



**National Institute for
Health and Clinical Excellence**

Transport interventions promoting safe cycling and walking

Evidence briefing

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Summary

Introduction

This evidence briefing aims to answer two related research questions:

- what transport interventions are effective in increasing active travel, specifically walking and cycling?
- what transport interventions are effective in increasing the safety of walking and cycling?

This briefing is intended to inform policy makers and decision makers within the NHS, local government and central government, including public health practitioners and the wider public health workforce employed in many different fields – transport, planning, economic development, environmental health and education.

Transport and health

The health impacts of transport are well known and wide ranging. Adverse health consequences result from air and noise pollution, road accidents and their deterrent effects on walking and cycling, as well as from less obvious impacts such as social isolation, community severance, and reduced quality of life in neighbourhoods affected by heavy traffic. 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.

These adverse and beneficial impacts are not distributed equally. The government's strategy on health inequalities, *Tackling Health Inequalities: A Programme for Action* (Department of Health 2003), points out that the most deprived local authority districts have five times as many child pedestrian accidents as the least deprived. The report

Making the Connections: Final Report on Transport and Social Exclusion (Social Exclusion Unit 2003) notes that many people are unable to access key services because of social exclusion, and that lack of access reinforces their social exclusion.

The evidence on the health benefits of physical activity is fully documented in the Chief Medical Officer's (2004) report *At Least Five A Week*. People who are physically active reduce their risk of developing major chronic diseases (such as coronary heart disease, stroke and type 2 diabetes) by up to 50%, and reduce the risk of premature death by 20–30% (Department of Health 2003). Regular physical activity also has benefits for mental health and sense of wellbeing.

However, the *Health Survey for England 2004* (Health and Social Care Information Centre 2005) shows that only 35% of men and 24% of women take sufficient physical activity to attain health benefits (at least 30 minutes a day of moderate intensity physical activity on five or more days of the week). The health impact of such inactivity in terms of coronary heart disease is comparable to that of smoking, and almost as great as high cholesterol levels.

UK policy context

UK transport policy is recognised by government as an important mechanism for increasing levels of cycling and walking, and for achieving potentially significant health benefits within our currently largely sedentary population.

Increasing the level of physical activity in the population is one of the six overarching priorities of the public health white paper, *Choosing Health* (Department of Health 2004). The action plan *Choosing Activity* (Department of Health 2005) asserts that a 'culture shift' is needed if physical activity levels in England are to increase, and

commits the government to creating opportunities by 'changing the physical and cultural landscape – and building an environment that supports people in more active lifestyles'.

A range of social, economic and environmental factors shape the circumstances in which people decide how to travel, and define the scope for personal choice of travel mode. Policies on a variety of topics, and from many sources in central government, have an influence on the likelihood of people adopting active travel modes such as walking and cycling. *Choosing Activity* illustrates an important feature of the current policy climate: the extent to which policy makers are recognising – and, in many instances, strengthening – the links among policy areas previously assumed to be separate.

Policies with potentially positive implications for active travel and physical activity are in the areas of health, community safety, sustainable development, sustainable communities, neighbourhood renewal and social inclusion, 'liveability', and urban renaissance and rural revival, as well as transport. Regional spatial strategies and local development frameworks support the practical joining up of these diverse policies for purposes of local delivery.

People are deterred from walking and cycling by the consequences of past policies. Despite increasing use by policy makers of techniques such as environmental, health and health inequalities impact assessments, some current policies (including those we have highlighted) may have unforeseen effects that are unintended, but similarly negative and long-lasting. In addition, there is a question mark over the implications for active travel of improving public transport, a major goal of policy, although there is evidence from transport surveys that walking and cycling can be a significant stage in journeys using an essentially passive transport mode (Department for Transport 2005a).

Review methodology

The methodology was informed by a model developed to examine research on the relationships between transport and physical activity. The model identifies possible pathways between dimensions of transport and land use, and individuals' decisions about travel and physical activity. It also helps in assessing evidence on the impact on these pathways of policies and interventions, and consequences for patterns of cycling and walking.

The review adopted a wide definition of 'transport interventions', encompassing transport policies, systems and initiatives that promote patterns of walking and cycling and/or increase the safety of walking and cycling. This includes national, regional and local transport and land-use policies and schemes (upstream) as well as interventions focused on the individual level or on particular groups (downstream). It includes interventions that may not necessarily be viewed as 'public health' interventions, intended to achieve objectives other than active travel, physical activity or health improvement, but that nevertheless have consequences for these areas.

Papers were included if they reviewed transport interventions in which walking and cycling and related outcomes or the economic costs were assessed. Outcome measures included both direct health outcomes (eg increased levels of physical activity, improved safety) and indirect health outcomes (eg increased levels of knowledge). They also included any significant adverse outcomes, such as injuries, and any differential impact of health benefits across different population groups that might increase health inequalities and limit effectiveness.

The following process was applied:

- systematic searching of all English-language literature published between 1996 and April 2005
- selection of relevant reviews
- critical appraisal of the reviews (transparency, systematic approach, quality and relevance)
- analysis and synthesis of the evidence.

A total of 15 review-level papers passed the critical appraisal process. Top-level findings from these papers provided the basis for evidence statements.

Findings

Planning and environmental factors, and walking and cycling

There is review-level evidence that variables in urban form influence levels of walking and cycling. However, there is unconvincing evidence about which specific characteristics of the built environment are most strongly associated with physical activity. There are important confounding factors:

- the relative importance of attitudes and characteristics of the built environment in explaining active travel is unclear and contradictory, eg individuals who are highly

motivated to walk may choose to do so regardless of whether the area is attractive for walking

- car ownership is a mediating variable in the relationship between the built environment and physical activity – individuals without access to a car for personal use are more likely to walk.

There is review-level evidence on the relationship between environmental attributes at the neighbourhood level and walking. This indicates that:

- there may be positive associations between certain neighbourhood environmental attributes (both perceived and objectively measured) and walking behaviour, non-walking physical activity, and overall physical activity
- neighbourhood environmental attributes associated with walking may vary according to the reason for walking – whether walking is for exercise or recreation, for getting to and from places, for pleasure, or to meet public health guidelines
- the availability, accessibility and convenience of destinations and facilities, as well as the general functionality of the neighbourhood and its aesthetics, are positively associated with various levels of physical activity.

Promoting active travel

There is review-level evidence that programmes based on the transtheoretical model of behaviour change, targeting people who are motivated to change their transport behaviour through individualised marketing, are effective in achieving a shift from car use to walking and cycling.

