach presented in the report could lead to significant improvements in the health of the nation and cost savings to the National Health Service.

EXECUTIVE SUMMARY

Levels of physical activity are decreasing in Britain, as in many other countries, and this is likely to lead to serious health problems because fewer than half the population of Britain achieve the recommended levels of physical activity. In 1996 the US Surgeon General produced a report which explicitly recognised the potential contribution of everyday physical activity, including walking and cycling, to health. This has been acknowledged by both the Department of Health and the Department of Transport in Britain. Walking and cycling have decreased over the years which may have contributed to the decline in physical activity. All forms of transport influence physical activity either directly or indirectly and so offer the potential for increasing levels of physical activity.

Much health research has been carried out into the effects of individual behaviour on physical activity. The evidence suggests that interventions need a supportive social environment to be effective. Evidence of the cost-effectiveness of interventions is limited and the is a need for on-going investment for them to be sustainable

Modifying the built environment has been identified as one way to influence levels of physical activity, for example by increasing the suitability of an area for walking and modifying the nature and layout of the street network. There are difficulties in this approach including issues of measurement and establishing causality. Whilst changing physical infrastructure alone may not have a direct effect on physical activity, there is evidence that good physical infrastructure may be a pre-requisite for the effectiveness of other, less tangible, measures.

Walking and cycling offer effective routes to increasing physical activity, but reversing their long-term decline would require a shift from the car because of its dominance as a form of travel. Cars have a number of negative effects including causing fatalities in road crashes, atmospheric pollution, community severance and, in the long run, decentralisation of urban areas, all of which adversely affect walking and cycling.

There are a number of ways that encouraging a shift from the car to walking and cycling can be approached: changing the travel behaviour of households, introducing measures to encourage more walking and cycling, charging for use of the road, land use measures, and a variety of softer measures. There have been a number of schemes which appear to have reduced car use, but there have been no systematic, robust studies that have shown unequivocally that particular measures do cause a shift from the car. Hence it not clear which are the most effective instruments for increasing walking and cycling.

It is very important to be sensitive to the political barriers to reducing car use. Car use has become entrenched into the lifestyles of many households in Britain. Rather than start what might been seen as an attack on the lifestyles of a large proportion of the population of this country, existing initiatives could be taken forward with increased effort and funding. There is a large overlap between the health agenda to increase physical activity and the transport agenda to encourage more sustainable travel because both can be aided significantly by behaviour changes to increase walking and cycling. This would be facilitated by more explicit links between health

and transport professionals, both researchers and policy makers, at national and local levels, for example by sharing knowledge of the evidence on the impact of walking and cycling schemes.

Existing levels of accessibility could probably be maintained whilst reducing car use by moving away from the present norm of a household owning one or more cars to a more pluralistic approach with households using a wider variety of modes. This would imply changing the costing system for the car from a large initial investment with trips being relatively cheap, particularly when travelling with others, to a system comparable with that for other modes. Households can access cars in a variety of ways including car clubs and neighbourhood car rental in addition to taxis and car rental. The economics of these schemes mean that many households that do not make many car trips would probably be better off by joining such a scheme rather than owning a car. There is evidence that people who do not own cars tend to walk and cycle more than similar people who own cars. By providing alternative forms of access to cars, such schemes enable more people to manage without owning cars and therefore may have the potential, over time, to increase their levels of active travel. People often consider their car ownership requirements at significant transition points in their lives such as moving home, so it could be effective to enable agencies involved in these processes to provide information to households. This strategy of shifting from household car ownership could be supported by complementary policies of increasing the cost of fuel, reducing car parking spaces and encouraging pay-as-you-drive motor insurance, plus more congestion charging schemes with the revenue going towards making the alternatives to the car more attractive. If there were a consequent reduction in car use it would be important to transfer road space from cars to walking and cycling to prevent the car trips being induced by the lower journey times caused by the reduction in traffic.

This shift from the car towards walking and cycling should make urban areas more attractive which should help to slow down the outward movement of households seeking more pleasant environments in which to bring up children, which leads to more car use. This would need to be complemented by providing suitable housing within urban areas.

Some of the transport models that have been used have not been very accurate at forecasting nor are they sensitive enough to forecast many of the relevant aspects of travel behaviour. One approach to doing so would be to use microsimulation modelling which represents the travel and related decisions of a set of households over time. The modelling approach currently used ignores the effects of changes to the transport network on locational decisions by both households and developers. It would be useful to have a debate about the models used for forecasting and to set up a programme like the Travel Model Improvement Program in the United States. It would be useful if the financial benefits of health resulting from more physical activity were incorporated into the appraisal process for new transport schemes. It may be appropriate to change the decision-making procedures used for schemes such as retail developments, hospitals and schools so that the travel demands of the users (customers, patients and their visitors, and pupils) and are taken into account explicitly in decisions about new locations.

This report shows that there is a large body of evidence about ways of increasing walking and cycling through a variety of measures. There is sufficient evidence available to pursue some of the initiatives now. However, it would be useful to carry out further research into a number of areas, particularly into ways of meeting the perceived accessibility needs of car users and their households, how to make alternatives methods of car access besides owning one or more cars more attractive and effective, understanding of the analytical relationships between the various modes, and significant improvements to the modelling and appraisal framework including more explicit representation of walking and cycling and their benefits.

The main findings of this report are:

- *Walking and cycling have key contributions to make to improving health through increasing physical activity;*
- *In order to increase walking and cycling it is important to reduce car use;*
- *Behaviour change is required to encourage a shift from the car to walking and cycling; evidence from health research shows that this is likely to be more effective in a supportive social environment;*
- *Modifications to the physical environment will not increase physical activity significantly unless supported by other measures;*
- *Changing the economics of car use towards a system that encourages a more rational consideration of modal choice should encourage a reduction in car use;*
- *A more rational form of household access to cars would involve the use of car clubs, neighbourhood car rental and car sharing;*
- *This approach could be complemented by measures such as congestion charging, pay-as-you-go car insurance and transferring road space from car use to walking and cycling;*
- *When schemes such as new shopping centres, hospitals and schools are being developed, the journeys of the potential users should be taken into consideration in the decision-making process;*
- *It would be very useful to have a wide debate about transport modelling to ensure that the models represent travel and locational behaviour effectively, including factors that represent physical activity; the discussion should include the cost effectiveness of making changes to the existing modelling system;*
- *The incorporation of more findings from research into the financial benefits of improvements to health resulting from more physical activity would improve the appraisal process for new transport schemes;*
- *Many benefits would arise from health and transport professionals working together more, for example, by sharing knowledge of the evidence about the impact of walking and cycling schemes;*
- *Further research would help in the shift towards a healthier, more sustainable future, but action to improve the quality of life by increasing walking and cycling can be taken now.*

1 Introduction

There is concern in Britain about health problems associated with low levels of physical activity (Department of Health 2004b). It is known that:

> *"Increasing levels of physical activity would contribute to achieving reductions in coronary heart disease and obesity, hypertension, depression and anxiety."* (Department of Health 2009, p. 4).

Also, those who are physically active have a significantly lower risk of type 2 diabetes by up to 50% and of premature death of about 20-30% (Department of Health 2004b).

Increasing levels of physical activity has become a central focus for national health policy. A report by the US Surgeon General (1996) put everyday physical activity firmly on the health agenda in the United States in 1996 and this was followed in 2000 with the publication of 'Healthy People' which outlined health objectives to be achieved by 2010 – including levels of physical activity (US Department of Health and Human Services 2000). In the UK, there have been a number of reports which have examined physical activity: a key document is At Least Five a Week: Evidence on the Impact of Physical Activity and its relationship to Health', published in 2004 (Department of Health 2004a).

The impact of physical inactivity on health emerged through research on cardio-vascular disease (Lee et al. 1995; Paffenbarger et al. 1993). Murray and Lopez (1996) found that inactivity was a leading cause of premature death and disability in developed countries, causing ten times as many years of life lost as road crashes. The report by the US Surgeon General (1996) identified physical inactivity as the second most significant contributor towards preventable deaths (after smoking). Since then, the ways in which it affects health have been substantially analysed and clarified and its full impact is now better understood. Kahn et al. (2002) reviewed a number of areas of health which were affected by physical activity such as ischemic stroke, non-insulin-dependent (type 2) diabetes, colon cancers, osteoporosis, depression and fall related injuries. Booth et al. (2000) identified at least 17 medical conditions the incidence of which is increased as a result of inactivity. Physical inactivity contributes significantly to the global obesity pandemic which the World Health Organization recognised in 1998 as being so dramatic that the health consequences threatened to overwhelm health systems and the health and wellbeing of the global community (World Health Organization 1998).

Despite the positive effects associated with moderate levels of physical activity, overall levels remain low and a sedentary lifestyle is a ubiquitous problem in the West. For example, in England, in 2008, only 39% of men and 29% of women reached the recommended level of health-enhancing physical activity (HEPA) for adults of at least 30 minutes of at least moderate intensity physical activity on five or more days a week (Department of Health 2004a; NHS Information Centre 2011). Health-enhancing physical activity includes the activities that people participate in during the course of their lives, such as housework, gardening, walking and cycling. The contribution that walking and cycling (or 'active travel') can make to physical

activity and hence to health has been recognised explicitly by the British Government (Department of Health 2009; Department for Transport 2011a). Global Advocacy for Physical Activity (GAPA) has identified transport policies and systems that prioritise walking, cycling and public transport as one of the seven investments that work for physical activity alongside a number of non-transport investments such as sports systems and programmes that promote 'sport for all' and encouraging participation across the life span (Global Advocacy for Physical Activity 2011).

The purpose of this report is to establish the contribution that transport can make to increasing levels of physical activity and hence improve health.

1.1 Trends in health, physical activity and travel

The Health Survey of England shows that obesity is increasing in England as Table 1 shows. About one quarter of the population of England is obese, a significant increase from sixteen years earlier.

Table 1 Proportion of the population of England in various BMI categories

	Men		**Women**	
	1993	2009	1993	2009
% Underweight	1	2	2	3
% Normal	41	32	50	40
% Overweight	44	43	32	33
% Obese	13	23	16	24
Total	100	100	100	100

Source: NHS Information Centre (2011).
Note: these percentages are based upon the BMI (Body Mass Index) of those surveyed. BMI is a person's weight in kilos divided by the square of their height in metres (Centers for Disease Control and Prevention 2010).

As Table 2 shows, the number of walking and cycling trips have decreased in recent years. In fact, walking grew from 1975/76 to 1985/86 and then declined. The number of cycling trips has remained fairly constant for the last fifteen years or so. Bus travel has followed a similar trend to cycling: a decline from 1975/76 to 1985/86 followed by a slower rate of decline and then a levelling off. The only mode that has grown in terms of trips is the car. The number of trips has declined in recent years having peaked in 2005, probably due to economic recession. The total number of trips also peaked in 2005.

Table 3 shows the average distance travelled per head. The figures for each mode follow similar trends to Table 2, but the rates of decline for walking, cycling and bus have been less steep with some growth in recent years in cycling and bus use. The lower rate of decline and the recent increases for distances imply an increase in the average trip length, which probably reflects decentralisation of urban activities. The distance travelled by car grew to 2005 and has declined since then, as has the total distance travelled, again probably due to the decline in the economy.

Table 2 Trips per head per year in Great Britain

	1975/76	1985/86	1992/94	1996/98	2005	2010
Walk	325	350	306	288	245	210
Bicycle	30	25	18	16	14	15
Bus	108	85	69	64	63	68
Car	429	517	618	643	671	618
All travel	935	1024	1053	1051	1044	960

Source: Department of the Environment, Transport and the Regions (1999a); Department for Transport (2011e)

Table 3 Distance travelled per head per year in Great Britain in km

	1975/76	1985/86	1992/94	1996/98	2005	2010
Walk	408	390	318	309	315	286
Bicycle	82	70	61	61	58	67
Bus	773	650	568	550	566	592
Car	5118	6074	7926	8467	9192	8409
All travel	7584	8507	10302	10765	11533	10762

Source: Department of the Environment, Transport and the Regions (1999a); Department for Transport (2011e)

It seems likely that much of the decrease in walking, cycling and bus use since the mid seventies is associated with the growth in car use. There are many factors at work here, some direct and some indirect (Mackett 2009). The direct ones are caused by the growth in car ownership and car driving licence holding which means that more people have the car as an alternative mode; the indirect ones are to do with the decentralisation of urban activities such as the development of out-of-town shopping centres, which, for many people, can only be reached conveniently by car, which in turn, has encouraged further decentralisation. The slowing down in the shift from walking, bicycle and bus to car in recent years may be partly due to the shift in planning policy to encourage the development of brownfield sites for development and discouraging the granting of planning permission for out-of-town developments, which can be observed in the growth of smaller stores within existing urban areas by the large supermarket chains. It may also be partly due to initiatives to encourage use of alternatives to the car.

Researchers have found evidence that physical activity levels are declining (Brownson et al. 2005; Lampert et al. 2005; Owen and Bauman 1992). However, the Health Survey of England showed that the 2008 levels of 39% of men and 29% of women reaching the recommended levels of HEPA in England were increases from the 1997 levels of 32% and 21% respectively (NHS Information Centre 2011). The apparent contradictions in the evidence on the trends in physical activity are interesting. Analysis of the trends in physical activity in the Health Survey of England from 1991 to 2004 show that physical activity levels at work declined over the period, while participation in sport increased (Stamatakis et al. 2007). Because of a change

in the question asked, it is only possible to examine the trend in brisk to fast walking from the Health Survey of England from 1999 to 2004, but this shows an increase in the number of minutes spent walking (Stamatakis et al. 2007). In contrast, the National Travel Survey (NTS) shows a decline in the time spent travelling from 70 hours a year per head in 1998/2000 to 67 in 2004 (Department for Transport 2005). This apparent anomaly may reflect differences in the definition of walking with NTS excluding walk trips across open countryside and in public spaces that are closed at night. It may also reflect overestimation of leisure time physical activity which has been found in surveys based on self-reporting of physical activity (Troiano et al. 2008). This is the method used in the Health Survey of England. A possible explanation of the anomaly between the increase in obesity and the apparent increase in physical activity in England in recent years is that leisure-time physical activity only accounts for a small proportion of adult expenditure of energy with non-exercise activity thermogenesis such as physical activity at work, accounting for most of the expenditure (Levine 2007). This suggests that the increase in obesity in Britain may be partly associated with the decline in manual employment, often in manufacturing, and the increase in sedentary occupations, which is a process which has been continuing in recent years.

Even if the evidence on trends in levels in physical activity is not entirely clear, there is a strong case for increasing it from its present low level.

1.2 The costs of physical inactivity

The costs of physical inactivity through direct medical expenses alone were calculated to be $77 billion a year in the United States in 2000 (Pratt et al. 2000). More recently, obesity has been estimated to cost the United States health care system more than $147 billion annually (Finkelstein et al. 2009). Davis (2010) reports that the direct costs in the UK have been:

> *"...conservatively calculated to be £1.08 billion per annum in direct costs to the NHS alone…"* (Davis 2010, p. 1).

The indirect costs in the UK have been estimated at £8.2 billion per annum at 2002 prices (Davis 2010). The costs are made up of between £1 billion and £1.8 billion annual costs to the National Health Service, about £5.5 billion due to sickness absence and £1 billion from premature death of people of working age (Department of Health 2009). These calculations exclude the additional contribution of physical inactivity to overweight and obesity, the overall cost of which has been estimated to be £6.6-£7.4 billion per year (National Audit Office 2001). Costs to the welfare state in the form of disability benefits do not appear to have been included.

1.3 The aims of this report

This report aims to bring together findings from the two normally unrelated disciplines of transport and health in order to identify the evidence on methods of increasing physical activity, establish the role transport can play in this and identify the further research which needs to be done to support this.

The report is aimed at a number of audiences: it is to provide evidence for policymakers from the fields of transport and health, particularly to make them aware of evidence from the field they do not normally work in; it is to inform health researchers about the broader scope of transport than many of them usually consider, for example the influence of the car on physical activity, and to make transport researchers aware of the large body of work on the benefits of walking and cycling that has been carried out in the health field.

The aim has been to identify best practice. The report highlights key areas and provides evidence for the reader who would like to know more. Because of the broad scope of the report, it was not practical to review every paper and report that could be relevant ranging from ecological theory with its epidemiological origins, through individual level interventions, the built environment, transport and its relationship to health, to sustainable travel. The information has been collected systematically. A number of search engines including Scopus and Web of Science have been used and databases searched including: the Database of Abstracts of Reviews of Effects, the Cochrane Database of Systematic Reviews, the Campbell Collaboration Website, the Campbell Library of Systematic Reviews, the Evidence for Policy and Practice Information Centre and the NHS Evidence National Library for Public Health. The main search terms used were ‘active travel’, ‘car use’, ‘physical activity’, ‘health’, ‘cycling’, ‘walking’, ‘transport’, and ‘public transport’. However, a systematic review was beyond the scope of the report. Rather the focus has been on reading reviews and reviews of reviews and considering those documents which have been most frequently cited in the literature. These are likely to have been more influential and therefore needed to be included in a synopsis. However, the research has in no way been restricted to these. Rather the data have been collected through an iterative process whereby a broad outline was drawn up, problems explored and possible gaps identified and these used to provide the cue for the next stage of research. This process was continued until the whole field had been covered and a point reached where gaps remained but the research findings are not yet available to fill them.

Literature covered within systematic reviews has been included. Other peer reviewed literature which developed the argument in a new direction was also included although it is recognised that further systematic review will be required to assess the validity of some of these arguments. Reports which had not been peer reviewed were excluded unless they were the only source of data available in that particular area or where they had had a significant impact on policy direction. As far as possible, this review concentrates on research carried out in Britain. However, much of the pioneering work on the role of physical activity was carried out in the US: significant papers from there (and elsewhere) have been included. The location of the research is usually indicated so that the reader can assess the transferability of the findings to Britain.

Although only systematic reviews carried out after the year 2000 were incorporated, some of these were based on older literature which was therefore also covered in the report. However as these data have been incorporated within the context of a systematic review, it has withstood the test of time (and where it has not, this is

stated). Older data are also incorporated where it has played a significant role in theoretical development. So, for example, work on the built environment by Saelens et al. (2003) has evolved out of work on ecological theory by McLeroy et al. (1988) which in turn was developed from Bronfenbrenner (1979). Older literature is also included where is has been subsequently backed up by more recent information, for example Cervero and Gorham (1995). Likewise, older papers which reflect gradual changes in policy (for example Dora 1999) or bring about step changes in research (such as the report by the US Surgeon General (1996)) are also included.

In Section 2, the evidence on the relationship between travel by various modes and physical activity will be examined followed by a discussion of the effects of personal behaviour on physical activity. Then ways that the built environment can be used to increase physical activity are considered, and then the role of transport in the process. Following from this, ways of overcoming the barriers to reducing society's dependence on the car are discussed. The evidence presented is used as the basis of a strategy to use transport to increase physical activity. The gaps in the evidence form the basis of the research recommendations.

1.4 Terminology

'Transport' in the report title refers not only to infrastructure and its use but also the financial, administrative, legal, economic, social and cultural systems which underlie the development and use of the infrastructure.

Various terms have been used to refer to the type of transport of greatest interest: 'non-motorised travel', 'active travel' (AT), and 'active commuting' have all been used; 'active travel' will be the term mainly used in this report. This will be taken to be travel that requires physical effort to move across space. Use of public transport is also included within the scope of active travel as it involves walking to and from public transport stops and within transport interchanges and is therefore a more active form of transport than travel by car.

Leisure time physical activity (LTPA) is also included in the scope of the review. The first interventions which tried to increase physical activity concentrated on this area and it is necessary to understand some of the problems and issues with LTPA in order to understand why AT came to have such an important role.

Body Mass Index (BMI) is a measure of how fat a person is, based on their weight and height. It is defined as a person's weight in kilogrammes divided by the square of their height in metres (Centers for Disease Control and Prevention 2010).

Much of the work in this area carried out by physical activity researchers has involved the use of a randomised controlled trial (RCT). This requires the carrying out of surveys before and after an intervention using samples chosen at random, with a parallel study of an equivalent sample the members of which are not subject to the intervention in order to allow for secular trends and other factors that might bias the apparent effects of the intervention. The participants are allocated to the two

groups (with or without the intervention) at random. This approach is used in the trial of new drugs and other medical interventions.

Researchers from the field of physical activity often use the term an 'ecological approach' or 'ecological model' to describe the method of considering a variety of factors affecting an individual's participation in physical activity and how this can be increased, by creating an environment that supports physical activity. The factors can include the individual, the social environment, the physical environment and policies and regulations.

2 Transport and physical activity

In this section the evidence of the impacts of various modes of travel on physical activity will be examined in order to establish the potential contribution of each of these to physical activity.

2.1 The contribution of walking and cycling to physical activity

In the introduction to this report, reference was made to the views of the Department of Health (2004b, 2009) and the Department for Transport (2011a) that walking and cycling can produce health benefits by increasing walking and cycling. There have been a number of studies to establish the effects of commuting by walking and cycling on a variety of health conditions.

Originally, interventions studied by health researchers tended to focus on LTPA and therefore were frequently dependent on participation in sports or attending a gym. This meant that the strategies were difficult to implement in areas where facilities were inadequate. It was also particularly difficult to get very sedentary people to participate. Attention turned increasingly to walking as this was not dependent on facilities and was a natural and inevitable part of people's lifestyle.

There were a number of factors supporting the attention given to walking. Health research showed how effective walking could be in promoting health. Brisk walking was identified as protective of physical health, independently of the benefits of more vigorous activity particularly if done consistently (Saelens et al. 2003; Wagner et al. 2001). It was estimated that half an hour of a moderate intensity activity, such as brisk walking 5 days a week, provided the regime required to keep fit (Ainsworth et al. 2000; Ainsworth 2002; Haskell et al. 2007; Marshall et al. 2009; Pate et al. 1995). Furthermore, it did not need to be done in a bout of half an hour a day, as there was growing evidence that accumulating shorter bouts of walking through the day was at least as effective as one single continuous bout in improving cardiovascular fitness and reducing blood pressure (Marshall et al. 2009; Murphy et al. 2009). There were also studies which showed that those who reported walking or cycling for transport were sufficiently active through it (Adams 2010).

More recent evidence has shown that *any* walking can contribute towards the regime required to keep fit. It has been shown that it is the number of steps rather than the

intensity of the walking that is critical. Tudor-Locke et al (2011) aimed to translate 30 minutes a day accumulated Moderate to Vigorous Physical Activity (MVPA) into the equivalent number of steps a day. They used concurrently detected ActiGraph accelerometer-defined step and activity count data collected as part of the 2005-2006 National Health and Nutrition Examination Survey (NHANES). They used statistical models to analyse data from 3,523 participants who were 20+ years of age and who wore the accelerometer for at least one valid day (i.e. over ten hours in 24) over seven days. They found that 30 minutes a day of MVPA translated to approximately 7,900 steps a day for males and 8,300 steps a day for females. In a subsample of participants (n=1,197) with valid data on all 7 days, they found 150 minutes a week of MVPA translated to approximately 7,000 steps a day. They concluded that accumulating approximately 8,000 steps a day is a good proxy for 30 minutes of daily MVPA, while accumulating 7,000 steps a day every day of the week is consistent with obtaining 150 minutes of weekly MVPA.

In addition to health benefits, walking has been found to be a very practical focus for interventions. Encouragement of walking was found to be the most effective tactic for the promotion of physical activity in a sedentary population (Hillsdon 1996). Evidence suggested that AT overcame one of the common barriers to physical activity – that of not perceiving oneself as 'the sporty type' (Zunft et al. 1999). It was also found that some people actually prefer non-motorised travel for short distances (Mokhtarian and Salomon 2001). Also, while LTPA was more important for understanding the levels of physical activity in some social groups, AT needed to be factored in to obtain a more inclusive picture. Berrigan et al. (2006) showed how LTPA and AT varied according to level of education, ethnicity and income. In addition there was enormous scope for increasing AT participation in the UK (Adams 2010). Another possible benefit of focusing on walking was pointed out by Blamey and Mutrie (2004). They explained that although local authorities play a major role in the delivery of opportunities and services for physical activity, they are not obliged through formal legislation to provide these leisure services. As walking itself falls under transport, which local authorities are obliged to support, this provides a more effective channel for intervention.

Andersen et al. (2000) examined the evidence on the influence of various factors on mortality rates for a cohort of people aged from 20 to 93 (13,455 women and 17,441 men) in the Copenhagen region in Denmark. After adjusting for age, sex and educational level they found that those who cycled to work spent three hours a week cycling on average and reduced the relative risk of all-cause mortality to 72% compared to those who do not commute by bicycle. Walking was not examined in the study. This evidence is used in the Health Economic Assessment Tool (HEAT) (Rutter et al. 2008) which is used in the WebTAG guidance on the appraisal of walking and cycling schemes developed by the Department for Transport (2010d).

Evidence on the contribution of walking and cycling to work to reducing the risk of cardiovascular risk was examined by Hamer and Chida (2008) in a review of eight studies, seven of cohorts in Europe and one in Japan. From the studies, an overall

reduction in cardiovascular risk of 11% was found resulting from commuting activity, with more robust results for women than men.

Hou et al. (2004) examined the impact of commuting physical activity which included the number of days and daily number of minutes spent walking or cycling to work on the risk of colon cancer in Shanghai, China. The survey included 931 colon cancer sufferers and 1,552 randomly selected controls. It was found that active commuting significantly reduced the risk of colon cancer, particularly amongst those who had high commuting physical activity for at least 35 years. It was found that active commuting modified the risk especially for those with high Body Mass Index (BMI), particularly those in the highest quintile of BMI and the lowest activity level.

Kwaśniewska et al. (2010) carried out a study of 6,401 randomly selected individuals in Poland. They found that active commuting, based on four categories of daily walking or cycling (0 minutes, 1-14 minutes, 15-29 minutes, and 30+ minutes), was associated with decreased likelihood of abdominal obesity, lower high-density cholesterol, and elevated triglycerides in men and decreased levels of abdominal obesity in women.

More recently, Lindstrom (2008) examined the link between means of travel to work, being overweight and obesity. This was based on the 2004 public health survey in a part of Sweden and included 16,705 employed participants. They found that walking and cycling to work were significantly negatively associated with being overweight and, to some extent, being obese.

It is noticeable that all the studies mentioned above focus on commuting and not other walking and cycling, even though commuting is only about 20% of the trips in Britain. This may be because the commuting trip is relatively easy to define and measure since it is usually a regular trip which those undertaking it are likely to know the duration of. If a relationship exists for commuting, walking and cycling that implies the more the better, then it is likely to be true of other walking and cycling, although the intensity may be lower.

2.2 Public transport and physical activity

Most public transport journeys include an element of walking both to and from the bus stop or railway station, and possibly at interchange points.

In the US it has been found that transit access trips were a significant component of walking, comprising 16% of all walking trips (Agrawal and Schimek 2007). In 2005 Besser and Dannenberg aimed to

> *"...estimate the daily level of physical activity obtained by Americans solely by walking to and from transit"* (Besser and Dannenberg 2005, p. 273).

They examined how this correlated with a range of socio-demographic variables. They found that Americans using public transport (transit in American parlance) obtained a significant amount of physical activity through the walks to and from the transport stops. The median rate was over 19 minutes with over 29% achieving over

the 30 minutes daily physical activity by walking to and from transit. They also found that rail users were more likely to walk to and from transit stops than bus users. The research was based on a sample of 3,312 transit users out of a sample of 105,942 adult respondents to the 2001 National Household Travel Survey. They point out that:

> *"Efforts to increase transit accessibility and usage may not only decrease road congestion and air pollution but may have the added health benefit of increasing the proportion of Americans who obtain ≥ 30 minutes of daily physical activity."* (Besser and Dannenberg 2005, p. 277).

A similar study was carried out by Wener and Evans (2007) who compared differences in levels of physical activity between car and rail commuters. One hundred and eleven rail and car commuters were asked to wear a pedometer for one week of commuting on their regular route and complete a standardized self-report physical activity index. Rail commuters walked on average 30% more steps per day, reported having walked for a period of 10 minutes or more while travelling significantly more often, and were 4 times more likely to walk 10,000 steps per day than car commuters. This showed how travel mode can significantly affect the amount of physical activity commuters accumulate during the course of a typical work day without planned or co-ordinated exercise programmes.

A study in Atlanta Georgia used a sample of 4,156 travel questionnaires to examine whether transit and car trips were associated with meeting the recommended levels of physical activity by walking (Lachapelle and Frank 2009). They measured only moderate physical activity related to travel on the street network, not overall physical activity which includes many other kinds of physical activity as well. They found that additional trips by any mode were more likely to be associated with moderate levels of walking, relative to the reference group. However, only additional public transport trips were significantly associated with meeting the physical activity recommendation for walking. Car trips were not associated with meeting the recommendation.