The review-level evidence is inconclusive on the effectiveness of publicity campaigns directed at groups in the population (not differentiated by motivation or personal travel circumstances) in achieving a shift from car use to walking and cycling – including campaigns using travel coordinators as ‘agents of change’.

The review-level evidence is inconclusive on the effectiveness of engineering measures – such as creating or improving cycle routes, constructing bypasses, traffic calming, or combinations of these – in achieving a shift from car use to walking and cycling.

The review-level evidence is inconclusive on the effectiveness of financial incentives – such as employer subsidies to employees who commute by modes other than driving, or tolls for commuters in cars – in achieving a shift from car use to walking and cycling.

The review-level evidence is inconclusive on the effectiveness of providing alternative services – such as car-sharing cooperatives, access to rail services, and neighbourhood telecommuting centres – in achieving a shift from car use to walking and cycling.

Making active travel safer

There is review-level evidence to suggest that area-wide traffic calming in towns and cities may be a promising intervention for reducing the number of road traffic injuries and deaths.

There is review-level evidence to suggest that engineering schemes and traffic-calming measures reduce accidents. Area-wide engineering schemes are cost effective. There is also some review-level evidence that cycle tracks reduce cycle injuries.

There is review-level evidence showing that new major urban roads have statistically insignificant effects on injury incidence, and that out-of-town bypasses and major new roads connecting urban centres can result in more substantial decreases in accident injuries.

There is review-level evidence showing that speed-limit zones are effective in reducing personal accidents and material damage. Creating raised road surfaces at crossroads may increase accidents, while noisy road surfaces (rumble strips) before crossroads are associated with reductions in accidents. Road humps and differential speed limits may reduce accidents locally, but increase them in surrounding areas.

There is review-level evidence showing that public lighting can reduce night-time accidents.

There is review-level evidence to suggest that the use of bicycle helmets reduces the risk of head, brain, facial and fatal injuries, but the evidence is unclear or equivocal for neck injuries, and there is very little evidence relating to helmet use and bicycling style.

There is review-level evidence to suggest that bicycle helmet promotion interventions can increase the use of helmets; the greatest effects are shown in younger children and girls. There is further evidence that reducing the cost of helmets through discounts and give-away programmes facilitates the uptake and use of helmets.

There is review-level evidence of sufficient quality that school-based education and public/parent education programmes encouraging the use of helmets by children

can reduce accident injuries. Health promotion and community-based programmes promoting helmet use (among 15–25 year olds) can also reduce accident injuries.

There is review-level evidence on the effectiveness of cycle helmet legislation in reducing head injuries. When combined with educational activities, legislation is an effective means of increasing observed helmet use. However, compulsory helmet use may lead to decreased bicycle use.

There is review-level evidence that visibility aids can increase visibility and enable drivers to detect pedestrians and cyclists earlier, but there is a lack of evidence for the effects of visibility aids on pedestrian and cyclist safety.

There is a lack of review-level evidence for the effectiveness of interventions to reduce inequalities in road injury rates in children under 15.

There is review-level evidence that training programmes improve children's skills, such as timing and crossing the road in a safe place. Also, practical roadside experience is essential.

There is review-level evidence to suggest that school-based pedestrian education programmes are not effective, but children's traffic clubs promoting parental teaching are effective in behaviour change. The evidence also shows casualty reduction.

There is review-level evidence that road safety programmes combining educational and environmental measures show some potential for reducing childhood accidents.

There is review-level evidence to suggest that safety education can improve children's knowledge and can change observed road-crossing behaviour, but it is difficult to predict what effect this might have on risk of pedestrian injury. The evidence also indicates that behaviour change and knowledge decline over time, suggesting that safety education must be repeated at regular intervals.

There is review-level evidence to suggest that community-based interventions are effective in increasing some safety practices, such as increased bicycle helmet use and use of car seats for children.

Gaps in the evidence base

The relationship between active travel and the actual and perceived safety of cycling and walking is one of

the focuses of this briefing. It is noteworthy that similar interventions have been used to achieve different aims: for example, engineering measures such as traffic calming, cycle routes and lanes, and bypasses have been used both to reduce accidents and to encourage walking and cycling. Unfortunately, this review finds that intervention studies have tended to concentrate on only one set of outcomes. Generally, opportunities have also been missed to investigate whether road safety interventions might also have an impact on travel behaviour, whether positive or negative.

There is very little review-level evidence of sufficient quality that addresses the specific research questions about the effectiveness of transport interventions in increasing active travel and/or the safety of walking and cycling.

This reflects, in part, the very limited amount of primary evaluation research on the impact of developments and changes in transport systems with respect to health and physical activity. There are very few primary studies of sufficient quality on the effectiveness of transport interventions on walking and cycling in the general population or in different population groups. The majority of studies are based on observational designs, and have not identified physical activity, specifically walking and cycling, as outcome measures. The impact of changes in transport systems has been evaluated using injuries and accidents as the principal outcome measures.

The research agenda in this field is therefore significant. Although research interest and efforts are growing, this agenda needs to be addressed through cross-discipline collaboration between transport, planning and public health.

Research recommendations

Based on this evidence briefing, the following research priorities are identified.

A common theoretical framework is required for identifying transport and related environmental characteristics and their influence on physical activity, specifically walking and cycling; and for the design and evaluation of transport interventions that promote increases in walking and cycling. This should clarify what constitutes a transport intervention, including the potential health consequences of various modes of travel involved in different types of journey.

Research is required to determine what transport and related environmental attributes and interventions are important in influencing different types of travel and physical activity, both at population level and with respect to different population groups. This should include work to define more systematically the rather disparate environmental attributes identified in studies to date.

Study designs need to be considered that can address areas of bias and confounding, and that can investigate decisions about residential location, car ownership, and the roles of preferences and perceptions – including attitudes to cars and bicycles – in these decisions. There needs to be a move towards the use of quasi-experimental designs for evaluation of transport and related environmental interventions.

Transport policy is ahead of the evidence base on what works in promoting walking and cycling. A range of transport policies and initiatives have the explicit or implicit aim of increasing levels of walking and cycling, as well as achieving other health, social and economic outcomes. It is important that the impact of such policies and initiatives on walking and cycling is evaluated. Many of these transport policy interventions constitute natural experiments. Their effects on population health – particularly their impacts on walking and cycling – should be evaluated using well designed prospective (and, where appropriate, controlled) studies.

Some examples of important research questions are as follows.