Cervero and Gorham (1995) found that walking was more commonly used for both work and non-work trips in neighbourhoods that were more oriented to mass transit than those oriented to the car. MacDonald et al. (2010) found that the use of a new light-rail system (LRT) resulted in increased physical activity (walking) and subsequent weight loss by people served by the LRT. Specifically, users of the LRT reduced BMI by an average of 1.18 kg/m^2 compared to non-LRT users in the same area over a 12-18 month follow-up period. This is equivalent to a relative weight loss of 2.9 kg for a person whose height is 1.67m. The use of LRT to commute to work was associated with an average reduction of 1.18 in BMI (statistically significant at the 95% level) and an 81% reduced odds of becoming obese over time. MacDonald et al. (2010) state that:

> *"Public transit systems can generate positive health impacts by encouraging greater numbers of users to walk to station stops and maintain more physically active lives. An added benefit of public policy investments in LRT, on top of the general transportation benefits*

> *accrued, is the potential reductions in obesity in the population."* (MacDonald et al. 2010, p. 111).

However, it should be pointed out that there were a number of weaknesses in the study, including use of self report measures, a small percentage of light rail users and low rates of follow up. Therefore this study requires follow-up studies with more rigorous methodologies and larger sample sizes before one can be confident about the findings.

A recent survey carried out in Montreal (Morency et al. 2011) collected empirical evidence to show that a modal shift from cars to public transport contributes to the daily volume of walking. The paper presents a method to calculate the walking distance related to transit trips; then the walking distance involved in every transit trip was associated with the individuals' characteristics to estimate the number of steps. The results show that, on average, a transit trip involves 1,250 steps, required to access and leave the network as well as to transfer between routes or modes. Thus, a round trip represents 2,500 steps which accounts for 25% of the recommended volume of physical activity required per day. They argue that such a positive outcome is an innovative argument to promote the use of transit that is also compatible with current sustainable travel goals.

Findings on obesity also suggest that public transport may be providing a source of physical activity. Lindstrom (2008) found that using public transport was significantly negatively associated with being overweight and also with being obese among men compared to the car driving reference group. However, as it was a cross-sectional study it is possible that the finding reflects some form of self selection: the men using public transport may choose healthy diets or take more exercise. However the possibility that the steps to and from transit stops when travelling on public transport are providing enough physical activity to reduce weight gain merits further investigation.

None of the studies cited in this sub-section were conducted in the UK and therefore their findings cannot be directly translated to the UK situation. However, most of the studies mentioned have a high level of rigour and the findings are of relevance to situations where the majority commute by car. The conclusions may be more difficult to apply to a city like London where many people already commute to work by public transport and car use has a very different pattern.

It should also be noted that none of the studies in this sub-section considered total levels of physical activity. Therefore it cannot be stated with complete certainty that public transport users have higher levels of physical activity than car users. This is a question which requires further investigation. However, it is possible to conclude that the travel patterns of those who do not commute by car contribute significantly to physical activity. It is also possible to suggest on the basis of these findings that as long as no other lifestyle changes are involved, people could greatly increase their levels of physical activity by using public transport rather than the car to travel to work.

2.3 Car use and physical activity

Cars offer the opportunity to go for walks or cycle in pleasant environments and to travel to the gym for physical activity. However, systematic studies have shown that car ownership and use correlate persistently with lower levels of walking and cycling. In the regression model developed by Saelens et al. (2003), car use explained physical inactivity in the final analysis. So, for example, when looking at relations between neighbourhood environments and walking and cycling in a range of studies they found that variables relating to car use remained independent and mediated the relationship between the environment and physical activity (Cervero and Radisch 1996; Frank and Pivo 1994; Kockelman 1997). Agrawal and Schimek (2007), exploring data from the US Department of Transportation's National Household Travel Survey found that walking increased with density via the intermediary of car ownership. Cerin et al. (2009) also reported on the strong impact of car ownership in their research:

> *"…the other negative influence linking income with frequency of walking for transport was the number of motor vehicles in the household, with this factor being particularly important in explaining differences across groups of different individual-level household incomes. The number of motor vehicles and traffic load explained most of the negative effect of individual level income on frequency of walking for transport."* (Cerin et al. 2009, p. 1019).

Even though the better off engaged in more active lifestyles and lived in neighbourhoods more conducive to walking, this could not mitigate the negative effects of their car ownership. Adams (2010) based on research using the 2005 UK Time Use Survey had similar findings:

> *"Markers of [social and economic position] were not consistently associated with AT. Having access to private transport was the one socio-economic variable associated with all three AT variables with access being associated with decreased AT."* (Adams 2010, p. 201).

Adams (2010) stated that her findings are similar to those of Giles-Corti and Donovan (2002b). Killoran et al. (2006) also noted how individuals without access to a car are more likely to walk.

Wennberg et al. (2006) found that regular car commuting was associated with increased risk of myocardial infarction (heart attack) compared with commuting by bus, walking or cycling after other factors had been taken into account.

Thomson et al. (2008) have pointed out that it cannot be assumed that changes from driving to walking will necessarily lead to increases in physical activity as those doing so may give up other forms of physical activity in the process. Also Popham and Mitchell (2006a) reported that car ownership was likely to be associated with increased levels of physically-active leisure independent of economic status. However, the evidence was reported in a conference paper and a peer review article

by them on the same topic does not confirm this finding (Popham and Mitchell 2006b). Nor has it been possible to find any other data to suggest that cars contribute positively to physical activity. However, various studies which have looked at the effects of reducing car use through, for example walking to work, have suggested that overall increases in physical activity or improvements to health did result (Mutrie et al. 2002; Oja et al. 1998; Vuori et al. 1994). Smith et al. (2008) have suggested that doubling the proportion of neighbourhood residents walking to work decreases an individual's risk of obesity by almost 10%. Wagner et al. (2001) also found that walking or cycling to work correlated negatively with weight gain. These and other findings led Saelens et al. (2003) to conclude that:

> *"Moderate intensity physical activity acquired through more non-motorized transport, undertaken by a large proportion of the population over time, would have a significant public health impact. Indeed, walking or cycling for transport to work appears to be associated with lower body weight and less adult weight gain over time, independent of the effects on body weight of more vigorous physical activity…."* (Saelens et al. 2003, p. 86).

One of the routes through which physical activity influences health is through body mass index (BMI), although the relationship between physical activity, BMI and health is complex. However to the extent that BMI can stand as a proxy for physical activity, the findings on car ownership back up the research cited above. So, for example, a prospective cohort study which followed Chinese adults over 8 years found that, compared to those whose vehicle ownership did not change, men who acquired a vehicle had a twofold risk of becoming obese (Bell et al. 2002). Likewise Frank et al. (2004) found a link between time spent in cars and obesity. Each additional hour spent in a car per day was associated with a 6% increase in the likelihood of obesity. Conversely, each additional kilometre walked per day was associated with a 4.8% reduction. A cross-sectional survey found that individuals who reported higher levels of car use (particularly for trips to the shop and the work/school commute) had higher BMI scores (Pendola and Gen 2007).

Other research has explored the links between vehicle miles travelled (VMT), obesity and physical inactivity. Merging data from three large scale surveys, Lopez-Zetina et al. (2006) found that the highest rank of VMT was associated with highest mean rank obesity. Similar rank patterns were also found between commute time, obesity and physical inactivity. However the relationship between physical inactivity and VMT did not reach statistical significance. This could possibly suggest that the sedentary behaviour caused by car use is causing obesity even where the person is physically active. It may be that higher levels of physical activity are required to compensate for extensive sedentary behaviour.

2.4 Sedentary behaviour and physical activity

There is research which points to the possibility that it is sedentary behaviour rather than the absence of physical activity which causes higher levels of obesity. Sugiyama et al. (2008) examined the joint associations of multiple sedentary

behaviors and physical activity with the odds of being overweight or obese. They concluded that:

> *"Those who spent more time in sedentary behaviors (but were sufficiently physically active) and those who were insufficiently active (but spent less time in sedentary behavior) had a similar risk of being overweight or obese. Reducing leisure-time sedentary behaviors may be as important as increasing leisure-time physical activity as a strategy to fight against obesity in adults."* (Sugiyama et al. 2008, p. 1).

Other research among children which looked at sedentary behaviour and obesity indices had similar results. Lazarou and Soteriades (2010) suggest that sedentary behaviours such as TV watching may be more important predictors of children's various obesity indices than physical activity behaviours and that interventions targeting sedentary behaviours, such as TV watching, may help in the prevention and treatment of obesity among Cypriot children. This had already been shown by Epstein et al. (1997; 1995) who found that interventions in controlled settings that specifically decrease the time children spend in sedentary behaviours led to increased physical activity.

It is also becoming increasingly apparent that sedentary behavior alone is a health risk. Healy et al. (2011) carried out a cross-sectional analysis with 4,757 participants over the age of 19. The data was from the 2003/04 and 2005/06 US National Health and Nutrition Examination Survey (NHANES). An ActiGraph accelerometer was used to derive sedentary time and breaks in sedentary time. Independent potential confounders were observed. They found the first population representative findings on the deleterious associations of prolonged sedentary time with cardo-metabolic and inflammatory biomarkers. They concluded that:

> *"Prolonged sedentary time is likely to increase with future technological and social innovations, and it is important to consider a whole of day approach to physical activity promotion. Reducing and regularly breaking up sedentary time may be an important adjunct health message, alongside the well-established recommendation for regular participation in exercise."* (Healy et al. 2011, p. 596).

These findings suggest that the route to good health could be achieved through trying to reduce sedentary behaviour as well as physical inactivity. Focusing on travel has potential because it means that people are out of the house which means they are likely to be more active than being at home. However as the car enforces sedentary behaviour to a greater degree than public transport does, its role in contributing towards the overall sum of sedentary behaviour needs to be considered.

2.5 Conclusions

The evidence shows that walking and cycling contribute to physical activity. Many of the studies have been on commuting and it would be useful to establish the contribution of all walking and cycling to physical activity, if only because quite a large proportion of the population is not employed. There are a number of risks

associated with walking and cycling and these will be discussed in Section 5.1. Whilst there is limited direct evidence of a positive association between physical transport usage and physical activity, because most public transport trips contain walking elements, it seems very likely that such a relationship exists. Conversely, car use and ownership do seem to be correlated with lower levels of physical activity. This suggests that there may be a good case for encouraging a shift from the car to walking, cycling and public transport use.

In the next section, the evidence of the effect of personal characteristics and individual behaviour of physical activity will be discussed.

3 The effect of individual behaviour on physical activity

There has been systematic research on the effects of interventions to change the behaviour of individuals in order to increase physical activity. They may be useful for indicating ways in which travel behaviour can be influenced.

3.1 The public health approach to physical activity

The public health field has traditionally considered three possible levels for understanding diseases and developing strategies for dealing with them: the host (the individual), the agent (the disease) and the environment (MacMahon and Pugh 1970; Teris 1987). During the 1980s, there was a shift of focus towards individual responsibility for disease perhaps partly stimulated by the focus on drugs, smoking and the AIDS epidemic. This drew attention to lifestyle and behaviour, and located responsibility for ill health with the individual, and sought solutions in changing behaviour. Behavioural sciences attained new prominence as psychologists developed behavioural change interventions the target of which was the individual. Perhaps the most clearly articulated ecological model was that of McLeroy et al. (1988), who, building on the work of Bronfenbrenner (1979), suggested five levels at which one could analyse human behaviour and intervene to change it (including increasing physical activity):

- Intrapersonal factors;
- Interpersonal processes;
- Organisational factors;
- Community factors;
- Public policy.

As discussed in Section 1.1, the role of everyday physical activity as a contributor to health was made explicit in the report of the US Surgeon General (1996) in 1996. This stimulated a whole field of research to establish which aspects of everyday activity could be used to increase physical activity. This meant establishing which interventions were effective for increasing levels of physical activity.

3.2 Assessing the effectiveness of interventions

3.2.1 Main axes

There are two key dimensions along which the effectiveness of an intervention can be assessed. Firstly, the amount that physical activity is increased by, and, secondly, the number of people affected. These two dimensions need to be considered in relation to each other. For example, an intervention may only increase a person's level of physical activity marginally; however if this is spread through a large population group, the overall difference could be great. The ideal intervention would increase physical activity significantly for a substantial proportion of the population.

The number of people affected by an intervention depends on whether it occurs at an 'upstream' or 'downstream' level. An intervention which is 'downstream' tackles the problem by trying to change the behaviour of the individuals concerned without necessarily identifying the cause of the problem. An 'upstream' intervention tries to get to the root of the problem and will usually require policy changes in order to bring the intervention about. It is likely to affect many more people than a downstream intervention which can take place at the local level without necessarily involving policy changes.

3.2.2 The target of the intervention

The characteristics of the person whose behaviour is changed need to be taken into consideration. An intervention which increases the physical activity of the most sedentary is of more value than one which gets healthy and active people out and about. Age is also important. For example although the relationship is complex, it appears that active children are more likely to become active adults (Kern et al. 2010). Therefore an intervention targeted at this level may have longer term effects. Similarly, there is evidence to suggest that the physical activity behaviour of parents provides a model for and influences that of their children (Crawford et al. 2010).

3.2.3 Effectiveness and efficacy

Some of these ideas are covered by the concepts of 'efficacy' and 'effectiveness' (Estabrooks and Gyurcsik 2003). 'Efficacy' describes the ability of an intervention to increase levels of physical activity under ideal and controlled conditions. Effectiveness trials are used in real life scenarios once efficacy is established. Demonstration studies are seen as the next stage where the intervention is applied to a whole system or large mixed population. Blamey and Mutrie (2004) conducted a review based mainly on the work of Eden, Kahn, Hillsdon and colleagues (Eden et al. 2002; Hillsdon et al. 2003; Kahn et al. 2002). They suggested that problems of effectiveness apply broadly across interventions, arguing that while many of the approaches worked in specific settings, it is difficult to generalise these sorts of interventions to the wider population. This, they suggest, is because there is a lack of discussion on how the effectiveness of the interventions varied between socio-economic and demographic groups.

3.3 Interventions to increase physical activity

Five physical activity reviews have been identified which reflect both the wide range of interventions and the breadth of the approach outlined above.

Foster et al. (2009) examined individual level interventions by focusing explicitly on adults aged 16 and over. All the interventions included were conducted by a doctor, nurse, health educator, counsellor, exercise leader or peer or a combination of these. They considered only randomised controlled trials (RCTs) with a minimum of a 6-month follow-up from the start of the intervention to the final analysis. Participants were recruited from primary healthcare centres, workplaces, a university or a community. They analysed the type of study according to the nature of contact with the individual and their level of supervision. Interventions were thus categorised according to whether they were self-directed only, self-directed with professional guidance or prescribed by the professional only. They also take into consideration whether the programme was structured and supervised, unsupervised and independent or mixed. They did not look at mass media interventions or multiple risk factor interventions. Hillsdon et al. (2005) carried out a review of existing reviews and meta-analyses and sought to answer the question 'What evidence is there that physical activity can be increased in insufficiently active, non-institutionalised, free living adults?'. The reviews which they included looked at interventions targeting individuals based in healthcare, community and workplace settings. They also looked at reviews of interventions targeting older adults, black and ethnic minority adults and adults with physical limitations. They did not consider reviews at the community, policy or environmental levels.

Kahn et al. (2002) carried out a review in response to the 'Healthy People 2010' report (US Department of Health and Human Services 2000). This had set out two main objectives; firstly to increase the amount of moderate or vigorous physical activity performed by people in all population subgroups and secondly to increase opportunities for physical activity through creating and enhancing access to places and facilities where people could be physically activity. The review provided information on both of these foci. They explored interventions in three main areas: information approaches, behavioural and social approaches and environmental and policy approaches. This review reflects more clearly the wider range of concerns of the ecological approach while the reviews by Hillsdon et al. (2005) and Foster et al. (2009) fit in more clearly with the behavioural change approach at the individual level**.**

Ogilvie et al. (2004) looked specifically at interventions which promoted a shift from car use to walking and cycling. The outcome metric was the:

> *"...absolute percentage share of all trips that were shifted from cars to walking and cycling combined" (Ogilvie et al. 2004, p. 1).*

Rather than including individual level interventions, the focus of this review was the best available evidence on the effects of population level interventions to promote a shift from car use to more active forms of travel.

A later review by Ogilvie et al. (2007) looked specifically at walking including both walking for leisure and walking for transport. They included interventions aimed at the individual, group and the population level and at RCTs and non-RCTs.

The reviews by Foster et al. (2009) and Hillsdon et al. (2005) used the most strict selection criteria. The former looked only at primary data based on randomised control trials while the latter looked at systematic reviews or meta-analyses of RCTs or quasi experimental studies. The focus of both reviews was on the individual.

The review by Kahn et al. (2002) used less rigorous inclusion criteria. Hillsdon et al. (2005) explain that they did not include it in their own review because it used non-experimental studies such as uncontrolled 'before and after' studies. They point out it used a broader definition of effectiveness, pooled effects from different types of experimental studies and included children. The review by Foster et al. (2009) also did not include the Kahn study and came up with conclusions which differed from it.

While these criticisms need to be taken seriously there are certain limitations involved in using a very rigorous approach. This has been discussed in some depth by Ogilvie et al. (2005):

> *"It is increasingly recognised that the usual approach to selecting studies based on a "hierarchy of evidence" may rely too heavily on study design as a marker of validity or utility. This may favour interventions most amenable to certain types of study design, particularly those with a medical rather than a social focus and those that target individual people rather than populations" (Ogilvie et al. 2005, p. 886).*

They explain how, as a result of this, less is known about many of population or area level studies which often have comparatively weak study designs. Consequently least is known about the effects of those interventions which are most likely to have a broad and significant influence on the health environment and more about those interventions which are possibly more limited in their influence, a problem described as an evidence deficit or 'inverse evidence law' (Nutbeam 2003).

Kahn et al. (2005), by having broader inclusion criteria, were able to include a range of types of study which do not appear to have been reviewed elsewhere and which included community and population wide studies.

The other reviews which had wider inclusion criteria were those of Ogilvie et al. (2004, 2007). In the 2007 review they looked at a very wide range of interventions including RCTs and non-RCTs, before and after experiments and observational studies of how much people walk. They included a very wide range of interventions including environmental, fiscal, legislative and other policy interventions.

3.4 The impacts of interventions

3.4.1 Interventions directed at individuals

A wide range of interventions in the review by Foster et al. (2009) had positive impacts including, for example, encouraging walking through an 8 week training programme followed by a choice of group or independent walking plus other support (Kriska et al. 1986). Cunningham et al. (1987) found that encouragement to attend exercise sessions plus some additional exercise at home increased levels of physical activity. Stewart et al. (2001) found that where the intervention group received face-to-face counselling based on social cognitive theory, and were offered follow-up appointments, educational materials, phone calls and workshops their net levels of physical activity increased. Lombard et al. (1995) found that participants who received a high frequency of follow-up phone calls (10 calls over 12 weeks) were more successful at changing their behaviour than those who did not.

Overall they concluded that a mixture of professional guidance and self direction with continuing professional support produced more consistently positive results. The long-term effectiveness of these interventions was not established as the majority of studies stopped after 12 months.

Ogilvie et al. (2007) in their review of interventions to promote walking found that these were very effective at the individual level. Brief advice given to individuals either in a workplace or by clinicians or an exercise specialist in primary care was found to significantly increase self-reported walking. Remote support to individuals, and the use of pedometers was also very effective. Similarly in their earlier review, they found that targeted behaviour change programmes which encouraged people to reduce their amount of car use in a range of settings and places (Scotland, Perth and Århus) were all very effective. The Department for Transport has similarly and much more recently had positive findings with this type of targeted behavioural change programme in their Cycling City and Towns Programme (Department for Transport 2010a).

3.4.2 Family-based interventions

Kahn et al. (2002) looked at family-based social support in increasing levels of physical activity. They saw this as having a potentially valuable role:

> *"Family-based interventions attempt to change health behaviour through the use of techniques that increase the support of family members for behaviour change. The family is a major source of influence for children in the modelling of health behaviours and is, therefore, an appropriate target of intervention."* (Kahn et al. 2002, p. 83).

However as the interventions were combined with a range of other strategies it was not possible to arrive at a conclusion about the appropriateness of the family as a target of intervention strategy.

Ogilvie et al. (2004) looked at the Travel Smart programme which, while not directed at the family specifically, was directed at the level of the household. Households interested in changing their behaviour were given a tailored selection of resources such as leaflets, timetables, maps and free trial bus tickets. This did find positive modal shifts which were then repeated in subsequent controlled studies in England.

3.4.3 The school as a site of intervention to increase physical activity

Kahn et al. (2002) looked at interventions which modified the curricula and policies to increase the amount of time students spent in moderate or vigorous activity while in PE classes. This was found to be very effective. Interventions which targeted colleges were also looked at, but were not found to be so effective.

The importance of the school journey as a potential source of physical activity has been recognised; see for example: Mackett et al. (2005), EPPI Centre (2001) and Derek Halden Consultancy (2002). A number of schemes have been developed and heavily promoted by the Department for Transport which aim to increase the number of children walking to school. These include: 'The School Travel Advisor Toolkit' and 'The Walking Bus: a Step by Step Guide', as well as advice on the development of school travel plans. Findings on these interventions have been somewhat ambivalent (see, for example, the Department for Transport 2010b). Rowland et al. (2003) carried out a cluster randomised controlled trial in primary schools in Camden and Islington in London. They found that having a school travel co-ordinator increased the production of school travel plans but that there was no evidence that this changed travel patterns or reduced parental fears about traffic danger. Pupils in the ten intervention schools who received one year's input from a school travel co-ordinator were no less likely to travel to school by car than those in the control schools. Ogilvie et al. (2004) report that in an uncontrolled repeated cross-sectional study of a new cycle route in Stockton there was a negative modal shift of 2% in their usual mode of travel to school 17 months after a new cycle route was opened in the town.

However a review of the data emerging from the Sustainable Travel Towns work on school travel plans suggests that, in general, there was a decrease in car use (particularly at secondary school level) and an increase in AT to school. Cycling seems to have played a more significant role in this than walking, which in many cases actually seems to have gone down. It was difficult to say from the emerging data how much of the increase in AT was due to the school travel plans and how much was due to greater awareness of sustainable travel issues from the other work on travel which was going on (Sloman et al. 2010). The possibility that school travel work does not have a big impact on children's travel is also suggested by recent data emerging from Panter et al. (2010).

3.4.4 Healthcare settings

In England, referral by a GP (general practitioner) typically means being referred to a local leisure centre for a 10 to 12 week exercise programme at a reduced fee

(Hillsdon 1998). Riddoch et al. (1998) explored the effectiveness of physical activity promotion through primary care and concluded that the published studies showed a small but potentially meaningful improvement in physical activity patterns. A subsequent review by Hillsdon et al. (2002) suggested that primary care settings were not effective in promoting physical activity unless advice had been sought. Lawlor and Hanratty (2001) also concluded that advice in routine primary care consultations is not effective in producing sustained increases in physical activity. Hillsdon (1998) argued that the biggest barrier to the success of this intervention was the difficulty of recruiting sufficient participants, possibly because of the doctors' and nurses' lack of knowledge about the benefits of physical activity. The review by Hillsdon et al. (2005) analysed here largely confirmed these findings. Most of the reviews which they looked at tended to describe the effectiveness of these interventions as modest or short term and had methodological limitations. They point out that although primary care interventions in the UK are very popular it is still not known whether individual advice from a person's GP can lead to significant increases in physical activity that can be sustained beyond three months.

3.4.5 The workplace

The review by Hillsdon et al. (2009) concluded that findings from studies which examined the effectiveness of workplace interventions suggested that these were inconsistent in promoting changes in physical activity.

Workplace interventions which focussed on increasing LTPA were very favourably reviewed by Kahn et al. (2002) who concluded that outreach activities combined with enhanced opportunities for physical activity can be very effective for increasing overall levels. One particular example which stood out was an intervention conducted in a workplace setting of 36,000 employees and retirees of an insurance company in the US. This included health and fitness programmes, health promotion centres, newsletters and media blitzes. They identified cost savings through absenteeism, deaths averted, savings in health care costs and increased productivity. While there was considerable outlay in personnel, overheads, equipment etc the adjusted estimates for benefits and costs worked out at $139 million and $43 million respectively (Golaszewski et al. 1992).

Ogilvie et al. (2007) reviewed interventions to promote walking as a mode of transport to work and found that this had a significant net increase in self-reported walking. They also found a directive that employers should subsidise employees who chose not to commute by car was associated with a significant increase in walking. In their earlier review (Ogilvie et al. 2004) the workplace also appeared to be a good site of intervention. Studies conducted by Oja et al. (1998) and Vuori et al. (1994) focussed on workplace commuting. They looked at a promotion project in a large industrial plant which was aimed at increasing walking and cycling to and from work. They concluded from this, that physically active commuting to work offers substantial potential as a health enhancing measure for the working age population.

3.4.6 Community settings

Hillsdon et al. (2005) found that those interventions targeting individuals in community settings (i.e. where participants are not recruited via a specific setting such as a general practice or workplace) are effective in producing short-term changes in physical activity and are also likely to be effective in producing mid to long-term changes. Interventions which promote moderate-intensity physical activity, particularly walking, and are not facility dependent, are also associated with longer-term changes in behaviour. Examples included weekly group exercise 'counselling', mailed self-help materials, telephone education advice and support.

The other reviews also included community settings. For example, Kahn et al. (2002) looked at social support interventions within a community setting and found that these were effective in promoting physical activity. They also looked at community-wide campaigns which combine mass media with other approaches such as self-help groups, counselling, screening and education, community events and walking trails. They found strong evidence that community-wide campaigns are effective in increasing levels of physical activity.

Ogilvie et al. (2007) looked at interventions which applied to geographical communities and which measured effects by population rather than in terms of those participating directly in an intervention. These all involved a combination of approaches such as mass media campaigns augmented by community events, modest environmental improvements and other supportive measures. Three studies found a significant net increase in self reported walking with some qualifications. The most robust evidence of effectiveness was for an intervention with a mass media component.

3.4.7 Interventions in the environment

A successful intervention which involved changes to the environment was point of decision prompts reviewed by Kahn et al. (2002). These are:

> *"...signs placed by elevators and escalators to motivate people to use nearby stairs."* (Kahn et al. 2002, p.77).

They reviewed five papers, covering six studies: Andersen et al. (1998), Blamey et al. (1995); Brownell et al. (1980); Kerr et al. (2000); Russell et al. (1999). From these they concluded that:

> *"…sufficient evidence shows that point-of-decision prompts are effective in increasing levels of physical activity, as measured by an increase in the percentage of people choosing to take the stairs rather than an elevator or escalator."* (Kahn et al. 2002, p. 77).

Kahn et al. (2002) suggest that their effectiveness would have been increased if the prompts had been tailored to provide more information on the benefits of stair use or had they been customised more carefully to appeal to specific populations.

They also looked at a range of other interventions and found strong evidence that enhanced access to places for physical activity combined with informational outreach activities are an effective intervention.

3.4.8 Mass media campaigns

Only the review by Kahn et al. (2002) looked specifically at mass media campaigns and because they were usually combined with other interventions it was not possible for them to report reliably on their effectiveness. There was, however, a subsequent review done by Cavill and Bauman (2004) which concluded that:

> *"These studies have shown that physical activity-related mass media campaigns are likely to result in high levels of awareness and recall of the campaign name and main messages, and lead to increases in physical activity compared with pre-campaign. Large-scale campaigns thus appear able to reach large number of people, and disseminate initial awareness of physical activity and its benefits."* (Cavill and Bauman 2004, p. 787).

Some problems with mass media campaigns have been identified. Firstly the evaluations available for reviews are often funded by the public sector, so there are pressures not to release negative findings. There is a lack of knowledge about dose, frequency, and duration of campaigns (Cavill and Bauman 2004). Finlay and Faulkner (2005) argue that mass media strategies which have been used to promote physical activity have not taken into consideration the way in which a mass media message is interpreted or construed by consumers of it. There is a tendency to assume that the intended effect of the message is what happens and little attention is paid to the processes which mediate the message. Cavill and Bauman (2004) also argue that there needs to be more effort made to understand the target audience and that media campaigns need to be reinforced by long term policy and environmental changes which also support physical activity.