- What is the impact of new city-wide transport policies and plans, which incorporate anti-congestion measures, on modes of active travel (walking and cycling)?
- To what extent do measures to reduce road accidents increase the actual and perceived safety of pedestrians and cyclists?
- What features of more attractive urban environments and different neighbourhood designs are effective in increasing levels of walking and cycling?
- What is the impact on travel and physical activity of improvements in transport systems as part of regeneration initiatives, including their differential impacts across population groups and communities?

Transport policies should be subject to more systematic use of health impact assessment. The negative consequences should be averted or minimised.

1 Introduction

Aims and objectives

This evidence briefing aims to answer two related research questions:

- what transport interventions are effective in increasing active travel, specifically walking and cycling?
- what transport interventions are effective in increasing the safety of walking and cycling?

The briefing adopted a wide definition of ‘transport interventions’. It encompasses transport-related policies, systems and initiatives that promote patterns of walking and cycling and/or increase the safety of walking and cycling. This encompasses national, regional and local transport and land-use policies and schemes (upstream), as well as interventions focused on the individual level or on particular groups (downstream). It includes interventions that may not necessarily be viewed as ‘public health’ interventions, which are intended to achieve objectives other than active travel, physical activity or health improvement, but nevertheless have consequences for these areas.

We were also concerned to identify any harmful or negative health consequences of interventions. We focused particularly on safety, perceptions of safety, and the promotion of safe conditions for physical activity as key issues. Any evidence on the differential impact of interventions across population groups that could increase health inequalities was also considered.

The objectives were to:

- identify all transport systematic reviews, syntheses, meta-analyses and review-level papers
- review these papers and highlight what transport interventions work to increase active travel and the safety of walking and cycling

- identify cost-effectiveness data on transport interventions that promote active travel and on the safety of cycling and walking for all population groups
- highlight gaps in the evidence and provide recommendations for those commissioning research at all levels.

Who is this briefing for?

This briefing is intended to inform policy makers and decision makers within the NHS and local and central government, including public health practitioners, and the wider public health workforce employed in many different fields including transport planning, economic development, environmental health and education.

This briefing is not a comprehensive review of all available evidence for this topic, as it is restricted to review-level evidence only. The Centre for Public Health Excellence at the National Institute for Health and Clinical Excellence (NICE) has been asked by the Department of Health to produce a programme of reviews of effectiveness covering a wide range of interventions designed to promote physical activity.

Transport and health

The health impacts of transport are well known and wide ranging. Adverse health consequences result from air and noise pollution, road accidents and their deterrent effects on walking and cycling, as well as from less obvious impacts such as social isolation, community severance, and reduced quality of life in neighbourhoods affected by heavy traffic. 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.

UK transport policy has been recognised by government as an important mechanism for increasing levels of cycling and walking, and for achieving potentially significant health benefits within our current largely sedentary population. The integrated transport white paper (Department for the Environment, Transport and the Regions 1998) identified transport as a health determinant, stating 'the way we travel is making us a less healthy nation'.

The evidence on the health benefits of physical activity is fully documented in the Chief Medical Officer's (2004) report *At Least Five A Week*. People who are physically active reduce their risk of developing major chronic diseases (such as coronary heart disease, stroke and type 2 diabetes) by up to 50%, and reduce the risk of premature death by 20–30% (Department of Health 2003). Regular physical activity also has benefits for mental health and sense of wellbeing.

However, the *Health Survey for England 2004* (Health and Social Care Information Centre 2005) shows that only 35% of men and 24% of women take sufficient physical activity to attain health benefits (at least 30 minutes a day of moderate intensity physical activity on 5 or more days of the week). The health impact of such inactivity in terms of coronary heart disease is comparable to that of smoking, and almost as great as high cholesterol levels. The Chief Medical Officer's analysis echoes the US Surgeon General's statement that physical activity is as important as smoking and diet as a risk factor for major causes of disease (US Department of Health and Human Services 1996).

The two Wanless reports on public health (Wanless 2002; Wanless et al. 2004) state that major increases in levels of physical activity are central to future gains in public health in England, as well as to the efficient use of NHS resources. The recent new public health strategy (*Choosing Health*, Department of Health 2004; *Choosing Activity*, Department of Health 2005) sets out how these increases are expected to be achieved through cross-government policies and local programmes. The extent to which these policies and programmes are informed by evidence is considered in section 3 of this briefing.

Terminology

Policy and research concerned with transport and physical activity use a variety of terms and definitions.

Transport

Most people need to travel as part of everyday life, whether to get to work, to shop, to meet friends and see family, to get to places of leisure and recreation, or simply for the pleasure of getting about. **Transport** – infrastructures, systems, networks and the various transport modes – facilitates mobility and enables people to undertake these journeys.

Physical activity

Physical inactivity is a primary contributor to a broad range of chronic diseases. One of the goals of public health policy is therefore to raise the level of physical activity in the population. **Physical activity** has been defined as 'any force exerted by skeletal muscles that results in energy expenditure above resting level'. The term therefore includes the full range of human movement, from competitive sport and exercise to active hobbies, walking, cycling or activities of daily living (Chief Medical Officer 2004).

There are several strategies to encourage physical activity and remove barriers to an active lifestyle. These involve interventions in many settings – neighbourhoods and communities, primary care, schools, workplaces, sport and leisure facilities, and green spaces – as well as changes to services and aspects of the physical, social and economic environment. Encouraging people to choose walking and cycling rather than other modes of transport is particularly important among these strategies.

Transport modes requiring physical activity

The terms **active travel**, **active transport** and **active commuting** are frequently applied to modes of transport that require physical activity, such as walking and cycling, in contrast to modes that require little physical effort, particularly the motor car. Public transport may appear to be an inactive mode – but using public transport may often involve walking or cycling to and from transport stops and transport interchanges.

Active travel and risk

Active travel helps reduce one risk to health but, unlike some other ways of raising levels of physical activity, it may increase another – the risk of accidental injury from traffic and other hazards. It is likely that some assessment of the risks and benefits of active travel will figure in people's decisions to choose activity.

Transport interventions

This briefing is concerned with **transport interventions**. These are interventions aimed at encouraging or facilitating active travel. They may emerge from various areas of policy and a range of government departments, but will have significance for active travel, even if health benefits are a subsidiary or unspecified goal (see section 4 on the policy context). Examples are policies on reducing social exclusion, creating sustainable communities, limiting crime and disorder, and tackling congestion as a barrier to economic growth.

Patterns of walking and cycling

Table 1 summarises trends in cycling and walking in England. Much of the information comes from the National Travel Survey, which is published annually by National Statistics and sponsored by the Department for Transport to enable progress against key personal travel indicators to be monitored (www.statistics.gov.uk/ssd/surveys/national_travel_survey.asp).