3.4.9 Other wide-level interventions

Ogilvie et al. (2004) found two studies, one of a new railway station and another of commuter subsidies, that showed some increase (5% and 1% respectively) in the shift from car trips to walking and cycling. They also found publicity campaigns, engineering measures, charging road users, telecommuting and car share clubs to be not effective. However in the case of the studies on car share clubs, only immediate, short term, and impact after a year were considered. A review of the same study four years after the introduction of the City Car Share programme found significant levels of behaviour change including mode shift to walking and bicycle travel (Cevero et al. 2002 a,b, 2007). This suggests that with these wider levels interventions considerable periods of time may have to elapse before significant behaviour change patterns occur.

3.5 Lessons from the evidence from health research

Despite differences in approach and methodology, some themes emerge consistently across the reviews. Short term interventions at the individual level benefited from brief advice from a health professional (Foster et al. 2009) and the need for on-going support of various kinds was a recurrent theme across all the reviews. Understanding the cognitive and behavioural factors associated with behaviour change was mentioned in the review by Hillsdon et al. (2005) and could be valuable for media-based interventions as well. The importance of tailoring interventions to the participants' requirements or circumstances was mentioned by Hillsdon et al. (2005) and was more strongly developed by Ogilvie et al. (2007). Tailoring included, for example, inviting households to choose from a menu of information resources to mapping children's individual journeys to school. Ogilvie et al. (2007) also discussed the importance of targeting interventions pointing out how some of the most effective results were achieved when the focus was on sedentary groups.

In terms of intervening with groups, the workplace appears to function well as a level of intervention, whether this is intervening to increase leisure time physical activity or walking to work. Community settings also appear to come out well. Findings about schools are not as conclusive, particularly with regards to active travel. Any weaknesses in these data may be a result of difficulties with researching at this level. In the Ogilvie et al. (2007) review there was found to be an average increase in walking of 30-60 minutes a week amongst the targeted participants. Although the overall increase would have been significantly lower than this, the successful implementation of these walking strategies suggests a viable avenue for future intervention. Another important point mentioned by Ogilvie et al. (2007) is that it is important to offer a wide range of approaches as a single approach will not be effective across the whole population.

3.6 Factors which mediate interventions

Levels of physical activity are influenced by a wide range of factors and these will influence the effectiveness of the interventions. However very little attention was paid to these in the studies or reviews. Foster et al. (2009) point out that the participants in the studies were generally white, well educated and middle aged and the other reviews also suggest that there might be difficulties generalising findings to the population as a whole. Some of the factors which will mediate the relationship between the intervention and participants affected by it are considered below.

3.6.1 Socio-demographic characteristics

Age

As the Health Survey for England (NHS Information Centre 2011) shows, the number of adults meeting recommended levels of physical activity declines steadily with age. However this pattern varies depending on the type of physical activity

which one is focusing on. While older people may obtain less physical activity through employment or leisure, rates of walking do not decline at the same rate. For example, the National Travel Survey shows that the number of walks of 20 minutes which a person undertakes remains largely the same throughout their life course till the age of 70 (Department for Transport 2010e). This suggests that walking is a very practical way for people to maintain levels of physical activity as they age.

Gender differences

There are also differences in patterns of physical activity between men and women. As discussed previously, the Health Survey for England (NHS Information Centre 2011) reports that between 1997 and 2008 rates of physical activity for men went up from 32% to 39% and for women from 21% to 29%. Men and women obtain their physical activity in different ways: for example men are more likely than women to do at least 30 minutes of moderate or vigorous physical activity a day as part of their occupation (24% and 11% respectively) (NHS Information Centre 2011). The National Travel Survey (Department for Transport 2010e) shows that in all age groups except 17-20 and over the age of 70, women actually walk more than men (although the differences are not large). Men, however, cycle more than women overall with men making three times as many trips. However as only a small proportion of the population cycle it seems unlikely that this extra cycling done by men could compensate for their lack of walking. Sustrans (2005a) found that there were differences between the genders in their use of the National Cycle Network (NCN), with 57.6% of the men using the network cycling, with the remaining 42.4% walking, while for women, 37.2% were cycling and 62.8% walking. Furthermore, the Health Survey for England finds that not only do men do more physical activity overall but they do more walking than women (Craig et al. 2008). It is difficult to explain these differences; however this does not alter the point that gender does affect levels and types of physical activity.

Ethnicity

Another socio-demographic characteristic which could mediate the impact of a physical activity intervention is ethnicity. Only one of the reviews (Hillsdon et al. 2005) looked at ethnicity and this was only in the context of interventions which focussed specifically on these groups. All of these studies were from the US, the interventions did not appear to be effective, and they did not compare minority groups with non-minorities.

However it does seem likely that ethnicity does have a significant impact. The National Travel Survey shows differences in car ownership between ethnic groups with those from white British, Pakistani and Indian backgrounds having higher car ownership than those from Black backgrounds (Department for Transport 2010e). Since car use appears to influence levels of walking and cycling, these are likely to vary as well. Data exploring these differences has been collected through booster samples by the Health Survey for England and has recently been analysed (Higgins and Dale 2010). There are some other sources of evidence. Williams et al. (2011)

explored physical activity in relation to South Asian women. Pomerleau et al. (1999) analysed ethnicity in relation to health behaviours and physical activity both in and out of work in the UK. Hillsdon (2007) examined ethnic identity in relation to physical activity amongst UK adolescents paying attention also to the role of socio-economic status.

Detailed analysis to address ethnic influences has been carried out in other contexts. Font et al. (2010) explored the role of the social environment and showed how differences in social norms can account for differences in obesity between Spain and Italy. Wen et al. (2007) tried to unpick the range of social and economic differences which could be encompassed by ethnic identity and looked at it in relation to marital status, individual socio-economic status and neighbourhood socio-economic status, as well as exploring how the length of time living in the US mediates the association between race, ethnicity and physical activity. Understanding more about the social, cultural, economic, familial and other differences between ethnic groups could help understanding about which aspects of ethnicity account for differences in physical activity behaviour. It might also be helpful to have more information on how ethnicity was defined (e.g. by colour, birthplace, parental birthplace, self identification).

Socio-economic status

Other important socio-economic characteristics which need to be taken into consideration in any assessment of the ecological context of physical activity are education and household income. This has been done in the UK in the context of ethnicity research as a possible confounder of the differences (Higgins and Dale 2010). However more detailed research on this appears to have been done in other countries, mainly the US.

Where research has looked at these variables, the findings tend to be very mixed. Trost et al. (2002), for example, found positive correlations between education and physical activity in general. However, a number of other researchers found negative correlations between walking and income (Badland and Schofield 2006; Berrigan et al. 2006; Giles-Corti and Donovan 2002a; Murakami and Young 1997; Plaut 2005). On the other hand, Ball et al. (2007) and Cole et al. (2006) found a positive association between income and walking. Similarly, an association between higher income and more LTPA has been found (Berrigan et al. 2006; Cerin et al. 2008; Hoehner et al. 2005).

These wide differences in socio-demographic variables should not be taken as evidence of inadequate research. Rather the differences between countries, areas and groups of people suggest that ethnicity, income and to a certain extent gender do not in themselves have that much influence on physical activity. Rather they signify the presence of other cultural, psychosocial, attitudinal environmental variables which are more difficult to test.

3.6.2 Personal social environment

Those who perceived high support from their social environment, for example family, friends, school and work places, were found to be more than twice as likely to be physically active as those who perceived low support (Ståhl et al. 2001). This was confirmed in the review of reviews conducted by Bull and Bauman (2007) who found that social support was consistently associated with higher levels of physical activity particularly among older adults, women and some minority populations. This emerged most clearly in their review of the work of Wendel-Vos et al. (2007) which showed that social support is the only environmental characteristic (and they looked at both physical and social environmental factors) which is consistently associated with physical activity.

Wen et al. (2007) found that the community social environment was also important in their exploration of the role of neighbourhood social cohesion. They found there was a significant association between neighbourhood social cohesion and walking at recommended levels after adjusting for individual socio-demographic factors, and neighborhood social and economic status and safety.

There is a relationship between commuting by bicycle and people's attitudes and perceived values. More cycling may result from positive perceptions of cycling or negative perceptions of car use. If the people in the individual's social surroundings have a positive opinion of cycling, there is a higher chance that the individual in question will cycle (Heinen et al. 2010).

Psychosocial factors need to be considered. These include self-efficacy and levels of information as well as people's attitudes and values. Self-efficacy refers to the confidence which a person has that they can be physically active. It is one of the most consistent intra-personal factors associated with physical activity and is one of the key components of social cognitive theory. Bull and Bauman (2007) explain that self-efficacy and its related constructs are measured frequently and have been found to be positively associated with physical activity across diverse population groups and populations. The consistent association between self-efficacy and physical activity has led to the development of numerous intervention programmes using self-efficacy and other social cognitive theory elements in the design of the intervention.

Other researchers who have also found interpersonal and individual factors to be useful in explaining walking and other forms of physical activity are Bagley and Mokhtarian (2002), and Giles-Corti and Donovon (2002b).

3.7 Travel behaviour

The present government is keen to encourage behaviour change as a way of addressing some policy issues, reflecting the fact that humans do not always behave in ways that might be expected if they behaved rationally. This is based on consideration of explicit attempts at behaviour change that have been used in health studies to curb unhealthy behaviour such as smoking, heavy drinking and unsafe sex

(Butland et al. 2007). The Government has looked at ways of applying behavioural insight to health (Behavioural Insights Team 2010). Two of the examples to increase physical activity are based on modal shift. One is the Step2Get initiative by Transport for London and Intelligent Health to incentivise children to walk to school by using swipe card technology, online gaming and rewards which have increased walking to school by 18%. The second example is the introduction of bicycle hire schemes in major cities such as the one in London (Transport for London 2011a). This is a scheme similar to that in many large cities around the world where cycles are provided at docking stations, for hire by users who have paid an access fee. In London the first 30 minutes of use are free (Aldworth 2011). The Behavioural Insights Team (2010) have argued that conventional economics would suggest that introducing large numbers of relatively cheap and easy-to-hire bicycles would make it less likely that people would buy themselves bicycles, but behavioural economics says that seeing more people cycle would create a new social norm and visual prompt so that more people would be encouraged to cycle. It seems that bicycle retailers have reported significant increases in bicycle sales since the London scheme started. This might also be due to the opportunity to try a bicycle at a low price without large financial commitment. Neither of these examples has been subjected to rigorous evaluation to establish their cost effectiveness. However, it has been stated that the business case for the London bicycle hire scheme had shown that the capital expenditure was justified by the time savings it would produce (Aldworth 2011). The capital cost was £70 million and the annual running cost £10 million a year with annual revenue of £4 million, mainly from the access fees.

The apparent success of the bicycle hire scheme in London might be seen as an example of using a ‘nudge’ to encourage behaviour change. A nudge is an intervention where the change of behaviour is easy and does not forbid choice (Thaler and Sunstein 2009). The local transport White Paper (Department for Transport 2011a) suggests that this approach is applicable to modal shift, but there can be difficulties because of structural factors which are external conditions beyond the control of individuals such as the location of infrastructure. For example, because of the decentralisation of urban areas, it may be too far to walk or cycle to the shops from some homes even though that may have been possible a generation or two ago, before the development of large out-of-town shopping centres led to the closure of many local food shops for groceries, meat and vegetables.

Underlying the concept of behavioural change to induce modal shift is the need to understand whether people believe that the use of the alternatives to the car could meet at least some of their travel needs. Examination of attitudes to transport in the 2010 British Social Attitudes survey (Department for Transport 2011b) showed that 41% of drivers say that they could walk many of the journeys of less that two miles (3.2 km) that they currently make by car, and 44% agree that they could cycle such trips if they had a bicycle. It is interesting to note that the National Travel Survey (Department for Transport 2010e) shows that 42% of the population over the age of five owns a bicycle, but only 24% cycle once or more a month.

There are concerns about the evidence on the effectiveness of interventions designed to produce behaviour change, particularly at the population level, including cost-effectiveness and long-term impact because of the lack of rigorous evaluation (House of Lords Science and Technology Select Committee, 2011). These examples from transport are interesting but they lack the rigour of the work carried out by health researchers. However, as discussed in the next section, there are some issues of concern about that work.

3.8 Key issues influencing the evidence

There are a number of issues that may undermine the findings from the evidence cited above.

3.8.1 Measurement

Measures of physical activity have traditionally relied on self-report, for example, a written survey or a telephone household interview. These methods are not always reliable. Foster et al. (2009) point out that when people report their own activities they may misclassify, which leads to:

> *"...less precision in measurement and increases the variance in measures of behaviour."* (Foster et al. 2009, p. 28).

Some self-report questionnaires have been assessed against objective measures in order to establish those with a high degree of validity and these are a valuable instrument of research (Rahman et al. 2003). Direct observation is used for recording the physical activity of others. The earliest example found was counting how many people used the stairs and escalators in a Philadelphia railway station (Brownell et al. 1980).

Objective methods such as pedometers and accelerometers appear to be more reliable; however, caution needs to be exercised here as well. For example, accelerometers are unable to calculate accurately the energy used whilst cycling because much of the energy used in cycling is caused by leg movement pushing the pedals and accelerometers only measure movement of the body. Whilst such problems are increasingly overcome by technological advances, the devices are still subject to human error and influence. Wearers may put them on incorrectly, remove them unnecessarily or forget to put them on. Another problem is what has been referred to as 'the Hawthorne effect' where people knowing that they are being studied might behave differently from how they normally would (Transportation Research Board 2005).

There are also problems because there is a great deal of variation in the amount of detail which is collected and the outcome variables which are presented. The data can be categorised in a range of ways; for example, whether the subject meets the recommended level of physical activity, or whether physical activity is recorded as a single variable in terms of minutes of activity or whether types of activities have been recorded (Bull and Bauman 2007). As a result, measures used across studies may not be strictly comparable with each other. Kahn et al. (2002) suggest that the

establishment of selected core measures which most researchers have used and which they then supplemented with their own measures, could provide a way forward for developing a more comparable study base.

3.8.2 Cost effectiveness

If an obese unhealthy person takes up physical activity, this is going to bring a greater health benefit than an already healthy and active person becoming more active. However this dimension is rarely built into cost-benefit analyses which are very difficult to conduct in this field. Müller-Riemenschneider et al. (2009) in their review of the cost effectiveness of interventions, identified 6,543 references, assessed the full text of 166 and found 8 which had adequate information to conduct a reasonably rigorous cost-benefit analysis. Three out of the 94 studies in a review by Kahn et al. (2002) included some kind of economic evaluation.

Blamey and Mutrie (2004) outlined two ways in which cost-effectiveness analyses can be conducted:

> *"First, cost-effectiveness studies of physical activity interventions compare the costs spent on interventions to achieve a certain health or behaviour impact and can be used to compare the costs of different interventions to increase physical activity by a certain amount. … Second, cost-benefit studies are more complex and require knowledge of the monetary costs of the intervention and a monetary value for the health gain achieved."* (Blamey and Mutrie 2004, p. 745).

Müller-Riemenschneider et al. (2009) drew attention to the difficulties of comparing studies with each other because of differences in study design participants, and duration of follow up. Also the ranking of the studies varied depending on how the outcome of the physical activity was assessed. Finally, it is very difficult to transfer the findings to another country because differences in the particular systems of the country (for example, the way in which health care is funded), mean that the actual costs for carrying out the intervention will vary. Further discussions on methods for measuring cost effectiveness can be found in Carande-Kulis et al. (2000).

Despite these problems, a recent Australian study evaluated the physical activity literature in order to model the cost impacts and health outcomes of six physical activity interventions over the lifetime of the Australian population (Cobiac et al. 2009). They concluded that intervention programmes which encourage the use of pedometers and mass media-based community campaigns were the most cost-effective strategies and likely to save money. They also found that an internet-based intervention programme, a GP physical activity prescription programme and a programme to encourage more active transport were likely to be cost effective. GP referral to an exercise physiologist was seen as the least cost-effective option.

3.8.3 Long term sustainability

A key issue is how long the effects of an intervention last after the intervention itself ceases. Funding usually stops with the intervention and therefore there are very little data available on how long the effects last. Examination of a range of reviews, for example the review by Foster et al. (2009), suggests that interventions often seem to be most effective where they have high levels of the right sort of follow-up, suggesting that without these being maintained, the initial results are unsustainable.

This issue has been explored systematically by Müller-Riemenschneider et al. (2008) who argue that, compared to previous systematic reviews, the evidence for the long term effectiveness of physical activity interventions has increased considerably. They conclude that there is evidence for the long term effectiveness of physical activity interventions in healthy adults and that the increases in physical activity are having meaningful health benefits:

> *"Comprehensive and high-quality interventions, using additional exercise prescriptions and booster strategies achieved most substantial long-term increases in physical activity behaviour…"* (Müller-Riemenschneider et al. 2008, p. 367).

They suggest that there needs to be more rigorous work done on the types of interventions which lead to long-term sustainability.

3.9 Conclusions

It has been shown that various aspects of the social environment influence levels of physical activity. Those who are interested in improving public health have used this knowledge to develop a range of interventions which have influenced the levels of physical activity of individuals, communities and other population groupings. Some of the most effective interventions have targeted population subgroups such as the workplace or community. Approaches which aim to change people's behaviour by providing them with information also have a valuable role, particularly in the form of community-wide campaigns. Mass media too has a vital role in changing people's attitudes as a precursor to behaviour change but more research needs to be done here. Measures which target the individual directly and which are tailored to their needs and provided on-going support also appear to have potential.

However, all of the methods have weaknesses which undermine their potential as a long term strategy to increase physical activity. Methods of measurement are unreliable and there is little evidence to suggest that they could be rolled out across the general population. However, the most serious problem is that many of the schemes need on-going investment in order to be sustainable over time. This means paying to maintain the healthy levels of physical activity which humans have taken for granted for most of their existence.

4 The effects of the built environment on physical activity

4.1 The potential for the built environment to affect physical activity

One way to increase walking and cycling is to modify the built environment to make walking and cycling more attractive.

The first observations of the links between physical activity and the environment emerged in the 1950s in a study of bus drivers which looked at the impact of the working environment on physical activity and health (Morris et al. 1953). Research on physical activity has increasingly come to focus on ways in which modification of the built environment can influence physical activity mainly by encouraging walking. There were a number of steps which led to this.

4.1.1 The contribution of the built environment to physical activity

It was recognised that social and informational interventions had their limitations, particularly in terms of maintaining physical activity on a long term basis which was necessary to achieve sustainable public health effects (Frank and Pivo 1994). Attention turned to ways in which interventions could integrate physical activity into daily life on a sustainable long term basis which would affect whole populations rather than only intervening with individuals or small groups. The built environment was seen to have a particular role to play here. As Saelens et al. (2003) observed, increases through environmental interventions may not appear to be as significant as behaviour change interventions but they:

> *"...reflect differences in physical activity across the entire population living in the target neighborhoods rather than changes in the small proportion of people who are motivated and volunteer to participate in intervention studies."* (Saelens et al. 2003, p. 86).

The other fundamental difference was that changes in the built environment could be expected to be fairly permanent:

> *"...in stark contrast to the well-documented lack of maintenance of health behaviour change programmes…"* (Saelens et al. 2003, p.86).

One of the problems that needs to be addressed is the very small number of ex-post evaluations of interventions to improve the local environment for walking that have been carried out in Britain (Living Streets 2011). Similarly there are few systematic evaluations of investment in cycling infrastructure. Whilst the Cycling City and Towns Programme does include the development of infrastructure in the form of cycling routes for example in Bristol, Colchester and York, these are all elements of comprehensive packages of measures to increase cycling including offering cycle training, events and cycle hire schemes (AECOM et al. 2011) and so it will be very difficult to establish the contribution of changes to the built environment to increases in cycling.

4.1.2 Theoretical developments

Analysis of the built environment was facilitated by the development of theoretical instruments. One of the most significant was the 'Analysis Grid for Environments Linked to Obesity' (the ANGELO framework). This provided a framework for examining how various environmental, biological and behavioural influences contributed to obesity (Swinburn et al. 1999). They also popularised the concept of 'The obesogenic environment' which was seen as the:

> *"...sum of influences that the surroundings, opportunities or conditions of life have on promoting obesity in individuals."* (Swinburn et al. 1999 p. 564).

There was also the development of data collection instruments which were used for assessing environmental characteristics. SPACES (Systematic Pedestrian and Cycling Environmental Scan) and NEWS (Neighborhood Environment Walkability Survey) are two of the better known ones (Pikora et al. 2000; Saelens and Sallis 2002). Another significant theoretical contribution came from Handy et al. (2002) who focussed more specifically on the ways in which the built environment affected physical activity. Their definition of the built environment included three elements: urban design (design of the city and its physical elements), land use (distribution of activities across space) and transport infrastructure (physical transport systems such as roads and rail).

4.1.3 The role of technology

In addition to these models and theoretical developments, there was the development of a whole range of technical instruments, for example Geographical Information Systems (GIS) such as ArcView, which made objective measurement of the environment possible at a micro level. Frank and Pivo (1994), for example, used a database providing categories of use for each parcel of land to develop a mixed use index. Handy (1996) measured distances from homes to destinations using the street network reflecting real distances travelled by walkers and cyclists. Further information on these instruments is provided by Brownson et al. (2009).

These instruments developed from a planning perspective complemented the parallel development of tools in the health field which made the measurement of physical activity possible (such as accelerometers) and greatly increased the potential for collaboration between transport, health and other research domains. Prior to this, researchers had had to rely on reported physical activity and perceptions of the environment which were far less reliable, although it should be acknowledged that the response of individuals to changes in the environment is based on their perceptions of it.

4.1.4 The role of transport and urban planning

Transport professionals are interested in AT to reduce congestion and carbon emissions. Although they were not initially interested in the physical activity implications of transport behaviour, they were very interested in finding out the

factors which encouraged people to walk, and pedestrian needs were considered by transport providers through the development of tools such as the 'Pedestrian Level of Service Framework' (Frank and Engelke 2000). All of this contributed to understanding how the environment affects physical activity.

The role of transport and urban planning in increasing physical activity was addressed in the development of guidelines on 'Promoting and creating built or natural environments that encourage and support physical activity' by NICE (National Institute for Health and Clinical Excellence 2008). Searches of electronic data bases using urban planning and design terms and physical activity terms produced 23,714 titles. Another 35 were identified by other means. When they had been assessed for relevance, whether they included an intervention related to modifying the physical urban environment and the quality of the data, 13 studies remained. A separate search of the data bases using transport terms and physical activity terms produced 19,376 references, with another 38 found by other means. These were reduced to 26 by the same process as for the references on urban planning and design. This illustrates the shortage of systematic studies of the effects of the built environment on physical activity. The relevant references on the built environment from this study are discussed in Section 4.2.5.

4.2 Aspects of the environment which influence physical activity

The new focus on walking and AT combined with the theoretical and technical developments led to physical activity research on the environment which started emerging in the late 1990s but really took off between 2002 and 2004. Foster and Hillsdon (2004) provide the following definition*:*

> *"The environment is defined in relation to health-enhancing physical activity as any aspect of the physical (natural) environment or the urban constructed environment that unconsciously or consciously relates to an individual and their HEPA behaviour."* (Foster and Hillsdon 2004, p. 756).

Most research focuses more specifically on the built environment which Brownson et al. (2005) conceptualised as 'The physical form of communities'. This can be seen as consisting of three components. The term 'Land use patterns' refers to the spatial distribution of human activities. 'Transportation system' refers to the physical infrastructure and services that provide the spatial links or connectivity among activities. 'Design' refers to the aesthetic, physical, and functional qualities of the built environment, such as the design of buildings and streetscapes, and relates to both land use patterns and the transportation system.

4.2.1 Density and diversity

Density and diversity are two key and interlinked measures of the built environment which have been found to influence physical activity. Density measures include density of population, employment and retail activity. Density of population can contribute to higher levels of walking because it means that more facilities can be situated in close proximity to each other as there will be more people to support them.

This is particularly important for the provision of public transport which is more sustainable in areas of high population density than low (Vojnovic 2006). Handy (2004) found that the greater the density of population, retail facilities and employment and the mix of land use, the greater the number of walking and other non-motorised trips. Part of the reason why density of facilities is believed to have this effect is because it contributes to neighbourhood accessibility (Krizek 2003). However, contradictory evidence to this has recently been presented by Frank et al. (2010a) where it emerged that in areas of high density and mixed use development, there is less walking because all the facilities were so close to each other.

The diversity of land uses is also very important because it increases the likelihood of there being places that people will want to visit. So, for example, if there are shops and leisure facilities located near residential areas, people will have somewhere to walk to, and, if these areas have high population density, people are likely to be able to walk to them. McCormack et al. (2008) have shown that each category of destination located within walking distance led to five minutes extra walking per week. Therefore a neighbourhood shopping centre which has a range of retail, service and leisure facilities would encourage more people to walk. The policy implication of this is that having clusters of destinations in each neighbourhood will encourage walking for transport.

4.2.2 Destination accessibility

Density and diversity are important because they are likely to influence accessibility to destinations. Destination accessibility measures the ease of access to trip attractions locally or further away. So, for example, it could measure the distance to the central business district or the number of jobs or other attractions reachable within a given travel time. For Handy and Clifton (2001a) local accessibility is defined as the distance from home to the nearest store.

Distance to a destination has been identified by Lee and Moudon (2004) as being the determining factor in travel mode choice. A long distance will discourage all travel, but particularly non-motorised, whilst close proximity of destinations will encourage walking. A key question is 'What is regarded as a walkable distance?'. Moudon et al. (2006) suggested that people will only walk a quarter of a mile (0.4 km) to a destination. However, this research was carried out in low walkable suburban communities in the US and the distance could be higher in environments designed to meet the needs of pedestrians. Vojnovic (2006), from her review of existing research, estimated that a walkable distance is less than 0.8 km whilst a cyclable distance is less than 5 km for short trips and everyday tasks. The McCormack et al. (2008) findings went further than this. Whilst people were much more likely to walk the shorter distances identified by Moudon et al. (2006) they found that many people would walk 1500 metres. In fact, they found that activity centres located within a 5 minute or a 15 minute walk were equally related to the amount of walking for transport. In the NICE study on physical activity and the environment the only relevant study on this theme identified out of the 23,717 references examined was the study of the location of shopping malls in the Czech Republic by Newmark et al.

(2004). The study did not include a survey before the intervention so the evidence is limited but it suggested that building shopping malls on the fringes of cities may lead to a reduction in the number of shopping trips, with more use of the car and fewer pedestrian trips.

The theme of accessibility has been developed to incorporate other variables. Saelens et al. (2003) conducted a review to find out what characteristics would increase the likelihood of people walking and established proximity (distance) and connectivity (directness of travel) as two key variables. They also took into consideration other factors such as travel cost and environmental quality which together form the differences between high and low walkable neighbourhoods. Their evidence shows that these can account for a difference of approximately one to two walk trips per week which translates into 1 to 2 km, or about 15 to 30 minutes more walking per week for each resident of high-walkable neighbourhoods. These differences can be seen as particularly significant in the American context where the rates of walking are very low. The main reports and articles which Saelens et al. reviewed for their paper were: Cervero and Gorham (1995); Cervero and Radisch (1996); Ewing et al. (1994); Friedman et al. (1994); Handy and Clifton (2001a); Handy (1996); Kitamura et al. (1994); McNally and Kulkarni (1997); Paffenbarger et al. (1984); and Parsons et al. (1993).

4.2.3 Distance to public transport

Distance to public transport is a subsection of the previous category in that nearby public transport stops are likely to increase destination accessibility. It is usually measured as an average of the shortest street routes from homes or workplaces in an area to the nearest railway station or bus stop. It can also be measured by calculating how many public transport routes are easily accessible or how many stations there are in an area. It is useful to combine destination accessibility and distance to public transport in one measure including the number of attractions that can be reached through public transport journeys within a particular time.

4.2.4 Walkability

Knowledge about relations between land use design, accessibility and physical activity has been consolidated by a number of different commentators into a composite variable of ‘walkability’ or what is sometimes referred to as a ‘walkability index’. An example is the ‘walkability index’ developed by Frank et al. (2006) which included retail floor area ratio. They found that in King County, Washington, a 5% increase in the index was associated with a 32.1% increase in the time spent walking and cycling. Frank and Kavage (2009) report that:

> *“Evidence is clear that there is an unmet demand for more walkable environments. The pent up demand for more walkable environments is perhaps best evidenced in housing and land values. One new study correlated property values to the 100-point scale used by walk score. The results showed that a 10 point increase in walkability increases property values by 5-8% depending on property type. Not everyone*

> *lives in the type of environment they prefer, and many that want to live in walkable places are priced out due to the lack of supply relative to demand for such places."* (Frank and Kavage 2009, p. S192).

A new walkability index has been developed recently (Frank et al. 2010b).

4.2.5 Transport infrastructure

A comprehensive overview of the links between transport and physical activity is provided by Frank and Engelke (2000). For them the transport system represents:

> *"...the aggregate result of investments in transportation infrastructure."* (Frank and Engelke 2000, p. 47).

It includes the network of streets in a city, the design of individual streets and highways, transit systems, and separated systems for non-motorized users.

According to Frank and Engelke (2000), street networks influence trip route and mode choice through the ways in which they connect trip origins and destinations. High connectivity networks have a large number of blocks and intersections per unit of area while those with low connectivity have far fewer. In the US, where most of the research on the built environment has been carried out, there are clear patterns in types of street network and these have an impact on levels of physical activity. The first phase of American development lasting until the Second World War was dominated by the classic gridiron pattern. This has been described by Frank and Engelke (2000) as the archetype of the high connectivity network. It involves a simple system of two sets of parallel streets crossing at rights angles to form square or rectangular blocks. They are non-hierarchical in that there is little differentiation of streets by traffic volume. They are, in theory at least, capable of increasing walking and cycling in both directions. They have a large number of intersections thereby reducing the distance between trip origins and destinations and allowing for alternative routes. The second phase, which began after World War II, rejected this pattern and emphasized instead street hierarchy, curvilinear design and disconnected networks. Residential streets often loop back upon themselves or are cul-de-sacs. The residential streets feed into major arterial roads which are designed for heavy traffic and do not have facilities for cyclists or pedestrians. In contrast to grids they are lower in connectivity and discourage walking and biking by increasing trip length and decreasing both route and modal choice (Frank and Engelke 2000). These two types of street configuration can be identified by housing from the distinct historical periods involved. The age of the housing can serve as a proxy variable for levels of street connectivity.

The gridiron system came to be associated with industrial America and blamed for the ills of its cities. There was therefore a movement to replace it with a discontinuous street network. It is, in fact, the latter which has created real health problems through the barriers it sets up to walking and cycling. Frank and Engelke (2000) explain that the problem was:

> *"…the separation of neighbourhoods by arterials creates islands for local residents, in effect walling them off and making travel across*

> *neighbourhood boundaries on foot or by bicycle dangerous (Unterman 1987). Further, as the number of automobiles has increased in society, the car has come to dominate even the internal residential streets, also to the detriment of bicyclists and pedestrians (Wolfe 1987).”* (Frank and Engelke 2000, p. 54).

These disconnected streets are now being replaced by the neo traditional school of design or new urbanism which emphasized the creation of walkable, liveable neighbourhoods ensuring connectivity and reduced distances for local trips.

The term ‘street design’ refers to the layout and design of the individual streets including the street surface and the adjacent off-street spaces. Certain types of designs encourage walking whilst others discourage it. So, for example, amenities such as trees, pavements and bike paths make walking and biking more attractive, as streets which discourage driving through the use of vehicle calming measures which are designed to slow vehicle speeds and hinder their movement. There are also a wide range of ways in which traffic is calmed which might also encourage people to walk.

The review on urban planning and design conducted during the development of the NICE guidelines on modifying the environment to increase physical activity found seven references on the effects of street level infrastructure changes on physical activity (National Institute of Health and Clinical Excellence 2008). In the transport review eight references were found on street calming, three on closing or restricting the use of roads, seven on improvements to cycling infrastructure and two on safe routes to schools. Of these references, Layfield et al. (2003) and Newby and Sloman (1996) looked at the effect of improvements to the street environment on its use by pedestrians. The former found a positive increase in the numbers walking and the numbers of children playing, but the evidence was not very strong. The latter found no change in the number of self-reported walking and cycling trips. Skjoveoland (2001) looked at the impact of three street parks in a Norwegian city and found an increase in the number of children in one of the two newly-created parks (with no change in any of the three control parks), but the presence of adults decreased significantly in one of the new parks and in two of the three control parks. Space Syntax (2004a, 2004b) looked at pedestrian counts in two London squares that had been redesigned. An increase was found after the changes in one of the squares and a decrease in the other. Space Syntax (2002) also looked at the effect of a new pedestrian bridge across the River Thames in London and found an increase in pedestrian activity as a result. Painter (1996) examined the influence of street lighting improvements on pedestrian street and footpath use and established that there were increased pedestrian counts. The seven reviews on cycling infrastructure all found an increase. Five of them found only an increase in cycling (Ashton-Graham 2003; Troelsen et al. 2004; Cope et al. 2003; Cycling Touring Club 1995a, 1995b), while one found a small increase in cycling and a significant decrease in walking (Mamoli 2003), and the other (Hartman 1990) found a small increase in cycling from a very high base and ‘a likely decrease’ in walking. Of the eight studies of the effects of traffic calming, five of the studies found increases in walking and cycling (Department of the Environment, Transport and the Regions 1999b; Kirby

2001; Morrison et al. 2004; Scottish Office 1999; Webster et al. 2006) but two others found slight decreases (Social Research Associates 1999, 2001) and one found no significant change (Babtie Group 2001). The three references on the effects of closing or restricting the use of streets (Cairns et al. 1998a,b; Gemzoe 2001) all found long term increases in the levels of walking within the area of the scheme, and one found that it also increased the level of cycling. The two studies of safe routes to school (Sustrans 2005b; Boarnet et al. 2005) both found that the introduction of the schemes led to short term increases in levels of walking and cycling within the area of the scheme.

A review which explores individual perceptions of the environment is the one by McCormack, et al. (2004). This looked at a wide range of factors including self-reported measures of aesthetic factors such as cleanliness, scenery, varied building designs, low traffic and greenery which were found to be positively associated with activity. Objective design measures were not examined.

Owen et al. (2004) conducted a review which looked at the environmental correlates for any type of walking. Walking for exercise tended to be related to an aesthetically-pleasing environment, convenient facilities and coastal location but the relationships tended to be insignificant. For AT, access to public open space, safety, perceptions of traffic and pavements all contributed to high walkability scores.

According to the Transportation Research Board (2005) report which looked at the relationship between the built environment and physical activity, evidence about a correlation of design features and aesthetic characteristics of neighbourhoods with physical activity is more limited than research on other aspects of the built environment. Design variables such as neighbourhood aesthetics and enjoyable scenery, emerged most strongly as significant correlates of physical activity, particularly walking. In the travel behaviour literature, one positive correlation with design variables is identified. Handy et al. (1998) found that positive perceptions of scenery, shade, people, traffic, walking safety and comfort were all positively correlated with walking trips to the local shopping area. Handy et al. (2006) used a telephone survey with people who had moved recently, with a control sample who had not moved, to establish the association between changes in the built environment as a result of moving and changes in levels in walking and cycling. The study was included in the NICE study on physical activity and the environment (National Institute for Health and Clinical Excellence 2008) which concluded that there was insufficient evidence to draw firm conclusions about the effects of urban structure on physical activity, but that there might be a positive impact on levels of walking and cycling.

Kitamura et al. (1994) found that, while density, public transit accessibility, mixed land-use, sidewalks, and other measures of pedestrian friendliness have been consistently associated with higher rates of walking, individual attitudes toward travel choices may be even more strongly correlated with travel behaviour than are neighbourhood characteristics. Research conducted by Handy (1996) found that there were high levels of walking in suburban areas even where they had been given

negative ratings in terms of walkability, suggesting that the built environment may not be that important if people are highly motivated to walk.

Understanding of people's values and attitudes enables planners to anticipate behaviours more accurately and to understand what might contribute towards AT. Giuliano and Hanson (2004), using evidence emerging from Orange County in California, showed how people value 'remoteness', affordable housing and convenience in ways which had not been predicted. It also emerged that people were willing to give up access to various urban activities in order to live in a particular type of housing.

An important piece of work on street design was done by Rapoport (1987). He showed features of value to drivers in terms of street environment were not appealing to pedestrians and vice-versa. For example, drivers of fast moving vehicles like an environment which is low in complexity, has wide streets, little detail and no abrupt corners. Pedestrians prefer a rich environment which maintains the pedestrians' visual and sensory attentions, so they like irregular, complex highly changing streets.

For cyclists, route safety and the presence of bicycling facilities is particularly important. The Federal Highway Administration (1994) summarised six design factors believed to have the greatest effect on cycle use. These include traffic volume as higher levels of traffic represent greater potential risks to cyclists and contribute to their sense of fear. The average vehicle speed is more important that the speed limit as this gives a realistic assessment of the speed at which people drive. Traffic mix is important as the presence of buses and trucks inhibits cycling. On-street parking reduces the width available for cyclists to travel along. Sight distance is important because it allows the motorists to slow or avoid bicycles when passing and the number of intersections can create problems for cyclists and pedestrians especially when bike lanes or separate paths are involved.

The findings reported by Frank and Engelke are similar to more recent research conducted by Heinen et al. (2010) on factors which affect cycling. They explain how cycling share is influenced by distance, function mixture, storage facilities, block size and density, the presence of bicycle infrastructure and its continuity, traffic lights and stop signs, land use, parking facilities and showers at work. Of these, distance is probably the most important factor.

Heinen et al. (2010) also looked at non-physical dimensions which affect cycle use. They explain that:

> *"...it is thought that individuals sometimes decide whether or not to commute by bicycle by comparing cycling with other transport options, in terms of cost, travel time and safety. Negative factors relating to car use or public transport could lead individuals to develop a more favourable view of cycling."* (Heinen et al. 2010, p. 76).

4.2.6 Personal safety

Concern for personal safety can have a particular impact on recreational walking. In low income neighbourhoods, often typified by isolation and high crime levels, there is more walking and transit use than average, although this is more out of necessity than choice. Concerns for personal safety can play a role in the use of pathways for walking and jogging in urban and regional parks. Adults, particularly older adults and female members of minority groups, can be deterred from walking and other physical activity by footpaths and recreational areas that are perceived to be unsafe.

The US Transportation Research Board commissioned a paper to look at the influence of safety and security on physical activity levels (Loukaitou-Sideris 2004, 2006). The main sources of danger caused by humans for pedestrians and cyclists are crime and vehicular traffic, and the main environmental sources are roadway design, infrastructure condition and unattended dogs. However neither Handy (2004), who also explored this topic in her work, nor Loukaitou-Sideris (2004, 2006), found strong evidence for a correlation. This seems likely to reflect weaknesses in the choice of included studies in the study design and the possibility that, by combining different variables in composite indices, important differences were obscured.

In the Transportation Research Board (2005) report it was shown that a study of urban youth (which included carefully collected data on local socio-economic and physical characteristics of 80 Chicago neighbourhoods) found that lack of community safety and measures of social disorder (public intoxication, selling drugs, prostitution) were associated with lower levels of recreational physical activity but that measures of physical disorder (graffiti, abandoned cars, needles and syringes) were not. These effects remained significant after differences in neighbourhood socio-economic characteristics had been taken into account (Molnar et al. 2004).

4.3 Difficulties in analysing the built environment

4.3.1 Issues of measurement

The scale of the environment

Vojnovic (2006) observed that the features of the built environment which are important for physical activity vary according to the scale which is being looked at. Her idea was that:

> *"…urban form and environmental correlates may be different at a micro-scale environment [e.g. the local neighbourhood factors which encourage walking to the shops] compared to the macro-scale environments [city design factors that encourage the development and use of public transportation systems and facilitate active commuting to and from public transport]."* (Bull and Bauman 2007, p. 22).

Type of physical activity

Measuring physical activity in the built environment is subject to the same sorts of problems which were outlined earlier with reference to physical activity interventions. Early studies on the built environment claimed to look at total physical activity but often it was really only LTPA which was considered properly. Attention moved to walking, as outlined above. However, walking can also be divided into the two categories of walking for recreation and walking for transport and this distinction was often not made. Studies vary in the degree to which they consider the full range of physical activity types, whether they distinguish between walking and other forms of physical activity, and if they do consider walking, whether they look at different types of walking.

Objective versus subjective characteristics

A key issue is whether objective or subjective data are used and the extent to which they are comparable with each other. There are a range of objective measurement techniques. Firstly, residential density can be established using census data, and land use diversity can be assessed by detailed observation of the field. Kitamura et al. (1997), for example, assessed such characteristics as street width, block size, presence of sidewalks and bike lanes, speed limits and public transit services. Other objectively assessed characteristics included the availability of facilities, road network distances, land use mix, and population density measures. GIS databases have also been used for this purpose; there are a number of examples of their use (Frank and Pivo 1994; Handy 1995; Handy 1996; Jones et al. 2009). Accelerometers provide objective measures of physical activity in the field of health and, combined with GPS, enable relationships between specific environments and physical activity to be identified (Jones et al. 2009; Mackett et al. 2007).

Subjective characteristics are assessed in those studies which focus on 'perceived' characteristics of the environment. Strong associations have been found between perceived characteristics of the environment and physical activity (Duncan et al. 2005). However, few studies have attempted to capture both objective and subjective measurements and explore the relationship between the two.

4.3.2 Endogeneity

The term 'endogeneity' is used by analysts to refer to the possibility that the reason that certain environments appear to encourage more walking is actually because they attract people who like to walk rather than by directly encouraging more walking themselves.

This relationship between attitudes and values and physical environment characteristics has been an on-going source of debate and research. For example, some research has shown that although compact development supports more walking and public transport use, these travel patterns also reflect differences in the household characteristics of those living at these different density levels (Dunphy

and Fisher 1996). Cerin et al. (2009), whose starting point was socio-demographic variables, found that the reason the better off or more educated people had higher levels of physical activity was because of the types of area they lived in. They found a whole range of pathways through which social and economic status influenced levels of walking. These included, for example, participation in LTPA, the type of environment people choose to live in, access to services, walkability of neighbourhood, links with social capital and social cohesion, and levels of education. In the final analysis, it was education and specific environmental features which shaped the positive links between social and economic status and physical activity. The environmental features mentioned included: increased residential density, reduced physical barriers to walking and traffic load, social support networks, public transport, and greener and more aesthetically pleasing environments in less disadvantaged areas.

This issue has been systematically explored in the research. Bagley and Mokhtarian (2002) looked at attitudes, residential location choice and travel behaviour and they concluded that:

> *"The results showed that, in terms of both direct and total effects, attitudinal and lifestyle variables had the greatest impact on travel demand among all the explanatory variables. By contrast, residential location type had little impact on travel behavior..." (Bagley and Mokhtarian 2002, p. 294).*

Later, Schwanen and Mokhtarian (2005) showed that there were people with particular types of attitude who would be more likely to travel by car but that the differences across neighbourhoods were greater than differences within neighbourhoods indicating that neighbourhood structure has an autonomous affect on travel choice. The Transportation Research Board (2005) report similarly concluded that:

> *"When individual attitudes and residential location preferences are taken into account, the autonomous effects of the built environment (e.g. walkability) on physical activity behaviour are often exhibited, but much less strongly and in a more nuanced way."* (Transportation Research Board 2005, p. 150).

Ewing and Cervero (2010) have conducted a review which found 38 studies which used nine different research approaches which attempted to control for residential selections. They concluded that:

> *"...nearly all of them found "resounding" evidence of statistically significant associations between the built environment and travel behaviour, independent of self selection influences (Cao, Mokhtarian et al. 2009a p. 389). However, nearly all of them also found that residential self-selection attenuates the effects of the built environment on travel."* (Ewing and Cervero 2010 p. 266).

4.3.3 Difficulties identifying causality

Much of the research on the built environment and physical activity is based on cross-sectional study designs which show associations between characteristics and

identify mediators and moderators which influence them. There is little conclusive evidence on cause and effect. The research done on endogeneity gets close to establishing causality in that it shows that the built environment does have an influence independent of attitudes although it may not indicate exactly what aspect of the built environment has this effect.

In order to get closer to establishing causality, there has been an increasing focus on longitudinal studies of interventions into the environment which are introduced by others external to the study (for example a local authority), but are likely to impact on it. These are known as 'natural experiments'. However there are many difficulties involved in conducting these. Impacts can be far reaching both spatially and temporally and therefore it is difficult to know whether they have been captured adequately. Health researchers usually set up a control group with which to compare the intervention group; however, this can be very difficult with environmental or policy interventions.

The UK Medical Research Council (MRC), which has a long history of funding research into the impact of complex interventions, has issued guidance on various methods for dealing with the difficulties involved in this type of research (Medical Research Council 2008; Craig et al. 2008). They suggest ways in which individually randomised trials and cluster randomised trials can be used to address difficulties in setting up conventional parallel group randomised trials. This guidance provides a very useful resource for developing research methodologies into large scale interventions which impact on the environment or on policy in a way which is likely to affect large numbers of people.

Where researchers are trying to understand the health effects of particular policy or environmental interventions it may make sense to use the best evidence available and weight it accordingly rather than hold out for only the most scientifically rigorous studies (Egan et al. 2005; Ogilvie et al. 2005). As Sallis et al. (1998) explain:

> *"...researchers must balance scientific rigor with the need for public health action."* (Sallis et al. 1998, p. 392).

4.3.4 Problems with composite indices

Research on the physical environment has tended to find that it is a combination of characteristics which influence physical activity rather than a single one. There are synergistic relations between aspects of the environment which affect behaviour. The challenge has been to identify which of these characteristics go together. This has led to the emphasis on 'walkability' which is conspicuous in the research.

A consequence of this is that it is very difficult to identify which characteristics are most important or which characteristics are having which effect. It could even be possible that composite variables contain indices which are having an opposing effect but this is obscured by the other measures with which they are combined. Humpel et al. (2002) noted, for example, that conflicting results from one study with college students may have been due to the use of a composite summary variable.

Therefore, while composite characteristics can be very useful, they need to be treated with caution.

4.3.5 Location of the research

Most of the research on the environment and physical activity has been carried out in the US with Canada and Australia also being important sources of research. The physical environment in America is very different to that found in Europe including the U.K. For example, many of the urban areas in the US were built in the past 150 years whereas much of the road network which shapes British towns and cities was established hundreds of years before that. The UK has very limited space compared to the US and this influences the way that planning is carried out.

These and other factors mean that, while there is much to learn from the American findings, extreme caution must be exercised when adapting any policy conclusions from them.

4.4 The implications for policy

Bull and Bauman (2007) carried out a thorough and systematic review of reviews of the environment and physical activity which included 13 systematic reviews representing in excess of 100 primary studies. In terms of the environment and physical activity they found:

> *"…reasonably consistent associations between access to physical activity facilities, convenient and proximate access to destinations, high residential density, land use and urban 'walkability' scores and measures of physical activity. There are also reasonably consistent associations between perceived safety, exercise equipment, footpaths and physical activity participation."* (Bull and Bauman 2007, p. 33).

Less clear associations were found for aesthetic features, parks, topographic factors and perceived crime. They found that, notwithstanding a few differences, the environmental characteristics which correlated with walking were similar to those which correlated with physical activity more generally. Within the former they found some which were more likely to encourage leisure walking and others more likely to encourage walking for transport.

They concluded the following from the review:

> *"The evidence base is sufficient to include environmental thinking in the mix of strategies that might summate to a comprehensive public health approach to physical activity. However, environmental change alone may not be sufficient to influence population level physical activity prevalence, and caution should be exercised, tempering unbridled enthusiasm for environments as the 'great white hope' for public health approaches to physical activity (Bauman 2005)."* (Bull and Bauman 2007, p. 39).

Sallis (2008), commenting on a paper by McCormack et al. (2008), identified measures in the built environment which can be taken to improve physical activity:

- Proximity to destinations is a defining element of walkable communities and if there are no destinations within a walkable distance people will be extremely unlikely to walk;
- Although it is good have destinations within a 5 minute walk many people will walk for 15 minutes to specific types of places;
- Clusters of destinations called 'activity centres' encourage walking;
- Each different category of destination added to an area is related to 5 minutes more walking a week;
- Being near multiple recreational facilities is strongly related to walking for recreation;
- To maximise physical activity, communities should have both recreational facilities and utilitarian facilities within a walkable distance.

4.5 Conclusions

The difficulties in analysing the effects of the built environment on physical activity, including measurement difficulties, identifying causality, and problems with composite indices, mean that the effects are not clear. Most of the variance in levels of physical activity caused by environmental factors including the environment remains unexplained:

> *"The total variance explained by environmental factors is still limited, with no more than about 5-10% of the variance in physical activity, even when all the environmental correlates are included together in statistical models."* (Bull and Bauman 2007, p. 37).

However, whilst this implies changing physical infrastructure alone may not have a huge direct impact on physical activity, there is evidence that good infrastructure is a prerequisite for the effectiveness of other, less tangible, measures (House of Lords Select Committee on Science and Technology 2011). Hence, there is a need to consider other aspects of transport including funding, safety and social aspects. These are discussed in the following sections of this report.

5 The complexity of transport

Notwithstanding some of the difficulties with measurement and evaluation it does seem clear that travel, in the form of walking and cycling, has a significant positive contribution to make to physical activity, and that one of the major causes of the decline in these is the growth in the use of the car. It is also clear that much of the more rigorous work has taken a very limited view of transport. For example, one of the most detailed reviews of research on transport and health has restricted its definition of transport to the following:

> *"...transportation includes the network of streets in a city, the design of individual streets and highways, transit systems and separated systems for non-motorized users."* (Frank and Engelke 2000, p. 47).

At no point does it refer to the financial, administrative, legal, economic, social and cultural systems which underlie that infrastructure. Brownson et al. (2006) identified the importance of transport policy as influencing the choice of whether to walk or drive and included in their list of possible transport policy interventions topics like roadway design standards, the expansion of public transport services and subsidisation of public transport through passes. However, as they point out:

> *"Due to too few qualified studies, this intervention strategy has insufficient evidence to make any type of recommendation. This is an important area for future research."* (Brownson et al. 2006, p. 354).

Badland and Schofield (2005) have also drawn attention to the lack of published literature on behavioural studies of travel choice and physical activity.

5.1 The risks associated with walking and cycling

It should be recognised that while walking and cycling offer increased health through physical activity, they also present risks through, for example, atmospheric pollution, road crashes and social inequality.

Pedestrians and cyclists breathe in the pollution caused by cars. In Europe, 40% of particulate matter is caused by transport. This has been associated with both short term and long term increases in mortality through increases in respiratory symptoms, greater use of drug treatments in people with asthma, reduction in lung function, and admissions to hospital for respiratory and cardiovascular disease (World Health Organization Regional Office for Europe 1995; Pope et al. 1995). Recent studies have also suggested an independent effect from low levels of carbon monoxide (CO) on admissions to hospital for, and mortality from, cardiovascular diseases (Morris et al. 1995). Ozone and carbon monoxide caused by pollution also have independent effects on health (Brunekreef 1997; Brunekreef et al. 1997; Burnett et al. 1998; Ciccone et al. 1998; Feychting et al. 1998; van Wijnen and van Der Zee 1998).

Transport-related air pollution is estimated to reduce life expectancy by a few months, an effect similar to or a little greater than, the estimated effect of passive smoking (Miller and Hurley 2006). Litman (2008) has suggested that pollution may cause as many premature deaths as traffic crashes; however it is more likely to affect older rather than younger people; therefore the number of life years lost may not be as great.

Another risk is being injured in a traffic accident (often referred to as crashes in the transport literature to remove the notion that nothing can be done to reduce the number of such incidents). Table 4 below shows the number of people killed and injured in making trips various modes per kilometre of travel. It can be seen that walking and cycling are much more risky than the other modes. It should be noted that care is needed in making such comparisons because trips tend to be of different lengths by the various modes, as shown by the average trip lengths in the table: this means, for example, that a shopping trip that is walked is likely to be much shorter that a car trip to the shops; however, someone who walks to the shops may make more shopping trips in order to carry home the goods that they need over a month.

Not withstanding this point, it seems to be the case that walking and cycling are riskier than using other modes.

Table 4 Passenger casualty rates and average trip length, 2009

	Passenger casualty rates per billion passenger kilometres travelled			**Mean trip length in km**
	Killed	Injured	Killed and injured	
Walk	26	1394	1420	1.4
Cycle	21	3423	3444	4.9
Car	1.6	216	218	13.9
Bus or coach	0.1	139	139	8.7
Rail	0.0	9	9	35.1

Source: Department for Transport (2011d,e)

Litman and Fitzroy (2011) have shown how per capita traffic fatalities increase with per capita annual vehicle mileage. They have also shown how the number of traffic fatalities goes down as a city becomes more oriented to public transport and also as the number of public transport users goes up. These statistics include all deaths including those from public transport vehicles (Litman 2004; Litman 2008).

Litman (2008) has also shown how clustered development patterns tend to increase traffic density which leads to an increase in crash rates per vehicle kilometre. However as people are travelling fewer kilometres overall and as the crashes which happen are less severe due to reduced speeds, the overall number of fatalities per head of population is reduced. By contrast, where land use patterns have become more sprawled, the number of traffic fatalities per head of population is nearly five times as high.

It might be argued that not having a car and so walking more is good, but there is some evidence that, in some circumstances, reliance on walking can have negative impacts on the welfare of families, because of the restrictions that a car makes to access to health and social care resources, particularly lone mothers with young children who are forced to walk through neglected and depressed areas because of the lack of a car or suitable public transport (Bostock 2001).

It should be recognised that both levels of atmospheric pollution and the risk of being a road casualty are functions of the number of cars on the road, and so, a reduction in the number of cars would probably reduce both risks. This issue is complicated by the speed of traffic: if the roads are so congested that cars can hardly move, there may be lower numbers of crashes than with fewer cars travelling faster. Nonetheless, it seems reasonable to believe that fewer cars on the road would pose fewer risks to pedestrians and cyclists.

5.2 The indirect impacts of car use

The World Health Organization has suggested that the greatest impact which motorized traffic has on health could be through its, as yet unquantified, effect on other people walking and cycling (Dora 1999). This is because cars and their infrastructure compromise pedestrian safety and therefore discourage walking and cycling. Jacobsen et al. (2000) showed how the safety of the pedestrian population of all ages appears to be inversely associated with high traffic speeds. The number of miles of major arterial streets in a neighbourhood also has a significant impact (Levine et al. 1995). These dangers result in a fear of traffic which Jacobsen et al. (2009) explain deters people from walking. In their literature search they found that negative traffic perceptions were associated with decreases in walking and bicycling and this finding was consistent across several types of study (Jacobsen 2003). Jacobsen also found that the amount of walking and cycling changed with both long-term and short-term changes in traffic volume and speed. Handy (1996) also found that the decision to walk was related to feelings of pedestrian safety and these were directly related to traffic speed.

Other research shows how, over two generations, the amount of walking and bicycling has decreased greatly in many countries, with far fewer children playing in the streets and this appears to be partly a result of concern about the increase in traffic levels (Hillman et al. 1990; Norton 2008). This is supported by evidence from developing countries which show how rapid motorisation has been accompanied by an even faster decline in bicycle riding. So, for example, a survey in China found that 43% of cyclists had decreased the amount they cycled. For 11% this was because they had bought a car; for the rest it was the perceived increased danger in the streets (York 2007). Similarly, in many African cities the share of commute trips by bike has plummeted because of the increasingly hostile and unsafe environment created by motor vehicle traffic (Howe 2001).

There are also more indirect, but probably more dramatic ways in which car use has resulted in greatly reduced amounts of active travel. Mackett (2009) explained how many services and retail facilities have taken advantage of the fact that people travel by car to locate to cheaper places beyond the town. This has in turn created a situation that people who might otherwise have chosen not to use a car are forced to, in order to have access to the facility involved. This has been repeated in all kinds of contexts resulting in an enforced car dependency. It is this process which explains the trend observed by Foster and Hillsdon (2004) who, using population trend data, point out how the increase in car numbers and trips has corresponded with a decrease in trips by foot or cycle over the past three decades. As businesses and services adapt to the reality of car ownership, the whole process becomes self-reinforcing, putting people without a car at a genuine disadvantage.

Another way in which motorised transport has negative effects on health is through community severance. This was most comprehensively documented by Appleyard (1981) and Appleyard and Lintell (1972) who looked at the way traffic volumes and speed influence how people used streets for non traffic functions. The three streets

of San Francisco that were selected were similar in all aspects except traffic volume. The streets were designated either ‘light’, ‘moderate’ or ‘heavy’. Those living on ‘Light Street’ had three times as many friends and twice as many acquaintances among their neighbours as those living on ‘Heavy Street’. It was perceived to be friendly and families with children felt relatively free from traffic dangers. By contrast in ‘Heavy Street’ there was little or no pavement activity, residents kept very much to themselves and had withdrawn from the street environment. There was little sense of community. Another US study reported a reduction in the number of people crossing a new road running through a neighbourhood and this effect was still observable 30 years later (Lee and Tagg 1976). Severance effects such as these are important because of the protective effect on health of social support networks, which can work either directly by promoting health or by buffering the adverse effect of stressors. Low levels of social support have been linked to increased mortality rates from all causes (Greenwood et al. 1996). This suggested that residents on busy streets had less than one quarter the number of local friends compared to those living on similar streets with little traffic.