Scope and approach of the briefing: best available evidence

It is increasingly recognised that the complex nature of many public health interventions poses challenges for traditional approaches to the evaluation and synthesis of evidence (Jackson and Waters 2004). Investigation of the impact of transport on physical activity demonstrates these challenges. The relationship between aspects of transport and physical activity is complex, and difficult to measure and evaluate. Transport and physical activity both have multiple dimensions, and research has sought to define these dimensions and determine the nature

of relationships and links between them. Evaluation of the effectiveness of interventions designed to promote physical activity, specifically cycling and walking, is a relatively new and growing research topic.

Handy (2004) summarises the current state of research in this area. Evidence has been derived from two different strands of research:

- urban planning and travel behaviour, focusing primarily on automobile travel, with cycling and walking categorised as a 'mode of travel'
- public health and physical activity, focusing on personal and social determinants of physical activity and patterns of physical activity.

Given the relatively recent emergence of research in this area, there is as yet no agreed theoretical framework or standardised vocabulary for differentiating how the different dimensions of transport (eg accessibility, safety, street design and aesthetics) might affect physical activity behaviour.

While experimental study designs – randomised controlled trials (RCTs) – provide the most robust approach for determining cause and effect between dimensions of transport and physical activity, the feasibility of undertaking such studies is limited in this field. Most research evidence is derived from observational studies (specifically, cross-sectional studies) and does not provide evidence of causation. Possible self-selection bias is therefore a critical issue affecting the quality of studies and findings. (It should be noted that self-selection bias may also be an issue in RCTs, and effects observed in motivated volunteers may not be replicated in the general population.)

Figure 1 Household car availability by income (2004)

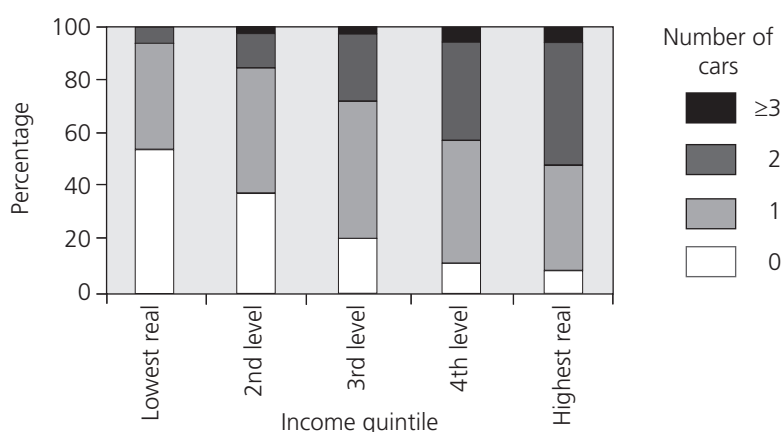


Table 1 Patterns of travel, walking and cycling

<p>Patterns of car use have had a major impact on levels of physical activity for most people. The proportion of trips made by car increased from 57% in 1989/91 to 63% in 2004 (Department for Transport 2006). People prefer to walk trips of under one mile, but car use for these short distances has increased from 15 to 17% between 1989/91 and 2004 (Department for Transport 2005a).</p>
<p>There has been an 18% decline in levels of walking between 1989/91 and 2004, as measured by average annual distance travelled on foot – from 237 to 196 miles per year (Department for Transport 2006). In the same period, the number of trips made on foot per year declined by 25% – from 328 to 246 (Department for Transport 2006). The length of an average walking trip has remained unchanged over this period at 0.6 miles (Department for Transport 2005a). Women walk slightly more frequently than men, making 27% of trips on foot, compared with 23% for men (Department for Transport 2005b).</p>
<p>The average time people spend travelling has remained fairly stable since 1989/91, at about 360 hours per person per year (or about an hour a day), but the proportion of travel time spent walking has fallen from 22 to 18%, so that in 2004, 11 of the 60 minutes of average daily travel are spent walking compared with 37 minutes by car (Department for Transport 2006).</p>
<p>There has been a 23% decline in levels of cycling between 1980 and 2004, as measured by the average number of miles cycled per person. Between 1989/91 and 2004 the average number of cycling trips per year fell by 33%, from 27 to 18 (Department for Transport 2006). Men cycle more frequently than women – 2% of trips, compared with 1% for women (Department for Transport 2005b).</p>
<p>Levels of walking decline broadly with age. For men there is a linear decline with age. However there is a 'J-shape' relationship for women, with 25% of women aged 17–39 years taking trips on foot, declining to 20% for those aged 40–59 years, and increasing again among older groups (Department for Transport 2005b).</p>
<p>The Health Survey for England 2002 reported that 70% of boys and 61% of girls aged 2–15 years were active for at least an hour a day. There is a clear decline in the levels of physical activity in girls with age after 10 years of age; by 15 years old only 50% of girls achieve the recommended level of activity of 1 hour a day (Health Survey for England 2002).</p>
<p>The number of schoolchildren walking to school has declined between 1989/91 and 2004, from 62 to 50% of primary schoolchildren and from 48 to 44% of 11–16 year old secondary schoolchildren. In the same period, the proportion of primary schoolchildren and of 11–16 year old secondary schoolchildren travelling to school by car rose from 27 to 41% and from 14 to 22%, respectively (Department for Transport 2006).</p>
<p>The proportion of primary schoolchildren cycling to school has remained steady at under 1% between 1989/91 and 2004. In 2004, 3% of 11–16 year olds cycled to school (Department for Transport 2006).</p>
<p>There are clear geographical variations in levels of walking and cycling. For example, 94% of respondents in London claimed to walk for 10 minutes or more at least once a week, with only 3% never walking for this long; whereas 85% of respondents in the East Midlands claimed to walk for 10 minutes or more at least once a week, with 6% never walking for this long.</p>
<p>Levels of physical activity vary with ethnicity. Compared with the general population, South Asian and Chinese men and women are much less likely to participate in physical activity. Bangladeshi men and women have the lowest level of physical activity, this group being almost twice as likely as the general population to be classified as sedentary (Health Survey for England 1999).</p>
<p>The relationship between levels of physical activity, social class and income is complicated. The Social Exclusion Unit (2003) reports that walking is the primary method of transport for people in low-income households, due in part to less access to cars. There is a clear relationship between income levels and access to cars, as indicated in Figure 1.</p>
<p>There are substantial differences between countries in the shares of transport modes. For example, in EU countries (EU Energy and Transport 2000 figures) the share of non-motorised transport in the total number of kilometres travelled varies from about 3% to 10% (compared with 3.4% in the UK; Rietveld and Daniel 2004).</p>

Ogilvie et al. (2005a,b) highlight the lack of guidelines on how to undertake systematic reviews of the health effects of social interventions such as those in the transport field. They evaluated different strategies of searching for studies and inclusion criteria. This was based on a systematic review of the effectiveness of interventions in promoting a population shift from using cars towards walking and cycling. They showed that few of the relevant studies were found in familiar literature databases. They suggested that, following a primary search of key databases, the assistance of authors and experts in finding papers might be a more efficient approach, although comprehensive searches (including use of the Internet) could make important contributions. They also showed that limiting inclusion to RCTs meant that certain categories of intervention were not represented in the review (including population-wide health promotion activities, environmental, engineering and transport service developments and incentives).

We acknowledge that our approach here to reviewing review-level studies cannot be regarded as fully comprehensive, given these barriers to identifying all the relevant material and the bias that exists in published review literature. We discuss this further in section 5.

Related effectiveness briefings

Two existing evidence briefings, produced by the former Health Development Agency (Millward et al. 2003; Mulvihill et al. 2005), are relevant to the promotion of safe environments that minimise risk of injury and accidents, and therefore provide conditions for physical activity. (Our exclusion criteria took account of the scope of these reviews to avoid duplication.) A summary of these briefings is provided here.

Prevention and Reduction of Accidental Injury in Children and Older People (Millward et al. 2003) presents the review-level evidence on the effectiveness of interventions for preventing and reducing accidental injury in children and older people. The evidence relating to children has been assessed in three main environments where child accidental injury occurs: on the road; at home; and during leisure pursuits. Motor vehicle traffic accidents account for nearly half of all accidental injury fatalities in children. Review-level evidence on effective interventions include 20 mph driving limit zones, cycle helmet legislation, child-restraint loan schemes and child-restraint legislation. Good review-level evidence for preventing accidental injuries to children in the home covers suffocation and

foreign bodies, fire and flames, drowning and submersion, falls and poisoning. No good or reasonable evidence was found for effective interventions during leisure activities, but there is some evidence for interventions targeting drowning, and play and leisure injuries. Very few studies have explicitly investigated child accidental injury in relation to inequalities.

On accidental injury in older people, the briefing found that multi-faceted prevention programmes based on assessment of risk factors and tailored interventions, in selected groups of at-risk older people, reduce falls. Some tailored home exercise programmes have been found to reduce falls in women aged 80 and over in the community, and there is also evidence for home assessment and surveillance for reducing falls in frail older people. Other review-level evidence includes the use of hip protectors, smoke alarms and automatic transmission cars, and signals and road markings designed for the older driver. There is very little research relating to inequalities in accidental injury among older people.

Prevention and Reduction of Alcohol Misuse (Mulvihill et al. 2005) presents an update of the evidence from systematic reviews, meta-analyses and other reviews about the effectiveness of public health interventions to prevent and reduce alcohol misuse. This briefing identifies effective interventions to reduce alcohol-impaired driving and to prevent alcohol-impaired crash fatalities, such as blood alcohol concentration (BAC) laws, BAC laws for young or inexperienced drivers, minimum legal drinking-age laws, sobriety checkpoints, ignition-interlock devices and training programmes for those serving alcohol. In healthcare settings, the review-level evidence suggests that heavy drinkers receiving brief interventions are twice as likely to moderate their drinking six to 12 months after an intervention, compared with drinkers who receive no intervention. Brief interventions are found to be equally effective for men and women. There is also evidence for the effectiveness of extended brief interventions (several visits) in reducing heavy drinking in primary healthcare settings for women. Other review-level evidence includes the use of self-help materials. In relation to inequalities, there is a lack of evidence on the effectiveness of interventions targeting specific socio-economic, ethnic or vulnerable groups.

2 Transport, health and physical activity: a working model

It is important that our research questions should be set in the context of a conceptual framework linking different dimensions of transport to physical activity. We have developed a working model for the purposes of this review, drawing heavily on US work. The nature of the US evidence base is examined in more detail in section 5 of this briefing.

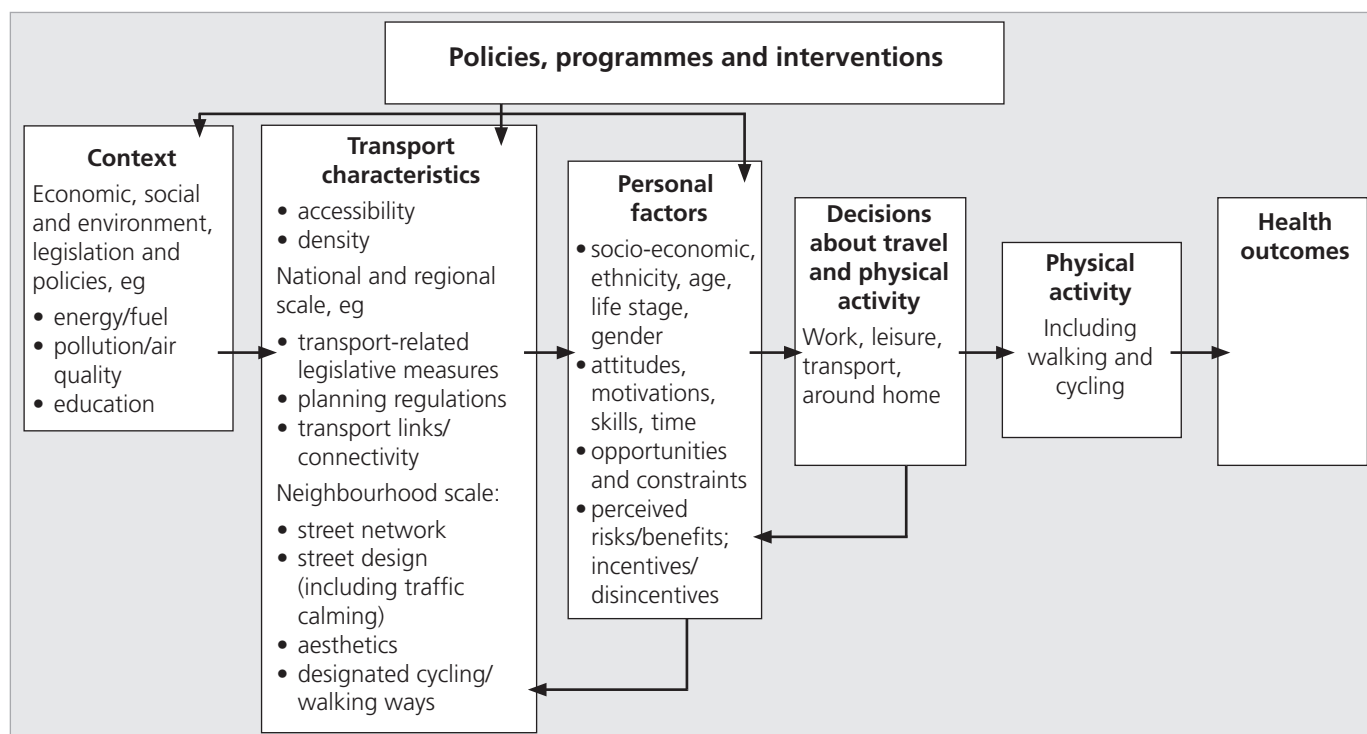
The model was intended to help assemble and examine research on the relationship between transport and physical activity. It identifies possible pathways between dimensions of transport and land use, and individuals' decisions about travel and physical activity. The model was also used to help assess evidence on the impact of policies