A repeat of the Appleyard and Lintell study was carried out in Bristol by Hart (2008). The study looked at three streets in north Bristol with light, medium and heavy traffic respectively. It was found that motor traffic had a considerable negative impact on quality of life, and those residents on busy streets had less than one quarter of the number of local friends compared to those living on similar streets with little traffic. One of the respondents who had 20,000 cars going past his house a day compared the road to a mountain range because of the degree to which it cut him off. Other consequences included constant noise, pollution, dust and danger outside the front doors. Many residents revealed that they experienced sleep disturbances, no longer spent time in the front of their homes, and curtailed the independence of their children.

Those with low incomes tend to have lower car ownership and lower car licence holding, and so tend to use the car less than those with higher incomes (Sustainable Development Commission 2011), so reductions in levels of car use ought to increase equity. However, the issues raised by Bostock (2001) about the negative impact on welfare of not having access to a car should be borne in mind, as discussed in Section 5.1,

However despite the significant impact of traffic which Jacobsen et al. (2009) have been able to identify, they explain that:

> *“In most urban areas around the world it is difficult to find locales where traffic danger is not a continuing reality of everyday life – traffic and traffic danger are almost ubiquitous – yet have rarely been studied as a causal component of people’s physical activity.”* (Jacobsen et al. 2009, p. 370).

The only area in which the impact of car use on physical activity has been identified is in relation to children. Children, whose need for physical activity exceeds that of the rest of the population, are also, as explained previously, the most vulnerable to

the impact of traffic and have been most severely affected by the traffic increases on the roads. While the causal relationship has yet to be established, it appears that children who use AT for school travel are more physically active, have higher rates of energy expenditure and are more likely to meet physical activity guidelines than children who are driven (Mackett et al. 2005; Timperio et al. 2006; Turbin et al. 2002). The relationship between car ownership and rates of AT was one of the most frequently cited economic variables in the review by Pont et al. (2009) of the correlates of children's active travel.

Hillman et al. (1990) reported that while 80% of 7 and 8 year olds went to school on their own in the early 1970s, less than 10% were doing so two decades later. Jacobsen et al. (2009) has identified a number of broader surveys from the US and the UK which show similar trends (McDonald 2007; Department for Transport 2002; US Environmental Protection Agency 2003).

A number of researchers have identified the negative consequences which traffic has on their lives and levels of physical activity. Frank et al. (2007) conducted a study which assessed the relationship between objectively measured urban form variables, age and walking in youth. They found that in the analysis of the full sample (3,161 5-20 year olds who completed 2-day travel diaries) the number of cars along with recreation space and residential density were most strongly related to walking. Giles-Corti et al. (2009) recently conducted a review which examined the evidence on the association between the built environment and walking for transport. On the basis of their findings they state that:

> *"If older children and adolescents are to enjoy health and developmental benefits of independent mobility, a key priority must be in reducing exposure to traffic…..through neighbourhood and building design, by encouraging others to walk locally, and by discouraging motor vehicle use in favour of walking and cycling. Parents need to be assured that the rights and safety of pedestrians (and cyclists) - particularly child pedestrians and cyclists - are paramount if we are to turn around our 'child-free streets...'* (Giles-Corti et al. 2009, p. 996).

A number of studies may be pointing indirectly to the effects of traffic. A review by Davison and Lawson (2006) found that the most consistent findings in explaining children's levels of physical activity related to transport infrastructure. For example, three studies reviewed by them indicated a negative association between measures of road safety or traffic hazards and physical activity (Carver et al. 2005; Timperio et al. 2004b; Timperio et al. 2006). With adults, the number of intersections was linked with frequency of walking as it indicated that there were good route connections to particular destinations. However with children, some evidence has suggested that number of intersections had a negative effect, possibly because it indicated a large number of roads to cross (Timperio et al. 2006). This has been confirmed more recently in research by Panter et al. (2010). Likewise increasing distances to be travelled to a destination are also inversely associated with rates of children's active travel in a very large number of studies (Gilhooly and Low 2005; Ham et al. 2008; McMillan 2007; Merom et al. 2006; Nelson et al. 2008; Schlossberg et al. 2006;

Timperio et al. 2004a; Yarlagadda and Srinivasan 2008; Ziviani et al. 2006). While it is seen as axiomatic that children do not like walking a long way to facilities or travelling far from home, children's willingness to play outside for hours on end or the distances which they will walk in rural areas suggest that distance in itself is not a deterrent. Part of the problem could be that the risks of 'stranger danger' are perceived to increase the further away a child moves from home. An alternative explanation could simply be that the number of roads to cross makes the whole venture more unpleasant and risky from both the parent's and child's point of view and that this is the real explanation underlying the issue of distance. The extent to which the number of roads a child has to cross and its relationship to AT needs to be examined.

A 'convincing non-significant relationship' has been found between AT and parental concern about travel safety (Pont et al. 2009). This suggested that concern about traffic deterred parents from allowing their children to play out. Part of the reason the relationship may not have been stronger is because the parent whose child plays out a lot is likely to be more anxious about traffic than the parent whose child does not play out. For this reason it would appear that the link between parental concern about traffic safety and AT is not as strong as it might be; however the association was found in a number of studies (Mota et al. 2005; Salmon and Timperio 2007; Timperio et al. 2004a; Ziviani et al. 2006).

Jerrett et al. (2010) looked at the relationship between traffic and the BMI of children. Many individual risk factors for BMI growth such as asthma and other respiratory conditions were also tested as confounders. Their analysis revealed a significant positive association between traffic density around the home and attained BMI at the age of 18 in a cohort of 2,889 children. Where there was increased traffic exposure within 150 meters of the home, there was a significant increase in attained BMI for both sexes. At 300 metres the effects were still there but had decreased. The effect of traffic density amounted to a 5% increase in attained BMI weight at the age of 18. Jerrett et al. (2010) point out that although the effect may appear small:

> *"...the ubiquity of exposure to traffic implies that potentially large populations may be affected such that even small changes in the BMI in response to traffic may be associated with impacts on overweight and obese status in the population."* (Jerrett et al. 2010, p. 556).

It could be argued that many of the problems caused by cars such as road safety, pollution, severance and decentralisation could also be attributed to other forms of motorised transport. So, for example, were the number of cars to reduce the number of buses might increase leading to the same sorts of problems. However, it seems unlikely that these problems could be attributed to other forms of motorised transport to the same degree. Buses can carry a large number of passengers and, where they do so, the level of CO_2 emissions is considerably less than were the equivalent number of passengers to travel by car. Bus drivers are highly trained, accountable to public authorities and therefore their driving can be more easily monitored than that of individual car drivers. One bus could theoretically replace a number of vehicles on the road therefore reducing the likelihood of an accident happening. Whilst reduction

in the number of vehicles can increase speed, measures could be taken to ensure speed does not go up. Finally whilst buses may contribute towards the segregation described by Appleyard (1981), it seems likely that roads would be easier to cross than where roads are predominantly used by cars, particularly as bus driver behaviour can be more easily monitored. Furthermore it can be argued that where cars contribute to individualisation and separation between people, buses could have the opposite role of bringing people together in a public space.

5.3 Conclusions

This section has shown how complex the interactions between travel and physical activity are, with the various modes of travel offering both positive and negative aspects. On balance, it seems very likely that the benefits of walking and cycling outweigh the disbenefits, and that, in order to use walking and cycling to increase physical activity it is necessary to move away from the present situation in which society has become very dependent on the car. This is considered in the next section.

6 Overcoming the barriers to reducing society's dependence on the car

The evidence presented so far suggests that increases in car use could be largely responsible for the significant decline in physical activity and that a process of decreasing car use could have very positive impacts on it. Just as past policies reinforced and accelerated patterns of increased car use and reduced active travel by accommodating them, virtuous circles of decreased car use could be established (Cabinet Office Strategy Unit 2009; Levett 2005). This section will explore the process through which society has become increasingly car dependent and will then go on to look at the methods which have been used to try and reverse this.

6.1 The barriers to reducing society's dependence on the car

6.1.1 The benefits of the car

As discussed in Section 1.1 car use has increased significantly in recent years. People choose to buy cars because of the benefits the car offers. For the user these include:

- Door-to-door travel: normally a car is parked very close to the owner's home and can be driven to a car park at or very close to the destination.
- Fully flexible timing: the car user decides when to set off, tailoring to the required arrival time, if desired.
- Relatively low travel times: cars can be fast which means that, combined with the opportunity to drive from door to door and the flexible timing, cars are quicker than other modes for most journeys in Great Britain.
- Low marginal cost: car ownership requires the initial expenditure of money to purchase the vehicle; there are then annual costs of vehicle excise duty and insurance, plus maintenance costs; however, once the decision to purchase a

car has been made and the costs mentioned paid, the marginal cost of each trip is relatively low, particularly if several people are travelling together.

- Comfort: cars offer a comfortable, controllable environment, with the entertainment chosen by the users, free from personal interference from other travellers.

These advantages, taken together, mean that the car offers the most convenient and comfortable form of travel that is cheaper (in marginal terms, at least) and quicker than other modes for most trips. Cars open up the opportunity to reach a range of destinations that are simply not possible by other modes. They also make it easy to carry heavy goods, such as shopping and sports equipment, and allow parents to keep their children under surveillance. Cars have enabled many extended families to remain in physical contact in a way that other modes do not: they have allowed many people to move away from their family, for work reasons or to allow purchase of affordable dwellings, but to remain in regular physical contact.

These advantages make cars attractive. They also act as status symbols, which car manufacturers often stress in advertising their vehicles.

The car also appears to offer some health benefits. So for example, Filakti and Fox (1995) found differences in mortality relating to housing tenure and car access. Macintyre et al. (1998) took this one step further and explored whether car ownership itself had any directly health-promoting or health-damaging effects. They concluded that it did both. So, for example, while car ownership did not appear to improve systolic blood pressure or waist hip ratio, it did appear to reduce the number of symptoms reported, improved respiratory function and reduced the number of long-standing illnesses. However the findings need to be treated with caution. All those who were long-term unemployed through illness were removed from the sample to reduce the possibility of reverse causality. However ill health can reduce the possibility of running a car without necessarily compromising one's ability to work. Therefore the possibility of reverse causality still exists. It should also be noted that some of the health problems which accompany lack of car ownership are actually produced by the car use of others (for example a range of respiratory conditions). Also, those without cars may have to subject themselves to the health consequences of having to walk considerable distances in poor weather where there is inadequate bus provision.

However, Ellaway et al. (2003) concluded, on the basis of the Macintyre et al. (1998) study and other studies, that car use does have positive benefits for health:

> *"Studies have shown that after controlling for age, sex and socio-economic circumstances (such as housing tenure, social class or employment grade) people in car owning households have lower overall mortality (Smith and Harding 1997), lower rates of long term illness, fewer symptoms, and better mental health (Gould & Jones, 1996; Macintyre, Ellaway, Der, Ford, & Hunt, 1998; Macintyre, Hiscock, Kearns, & Ellaway, 2001). Car ownership has also been shown to*

> *perform as well if not better than current income in predicting health (Benzeval, Judge, and Shouls 2001).”* (Ellaway et al. 2003, p. 218).

They set out to explore why this was the case, focusing on the role of psychosocial benefits. They found that those with access to a car gained more psychosocial benefits from their habitual mode of transport than do those who are public transport users. In particular they scored very well on items relating to control which may go some of the way to explaining the better health of car users: having a sense of efficacy and power over one’s environment is related to enhanced wellbeing (Bostock and Beck 1993). Autonomy (control, flexibility, convenience) was particularly important for both sexes with protection more important for women and prestige of more significance for men. Those with ‘car access’ as opposed to ‘no car access/public transport user’ had higher levels of ontological security although the areas which generated this security were different for women and men. For example, men’s self-esteem was found to be more strongly related to car access while for women, mastery was more important, possibly reflecting the practical rather than symbolic importance of cars to women.

It should be borne in mind that, while car ownership produces psychological benefits in car owners, it also produces disbenefits possibly through feelings of stigma and social exclusion in non-owners. Any assessment of the overall benefits of car ownership needs to take both aspects into consideration.

Killoran et al. (2006) point out that:

> *“...effective transport networks also bring health benefits – by giving people access to work and essential services (such as the NHS) and to shops and leisure facilities, and enabling social contact and civic engagement.”* (Killoran et al. 2006, p. 16).

There is a great deal of research evidence which shows the vital role social support networks have in maintaining health and wellbeing. Networks with other people are also the basis of ‘social capital’. They are particularly important for certain sections of the population such as the elderly, the disabled or mothers with young children. Research on this subject was conducted in New Zealand on how essential car travel was to maintaining social networks with family and friends (Greenaway et al. 2008). Car travel is particularly important here because public transport developed around the connections between the private realm of the home and the public realm of work, services and retail. Interconnections within the private realm, that is, relations between extended family members and friends have seldom been examined.

Cars may currently be a crucial mechanism for providing this transport network as society has largely been constructed around the car and therefore not owning one could lead to forms of social exclusion not dependent on income, as mentioned in Section 5.1 in the context of lone mothers forced to walk to reach essential health and social care resources because they lacked access to a car (Bostock 2001). Questions around car ownership and social exclusion have been explored by Houston (2001) and the Social Exclusion Unit (2003). All this suggests that while

cars reduce levels of physical activity it cannot be assumed that reducing car use or ownership will actually improve health. Mechanisms of exclusion, reduced mobility and access could, theoretically at least, outweigh the benefits of physical activity. Therefore the negative impact of not owning a car needs to be built into any analyses exploring the relationship between car use and health.

This all means that it is difficult to encourage more people to use alternatives to the car. It is not simply a matter of reversing the pattern of switching from active modes to the car. Many people have grown up in an environment where society is largely geared up to using the car. For them, it is the easy choice, enabling fast journeys and opening up opportunities unreachable by any other means. It enables people to continue the comfortable lifestyle that they have created. It enables them to project an image of success to their friends and neighbours. This car-oriented lifestyle is not true of everywhere in Britain, because there are places, for example within London, where people do manage without cars, cycle to work and walk with their children to school. There are parts of London where the percentage walking to work is as high as 65% (Transport for London 2008b). However, overall, such people are in the minority.

6.1.2 The political difficulty of reducing car use

The benefits of the car discussed above make it very difficult to implement any policies that car users believe is restricting their use of the car or costing them money for facilities that they perceive as having previously received free, such as roads. By implication, car users accept that they need to pay to buy their vehicles, and the need to insure them. They pay vehicle excise duty (VED) which is an annual tax on car ownership and duty on fuel. These latter costs seem to be accepted because they have existed almost as long as cars have. The licensing of cars was introduced in The Motor Car Act of 1903 to help identify vehicles, with a charge of £1 (Driving Vehicle and Licensing Agency 2006). In 2001, new cars with CO emissions below pre-defined limits benefited from reduced VED. Research suggested that the differential was not large enough to encourage behaviour change (Department for Transport 2004). More complex variable rates based on CO_2 emissions have now been introduced. Similarly, the idea of tax on fuel has been here for a long time. A 3d (1.25p) tax was levied on a gallon of petrol (4.5 litres) under the Finance Act 1908, and has been increased by successive governments as a means of raising revenue.

Whilst there seems to be general acceptance of paying the taxes associated with motoring, when large increases are proposed, for example in fuel duty, the motoring lobby may protest. This was seen in 2000 when the proposed increase in the duty was seen as being high and demonstrations were seen on the streets. One reason the price of fuel had become so high was the ‘fuel-duty escalator’ which was a method of increasing the duty automatically as a function of inflation, designed to encourage less motor vehicle use, and thus help combat climate change. The abolition of the fuel-duty escalator was announced on 9 November 2000 in response to the protests. Fuel duty has been increased since then. In March 2011, the Government announced the introduction of the ‘Fair Fuel Stabiliser’ which meant that,

if the price of oil increased above $75 a barrel, fuel duty would not increase above the rate of inflation, but a tax would be imposed on the resulting increase in the profits of the oil companies.

The discussion demonstrates the complexity of the issue: the government knows that car use is high, and that some reduction would help address the problems of caused by the car such as low levels of physical activity, congestion, atmospheric pollution and CO_2 emissions, but the benefits of the car to the user make this politically difficult. Successive British governments have been reluctant to take any actions that they believe that the public will perceive as anti-motorist. This is complicated by other pressures such as the need to reduce greenhouse emissions as required under the Kyoto treaty.

For many years the main method for controlling the number of cars in urban areas was parking controls. In the late 1950s road congestion began to be a problem in London (Kay and Evans 1992). Parking restrictions were seen to be the answer. In 1956 powers were obtained for parking meters, with the first coming into use in London in 1958. However, there was a problem: whilst local authorities could control the number of parking spaces it provided on- and off-street, it could not control the number of private spaces. Legislation in the 1960s had required developers to provide parking spaces in all new developments, in an attempt to reduce on-street parking. The unfortunate consequence of this was that local authorities had no control over much of the parking space in their areas. In fact, they did not even know how much there was in private hands, and so did not know the total number of parking spaces in their area. It became clear that parking was not a strong enough policy lever to control car use in urban areas.

The dilemma that governments face is illustrated by the actions of the Labour Government that came to power in 1997. The Deputy Prime Minister, John Prescott, chose to be in charge of the environment including transport and the functions of planning, housing and the regions. He made it very clear that he intended to reduce car use. He is quoted as saying in June 1998:

> *"I will have failed if in five years time there are not . . . far fewer journeys by car. It's a tall order but I urge you to hold me to it" (Hansard 1998, column 1071).*

Figures on the number of journeys are difficult to obtain, but between 1998 and 2003 the amount of car and taxi traffic increased from 370.6 to 393.1 billion vehicle-km (Department for Transport 2010f), so it is extremely likely that the number of car journeys also went up.

The transport policies of the Labour Government elected in 1997 were spelt out in the White Paper 'A New Deal for Transport: Better for Everyone' issued in the summer of 1998 (Department for Transport 1998). It demonstrated well the difficulty of addressing the issue of reducing car use. As illustrated by the quote from John Prescott above, this was the Government's intention, but it was not politically expedient to be explicit. Instead the document focussed on 'integrated transport', by which it meant, amongst other things, improving interchange between public

transport modes so that it could compete more successfully with the car. The arguments for reducing car use were focussed on specific objectives such as encouraging healthy lifestyles and reducing pollution. There was a clear statement that an objective of the proposed framework was to reduce road traffic growth (Department for Transport 1998, page 20). Reducing road traffic growth is not the same as reducing the number of journeys by car which John Prescott promised: indeed it is not clear quite what it means, since it is not clear what the growth was being reduced from.

A key aim of the 1998 White Paper was to change travel habits, in particular to reduce the habit of using the car. Two key policies were proposed: charging motorists for use of the road and charging a parking levy. It was proposed that local authorities would be able to charge road users to reduce congestion and that trials for charging users would be carried out on national motorways and trunk roads. A key point about the congestion charge was to be that local authorities could keep the revenue for investment in transport (hence it was a 'charge' rather than a 'tax'), which was unusual in Britain since The Treasury is normally strongly opposed to hypothecation of revenue: it wants all money raised by government to be pooled so that it can be spent as the government sees fit.

Parking levies were to be imposed by local authorities on employers, who would apply for a licence to allow a certain number of vehicles to be parked on their site. The employer could either pass the levy onto its employees as a parking charge or could absorb the cost. Either way, it would force an employer to consider seriously how many parking spaces to provide. It was also suggested that parking levies could be introduced at other developments such as retail and leisure centres, but this was not a specific proposal.

Another concept that was proposed in the 1998 Transport White Paper was green transport plans which are statements of measures to encourage members of the organization to use alternatives to the car, produced by organizations such as employers and schools. These are usually called travel plans now.

Recent work by Douglas et al. (2011) has likened the response to attempts to reduce car use to the response of the tobacco lobby to attempts to reduce tobacco. They point out that the marketing strategies are very similar with 2.5-3.5% of car manufacturers' revenue spent on marketing giving some indication of the importance of these strategies. Both the car and the tobacco industry use professional lobbyists and front organisations; for example, within the EU there are at last 70 professional car industry lobbyists, as well as public affairs consultants working for car manufacturers (Corporate Europe Observatory 2007). Both tobacco and cars are positioned as individual choices or even rights. Forest (Freedom Organisation for the Right to Enjoy Smoking Tobacco) says their arguments are about 'freedom of choice' (Forest 2011). The Drivers Alliance states, 'freedom to travel is a fundamental human right', and they use the term 'nanny state' to attack measures to restrict driving speeds treating it as an individual matter and ignoring its wider social implications (Chapman and Lupton 1994).

The car industry has worked to oppose policies which would restrict car use using tactics similar to those used by the tobacco industry. In 2007 a group of car manufacturers and related organisations succeeded in watering down mandatory targets on CO_2 emissions from cars (Corporate Europe Observatory 2007). Their tactics included an intense public relations campaign, placing information in German newspapers claiming German cars would be disproportionately affected and gaining support from the German chancellor. Smith et al. (2010) showed that a coalition of business groups including both tobacco and car companies achieved changes in EU policy-making so that business interests would be favoured over public health. According to the Union of Concerned Scientists (2007) ExxonMobil funded a network of organizations to present misinformation about the scientific consensus on climate change to prevent effective action to reduce CO_2 emissions

Douglas et al (2011) conclude:

> *"There are many similarities in approach but the car lobby is more diffuse. It may include car manufacturers, car retailers, car hire companies, garages, motoring organisations, oil companies, road builders and others."* (Douglas et al. 2011, p.162).

6.1.3 Habitual car use and physical activity

Car use has become such an embedded habit that it creates inertia that discourages use of anything other than the car. There is evidence for this. Gärling et al. (2000) found that people who were more likely to choose the car over any other mode and who drove more frequently than other people had much lower distance thresholds for driving. They hypothesized from this (but did not test), that the more people drove, the more likely walking appeared to be an effort, so the more likely they were to drive. 'This hypothesis was explored much more fully by Loukopoulos and Gärling (2005). By including questions on perceptions of physical exertion, they found that the more people drove, the more likely they were to perceive walking to involve high levels of exertion and that this affected the amount they were prepared to walk. If habitual drivers become more averse to walking short distances, changes to the environment are likely to be ineffectual in encouraging AT.

Another relevant piece of research is a comparison of three Swiss Alpine communities with varying access to motorised transport (Thommen Dombois et al. 2007). Alpine resorts were selected as they are generally considered to be conducive to physical activity and leisure time sports. However, it was only in the community which was free of motorized traffic that residents were much more likely to achieve recommended levels of physical activity, despite otherwise having similar environments. In the other two communities, people were unlikely to achieve recommended levels of physical activity. This was unrelated to their participation in vigorous physical activity. The main determining factor was the amount of moderate physical activity and this depended on the extent to which they used the car for travelling to and from work and other leisure activities. This suggests that even

where the environment is a walkable one, if car use is prevalent, ideal levels of physical activity are unlikely to be achieved.

6.1.4 Modern lifestyles

There is a range of ways in which cars have become embedded into people's lifestyles to a degree where these would no longer be sustainable if they did not have a car. For example, it has now become accepted practice and is usually necessary for both partners in a household to be employed. This means that running a household, organising children and employment need to be fitted into a tight schedule. As cars provide transport from the front door right to the destination, are fast and can carry a number of people as well as shopping and luggage with minimum fuss and no exposure to the elements, they provide the most convenient, reliable and comfortable way of doing this.

In the past, before the widespread presence of the car, children played outside in a way which did not require a high level of adult supervision. That has now become much rarer because of parents' anxieties mainly about traffic but also about 'stranger danger'. The current practice is to take children to a range of activities outside the home. Cars enable children to have access to a much wider range of activities and therefore parents have come to rely on them in managing their children's lives. This may make children car dependent when they grow up (Mackett 2002). These phenomena exist in other countries as well as Britain, although Britain seems to have gone further in reducing children's independence than other countries (Hillman et al 1990; Fyhri et al. 2011).

Another role of the car is maintaining contact with family and friends. Once the cost of owning and running a car came within the budget of most of the population, living near family and friends may not have seemed as significant as it was prior to increased individual mobility. Consequently, many people live far from their family and even their friends, and have come to rely on a car to meet up.

Research was carried out at UCL to establish why people used their car for trips of 8 km or less instead of walking, cycling or using the bus (Mackett 2001; Mackett 2003; Mackett and Ahern 2000). Short trips were identified in diaries that the respondents kept and then they were interviewed about these trips to see if they could have been made in other ways. The reasons cited for driving cars for short trips are shown in Table 5. It can be seen that carrying heavy goods, mainly shopping, was the top reason, reflecting the common use of the car for trips to shops to buy a household's food and other goods or trips to take sports equipment for leisure purposes. This was followed by giving a lift to a family member or friend, usually children. The next reasons, in order of popularity, were shortage of time then distance and convenience. These reflect the use of the car to make journeys quickly and easily within the time constraints created by modern lifestyles. The next reasons for needing the car are for a further trip and at work which reflect the complexity of many car trips, which are linked to other trips. Essentially the reasons identified reflect modern lifestyles of using the car for shopping trips to large supermarkets or for leisure purposes, for

convenience to make trips quickly and easily, or because of the complexity of the trip making.

Table 5 Main reasons for driving a car for short trips (%)

Reason	**%**
Heavy goods to carry	19
Giving a lift to a family member or friend	17
Shortage of time	11
Length of trip	11
Convenience	10
Car needed for a further trip	9
Car needed at work	5
Bad weather	5
Darkness	4
Social trip	4
Taking and elderly or ill person	3
Other	2
Total	100

Source: Mackett (2003)

Faced with the alternative of making a (short) trip either using the car which will make the journey quickly and comfortably, safe from the weather, or walking, cycling or taking the bus, which will take longer, require effort and involve exposure to the weather, many people choose the car. Many of these short trips made by car could be replaced by walking, cycling or bus use.

6.1.5 Land use patterns

It was shown earlier how some urban environments accommodate physical activity by, amongst other things, having many destinations located close to home. However as a result of widespread car use, there has been a process of decentralisation with facilities located at increasing distances from residential destinations so the patterns prevalent in the US have been adopted in Britain too.

For example, as cars have become more widely available, suppliers, such as retailing chains, have chosen locations best served by cars, and households have felt an increasing need for a car (or two) to help them reach the opportunities offered. As retailers are motivated by a desire to make money, they are unlikely to want to change their location unless it makes financial sense. There has been a trend towards setting up local stores by the large supermarket chains in Britain, partly in response to difficulty in obtaining planning permission to develop out-of-town stores. In theory, this should have increased walking, but often they have replaced existing small shops, and so may not have increased the total stock. In many ways, the damage is already done, with many households taking advantage of the convenience of the car to carry out a large bulk shopping trip: it is hard to see many

households switching back to doing all their shopping at the local shops and then carrying it home.

This process has been fuelled by decisions by public bodies to concentrate facilities such as schools and hospitals into larger premises to offer economies of scale and a greater range of activity within the premises. The transport implications for users are rarely considered. Given that one of the motivating factors behind this trend has been reduction in public expenditure, it may be difficult to reverse it.

6.1.6 Household locational decisions

In recent years, urban areas have spread. Suburbs have been developed, providing high quality housing with individual gardens where families can create their own environment largely free from interference from neighbours. Usually such dwellings have one or more garages. It is usually possible to walk in such areas and often quite pleasant to do so, because they contain trees and other greenery, have suitable pavements and low crime rates. However, the size of the plots mean that densities are fairly low, and so many people tend not to live very near to the activities they need as part of their lives, such as employment, shops, schools and leisure facilities. Because those living in the suburbs tend to have cars and the roads are usually not very busy, the mode of travel usually used is the car. The situation is more extreme in the United States where suburban densities tend to be lower and car ownership higher. Conversely, in some countries in continental Europe, urban densities are often higher and walking and cycling more popular than in Britain, or more public transport available.

There is a further dimension, which makes it particularly difficult to increase the volumes of walking, cycling and using the bus. Many households have chosen to live in places where car is the only way to reach the desired range of destinations. Many families live in different types of residential environments to their parents and grandparents: lower density, suburban or rural, poorer access to public transport, and further from shops, schools and leisure activities. This works well if there is a car available, but fails if there is not. More importantly in this context, it means that few journeys can be walked, cycled or made by bus. Of course, it is possible to go out for a walk or cycle ride for pleasure or exercise, but busy lifestyles often make that difficult.