and interventions on these pathways, and consequences for patterns of cycling and walking. Figure 2 sets out our working model.

Context

Transport issues operate within macro- and micro-environments. Some factors, such as the weather, are clearly not amenable to change, while others can be changed at different levels. International comparison demonstrates that the historical mix of broad economic, social and environmental characteristics and policies in different countries has given rise to particular patterns of physical activity, including cycling and walking.

Figure 2 Working model – transport and physical activity



Measurements of levels of physical activity vary between countries (including use of self-reported data), making comparisons difficult. However it appears that in countries such as Canada and Australia, about 45% of the adult population report being physically active for at least 30 minutes, four to seven times a week, compared with 35% in England (Prime Minister's Strategy Unit 2002).

Higher levels of walking and cycling in some European countries are attributed, in part, to a range of progressive policies. One comparative study (Parker 2000) indicates that the Netherlands has been successful at 'achieving synergetic joint outcomes between areas of road safety, health and the environment'. The Netherlands has better facilities for walking and cycling; urban design and spatial planning more sensitive to the needs of cyclists and pedestrians; lower speeds on urban roads; restrictions on motor vehicle use and parking; more rigorous traffic education; and strict enforcement of traffic regulations protecting non-motorists.

Transport and related land-use characteristics

A number of characteristics of transport and related land use interact with personal attributes to influence individual decisions about travel behaviour and types of physical activity.

Two relationships appear particularly important (Handy 2004):

- access – distance to nearest destination, unsurprisingly, is negatively correlated with non-motorised travel; longer distances discourage all travel, but especially non-motorised
- density – a number of density measures (population, employment, land-use density and mix) are positively correlated with walking or cycling for travel: the greater the density of population, employment, stores and mix of land uses, the greater the number of walking and other non-motorised trips.

Access and density, as well as other variables, operate at different scales.

Geographical scale: national, regional and neighbourhood

A range of transport and land-development policies at national and regional levels are important in influencing travel decisions and patterns of physical activity.

Zoning and land-use policies and regulations influence development densities and mixing of land uses, which appear to be important factors linked to a community's 'walkability and bikeability'. Meyer and Dumbaugh (2004) indicate that zoning and land-use controls can make it difficult to provide many of the characteristics that promote walking and cycling. Low-density development, for example, often results in long distances between destinations, while walking and cycling are highly sensitive to distance compared with automobile travel.

More locally, certain neighbourhood types (traditional neighbourhoods characterised by a people-orientated, small-town scale with pavements) are positively correlated with walking and non-motorised travel. Several characteristics appear to be important.

Street network

In higher-connectivity systems such as grid-like layouts, travel to nearby locations on foot, bike or public transport or by car is eased by the larger number of street connections. Shorter blocks reduce travel speeds and increase the safety of pedestrians. In disconnected or hierarchical layouts, lack of connectivity and pavements make it necessary to drive to nearby locations. Hierarchical street networks facilitate higher travel speeds and reduce pedestrian safety.

Street design and aesthetics

Some streets encourage walking and cycling, for example those characterised by pavements, bike lanes and other amenities. Road design standards traditionally have encouraged high-speed motorised travel. However, more recently level-of-service standards have started to take account of how well roads operate for pedestrians and cyclists as well as motorists. Traffic-calming measures have been adopted in many European countries as a way of minimising undesirable features, including speed and number of potential accident sites, pollution and noise, and improving urban space.

Separate cycling and walking systems

In Europe and the USA there has been a growth of trails providing designated, separate cycling and walking routes. For example, in the UK the environmental and transport charity Sustrans has played a leading role in several initiatives to develop off-road cycle routes: the National Cycle Network, Safe Routes to School and Home Zone demonstration projects (Mellor 2002).

Personal characteristics and decisions about travel and physical activity

At the individual level, a range of factors 'mediate' the relationship between aspects of transport and decisions about travel and whether to cycle or walk. Personal characteristics including age, gender, life stage, ethnicity and socio-economic characteristics (such as education and income level) are important, as well as personal attitudes, preferences, motivation, skills and time.

Individuals' decisions about travel and whether to cycle or walk appear to be influenced by perceived and/or actual potential barriers and constraints to different travel/physical activity options, including specific incentives and disincentives (Box 1).

- Surveys indicate that reasons for not walking or cycling include weather- or time-related factors, and lack of safe places to ride or walk (Department for Transport 2003; Oja and Vuori 2000).
- It is important to acknowledge that some groups may rely on walking because of lack of access to a car, which may have negative consequences. Qualitative research reveals how no access to a car for low-income mothers can have important negative effects on the welfare of families (Bostock 2001).
- Survey findings (Davis 2000) suggest that environmental factors play an important role, depending on the activity. For example, cars are the dominant means of transporting children to school. Long distances, dangerous traffic and crime have been identified as barriers to children walking and cycling to school. Such concerns led to the policy in the UK on school travel plans, which cover a range of engineering, educational and transport measures (Department for the Environment, Transport and the Regions 1998; Department for Education and Employment 1999).
- Barriers and constraints to cycling and walking are well demonstrated in low-income neighbourhoods where crime, disinvestment and isolation can act as deterrents.

Box 1 Public views and perspectives

Travel behaviour is affected by land-use planning (including the relative priority given to cars, public transport, and active travel modes) and by environmental design and maintenance. For example, where there is a dispersed pattern of land use, people will tend to think they need to drive their children to school and leisure facilities; increasing car dependency is associated with declining public transport; and the design aspects of environmental planning are seen as hostile to walking and cycling (Oja and Vuori 2000). Busy roads deter people – especially children and older people – from walking and cycling (Social Exclusion Unit 2003), whereas better road safety might encourage more walking (Commission for Integrated Transport 2001). If pavements were maintained better, people might use their cars less (Department for Transport 2003).