6.1.7 Transport modelling and appraisal

In Britain, and other countries, decisions about investing in transport infrastructure are informed by, amongst other things, comparing the anticipated impacts brought about by the new infrastructure with the anticipated costs. This evaluation process carried out as part of the development of schemes is usually called ‘appraisal’. Since infrastructure tends to last a long time, it is necessary to consider these costs and benefits over a long period. In this country this is usually 60 years for roads because that is regarded as the period that is required before major rebuilding is necessary, and shorter periods for smaller schemes. This means that it is necessary to predict the future costs and

impacts including the benefits arising from the scheme. The costs are fairly straightforward engineering calculations, to estimate the costs of building and maintaining the infrastructure. The benefits are more difficult. The main benefits of building a road are usually seen to be travel time savings, accident reductions and environmental benefits. These are functions of the numbers of travellers using the infrastructure. Only schemes where the benefits exceed the costs will be built (and not necessarily all of those). Usually a number of alternatives are considered and the one chosen is the one that produces the greatest benefits relative to the costs. The benefits are usually estimated as the difference between the situation with the new infrastructure and the situation without it.

The main tool for the forecasting process is a model. A model is a simplified representation of reality. It is a collection of assumptions and theories. In this context, models are usually sets of mathematical equations that relate the number of travellers to various relevant variables. The models are programmed into a computer and need a suitable data base to represent the various inputs. Travel demand modelling is very complex, and cannot be described fully here (see Department for Transport (2011c) and Ortúzar and Willumsen (2011) for more information). A key point is that it is assumed that people are rational and choose the alternative that gives them the highest utility. This means that spending less time travelling is assumed to be better than spending more. As indicated above, travel time savings are an element of the benefits arising from a new scheme. In fact, time savings to travellers are usually the largest element. This means that the scheme that gives the largest travel time saving is probably going to give the largest benefit. Only the marginal monetary cost of car use (usually only the cost of fuel) is considered, not the costs of ownership because empirical evidence shows that this is what people do. A scheme which makes car use easier, for example, by building a new highway, is likely to attract trips from walking, reducing physical activity, because the time spent walking trips will not change. Public transport trips usually include walking, so any switch to car from public transport is also likely lead to a reduction in physical activity.

The method used for forecasting travel demand tries to replicate the observed reality, usually using generalised cost to determine mode and destination choice and travel time for route choice and assignment. Generalised cost is a linear sum of monetary and time elements including access elements such as walking and waiting and parking charges. In order to convert the elements to common units in order to sum them, the value of time is used as a conversion factor between time and money. The structure of the model used for forecasting the potential impact of new transport infrastructure has been in use for over forty years with only marginal changes. Essentially, the model tries to replicate the observed travel patterns by using forecasts of car ownership and other exogenous changes to take the forecasts forward over time. The models are usually aggregate which mean that they use a zoning system and work with matrices of the trips between pairs of zones. The models are used to examine alternatives such as a set of possible routes. It has been observed that people usually do not take the reduction in travel time as an opportunity to spend the time saved in other activities: instead they tend to travel further, sometimes as part of a long term decision about where to live. This means that they are benefiting from the greater range of

opportunities offered by the greater speed. This is illustrated by the remarkable constancy of total time spent travelling in Britain (at about 60 minutes per day per head) (Department for Transport 2010e; Metz 2008). This means that the solution that is optimal is likely to lead to more people choosing to live further way from where they work, often in areas of low residential density. This in turn is likely to stimulate more car use for local trips, leading to less walking and cycling.

In Britain the effects of changes to transport networks and policies on locational decisions are not normally modelled when transport schemes are being examined. As implied above, when it becomes easier to travel further because of a new road, people often choose to live further from their workplaces or choose a job further from where they live. They may also choose to shop further away. This process is reinforced by the actions of developers who will develop new housing, retail and employment opportunities in places that have become more accessible. These phenomena can be seen in the M25 motorway around London that was near capacity soon after it opened and stimulated the development of retail parks at Lakeside near Thurrock and Bluewater near Dartford. However, it should be acknowledged that models that represent locational decisions satisfactorily are complex, and so any decision about their use would need to consider whether the additional information they produce justifies the extra resources required.

Because walking and cycling contribute to physical activity, more time spent on either will help to improve health. This means that a longer trip is better than a shorter trip. This is in direct conflict with the fundamental assumption which underpins the conventional transport methodology that a short trip is better than a long one because it consumes fewer resources. This apparent paradox can be overcome by putting a value on the health benefits to be gained from physical activity. The system used by the UK Department for Transport for evaluating walking and cycling schemes (Department for Transport 2010d) is based upon research commissioned by the World Health Organisation (2003), using the Health Economic Assessment Tool (HEAT) for cycling (Rutter et al. 2008). This involves calculating the number of preventable deaths per person by taking up moderate physical activity through walking and cycling using data from the study in Copenhagen on the reduction in risk of all-cause mortality by those who cycle for three hours a week compared with those who do not commute by bicycle (Andersen et al. 2000). This work also forms the basis of the method for assessing the physical activity implications of highway schemes, using a dose effect, that is, assuming a direct relationship between the time spent cycling and the health benefit. These methods do not include the reduction in morbidity or sickness. There is a need for more research into the financial benefits of health resulting from more physical activity.

6.2 Overcoming the barriers to reducing car use

Most of the strategies to reduce car use have emerged from sustainable travel initiatives and often involve encouraging a shift from the car to the more sustainable modes of walking and cycling. This means that sustainable travel goals are very

compatible with physical activity goals although they do not overlap completely (Mindell et al. 2011).

The sorts of policies which have been pursued through sustainable travel can be categorised into 'hard' and 'soft' measures. 'Hard measures' have been described by Sloman et al. (2010) as

> *"…physical improvements to transport infrastructure or operations, traffic engineering, control of road space and changes in price although some soft factors do include elements of this nature." (*Sloman et al. 2010, p. 12).

Soft measures have been defined by Santos et al. (2010b) as:

> *"…non-tangible aiming to bring about behavioural change by informing actors about the consequences of their transport choices, and potentially persuading them to change their behaviour."* (Santos et al. 2010b, p. 46).

While they aim to reduce car use, the choice to do so is entirely voluntary. Although there has been some uncertainty about the effectiveness of soft measures they have been widely adopted, probably, because they do not encounter as much opposition as traditional economic policies such as taxes and charges.

In order to increase levels of physical activity through increasing walking and cycling there will need to be a reversal of the shift to the car away from walking, cycling and public transport. Given all the advantages of comfort, speed and convenience that the car is perceived to offer, there will need to be significant changes of behaviour away from the car-oriented lifestyles that many households have adopted (Mackett 2010a).

6.2.1 The difficulty of encouraging more walking and cycling

The project on short trips by car carried out at UCL (Mackett 2001, 2003) included information about the alternatives that drivers would consider using instead of the car, as shown in Table 6. It can be that the drivers stated that there was no alternative for 22% of the trips, for example because the car was needed at work or for another trip. For the other 78% of trips, walk and bus were seen as the main alternatives, with both seen as the alternative for 31% of the trips. Cycling was a much less popular alternative at 7%. Only two per cent of the trips would not have been made. This suggests that there is considerable potential for alternatives to the car for short trips which would increase physical activity. This raises the question of how such change could be stimulated. Table 7 shows the actions that might bring about such changes, based upon the respondents' answers.

Table 6 The alternatives considered by car drivers (%)

Alternatives	**%**
No alternative	22
Modal alternatives	
Walk	31
Bus	31
Cycle	7
Taxi	3
Train or tube	2
Public transport (not specified)	2
Motorcycle	0
Tram	0
Other alternatives	
Somebody else make the trip	2
Would not make the trip	2
Total	100

Source: Mackett (2003)

It can be seen that 'no specific action' was identified for 21% of the trips. This probably includes many of the trips where the driver could have walked, cycled or used the bus but chose to use the car because it was available. For another 11% of the trips the need to take personal action was explicitly acknowledged. Thus 32% of the trips are a very difficult set of trips to shift from the car because that would require individuals to take decisions for themselves, which means convincing them that the alternatives are better in some way. For 22% of the trips there was a specific suggestion made which was to improve bus services. The respondents suggested that improvements to walking and cycling facilities would not make much difference, since each would only reduce car trips by 2%. Similarly, reducing the need to travel would not make much difference, affecting only 4% of the trips, nor would reducing the cost of the alternatives which means reducing the cost of bus travel make much difference.

Table 7 Actions required to reduce car driving for short trips.

Action	%	Responsibility
No alternative	22	-
No specific action	21	Individuals
Improve bus services	22	Public transport operators, Central government, Local government
Take personal action	11	Individuals
Improve the weather	7	Nobody
Improve dependents' travel	5	Public transport operators, Central government, Local government
Reduce the need to travel	4	Local government, Retailers
Reduce the cost of travel	2	Public transport operators, Central government, Local government
Improve walking facilities	2	Local government
Improve cycling facilities	2	Local government, Employers
Improve rail services	1	Public transport operators, Central government, Local government
Cancel activity	1	Individuals
Total	100	

Source: Mackett (2001)

Table 8 indicates which of the actions would encourage a shift to the various alternative modes. It shows how difficult it is to encourage people to shift from the car to walking and cycling. Actions by government, local or central, such as improving walking or cycling facilities, would shift about 3% of trips. The only action that would make much difference would be improvements to bus services, which would shift 21% of trips. It would require decisions to walk or cycle by many individuals to make a significant difference, and government has limited ability to influence this.

Table 8 Overall effects of actions on transfers to the alternative modes (%)

Action	Walk	Bus	Cycle	Other	Total
No alternative	-	-	-	-	22
No specific action	12	5	2	2	21
Improve bus services	0	21	0	1	22
Take personal action	8	1	1	1	11
Improve the weather	5	0	1	0	7
Improve dependents' travel	2	2	0	1	5
Reduce the need to travel	2	1	1	1	4
Reduce the cost of travel	0	1	0	2	2
Improve walking facilities	2	0	0	0	2
Improve cycling facilities	0	0	1	0	2
Improve rail services	0	0	0	1	1
Cancel activity	1	0	0	0	1
Total	31	31	7	11	100

Source: Mackett (2001)

It should be acknowledged that the figures shown in Tables 6 to 8 are based upon statements about hypothetical changes, but it was actual car trips that were being discussed. The figures indicate the potential difficulties of shifting large numbers of short car trips to the alternatives and how much the convenience that the car offers is a significant barrier to increasing walking and cycling. They also reflect the perceptions of car users about the alternatives and it is perceptions that influence attitudes and behaviour.

Other more recent research provides somewhat more optimistic evidence about the potential for behavioural change by exploring social attitudes. Stradling et al. (2007) use British Social Attitudes data to answer the question:

> *'What is the potential for demand-side change in the use of motorised private transport in Britain?"* (Stradling et al. 2008, p.143).

The approach they took was that changes in attitude typically precede changes in behaviour so they look at direct measures of public attitudes and how these might affect efforts to reduce car use. They explored responses to the proposition put in the BSA survey that:

> *"For the sake of the environment everyone should reduce their car use"* (Stradling et al. p.152)

and took agreement with this, as indicating willingness to change one's own car-use behaviour. They took responses to this question and sorted them according to evidence emerging from the survey on the respondent's ability to replace some car journeys with more sustainable forms. Through analysing these data they showed that drivers might be sorted into a number of subgroups:

- The largest group (45%) were *willing* to reduce their car use and *able* to substitute one or more sustainable modes for short car journeys of under two miles.
- Almost a fifth (18%) were *willing* to cut car use but, for whatever reason, *unable* to switch to cycling, walking or taking the bus for their current short car journeys.

- 12% were *able* but unsure if they are willing (although they might be persuadable, given that they could)
- A further 10% are unsure whether they were willing but claim to be *unable* to anyway.
- 5% were *unwilling* though *able*, and a further six per cent are *unwilling* and *unable*

They suggest that the first group probably needs encouragement. Encouragement may be sufficient for the second group. The third group may need supply side measures. As the article points out:

> *"These three groups together account for three-quarters of the population, which suggest that even limited intervention could have substantial effects in this favourable climate of public opinion."* (Stradling et al. 2008 p.153).

It should be noted that, in contrast to the work described by Mackett (2001, 2003) respondents were being asked a general question about their views on public attitudes, not about their own behaviour.

It is worth comparing the amounts of walking and cycling in Britain with those of other countries. As Table 9 shows, in 2000 the United Kingdom had almost the lowest levels of walking and cycling in the fifteen countries then in the European Union, with only Portugal having less walking and Portugal, Luxembourg and Spain less cycling. The trends over the previous five years in the UK were similar to the overall average, but with such low levels of both walking and cycling, this is not very impressive given that the levels are so far below the average. This suggests that there is scope for improvement in the UK: whilst it might be argued that the relatively flat terrain in the Netherlands and Denmark helps to explain the much higher levels of cycling, this is not true of, for example, Austria and Italy.

Table 9 Walking and cycling in the European Union

	Walking		Cycling	
	Distance per head in 2000	% change 1995-2000	Distance per head in 2000	% change 1995-2000
Austria	419	2	136	-9
Belgium	380	1	322	-1
Denmark	431	2	936	-5
Finland	386	-2	251	-2
France	404	4	75	-1
Germany	372	-1	291	0
Greece	389	5	76	0
Ireland	368	2	184	-5
Italy	410	1	154	-2
Luxembourg	457	-9	23	0
Netherlands	377	1	848	0
Portugal	342	-3	29	-4
Spain	368	5	20	-2
Sweden	383	2	271	-1
UK	355	1	75	-2
Mean	382	2	188	-1

Source: European Union (2003).

6.2.2 Charging for use of the road

The origin of the idea of charging for the use of roads in Britain is usually seen as coming from the Smeed Report 'Road pricing: The economic and technical possibilities' published in 1964 (Ministry of Transport 1964), based on ideas by Alan Walters (Walters 1961). A trial was conducted in Cambridge, by Cambridgeshire County Council, but the Council did not have the legal powers to implement a scheme and political and public opposition prevented it from going ahead (Ison 1996).

The first congestion scheme implemented in Britain was introduced in Durham on 1 October 2002 (Santos 2004). This is a very small scheme in which a £2 charge was imposed to control entry to one street and the Market Place. The monitoring report (Durham County Council 2003) found an 85% reduction in vehicular traffic and a 10% increase in pedestrian activity as a result of the scheme. Apparently the scheme reduced the traffic more than expected which meant that the revenue coming in did not cover the cost of its operation and that of the accessible minibus service in the area, but the shortfall was covered by revenues from parking charges.

The other congestion charging scheme in Britain is in London. The scheme started on 17 February 2003, having been set up under powers granted to Transport for London (TfL) under the Greater London Authority Act 1999 (Santos 2004). There had been discussions about the possibility of such a scheme over a number of years.

The main proposals came from the ROCOL report (ROCOL Working Group 2000). The scheme was part of the election strategy of Ken Livingstone, the successful candidate for the post of Mayor of London. He was elected in May 2000.

The scheme involves a charge of £10 a day (originally £5, later increased to £8) for being within the congestion cordon in the period from 7.00 to 18.00 on weekdays (originally it was until 18.30). It can be paid the day after the one on which the charge was incurred at a higher cost. If this is not paid there is a penalty charge of £100, reduced to £50 if paid within 14 days. Residents of the area receive a 90 per cent discount, but have to pay for a minimum of a week. The following are exempt: buses, licensed taxis and minicabs, emergency service vehicles, certain military vehicles, certain NHS (National Health Service) vehicles, certain alternatively-fuelled vehicles, bicycles and powered two wheelers. The scheme works by using cameras to read car registration plates automatically and comparing the list of number plates of those in the area with a list of those who have paid the charge. Penalty notices are sent out to those who are found not to have paid. The scheme is generally regarded as successful. It brought about a larger decrease in traffic than was predicted so the revenue was lower than that projected. The congestion charging area was extended to the west on 19 February 2007. In May 2008 Boris Johnson was elected Mayor of London in place of Ken Livingstone. This led to a review of the transport policies in London which led to the removal of the Western Extension to the congestion charge area on 4 January 2011 after a period of consultation (Transport for London 2010).

According to TfL, the number of vehicles entering London in 2007 was 16% lower than in 2002, and the number of cars, minicabs and lorries fell by 29% in the same period. The number of buses entering London increased by 33% and the number of people using them during morning peak hours rose from 87 000 to 113 000 with £137m being raised, in the financial year 2007/08, for investment into improving transport in London (Transport for London 2008a). It has now been found that congestion has risen back to pre-charging levels but, according to TfL, would be much worse without the charge. TfL says that the rise in congestion was due to widespread water and gas main replacement works, which greatly reduced the road capacity, and traffic management measures put in to help pedestrians and other road users.

It is interesting to consider why it was possible to implement congestion charging in London when, as discussed above, it is politically difficult to introduce a system in which motorists are charged for something they have not paid to use previously (Mackett 2010b). Pearce (2009) investigated how the proposal was implemented. His interviews with the key players showed that there were a number of favourable factors at the time, for example, the public debate about transport associated with the 1998 White Paper, public perception of congestion on the streets of London, the new structure of local government in London and the research that had already been carried out. In the London mayoral election in 2000, most of the media attention was focused on the personalities involved rather than their policies, with all the main candidates consenting to the idea of congestion charging. Because it was in his manifesto, Ken Livingstone was able to claim that the public had voted for

congestion charging by electing him, so there was no demand for a referendum on the proposal. Pearce (2009) argued that whilst Ken Livingstone would probably have not conceived of the scheme himself, he was sufficiently astute politically to see that successful implementation of a scheme would be in his own interests. He was determined that a congestion charging scheme would be operational by the time he came up for re-election four years later. In order to achieve successful implementation he built alliances with business and other stakeholders. He allowed exemptions from the charges for taxis since taxi drivers could have provided considerable opposition. The press was strongly opposed to the scheme and predicted failure. A positive aspect was the decision to introduce a variety of payment methods, none of which caused any disruption to the flow of traffic. The scheme used technology that was known to work so there were no significant risks of technical failure, although it was a major challenge to have all the infrastructure in place and operational on time. There was a major investment in buses prior to the implementation of the scheme. The Mayor and his technical team remained committed to the scheme throughout the process, despite various non-technical advisors expressing doubts. The technical team recognised that that they needed to be involved in overcoming political barriers as well as technical ones. Pearce (2009) concluded that the key lessons seemed to be that there were a number of political requisites and that the character and abilities of those leading the implementation were crucial.

There have been proposals for congestion charging in two other cities in Britain – Edinburgh and Manchester. The scheme in Edinburgh was to have used similar technology to that in London, but with two cordons, the outer one in force from 0700 to 1000, with the inner in force between 07.00 and 18.30, with a charge of £2 for crossing one or both cordons in the charged direction, but with no charge for driving wholly within one cordon or between cordons (Rye et al. 2008). The proposal was put to a referendum in February 2005, when the proposal was rejected by the electorate and subsequently abandoned. Rye et al. (2008) identified a number of reasons for the rejection, including opposition from the local press, and the complexity of the institutional context of the scheme which meant that there was not a single institution responsible for implementing the scheme (and hence no strong ‘champion’ for the scheme). There seemed to be confusion about the objectives of the scheme, with the two cordons making the scheme seem rather complex.

The proposed scheme in Manchester suffered a similar fate, being rejected in a referendum in December 2008. The scheme was fairly similar to that in London, but there would have been two cordons, with charges imposed only during the peak times, inwards between 07.00 and 09.30 and outwards between 16.00 and 18.30, with drivers charged via a pre-pay ‘tag and beacon’ system when they crossed a cordon (Wikipedia 2010).

Whilst there have been two cities in Britain in which congestion charging has been implemented, stemming from the thinking associated with the new government elected in 1997, there have, to date, been no examples of implementation of workplace parking levies, the other method to reduce car use proposed in the 1998 White Paper. However, a scheme is being introduced in Nottingham with a levy charged on all employers who

provide more than ten parking spaces from 1 April 2012 (Nottingham City Council, 2011).

The London congestion charge has been very effective in reducing car use but there is no record of its impact on physical activity. However there has been a study in Stockholm on the impact of congestion charging and physical activity which suggested that it certainly had some effect. Bergman et al. (2010) reported that:

> *"While the congestion road tax was in effect, the subjects in Stockholm reported more time doing moderate intensity physical activity, less time sitting, and more overall physical activity than before the tax … The largest change … was a reduction for reported times spent sitting among those from Stockholm. Time spent sitting has been associated with BMI and health outcomes in both cross-sectional and prospective studies. Reducing time spent sitting may therefore be at least as important to public health as increasing time spent being active."* (Bergman et al. 2010, p. 174)

They also point out that although the effects are fairly small (compared to some of the more direct behavioural interventions) interventions that have small effects may contribute to improved public health if many individuals are affected by them.

Political skill was demonstrated in the implementation of the Stockholm scheme, which was introduced on a trial basis from 3 January to 31 July 2006 (Eliasson and Jonsson 2011). There was considerable opposition to the scheme at the time. A referendum about the scheme was held following the removal of the charges after the trial. The majority of voters in the City of Stockholm voted in favour of the reintroduction of the charges, and so the government decided to implement charges from August 2007, with the revenues going towards road investment within a comprehensive package of road and public transport measures. Eliasson and Jonsson (2011) claim that public support for the scheme has increased further since the reintroduction of the scheme.

Meland et al. (2010) suggests that removing a charge for using the road can have a negative effect on physical activity by decreasing rates of walking and cycling. The work involved modelling the impacts of removing the Trondheim toll cordon which was removed in 2005 after 15 years because this was the period the Norwegian parliament had originally agreed to.

6.2.3 Land use measures

Land use patterns can affect the overall distances that people need to travel. Land use policies which make walking and cycling more accessible will increase their desirability. The following are some of the approaches which can be being used:

- Physical integration, for example, through bicycle racks at railway stations, park and ride and multi-modal public transport terminals.
- Building bus stops and cycling lanes near residential areas and areas of interest such as employment and shopping centres.

- Mixed use developments incorporating residential and commercial developments with new transport links.

With regards to new developments, there is much debate around whether polycentric or monocentric cities are more desirable. Other aspects to take into consideration for new developments are settlement size, density and design, for example, development of car free neighbourhoods such as Floridsdorf in Vienna.

Another approach to reducing the distance people need to travel by car is to increase residential densities. Densities fell with the suburbanization process, which led to longer trips, which, in turn, led some people to use cars rather than walk or cycle. The increase in the forecast population has led to pressure to build on 'brown-field' sites, that is, largely within existing urban areas. This may cause densities to increase, but will not reduce the distance of existing residents from shops, schools and so on, unless new shops and schools are built to meet the increasing demand, and they are within walking distance of existing residents.

6.2.4 Smarter Choices

There are a number of soft initiatives carried out under the 'Smarter Choices' branding although other terms have been used such as travel demand management and mobility management. They involve the use of a range of methods which usually revolve around providing people with the information and knowledge to enable them to find ways of making their journeys other than by car. As well as directly providing information about travel alternatives, initiatives are usually accompanied by some sort of community publicity campaign and possibly some incentives such as free tickets or free bicycle servicing. There are often parallel 'harder' initiatives going on at the same time such as improvements to bus services and new cycle lanes. Increases in levels of walking and cycling are usually captured by the data in order to assess the full range of benefits accumulating from the campaign.

Travel plans are a core part of the Smarter Choices initiatives. Initially, they started with workplace travel plans aimed at employers to encourage their staff to use more sustainable modes. Staff were encouraged to find an alternative to cars for travelling to work. As additional incentives, they were sometimes given free public transport passes and incentives were offered to employees for sharing cars, or they were given cash pay-outs when they did not use their parking space.

These were followed by school travel plans where schools were encouraged to draw up individual strategies with their local authorities to address school travel issues on a long term basis. They aimed to encourage a shift from cars to walking for the school run by improving the safety and perceived safety of alternative modes. A range of strategies could be included within them, for example, physical improvements including safe crossings, 20 mph (32 km/hour) zones and cycle paths. Consultations with the local community and school, road safety training and walking buses were also used. Another strategy was measures to encourage bus use such as personalised timetable information, new bus services and dedicated school buses.

In all the towns where the Smarter Choices measures were introduced, most schools (between seven and eight out of ten) demonstrated a decline in the number of pupils travelling to school by car. In three of the towns, the overall reduction in car use for the school journey was between 9% and 17%. Active travel to school increased in all the towns (Sloman et al. 2010). However, it was difficult to know how much of this change was attributable to school travel plans and how much to other Smarter Choices initiatives going on in the area.

Personal travel plans were designed to be directed at the level of the household. They included things like town centre guides and walking information, cycle training and cycle loan schemes, public transport information (for example bus stop specific timetables), personal journey plans for specific journeys and travel advisors who did presentations to community groups (Sloman et al. 2010). Earlier, Cairns et al. (2004) provided an overview of personal travel planning from the literature and concluded that the effects were relatively robust:

> *"…personalised travel planning typically reduces car driver trips amongst targeted populations by 7-15% in urban areas, and (based on rather less evidence and therefore a considerably less certain conclusion) by 2-6% in rural areas."* (Cairns et al. 2004 p.120).

They also found information about effects on car mileage suggesting that both long and short car trips are equally susceptible to influence. Within the sustainable travel towns where the Smarter Choices programmes were rolled out, they found evidence of reduced car use, increased walking and cycling, increased public transport use, increased viability of local shops and businesses, and in some places improved interaction by different players in the community (Cairns et al. 2004). However, some concerns have been expressed about the robustness of the methodology used in the evaluation of the Smarter Choices work (Graham-Rowe et al. 2011; Yang et al. 2010).

6.2.5 Internet shopping

The growth in internet shopping could indirectly be having a positive effect on physical activity, freeing up time to be spent elsewhere being more active, and, in the longer run, reducing dependence on the car, since carrying heavy goods was one of the main reasons cited for using the car for short trips discussed in Section 6.1.4.

6.2.6 Policy combinations

The most effective transport policies may involve a mixture of hard measures both physical and financial and softer policies. This can be seen in Germany which has successfully reduced the number of car trips despite having very high levels of car ownership (Pucher et al. 1998). Another key characteristic is integration between different types of policies. For example, the most effective public transport schemes are integrated both physically and through their pricing and information systems with different modes of transport whilst also being integrated with economic, environmental and health policies and at an institutional and administrative level.

6.2.7 Improving the modelling and appraisal methodology

Some of the transport models that have been used have not been very accurate at forecasting (Flyvberg et al. 2005), nor are they sensitive enough to forecast many of the issues discussed above such as those in Section 6.2.1 because they do not capture the full subtlety of changes of travel behaviour by individuals. One approach to doing so would be to use microsimulation modelling which represents the travel and related decisions of a set of households over time (Mackett 1990; Feldman et al. 2010). As discussed in Section 6.1.7, one of the problems with the modelling approach currently used is that it ignores the effects of changes to the transport network on locational decisions by both households and developers. Models exist which can be used to represent such effects, but there is no commonly agreed methodology and they are seen as rather complicated (Mackett 1993). It would be useful to have a debate about the models used for forecasting. This could include a change of philosophy away from the idea of predicting the future by trying to reproduce past trends towards a more normative approach that incorporates policy objectives into the modelling process, including increasing physical activity within an overall objective of improving wellbeing. It might be possible to set up a programme like the Travel Model Improvement Program in the United States (US Department of Transportation, 2011).

It would be very difficult to revise the analytical approaches outlined in Section 6.1.7 for several reasons. These include vested interests in maintaining the status quo, because various bodies involved developing transport schemes have invested time and money in the present system and it would cost a lot of money to change. Furthermore, if there were a paradigm shift to a new methodology, some schemes that were selected in the past might not have been and others that were rejected might have been built, which could be politically embarrassing.

There are two ways in which the appraisal methodology could incorporate wider wellbeing factors as part of the criterion to be optimized. One way would be to use a form of multi-criteria analysis with suitable weights on the social, health, environmental and economic criteria. The other way would be to retain the existing framework, but putting monetary values on all factors. This would be very difficult in some cases, but is consistent with the guidance from H M Treasury (2003) on the appraisal of projects being funded by central government. This would mean, for example, estimating the benefit to society and the individual concerned, of increasing the length of life of an elderly person by encouraging them to be more active. This is a complex research question but is, arguably, just as valid as trying to place a value on a minute of travel time saving for a business person. It is widely recognised that the method used to place values on travel time savings is very crude. The fact that it has been done for many years and has been accepted as a pragmatic way to obtain values to place on alternative transport developments so that they can be ranked, does not mean that it is sound or sensible. It certainly does not mean that other factors are not equally valuable to society. Further research is required into the value of changes in health, social and environmental factors caused by changes in transport infrastructure. The methodology should include negative factors such as

the marginal increase in the damage to health (and therefore cost to the National Health Service) of people switching from walking, cycling and bus use as a result of a scheme to improve roads for cars.

6.3 The effectiveness of strategies to reduce car use

Graham-Rowe et al. (2011) have reviewed studies on ways of reducing car use. They carried out a systematic review of the literature and initially identified 3486 reports. This was reduced to 240 studies on the basis of the title and 78 further papers identified by supplementary searches. These 318 papers were checked for relevance and 43 were found to meet the inclusion criteria. The references of these were searched and other methods used to find further papers. They examined 69 reviews they had identified at this stage. They eventually found 77 primary interventions which included car reduction measures. They concluded that the evidence base was weak, with only 12 evaluations regarded as methodologically strong: even some of these may have been flawed because the methodology adopted meant that the intervention and control groups were not randomised or matched and so may have had different characteristics or histories. Fourteen studies had methodologies that were rated as 'medium' either because different samples were use pre- and post- intervention or because no information was reported about the control or comparison group, so the effectiveness of the intervention could not be established. Three more studies were regarded as being of medium/low methodological quality because it was not possible to measure outcomes across the groups. The other 48 studies were all rated as having low methodological quality. Each of the twelve studies considered to have a high quality methodology will be considered to establish whether there is sound evidence that car use can be reduced and whether there are implications for walking and cycling.

Bamberg (2006) examined the impact of giving a free public transport ticket and personal schedule information to 92 people who six weeks after moving home in Stuttgart in Germany compared with a control group of 99 who did not receive the ticket or information. About six weeks later the participants received a second questionnaire to complete. This was completed by 191 participants 99 in the experimental group, 92 in the control. It was found that the intervention increased public transport use (18.2% of trips before to 35.8% after) while car use declined (53.0% to 39.2%). There was a slight decline in cycling and a slight increase in the number of walking trips, but these changes were not statistically significant. The extra bus trips would, almost certainly, contained elements of walking to and from the bus stop.

Cervero et al. (2002b) examined a car share scheme in San Francisco in the USA. They found that it did not reduce the distance travelled by car, but did reduce the time spent travelling. It was found that, relative to non members, members of the scheme became less inclined to walk or cycle for most trip purposes suggesting that membership of the car share scheme did not increase walking and cycling. (In the longer term some shifts to walking and cycling were found (Cervero 2007)).

Eriksson et al. (2008) carried out a study of the impact of an intervention in two municipalities in Sweden. The intervention involved a home visit from a researcher to discuss the possibility to reduce car use in the week after the visit. There were 22 households in the experimental group and 29 in the control. No overall effect on car use was found. The impacts on other trip modes such as walking and cycling were not examined.

Foxx and Hake (1977) examined the impact of offering a range of incentives to reduce driving to psychology students at the University of Maryland in the USA. The incentives were cash, a tour of a mental health facility, car servicing and a university parking sticker with the value of the incentive scaled in terms of the size of the reduction in driving. There were twelve participants in the experimental group and nine in the control group. The experimental group reduced their daily mileage by almost 20% while the incentives were offered. The control group showed no such reduction. When the incentives were no longer offered the experimental group returned to their previous level. The effects on other modes were not examined.

Foxx and Schaeffer (1981) carried out a similar experiment at a research and development consulting firm in Washington DC in the US using entry to a lottery as the incentive. There were eight people in the experimental group and seven in the control. During the experiment, those in the experimental group reduced their average daily mileage by 11.6% relative to the baseline mileage while the control group increased theirs by 21.2%. The effects on other modes were not considered. There were some concerns about the comparability of the two groups, caused mainly by the need to relax some selection criteria in order to recruit sufficient numbers for the experiment.

Fujii and Kitamura (2003) examined whether a one-month free bus ticket given to 23 drivers who were students Kyoto University in Japan would increase public transport use. There were 20 in the control group. The differences in car use between the experimental and control groups were not statistically significant, but the increases in bus use in the later stages of the experiment were statistically significant. The effects on walking and cycling were not considered.

Fujii and Tanaguchi (2005) carried out an experiment involving 292 school students and their families in Sapporo in Japan. 151 subjects received individualized information and advice about reducing family car use while 137 subjects were asked to make behavioural plans with respect to methods of reducing car use. No control group was used: instead the comparison was between the two interventions. The reduction in car use in the group asked to make behavioural plans was significant whereas it was not in the group given information and advice. For the group making the reduction it was 27.7% in terms of total trip duration and 11.6% in terms of days of car use. The effects on the use of other modes were not considered.

Garvill et al. (2003) carried out an experiment in Umeå in Sweden involving 60 subjects in 33 households in the experimental group and 54 subjects in 27 households in the control group. The intervention was information about the context

of each car trip and information to increase awareness of the alternatives in the travel diaries completed by the experimental group. The control group completed travel diaries but they were not supplied with the additional information. It was found that those in the experimental group with a strong habit of car use reduced their frequency of car use whereas those with a weak car habit did so to a lesser extent. The effect on the use of other modes was not examined.

Hodgson et al. (1998) looked at the impact of a public awareness campaign in Maidstone in Kent with residents in Tunbridge Wells used as a control group. No statistically significant differences in the number of trips by each mode were found in the two towns over the period 1994 to 1996. The modes considered were car, bus, park-and-ride (in Maidstone only), bicycle and walking. The total numbers of questionnaires returned were 3251 in three phases with about three-quarters in Maidstone.

Jakobsson et al. (2002) conducted a complex experiment in Gothenburg in Sweden involving eighty two households divided into four groups. Two of the groups were charged about 100% of the normal cost per kilometre of driving for two weeks (out of a sum of money they were offered). The third group had the charge imposed for four weeks. One of the two former groups and the third group were ask to complete a prospective car log for the following week. The fourth group was the control group and was not charged or asked to complete the log. All the experimental groups reduced their car use statistically significant amounts relative to the control group. The impacts on other modes were not considered.

Mullins and Mullins (1995) evaluated the fifteen-month proximate commuting demonstration project of the Key Bank of Washington in the USA. The project involved offering nearly 500 employees of the bank the opportunity to be assigned to a bank branch nearer to their homes. Those who transferred to another branch reduced their commuting distance by 65% with a 17% reduction in the overall average commute distance per branch while those in the control group increased their average commute distance per branch. Walking and cycling were not considered as possible alternatives because of the length of journey being examined.

Tertoolen et al. (1998) examined the response of 350 petrol car drivers in Gouda in The Netherlands who were provided with information about the negative environmental and financial consequences of car use and asked to monitor their car use and provide feedback on it. The sample was divided into five groups. Four were asked to monitor and provide feedback on their car use. One of these was given environmental information. Another was given financial information. A third one was given both and the fourth given neither (but did the monitoring and gave the feedback). The fifth was the control group and did none of these things. None of the instruments had a statistically significant impact on car use. The impacts on walking and cycling were not considered.

Of the twelve studies, four were carried out in the USA, two in Japan and six in Europe: three in Sweden, and one in each of Great Britain, Germany and The

Netherlands. Four of them found no evidence of an effect on car use while eight found at least some evidence, but it was pretty weak in at least two cases, and not sustained in at least one (most of them did not look at the long term effects). Some of the sample sizes were very small, and some of the populations examined were atypical such as university students. Only three of the studies considered the possible transfer to walking and cycling, and none of those found a significant transfer.

Given the systematic and comprehensive approach adopted by Graham-Rowe et al. (2011) it seems likely that they identified all the important studies that have been reported. Very few were methodologically sound, and none of those showed significant transfers from car use to walking and cycling. Hence, it can be argued that there is no convincing evidence of successful interventions to transfer trips from car to walking and cycling.

As shown above, only one of the studies regarded as methodologically sound was carried out in Britain (and no effect was found). There have been some interesting studies carried out in Britain, for example, looking at the impact of packages of soft measures, including personal travel planning, travel awareness campaigns, cycle and walking promotion, and school and workplace travel planning. These have been implemented in the towns of Darlington, Peterborough and Worcester in the Sustainable Travel Towns programme (Department for Transport 2010g). It was found that there were increases in walking and cycling over the period 2004 to 2008. The number of walking trips increased by 12 to 14% in the three towns. In Worcester, cycling increased by 19% and in Peterborough it increased by 12%. It increased by considerably more than this in Darlington, but it was also a Cycling Demonstration Town for part of the period. The proportion of respondents who did not walk or cycle fell by 11% from 23.4% to 20.9%, while the number reporting that they walked or cycled 'almost daily' increased by 6% from 46.6% to 49.4%. The number of car driver trips fell by between 7% and 9% in the three towns. However it is not clear how robust the findings are:

> *The study was commissioned some time after the beginning of implementation of the Smarter Choice Programmes in the three towns, and before the completion (in late 2008) of draft guidance from the Department for Transport on the evaluation of so-called 'better use' measures. For these reasons, the study did not formally follow the guidance contained in the Department's draft better use evaluation framework.* (Department for Transport 2010g, p. 6).

In their review of evidence on measures to reduce car use Graham-Rowe et al. (2011) classified the methodology used in the study as being of 'medium quality'. Concern was also expressed about the methodology used in the evaluation of the Cycling Demonstration Towns by Yang et al. (2010).

6.4 Conclusions

There is no shortage of strategies that could reduce car use. Unfortunately, the evidence on their effectiveness is very limited. Part of the problem is methodological. It

is very difficult to apply the rigorous methods used by health researchers in controlled environments such as those used in drug trials, to natural experiments such as major transport schemes. There are several reasons for this. Firstly, it probably needs a large transport scheme to show significant impacts and there have been very few of these, as was found in the NICE development of the guidance on Physical Activity and the Environment (National Institute for Clinical and Health Excellence 2008). The evaluation of the London Congestion Charging scheme did not include a systematic before and after survey. However, the impact of the Cambridgeshire Guided Busway on walking and cycling is being monitored systematically and this should yield valuable results (Ogilvie et al. 2010). Secondly, it is very difficult and expensive to carry out such studies, particularly as they need to be carried out over a long period to establish all the impacts, some of which may be quite long term. Thirdly, it is, in practice, impossible to carry out such studies in a completely systematic way: in a medical experiment it is possible to control for differences between the two populations (those subject to the intervention and the control group), but this is not the case for transport interventions for several reasons: since people live and work in different locations, their travel patterns will vary, so it is never possible to have identical travel opportunities open to both samples; also, much of the effect of a transport intervention will be based on information, much of which will be in the mass media and it is impossible to prevent some of this information reaching the control group. The need to accept that such rigorous standards cannot be applied to transport interventions has been recognised by physical activity researchers such as Egan et al. (2005), Ogilvie et al. (2005) and Sallis et al. (1998).

It was shown in Section 6.2.1 that for many short trips by car there are no institutional barriers to shifting them to walking or cycling: it requires a decision to change and then a change of behaviour by the individual concerned. In Section 6.2.2 it was shown that there is evidence that charging for making a specific car journey, for example, through a congestion charge, does have an impact on levels of car use. This suggests that a change in the economics of car use towards a system that makes individual car trips more expensive may encourage a shift to other modes. The lack of systematic evidence of the effectiveness of interventions to reduce car use and increase walking and cycling means that caution is required in proposing strategies to increase physical activity. However, the need to address the health risks posed by decreasing levels of physical activity mean that it is important to take action. This is addressed in the next section.

7 The way ahead

It has been shown that there is a need to increase walking and cycling in order to increase physical activity. Whilst it is possible to implement methods intended to increase walking and cycling directly, there is considerable scope to shift many people from their cars to walking and cycling because of the large number of short trips being made by car (Department for Transport 2010e). However, it is also important to ensure that personal accessibility is not reduced significantly in doing so. In this section, strategies will be discussed which can be developed to create a

climate more favourable to a reduction in car use which would lead to an increase in physical activity.

7.1 Encouraging more walking and cycling

The increases in cycling found in the Cycling Demonstration Towns (Sloman et al. 2009) show that, with comprehensive packages of measures, it is possible to increase levels of cycling, but at a cost (about £5 per head per year compared with a figure of £1 per head per year at the beginning of the scheme). It is argued (Sloman et al. 2009) that the benefits from the reduced mortality as a result of the extra physical activity exceed the costs of the scheme.

In order to encourage more people to walk and cycle it is important to make them easy to do. Possible methods of overcoming the barriers associated with the perceived difficulties of walking and cycling are relatively easy to identify. Improving the walking environment by investing in better and wider pavements, installing more street lighting, putting in more benches, and paying staff to clear up litter and dog mess are straightforward (ADONIS 1999; Moudon and Lee 2003). Measures which make cycling more attractive include improving and building cycle lanes and paths, giving cyclists priority at junctions, wider, clearly marked colour co-ordinated cycling lanes and separate traffic lights. It is also important to provide convenient and safe cycle parking at popular locations including shopping areas, railway stations etc. It is also important that, when commuting, cyclists are able to interchange seamlessly between a set of transport modes (Santos et al. 2010b). The bicycle hire scheme in London is generally seen as a success despite not covering its costs (see Section 3.7) so similar schemes could be set up in other cities. There is a need for effective evaluation of the various schemes so that those that are cost effective can be set up in other locations. Such improvements, together with effective policing may help to reduce crime levels. If local residents can be convinced that this has happened, they may be more willing to walk or cycle.

For those not currently walking or cycling, the motivation to do so will need to be based on the intrinsic benefits, such as health. This requires increasing awareness of the health risks associated with lack of physical activity. Advertising campaigns may help here, but it seems unlikely that these alone will have very much impact on those who currently choose a sedentary lifestyle. In some cases, it may be more effective to target other members of the household who can repeat messages to their more sedentary spouses, children or parents whenever they think it is appropriate.

It seems very unlikely that such measures will have much impact without policies to reduce car use. It is also important to understand more about the links between travel and physical activity. These issues are discussed below.

7.2 Analysis of the relationship between travel and physical activity

The evidence presented above suggests that there is a causal relationship between travel mode and physical activity. However these data do not form a coherent body of work at present, nor has it been analysed systematically. A starting point for the strategy would be to develop an authoritative systematic review of the relationship between car use, public transport and physical activity. This information could then be used to develop an elasticity measure to show how much AT increases in response to a reduction in car travel and vice versa and the likely impact of measures to reduce car use on walking and cycling. The paper by Frank et al. (2010a) in which they examined the relationship between car use, active travel and various environmental characteristics provides a useful model.

This elasticity could then be used, with other sources of information, for the development of a comprehensive model which would be able to estimate the health consequences in economic terms, of changes in levels of active travel and car use. Such a tool or model would be used not only to assess the direct impacts of changes to levels of active travel, but would include the indirect impact as well. It could be based on the work developing the Health and Economic Assessment Tool (HEAT) (Rutter et al. 2008, Kahlmeier et al. 2010) which answers the following question:

> *"If x people cycle y distance on most days, what is the value of the health benefits that occur as a result of the reduction in mortality due to their increased physical activity?"* (Rutter et al 2008, p. 7).

More explicitly HEAT calculates:

> *"The total value of the economic savings due to reductions in all-cause mortality among these cyclists."* (Rutter et al 2008, p. 9).

Therefore it only takes into consideration the benefits which occur to the people who cycle compared to those who do not cycle. What it does not take into consideration is how the reduction in motorised transport which occurs as a result of their cycling benefits others as well. It also does not take into consideration how the choice to walk affects the level of car travel (although a HEAT tool for walking is currently being developed) and the indirect benefits of this. This means that a tool needs to be created (based on the analysis described previously) which looks at total changes in the level of AT, how this affects changes in the level of motorised travel, and what the total direct and indirect health consequences of this are, and, what the economic consequences might be. Again while this is extremely complex, there has been a great deal of work done on the health consequences of transport for example the report by the Pan European Programme on transport, health and the environment (Boesch et al. 2008), or recent work for the Department of Health and the Department for Transport (Buroni and Jones 2010). Such a model could have a number of practical applications, as discussed below.

Once the relationship between active travel and car travel had been consolidated through a review and expressed in a model which calculated health costs, this could go some way towards increasing people's awareness about the substantial external costs of transport (Dora and Phillips 2000), particularly those caused by physical inactivity. In a recent review of policy instruments, Santos et al. (2010a) discussed

how the cost of externalities is not reflected in the current market prices of road transport. When mentioning what the externalities are, they do not include the health consequences through physical inactivity in the calculations. However evidence emerging from the Sustainable Travel Towns project (Department for Transport 2010g) estimates the impact of changing transport modes towards more sustainable forms. The benefits of reduced congestion and pollution on the environment came to £14.40 per consumer, whilst the monetary benefits in terms of increases in physical activity came to £49.90 per consumer. This suggests, along with analyses conducted by Litman (2008), that the costs of physical inactivity are one of the biggest costs of car travel.

7.3 Linking together sustainable travel and active travel

7.3.1 The physical activity benefits of not using the car

Active travel could be more promising as a message to the public than the environment in encouraging people to reduce the amount that they use cars. Evidence emerging from Anable et al. (2006) and Bonsall et al. (2009) shows that the environment has not motivated people to change their behaviour. However it seems possible that the active travel increases obtained through using the car less could be more effective. For example, market research studies carried out in the US showed that the reasons people engaged in physical activity were because it resulted in feeling better or more energetic, it helped to reduce stress, they were less likely to feel out of breath and felt stronger. Older adults expressed similar views (Transportation Research Board 2005). By focusing on wellbeing, attention is moved from an elusive future into the present, and from the impact on others (not yet born or unrelated to oneself) to the consequences for oneself. Evidence on behaviour change strategies show that some key motivators are desire for personal gain and for approval by peers as well as self, concern for societal values and fear of adverse consequences (Bonsall et al. 2009). If the wellbeing benefits of active travel are properly promoted so that people obtain peer and social approval, this could lead to people reducing the amount they use the car.

Currently, travel mode decisions are frequently made on the basis of time, cost and effort which often lead to people choosing the car. However with the right sorts of media campaigns, it seems feasible to build health rewards into part of the individual decision-making process and this could lead people to decide against using the car.

7.3.2 Creating institutional links between sustainable travel and health

On the whole, the gains of sustainable travel and health are mutually reinforcing (Mindell et al. 2011); however, they need to be considered in the context of each other to be sure that the outcomes are in the interests of the goals of both areas. Sustainable travel policies have focussed on, for example, home working which has the potential to be detrimental to AT as the person may spend a lot of time at home. Other policies have focussed on increasing the fuel efficiency of cars so they do not burn so much petrol. Again this has no benefits for physical activity. Interestingly

both of these measures failed in relation to sustainable travel as well. The cars of some employees who switched to home working ended up being used by other family members (Cairns et al. 2004) and people took advantage of the fuel efficiency of their car to travel further leading to the various negative impacts of more car use (Frondel and Vance 2009). Perhaps if physical activity implications had been considered from the outset, any resulting reduction in car use would have been more beneficial to sustainable travel as well. Another area in which it could be useful to consider both goals together is in relation to journey type. An emphasis on CO_2 reduction highlights the importance of reducing the number of long car journeys as these use larger amounts of fuel per trip. Reducing the number of shorter journeys is actually more beneficial for physical activity as these are the journeys more likely to be replaced by active modes. However short car journeys are grossly inefficient and can be more environmentally damaging than longer journeys as during the first three kilometres exhaust emissions are more than 50 times higher per kilometre (Loukopoulos and Gärling 2005, De Nazelle et al. 2010).

There are other values in institutional collaboration between transport and health professionals which have been pointed out by Wright and Egan (2000). Part of the reason why it is difficult to introduce strategies which directly reduce car use is because of their political unpopularity. People would assume that any penalties, for example, were about trying to increase revenue. A co-ordinated approach between interest groups would help to create a distance from the political process making any campaign more viable. Secondly, such a coalition would allow for pooled resources which would increase the scope of what could be done. In particular, as discussed below, it could allow for advertising to demarket car use. Another point which Egan and Wright make is that a:

> *"...coalition confers moral authority. The campaign would be perceived as sincere, representing not just one interest group but several organisations that together made up a significant body of public opinion."* (Wright and Egan 2000, p. 293).

7.4 Understanding the role of the car

The car plays a positive role in the lives of many households. This means that if car use is to be reduced in order to increase physical activity, it is important to establish exactly what the benefits are that the car provides. Any coercive or other measures to reduce car use could be counterproductive if they do not take into consideration the positive role which a car plays in people's lives.

There appear to be two main areas in which research needs to be conducted. One is the practical implications of car use. The other is its psychological effects.

7.4.1 The practical implications of car use

It was shown in Section 6.2.1 that there were many car journeys which could not have easily been done with another form of transport either because it was dark,

there was poor weather or there were people or goods that needed to be transported as well.

Research needs to be conducted into how car access affects a person's or family's lifestyle so that its role is understood, and therefore there would be a clearer picture of how to replace the advantages which accrue from the car. This research would need to be conducted in a way that ensures that car owning and non-car owning households came from the same socio-economic groups so that their lifestyles could be properly compared. Some possible topics for analysis are considered below.

Just as car availability has shaped interaction with the public realm of work, leisure, shopping and services, it has also shaped the spatial arrangement of social networks in people's private lives. While in the past, people may have chosen to locate close to friends and family in order to maintain contact with them, the presence of the car means that residential proximity is no longer required.

While planning, transport and land use policies are beginning to deal with the problems inherent in the spatial relationships between the private and public realm in a way which makes sustainable travel patterns more viable, there is very little knowledge about the links between active travel, car travel and personal relationships. As discussed in Section 6.1.1, there has not been very much research into the role of the car in the development and maintenance of social networks other than the work by Greenaway et al. (2008). This is a serious shortcoming. It is important to increase this understanding if some households are going to reduce their level of access to a car but wish to maintain their wellbeing, of which personal relationships are a vital element.

Social travel as a proportion of the distance travelled is likely to increase as 'soft measures' ameliorate the car travel demands of school, shopping and work. Attention is likely to turn to ways in which social travel can be reduced. Understanding more about family travel may help to plan future transport and housing services in ways which minimise the need for car travel. Some examples of types of strategy are listed below:

- If there were a significant number of trips made between certain locations which were not being catered for by public transport some form of minibus service could be provided;
- Social housing policy could be even further adapted to accommodate the requirements of social networks;
- If close proximity between extended family members was seen as a viable and popular factor, this might influence the types of housing developments which developers chose to offer;
- Certain groups of social network might be identified which could be seen as possible 'hubs' for the development of new methods of collective car use, moving away from the current model of households owning one or more cars, leading to their frequent use simply because of their availability and convenience, in turn leading to many of the problems discussed above. Some alternatives are discussed in Section 7.5 below.

An important dimension of the research would be finding out the number of different types of facility, and the number of each facility which car owners use compared to non-car owners. It would then need to consider what the costs and benefits are of having access to these facilities for the individual.

Time allocation would be another crucial dimension. Lack of time is one of the most frequently cited reasons for using a car and modern life is time pressured for many. This could be examined by considering how not having access to a car affects the way in which a non-car owner allocates time compared to a car owner, identifying the benefits and disadvantages which accrue on account of this.

7.4.2 The psychological dimensions of car use

Very often the social environment is ignored from studies of car use and, to the extent that it is included, it often gets missed out at the stage of systematic review. As a result, understanding of attitudes and values surrounding car use is extremely limited.

In the US, focusing on the environment may be the most appropriate mechanism for increasing physical activity; however, in Britain most of the strategies seem to focus on behaviour change. The idea is that people's behaviour can be changed by changing their attitudes and there has been a great deal of tried, tested and thorough research on the ways in which this can be done. Some examples of possible approaches are: making a new behaviour seem more advantageous, or more salient to the person, and making the behaviour appear to be more prevalent than it actually is. The media can play a very important role in this. It is also very important a new behaviour seems possible.

What emerges from studying the literature is how malleable people's behaviour can be as Avineri and Goodwin (2009) discuss:

> *"The scale of the change varies…but it does seem established that the behaviour of individuals does change, substantially, and is amenable to well designed influence which is clearly defined, goes with the grain of experience, sensitive to time scales, and has genuine and demonstrable advantages." (*Avineri and Goodwin 2009, p. 28)

Understanding the psychology of car use could contribute to this.

The subject areas which deal with behaviour change include, for example, behavioural economics, advertising, information, persuasion, social marketing, holistic approaches and 'choice architecture'.

For those who make short trips by car it is necessary to make the alternatives appear to be more attractive relative to the car, or, putting it another way, make use of the car less attractive. One of the ways of doing this is to employ marketing strategies to discourage car use. This possibility has been explored by Wright and

Egan (2000) who describe the strategy as ‘demarketing car use’. Focusing on usage rather than ownership is seen as a more realistic as:

> *“Persuading someone not to drive a few hundred meters to the local newsagent does not involve a confrontation with such intense and deeply rooted desires.”* (Wright and Egan 2000, p. 291).

Wright and Egan (2000) showed how an understanding of psychology and human motivation could be used along with knowledge of behaviour change mechanisms (for example, the Theory of Planned Behaviour developed by Ajzen (1991)) to develop a campaign which would de-market car use. These campaigns would require creativity and skill. Wright and Egan (2000) also outline the sorts of themes and straplines around which these campaigns could be built. Some of their examples were:

- ‘Walk and live longer’
- ‘Look after your car - leave it at home’
- ‘Real men cycle’
- ‘When you drive, you risk killing your child’

An additional one might be ‘Burn fat not fuel’.

Knowledge about the psychology of car use would help contribute to such a campaign.

Market research results underscore the importance of understanding the beliefs and attitudes of those whose behaviour one wishes to reinforce or change (Transportation Research Board 2005). It is very important to ensure that interventions are targeted towards specific groups rather than delivering mass messages. Segmentation is a way of doing this. According to Anable et al. (2006) this starts from the premise that:

> *“...different people must be treated in different ways because they are motivated by different factors, experience different impediments to change and are affected in different ways by policy. As such, the same behaviour can take place for different reasons and the same attitudes can lead to different behaviours.”* (Anable et al. 2006, p. 14).

They also point out that whilst such research is the cornerstone of any travel behaviour change programme, research in this area is still in its infancy and there have been very few attempts to define mobility segments in a systematic and psychologically meaningful sense. A study of the psychology of car use could make a valuable contribution here.

7.5 Development of alternatives to household car ownership

In Britain today, most households own one or more cars because of the great benefits that car ownership bestows in terms of flexibility in trip making over both time and space. Car travel tends to be relatively cheap, particularly when several people are travelling together, and offers the opportunity to carry heavy goods such as shopping or the paraphernalia associated with babies. Any strategy to reduce car ownership must be able to offer a level of accessibility similar to that offered by the

car. Although no other single mode can offer this, it may be possible to obtain a similar level of flexibility by using a mix of modes. A household might well be willing to give up owning a car and use walking, cycling and public transport to meet most of their travel needs providing they can have access to a car for those trips where a car is seen as essential such as family holidays or supermarket shopping. If they can have access to a car occasionally, but avoid having one sitting outside their house and so they pay a higher cost per car trip (but a low or zero fixed cost compared with purchasing a car), they are likely to make more rational choices about which mode to choose for a particular journey.

Cairns (2011) has identified a number of alternative models of accessing a car. Some methods, such as taxis, have existed for many years, while others, such as car clubs, are recent innovations. The following are possible methods of accessing cars other than individual ownership:

- **Taxis:** About 1% of trips are currently made by taxi, but with an average length about half of that made by car (Department for Transport 2010e), with those aged 17 to 29 making the largest number of taxi trips. Older women also make more taxi trips than most other groups in the community. People living in households without a car make about four times as many taxi trips as those living in households with one. Because a taxi ride involves being driven by a professional driver, taxi journeys tend to be quite expensive. In London taxis cost a minimum of £2.20 which includes the first 279.6 metres and then 20p for each extra 139.8 m (Transport for London 2011b). This is the minimum rate. This means that a 10 km journey would cost a minimum of £16.20. An alternative to a taxi (or 'black cab'), which can be hailed on the street, would be a minicab which has to be booked in advance. The fares are negotiated but are, typically, about half those of a taxi.

- **Shared taxis:** Modern communications technology opens up the possibility of diverting taxis to pick up further passengers each paying less than for an individual taxi.

- **Car rental:** Many companies offer cars for hire for self-drive for a variety of periods. The typical price for hiring a medium size car in London for a day from a major company is about £60, but could be less at a smaller company. This includes some insurance but not fuel.

- **Car clubs:** A car club such as Streetcar (2011) offers members access to a fleet of vehicles in their neighbourhood in return for an annual membership fee and a per hour hire charge. The annual membership fee for Streetcar is £59.50. Rental of a medium size car is £6.25 per hour or £62.50 for a day including insurance, 20 miles (32 km) worth of fuel per calendar day and access to a breakdown service. The cars are all modern and fuel-efficient and are accessed through smartcards and electronic keys. Booking is done through a website and cars can be collected from many parking places, some

provided by local authorities and others by private individuals at their homes who receive free membership and credit towards vehicle hire.