Fear of crime or antisocial behaviour may deter people from walking and cycling, particularly in urban areas (Social Exclusion Unit 2003).

The social status of the various modes of travel may affect travel behaviour. For example, the social status of walking and cycling may be seen as lower than that of travel by car (Oja and Vuori 2000), and such perceptions may influence people's thinking about the importance of walking and cycling as a transport mode (Department for Transport 2003).

People might use their car less if they had more time to walk (Department of Transport 2003). 'Time poverty' may be a particularly important factor for women, who often rely on fast and reliable transport to perform multiple roles (Hamilton et al. 2005).

Living with disabilities or long-standing health problems prevents people from walking and cycling, as may levels of perceived or actual fitness (Social Exclusion Unit 2003).

Barriers to cycling are numerous, and include lack of cycle storage space; the ability or desire to cycle (Costley 2002); lack of secure cycle parks at destinations (Oja and Vuori 2000); lack of cycle lanes (Department for Transport 2003, 2004a); dangerous road surfaces; and the risk of bicycle theft (Costley 2002).

Although actual and perceived risks to safety and security might be assumed to influence decisions about walking and cycling, evidence is unclear. Generally studies have not distinguished between different types of safety (eg crime, traffic), which could obscure significant findings.

However, the results of studies of particular sub-groups of the population, including women, children and older people, have identified a stronger positive correlation between real and perceived dangers to personal safety and sedentary lifestyles. For example, studies have found that crime and fear of crime are barriers to exercising and outdoor physical activity for women. In neighbourhoods with high rates of violent crime and limited social support, older people may be afraid to go out and may suffer isolation (Social Exclusion Unit 2003).

The evidence shows that children and older people are more vulnerable to traffic accidents. Child pedestrian injuries are higher in poor neighbourhoods (Millward et al. 2003). The safety of the pedestrian population of all ages appears to be inversely associated with a number of characteristics relating to transport features, including traffic speed, miles of major streets in a neighbourhood, poorly located bus stops and poor lighting (Transportation Research Board 2005).

Feedback loops

The model also shows that important feedback loops operate. The interdependent nature of the decisions people make in choosing how to travel means that such decisions have the potential to generate positive or negative externalities. For example, one person's decision to drive to work or school may contribute to creating an adverse environment for active travel, and therefore influences the probability that another person will decide to ride a bike.

Modelling relationships

A number of theories have been developed in the fields of travel behaviour and physical activity and used to investigate model relationships and patterns of travel behaviour and choices (the pathways between transport and personal characteristics).

Research on travel behaviour has drawn primarily on demand theory. This assumes most choices are rational, are made on the basis of their feasibility and relative costs and benefits to the individual, and are primarily motivated

by economic self-interest. This approach has been used primarily to forecast travel behaviour for motorised transport, and to understand the possible impacts of transport investments. But demand theory has not been extended to consider walking and cycling.

Travel behaviour theories do not address fully the range of factors operating at different levels and over different time periods. For example, social norms may operate in mothers' use of cars to take children to school. People's desire for low-density living tends to promote car dependence. Health behaviour research has used approaches such as the theory of planned behaviour and social cognitive theory to examine physical activity and how attitudes and beliefs might influence perceptions of the factors involved in making choices.

Ecological models have also been used that bring together behavioural theories and ecological principles, and that recognise the interactions of physical and social influences with individual choices (eg Owen et al. 2004). However, there is still no unifying theory in this area of active travel and physical activity (Handy 2004).

Our working model is intended to present the complexity of the relationships and possible pathways between dimensions of transport and land use, and patterns of travel and physical activity. It aims to make explicit the range of factors that need to be considered from a theoretical perspective, and will be relevant to the design and evaluation of policies and interventions that promote walking and cycling.

3 Transport and physical activity: the policy context

This section considers how policy in England has responded (either explicitly or implicitly) to the challenge of increasing levels of physical activity in the population to bring about long-term health improvements. We use the working model described in section 2 to identify how policies may impact on physical activity, specifically walking and cycling. Policies and initiatives intervene at different levels.

The link between transport and physical activity has become an increasing focus of public health policy, given rising levels of obesity and evidence on the role of physical activity in preventing diseases such as coronary heart disease and stroke, cancer and diabetes, and in enhancing mental health. The adverse health impacts of transport are well known. They result from air and noise pollution, road accidents, deterrent effects on walking and cycling, as well as less obvious impacts such as social isolation, community severance, and reduced quality of life in neighbourhoods affected by heavy traffic. 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.

These adverse and beneficial impacts are not distributed equally. The government's strategy on health inequalities, *Tackling Health Inequalities: A Programme for Action* (Department of Health 2003), pointed out that the most deprived local authority districts have five times as many child pedestrian accidents as the least deprived. The report *Making the Connections: Final Report on Transport and Social Exclusion* (Social Exclusion Unit 2003) noted that many people are unable to access key services because of social exclusion, and that lack of access reinforces their social exclusion.

Increasing the level of physical activity in the population is one of the six overarching priorities of the public health white paper, *Choosing Health* (Department of Health 2004). The subsequent action plan, *Choosing Activity* (Department of Health 2005), asserts that a 'culture shift' is needed if physical activity levels in England are to increase, and commits the government to creating opportunities by 'changing the physical and cultural landscape – and building an environment that supports people in more active lifestyles'.

A range of social, economic and environmental factors shape the circumstances in which people decide how to travel and define the personal choice of travel mode. Policies on a variety of topics, and from many sources in central government, have an influence on the likelihood of people adopting active travel modes such as walking and cycling. *Choosing Activity* sets out the contributions of several government departments to the goal of increasing physical activity. It illustrates an important feature of the current policy climate: the extent to which policy makers are recognising – and, in many instances, strengthening – the links among policy areas previously assumed to be separate.

Table 2 concentrates on the positive implications for active travel and physical activity of key policy documents from the past 8 years, and gives a brief summary of the proposals contained in them. These policies are in the areas of health, community safety, sustainable development, sustainable communities, neighbourhood renewal and social inclusion, 'liveability', and urban renaissance and rural revival, as well as transport. Table 2 also includes guidance on regional spatial strategies and local development frameworks, as much of the practical 'joining up' of diverse policies for purposes of local delivery is supported by these interrelated planning processes.