- **One-way car rental:** This is similar to a car club but cars can be left in any legal parking space or a parking space designated as part of the scheme. There are no schemes in Britain as yet but car2go (2011) has set up schemes in Hamburg and Ulm in Germany, Vancouver in Canada and Austin, Texas, in the USA.

- **Neighbourhood car rental:** A recent innovation in Britain is neighbourhood rental which is a scheme such as Whipcar (2011) in which individual owners offer their cars for hire on a website at a price of their choosing. The price includes insurance. Typical prices for a medium size car are £7 an hour or £35 for a day.

- **Car sharing:** Car sharing is the process of two or more people sharing a car and travelling together. They may both be car owners who take it in turn to use their cars, thereby sharing the effort of driving and the cost or one person may drive regularly and receive contributions towards the cost from the passengers. It is also known as car pooling, liftsharing or ridesharing. There are a number of models of car sharing (Carplus 2011) including national schemes such as Liftshare.com, workplace schemes, and van pooling where a group of work colleagues share a multi-occupancy vehicle to travel to work together each day, with the car share operator supplying the vehicles, the users sharing the costs of running it and the employer sometimes subsidising it, to reflect the reduction in the cost of car parking and the compliance with the workplace travel plan.

The potential for these alternative methods of accessing cars is acknowledged in the White Paper on local transport:

> *"Schemes such as car clubs or car sharing can help to address congestion and emissions while preserving the freedom and flexibility that the car brings"* (Department for Transport 2011a, p. 68).

The mechanism for this is not made clear, but implication is that it is through reduced car use. The White Paper also says that the Government is keen to encourage more flexible use of existing taxi and private hire services.

According to Family Spending (National Statistics 2011) in 2009, each household in Great Britain spent an average of £39.90 a week on the purchase, repair, insurance and taxation of cars and vans, and spent £19.20 a week on petrol and diesel fuel. According to Transport Statistics Great Britain (Department for Transport 2010f), in 2009, the average distance travelled by each car was 8420 miles (13472 km) and each household owned 1.14 cars on average, implying they travel 9599 miles (15358 km) a year. A weekly spend of £19.20 on fuel implies an annual expenditure of £998.40 on fuel, which is 10.4p per mile (6.5p per km) on top of the daily average expenditure of £5.70 on fixed costs. The £5.70 is an average cost every day, spent whether or not the car is used. A household that made only one trip a week would be

spending £39.90 in fixed costs per trip. For households who make relatively few trips, some of the alternative methods of accessing cars such as car clubs or neighbourhood car rental would be an attractive option in financial terms. It should be recognised that the figures here are averages, but a household that walked or cycled for short trips and used public transport for many longer trips such as commuting and hired a car using one of these schemes could meet its accessibility needs, probably at a lower cost than owning one or more cars. Given the low (or zero) fixed costs of using these schemes it would be straightforward for many households to use a mixture of schemes to meet their needs. There are other possible options, such as households who would otherwise own two cars owning only one and renting at times when they need two cars simultaneously or a different type of car, such as a large one for a family holiday.

Support mechanisms for car club membership from around the world have been identified (Enoch and Taylor 2006):

- In some countries (for example Germany and Switzerland) public transport bodies have been willing to subsidise car club membership as they have found that this increases their own customer base. Similar solutions are being developed here (Huwer 2004; Muheim 1998).
- Local authorities and developers can support car clubs by providing parking spaces for them.
- Local councils can facilitate car club development in their area by themselves being customers for car club vehicles which often remain dormant during the week.
- Car club members can be offered incentives such as reduced congestion charges, tax breaks or subsidized parking opportunities.

Most of the alternative schemes for accessing cars are in urban areas, and so less useful to those living in rural areas. According to Harmer and Cairns (2011) 82.9% of car club members were based in London in January 2011. It is, however, possible to set up schemes in rural areas, as shown by the success of Car Share Devon set up by Devon County Council. It brings together various large employers in the county, with a free public scheme for those who work for other employers. The scheme was launched in 2004 and now has 7,500 active members (Department for Transport 2011a).

These alternative methods of accessing cars are growing fast. For example, membership of car clubs has grown from 32,000 members in December 2007, 64,000 in December 2008 to 161,172 in January 2011 using 3055 car club vehicles (Harmer and Cairns 2011).

Car clubs appear to have a significant impact on car ownership (Harmer and Cairns 2011). One third of members surveyed reported a reduction in their household car ownership, 30% said that they had deferred buying a car and 61% of respondents reported that, as a result of joining a car club, they were unlikely to buy a car in the next few years. 78% of car club members walked for 20 minutes or more once a week compared with the national average of 55%, and 32% cycled at least once a

week compared with 9% nationally. 66% of car club members used a bus at least once a week compared with 16% for the whole population. Car clubs are run on a commercial basis. They therefore have the potential to be self sustaining unlike interventions designed to increase AT directly (Cairns et al. 2004). With a car club car, members only pay when they use the car. This makes people think a lot more about if they really need to drive. Cervero et al. (2007) reporting on City Car Share, a car club in San Francisco explained that:

> *"...mindful of the cumulative costs of driving Car Share members appear to have become more judicious and selective when deciding whether to drive, take public transit, walk, bike or even forego a trip …. Carshare membership instils a resourcefulness in travel habits, whether in the form of multiple occupant car share travel or taking transit, walking or cycling when not driving Car Share vehicles."* (Cervero et al. 2007, p. 79).

If these alternative methods of accessing cars lead to fewer cars on the road, road space will be freed. It is important that this road space is removed from car use and is used to create more space for cyclists and pedestrians and to create a more pleasant environment or else new car trips that were previously suppressed because of congestion may be induced.

These alternative methods of car access can also help to reduce social exclusion by giving access to a car to those who are not able to afford to buy one (Cairns et al. 2004).

Behavioural theories often assume that decisions are made on a rational basis. However research has shown that the existence of habit throws that assumption into question and that habit is often the reason that people do not behave in a rational way. Evidence suggests that periods of transition, for example, going to college, having a baby or getting a new job are good time windows for bringing about behaviour change (Sloman et al. 2010). A key point could be after people had passed their driving test. There could be an incentive scheme whereby new learners who had also taken the Pass Plus exam could possibly be given incentives to try the alternatives such as free membership of a car club and reduced hourly rates for a limited period of time. It would be worth giving quite generous incentives for this group as they could provide a client base for commercial schemes for a many years. Another key transition time when non-car owners are most likely to think of buying a first or second car is when they have a child. Mothers are in the important position of shaping not only their own habits and possibly those of their husbands or partners. Through their behaviour, they also shape the future choices of their child. Mothers also come with a lot of social capital assets: this means it could be worth trying to adapt a car club and car sharing schemes to meet their needs. Mothers have very good social networks, not only with other mothers but they are linked in with institutions like Sure Start and the National Childbirth Trust, as well as online networks like Mumsnet and Net Mums. These could provide channels through which marketing could take place. They tend to go to the same sorts of places as other mothers, often know each other and seek out the company of other mothers with

their children. Therefore it could be possible to develop some sort of alternative scheme membership where a group of mothers have ownership of a car and co-operate with each other in the way that it is run. Retirement could provide another possible window of opportunity as could people moving house. As house buyers and sellers are linked to estate agents it would be possible for a car club or car share scheme to see what incentives might be worth offering here.

7.6 Reducing car use through planning

Just as it has been possible to reduce the pace of development of large, out-of-town superstores, it could equally be possible to use planning controls to reduce the development of large facilities such as hospitals and schools. There would probably be a cost associated with this but this could, in theory, be offset against the financial saving to the National Health Service of the reduction in illnesses associated with low levels of physical activity. One difficulty would be to establish that there would be an increase in the volumes of walking and cycling, and then to put a monetary value on the resulting health improvement. It may be appropriate to change the decision-making procedures used for schemes such as retail developments, hospitals and schools so that the travel demands of the users (customers, patients and their visitors, and pupils) and are taken into account explicitly in decisions about new locations.

Some land use measures to reduce car use were discussed in Section 6.2.3 including measures to support walking and cycling and increasing residential densities. Even if planning policies of increasing densities and providing local shops and services are implemented further, they will do little reduce the car dependency of people living in rural or low density suburban areas. It also seems unlikely that many of them are going to return to high density urban living. However it should be borne in mind that the population is dynamic: new households are being formed all the time, while others dissolve. This means that, whilst the existing households who have moved right out of the city may not move back, the equivalent households going through the stage in the life cycle when households in the recent past chose to move out, might come to a different conclusion and choose a more urbanised lifestyle. This could be encouraged by focusing more attention and resources on improving the quality of life in urban areas. If urban areas become recognised as places where people are more physically active, and offer a better quality of life, people may think twice before choosing to move out. Slowing down the movement of population from urban to rural areas might have the effect of making more homes available in rural areas for local residents including first time buyers and might slow down the growth in property prices. However, it might also adversely affect the local economy with less money entering it and less support for local services. An explicit policy to slow down decentralisation as part of a policy to reduce car use ought to consider these issues.

There are other ways in which households could be targeted to discourage them from moving to less dense suburbs. One way might be through ticket pricing and the costs of intraurban travel compared to interurban travel. Another is location-efficient

mortgages (Hoeveler 1997). These are based on the idea that if people live in an area with good public transport and good connections, they will have to spend less on transport and will therefore be more able to pay their mortgages. This could then be reflected in lower mortgage rates which would act as an incentive to encourage people to move to or stay in more walkable urban environments.

7.7 Changing travel behaviour

In an environment more hospitable to forms of AT in which people are more interested in walking and have reduced their psychological and practical dependence on the car, there are tools which could be used to shape AT behaviour. The two main types of tool identified are command and control strategies and incentive-based policies (Santos et al. 2010a). These can include allocating permits or rights to emitters, fiscal instruments, registration, charges based on fuel emissions, taxes, parking restrictions, congestion charges, subsidies given to those who scrap old cars and buy fuel efficient vehicles, high occupancy lanes and pay–as-you-drive insurance.

As discussed in Section 3.7, the British government is keen to encourage behaviour change to address some policy issues, including the use of 'nudging' (Thaler and Sunstein 2009).

To choose from the wide range of policy instruments available it is necessary to have a thorough knowledge of the effects of prices on travel behaviour both in the long run and short run. There is a substantial body of empirical and case-study evidence that price has a material effect on behaviour. This consists:

> *"...of a literature of several hundred published articles which have themselves been periodically reviewed in published literature surveys."* (Avineri and Goodwin 2009, p.9).

The types of research include econometric studies, modelling studies of the effects of changes in prices using best practice transport models, and before and after studies of the effects of particular real world policy interventions (see for example Balcombe et al. (2004), Goodwin et al. (2004) and Paulley et al. (2006)).

As discussed in Section 3.7, there needs to be more work done on establishing the effectiveness of behavioural change particularly at the population level (House of Lords Science and Technology Select Committee 2011).

7.7.1 Charging for the use of the road

Increasing the cost of car use is likely to encounter political difficulties, as discussed in Section 6.1.2, but this can be overcome with political skill as used to implement the London Congestion Charging Scheme (Section 6.2.2.). It would seem sensible to use the lessons learnt in London, recognising that congestion charging only applies in large, congested urban areas, but once further successful schemes have been set up, it will be possible to extend the scheme to smaller areas.

It is worth considering the factors that made the London scheme successful. It seems to be possible to convince motorists about measures if they are aware of the problems (e.g. congestion) and they receive something in return (e.g. faster trips). It seems to be better to avoid a referendum before implementation because, as shown in Edinburgh and Manchester this is likely to fail. It would be better to follow the example of Stockholm where the referendum was held after the system had been trialled for seven months and then removed. There needs to be a strong champion who is able to ensure there is strong support across the political spectrum and able to build alliances with possible opponents such as taxi drivers. It needs to be a simple scheme: it can be made more complex, for example charges varying by time of day or congestion levels, once it has been implemented and seen as effective by the population.

7.7.2 Fuel pricing

Increasing taxation on vehicle fuel is politically difficult even though evidence on the effects of fuel prices and other motoring costs on car travel has shown that a 10% increase in fuel price caused a 1.5% reduction in traffic volume in the first year building up to about 3% over a 5-10 year period (Goodwin et al. 2004). The increase in effect over time showed that it takes several years for the behavioural adjustment produced by the price rise to take place because of the effects of inertia and habit. There are many complexities involved in working out the effects of fuel prices on trips because of the influence of the nature of the trips, driving styles and choice of vehicles. Cars have become more efficient over time, and the growth in electric and hybrid vehicles has reduced sensitivity to increases in fuel price.

The price of fuel is likely to increase over the next few years if the supply is restricted by events on the international scene, so it may be better to avoid significant increases in fuel duty beyond the present system, instead relying on schemes to charge for driving in urban areas (where the opportunities to walk, cycle and use public transport to destinations are likely to be greater) and the growing popularity of new methods for households to access cars.

7.7.3 Pay-as-you-drive vehicle insurance

Pay-as-you-drive vehicle insurance has been suggested as the number of accidents people have is closely related to the distance travelled. The idea is that if they had to pay for their mileage this would motivate them to look for other means of transport. Litman (2008, 2010) calculated that this kind of system could in America at least reduce vehicle miles travelled by 10 to 12%, reducing traffic crashes as well.

7.7.4 Reducing car parking

Parking provision plays a key role in influencing the demand for car journeys as shown by its use in many British cities as a major form of traffic restraint. Parked cars reduce the space available for cyclists and pedestrians and kerb side parking encourage cruising at low speeds causing congestion and pollution (Shoup 2006). One option

suggested by Knoflacher (2006) is to provide garaged car parks at public transport stops at low cost and to charge high rates on domestic parking which are three to four times higher than the rates charged at the garaged car parks at public transport stops. He argued that this could result in 70% of urban space becoming car free.

7.7.5 Legislative interventions

Behaviour can be changed through strong enforcement of existing or new laws. While marketing communications change people's understanding of the world

> *"...legislation changes the world itself: by attaching new consequences (typically a penalty) to a behaviour, and so changing how advantageous it seems."* (Christmas et al. 2009 p. 38).

Some of the characteristics of successful intervention have been identified. They must be clear and unambiguous. They need to have credible enforcement to embed them in the population which can be easily monitored and policed. They need to have a clear rationale which is understood by the public. Where introduced correctly, legislation can be effective in bringing about behaviour change even where initially it is seen as controversial. The best legislation to change behaviour builds on previous shifts in attitudes rather than seeking to create new attitudes (Avineri and Goodwin 2009).

8 Conclusions

In 1996 the US Surgeon General produced a report which explicitly recognised the potential contribution of everyday physical activity, including walking and cycling, to health. This has been acknowledged by both the Department of Health and the Department of Transport in Britain. Levels of physical activity are decreasing in Britain, as in many other countries, and this is likely to lead to an increase in coronary heart disease, obesity, hypertension, depression, anxiety, and type 2 diabetes which will cause a huge increase in the cost of health care in this country. Fewer than half the population of Britain achieve the recommended levels of physical activity. Walking and cycling have decreased over the years which may have contributed to the decline in physical activity. Hence there is potential to see if they can be increased in order to improve the health of the nation. This needs the combined efforts of researchers and policy makers from the fields of transport and health.

All forms of transport can provide physical activity, either directly or indirectly: walking and cycling because their require expenditure of energy, public transport because almost all journeys involve one or more walks, and car because it provides the means to reach some opportunities for physical activity.

One approach to increasing everyday physical activity is to focus on personal characteristics and behaviour, looking at a range of approaches in various settings, including focusing on the individual, the family, the school, the workplace, and the

community through both personal contact and the mass media. Some of these methods have been found to be effective, particularly when provided in a social environment where there were significant levels of support, for example from family, friends and work places. However, it has been found that methods of measurement used were sometimes unreliable and the cost effectiveness of the schemes rarely established. The biggest weakness is that most of the schemes would need on-going investment in order to be sustainable over time, which would require significant amounts of public investment if they were to be applied to the whole population.

One way to overcome this problem would be to modify the built environment in order to increase physical activity. This approach is supported by evidence that everyday walking can provide significant levels of physical activity, which has the advantage over some other forms of physical activity in that many people do it already (but not to a sufficient extent), it does not require expenditure and does not generate an image of being 'sporty' which could deter some people. Cycling can also provide significant physical activity. A number of features of the built environment that could potentially influence levels of physical activity have been identified including urban density, diversity of land use, and distance to public transport, the suitability of the area for walking and the nature and layout of the street network. There have been difficulties in analysing the role of the built environment including issues of measurement, the fact that some environments may attract people who like to walk rather than actually encouraging walking by sedentary people, the difficulty of establishing causality because of the difficulty of setting up studies of significant changes to the built environment, and the difficulty of isolating the specific causes of changes in physical activity from amongst the large variety of aspects of the built environment. Whilst modifications to the built environment alone may not induce large behaviour changes, they may have an essential role within packages of measures that may also include information, training and fiscal measures.

The work on the role of the built environment was carried out by health researchers who recognised that transport had a crucial contribution to physical activity but usually only considered physical aspects of the transport infrastructure such as street networks, the design of individual streets and access to public transport systems. They did not, in general, consider the financial, legal, economic, social and cultural systems which underlie the infrastructure. In particular, they did not, in general, recognise the influence of the car on levels of walking and cycling. On the other hand, transport researchers and professionals who were aware of the influence of the car on the use of other modes were not, in general, focusing on issues around physical activity and health but concentrating on issues such as congestion, safety and the environment. Thus there was the ironic situation of two bodies of professionals interested in the use of transport modes, carrying out useful and relevant work, but with very little interaction between them and, probably very little awareness of that work in the other field. Part of the problem lay in the different methodological approaches adopted. Those working in the health field tend to be more rigorous in their methodologies, stemming from the approach adopted in medicine where it is usually possible to control for external factors in examples such as trials of new drugs. The approach adopted by health researchers is to examine an

intervention, that is a new scheme of some sort, with before and after surveys, using a control sample with similar characteristics to the population under study, but not subject to the intervention, and with participants allocated to the two samples at random and not aware of which they are in. Transport researchers tend to be more pragmatic, adopting a wider range of approaches, recognising that, in the outside world where transport schemes exist, it is not possible to control all the external factors such as the mass media which can make everyone aware of new initiatives, including those without the opportunity to benefit from it, and where each household has a unique set of travel opportunities because of locational differences.

The car has a number of negative effects including fatalities and casualties through road crashes and atmospheric pollution, but more importantly for physical activity, by deterring others from walking and cycling and in other less direct ways such as community severance and increasing the dispersal of urban areas thus making journeys longer which also discourages walking and cycling. It is clear that the link between the car and wellbeing is complex, but it does seem to be clear that one of the main causes of the decrease in physical activity is through the decline in walking and cycling, and that a significant cause of this has been the growth in car use. This suggests that society should be trying to reduce car use, but ensuring that the benefits which the car provides are maintained as far as possible.

Car use has become entrenched into the lifestyles of many households in Britain, for example, for carrying shopping home from the supermarket, taking children to school, maintaining contact with the extended family, and making journeys quickly within the time constraints of modern family life. There are a number of barriers to reducing society's dependence on the car including the political difficulties and the methods used for forecasting and appraising new transport infrastructure schemes, which it can be argued are biased towards meeting the needs of car users and so contributing to the decreasing levels of walking and cycling. These issues are compounded by more dispersed land use patterns, partly caused by the greater availability of cars, and the lifestyles adopted by many households, often in suburban and rural locations, which require greater use of the car to reach employment, schools, shops and leisure facilities.

There are a number of ways that encouraging a shift from the car to walking and cycling can be approached: introducing measures to encourage more walking and cycling, changing the travel behaviour of households, charging for use of the road, such as the congestion charging system in London, land use measures, and a variety of softer measures such as travel plans and internet shopping. One of the difficulties is that it is not clear which measures to reduce car use are effective. There have been a number of schemes which appear to have reduced it, but there have been no systematic, robust studies that have shown unequivocally that particular measures do reduce car use. It is quite clear, for example, that the introduction of the London congestion charge reduced the volume of traffic within central London, but is not certain whether there was an increase elsewhere or that there was a reduction in the total distance travelled by car. Similarly, there is evidence that it is possible to produce some changes in travel behaviour, but it is not

certain that there are not compensatory increases in car use elsewhere or that the apparent increases in walking and cycling are not just existing walkers and cyclists travelling further rather than a genuine mode shift. Hence it not clear which are the most effective instruments for increasing walking and cycling use. Whilst it is clear that there is a need for more systematic research into the most effective ways to shift people from their cars to the alternatives, the issue of decreasing levels of physical activity and the consequent risks of increased long-term illness and mortality, with consequent huge cost implications for the National Health Service mean that it would be wrong to take no action now.

It is very important to be sensitive to the political barriers to reducing car use. Rather than start what might been seen as an attack on the lifestyles of a large proportion of the population of this country, existing initiatives should be taken forward with increased effort and funding. There is already a significant effort being made in the transport sector to address issues associated with sustainability, for example, meeting the nation's obligations under the Kyoto Treaty. Whilst some of those initiatives are technological and so have nothing to do with increasing walking and cycling, it is clear that there is a large overlap between the health agenda to improve health by increasing physical activity and the transport agenda to encourage more sustainable travel because both can be aided significantly by behaviour changes to increase walking and cycling through encouraging less car use. This would be facilitated by more explicit links between health and transport professionals, both researchers and policy makers, at national and local levels.

As suggested above, it would be essential that households can sustain their levels of accessibility (or very close to it) if car use is being reduced. This could be done by moving away from the present norm of a household owning one or more cars to a more pluralistic approach with households using a wider variety of modes. Part of the problem is that the costing system for the car is different from that of other modes: buying a car is a large investment but subsequent trips are relatively cheap, particularly when several people are travelling together. In recent years there has been an increase in the number of ways that a household can access a car. Taxis and car rental have been available for many years, but a number of schemes have emerged more recently including car clubs and neighbourhood car rental. These schemes require a very low capital expenditure by the users but a higher expenditure per unit distance travelled, putting the car more on a par with other modes. The economics of these schemes mean that many households that do not make many car trips would probably be better off by joining such a scheme rather than owning a car. There is evidence that people who give up their cars and join such schemes tend to walk and cycle more than similar people who own a car. This is because of the different cost regime and the fact that a car is no longer sitting outside the home offering a convenient but unsustainable and unhealthy option. There is evidence that people often consider their car ownership requirements at significant transition points in their lives such as moving home, having a baby, passing the driving test and retiring, so it could be effective to enable agencies involved in these processes to provide relevant information about the alternatives to the households. This strategy of shifting from household car ownership could be

supported by complementary policies of increasing the cost of fuel, reducing car parking spaces and encouraging pay-as-you-drive motor insurance, plus more congestion charging schemes with the revenue going towards making the alternatives to the car more attractive. This should all increase levels of walking and cycling. If there were a consequent reduction in car use it would be important to reduce the amount of road space available to car users or else there might be car trips induced by the lower journey times caused by the reduction in traffic levels. The space removed from roads could be used to produce more attractive spaces for walking and cycling. By focusing attention on the increase in the number of options available to motorists, both in terms of access to cars and making the alternatives more attractive, it should be possible to avoid political confrontation with the motoring lobby. By making walking and cycling easier options to choose relative to the car, some motorists may find that they enjoy them, and so choose to leave their cars at home in the short run, and manage with fewer cars in the long run, with the added benefit of better health.

This shift from the car towards walking and cycling should make urban areas more attractive which should help to slow down the outward movement of households seeking more pleasant environments in which to bring up children, which leads to more car use. This would need to be complemented by providing suitable housing within urban areas. Care would be needed to ensure that any such strategies do not have an adverse impact on rural areas in terms of the local economy.

There would need to be a change of philosophy about investment in transport schemes, with a shift from an overall objective of increasing economic efficiency to one of increasing wellbeing, including health so that the contribution of walking and cycling to health would be more explicitly recognised in scheme appraisal. This would need to be accompanied by a paradigm shift in the approach to modelling so that the models are sensitive to a much broader range of changes in travel behaviour than the present methodology. There would also need to be a shift in the evaluation procedure used for schemes such as retail developments, hospitals and schools so that the travel demands of the users (customers, patients and their visitors, and pupils) and are taken into account in decisions about new locations.

This report has shown that there is a large body of evidence about ways of increasing walking and cycling through reducing car use and other measures. There is sufficient evidence available to pursue some of the initiatives. However, it would be useful to carry out further research into a number of areas, particularly into ways of meeting the perceived accessibility needs of car users and their households, how to make alternatives methods of car access besides owning one or more cars more attractive and effective, understanding of the analytical relationships between the various modes, and significant improvements to the modelling and appraisal framework including more explicit representation of walking and cycling and their benefits.

A programme of research should be set up to investigate the following issues.

- More interventions to designed to produce behaviour change to increase walking and cycling should be evaluated rigorously, including the long-term effects;
- Comparative research should be conducted into the lifestyles of car owners and non car owners in order to identify potential negative consequences of reduced car use, measures to ameliorate these consequences, and the advantages garnered from reduced car ownership.
- Research should be carried out into the role the car plays in family life, including the use of time and the provision of escort trips for others, both within and outside the household, so that the key forms of support that the car provides to family life can be identified. The potential for alternative forms of transport, and policy changes such as the mix of housing, to meet these social needs should be established and pilot schemes developed to see whether these needs can be met by means other than the car.
- Research should be carried out into the psychology of car use, in order to increase understanding of the role that the car plays beyond that of meeting the immediate need to make trips. This role includes providing perceived status, facilitating the flexible organisation of activities, providing security and offering the potential for social interaction. The findings would contribute to:
    - The process of de-marketing the car;
    - Strategies to change car use behaviour;
    - Development of segmentation models on which to build publicity material.
- Research should be carried out to establish whether awareness of the contribution of car use to a variety of serious medical conditions resulting from low levels of physical activity, would motivate modal change.
- Research should be carried out into forms of car ownership to replace the current norm of individual households owning one or more cars including car clubs, neighbourhood car rental and car sharing, plus the potential of pay-as-you-go car insurance.
- Detailed modelling exercises should be carried out to establish how driving and parking restrictions, fuel standards, tradable energy quotas, congestion charges, pay-as-you-go insurance, fiscal instruments, petrol prices, charges on fuel emissions and incentive-based policies would impact, through car use, on levels of walking and cycling.
- A systematic review of the relationship between car use, public transport use, walking and cycling should be carried out in order to establish how levels of walking and cycling (trips and distance) vary with respect to changes in levels of car use (trips and distance) and the factors that influence it.
- Research is needed into the development of new transport models that are sensitive to a much broader range of changes in travel behaviour than the present methodology. The new models would probably be disaggregate and dynamic, and have the ability to represent travel and locational behaviour.
- The financial benefits to health from increasing physical activity should be investigated, including disaggregating by existing levels of physical activity so that appropriate weight can be given to a person who is not currently active

compared with an equivalent increase in physical activity by a person who is already active.

To sum up, the key findings of this report are:

- Walking and cycling have key contributions to make to improving health through increasing physical activity;
- In order to increase walking and cycling it is necessary to reduce car use;
- Behaviour change is required to encourage a shift from the car to walking and cycling; evidence from health research shows that this is likely to be more effective in a supportive social environment;
- Modifications to the physical environment will not increase physical activity significantly unless supported by other measures;
- Changing the economics of car use towards a system that encourages a more rational consideration of modal choice should encourage a reduction in car use;
- A more rational form of household access to cars would involve the use of car clubs, neighbourhood car rental and car sharing;
- This approach could be complemented by measures such as congestion charging, pay-as-you-go car insurance and transferring road space from car use to walking and cycling;
- When schemes such as new shopping centres, hospitals and schools are being developed, the journeys of the potential users should be taken into consideration in the decision-making process;
- It would be very useful to have a wide debate about transport modelling to ensure that the models represent travel and locational behaviour effectively, including factors that represent physical activity; the discussion should include the cost effectiveness of making changes to the existing modelling system;
- The incorporation of more findings from research into the financial benefits of improvements to health resulting from more physical activity would improve the appraisal process for new transport schemes;
- Many benefits would arise from health and transport professionals working together more, for example, by sharing knowledge of the evidence about the impact of walking and cycling schemes;
- Further research would help in the shift towards a healthier, more sustainable future, but action to improve the quality of life by increasing walking and cycling can be taken now.

There is now an opportunity for transport and health professional to make a significant contribution to health in this country by working together to increase physical activity by drawing upon the evidence and methods from both fields.

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