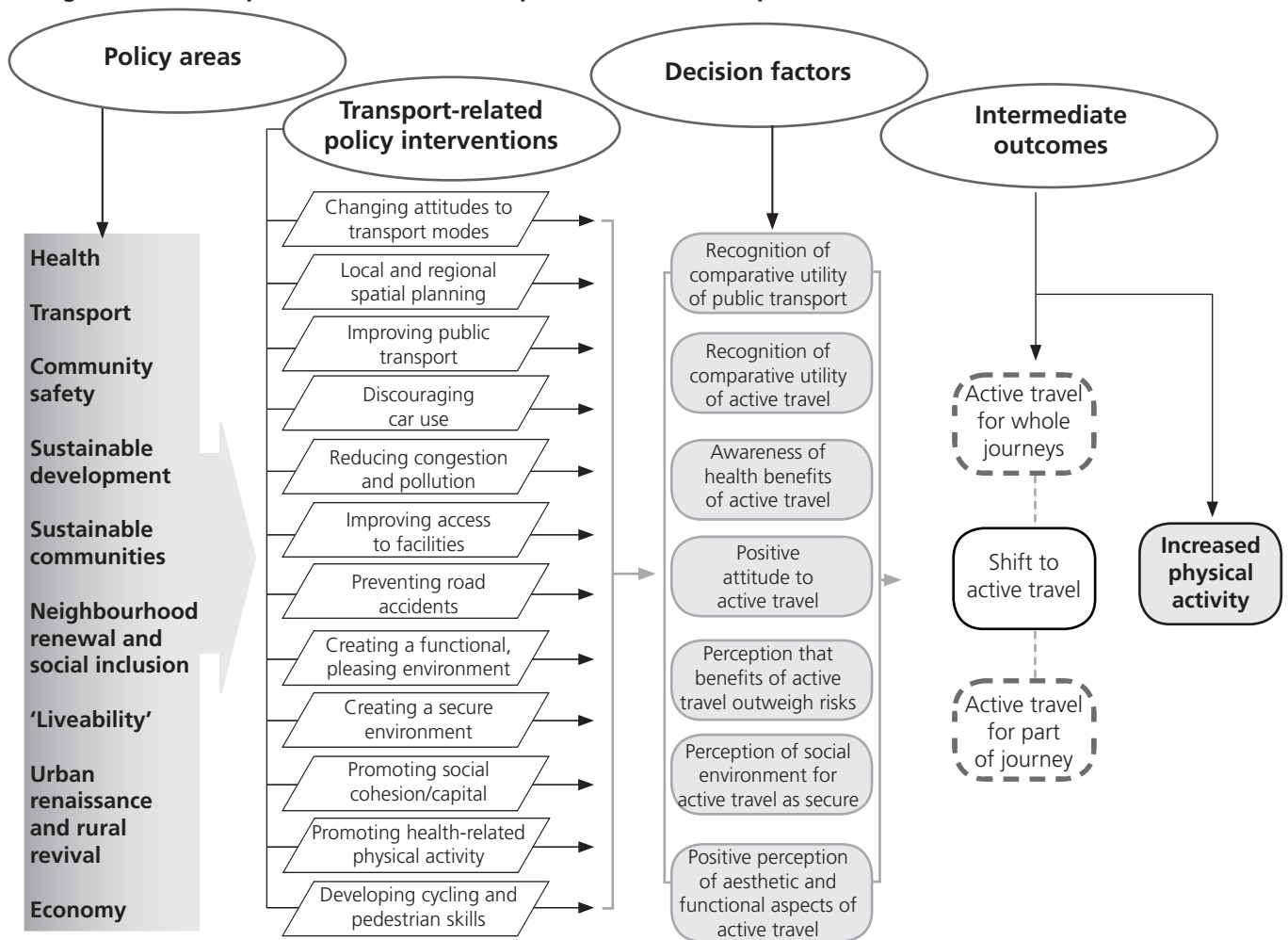
Table 2 Summary of main government policy and guidance documents with potentially positive implications for physical activity (in chronological order)

<p>Acheson (1998) <i>Independent Inquiry into Inequalities in Health</i></p>	<p>Argues that improved public transport should lead to improved access to people and facilities fundamental to health, such as family and friends, shops, parks and leisure facilities, and healthcare. This, in turn, should lead to improved quality of life and health. More affordable transport would release resources that might be used for health-promoting activities and goods. Increased use of public transport by the general population would decrease air and noise pollution, which is suffered disproportionately by people experiencing disadvantage. A decrease in car use would lead to a reduction of accidents. This would be likely, but not certain, to be accompanied by a reduction in inequalities in accident rates.</p>
<p>Department for the Environment, Transport and the Regions (1998) <i>A New Deal for Transport: Better for Everyone</i></p>	<p>Sets out the government's plans for creating a transport system that is safe, efficient, clean and fair. Argues that an integrated transport policy is the way forward, and announces better local and national planning; wider transport choices including higher priority for walking, cycling and public transport; targets for increasing walking and cycling in local transport plans and measures to ensure they are safer and more attractive options; better buses and public transport information; better trains; safer and more secure travel; better access to transport as a means of creating a more inclusive society.</p>
<p>Department for Transport (2000a) <i>Tomorrow's Roads: Safer for Everyone</i></p>	<p>Defines road safety targets for 2010 and describes actions under 10 main themes, including safer for children, pedestrians and cyclists; safer drivers, infrastructure, speeds and vehicles; better enforcement; promoting safer road use.</p>
<p>Department for Transport (2000b) <i>Transport Ten Year Plan 2000</i></p>	<p>Sets out the government's spending plan for implementing the 1998 white paper <i>A New Deal for Transport: Better for Everyone</i>. Predicts public and private investment totalling £180 billion over 10 years.</p>
<p>Office of the Deputy Prime Minister (2000) <i>Our Towns and Cities: The Future. Delivering an Urban Renaissance</i></p>	<p>Strategy to make all urban areas places for people by getting the design and quality of the urban fabric right; enabling all towns and cities to create and share prosperity; providing the quality services people need; equipping people to participate in developing their communities.</p>
<p>Office of the Deputy Prime Minister (2002) <i>Living Places – Cleaner, Safer, Greener</i></p>	<p>Sets out the government's approach to making cleaner, safer, greener public spaces. Programme of action to include improving coordination of policies and funding; ensuring public spaces are accessible to all; tackling the particular problems of the poorest communities; focusing on urban parks and green spaces; raising awareness and promoting best practice.</p>
<p>Office of the Deputy Prime Minister (2003) <i>Sustainable Communities: Building for the Future</i></p>	<p>Sets out a long-term programme of action for delivering sustainable communities in both urban and rural areas. Aims to tackle housing supply problems by accelerating housing provision in four 'growth areas' in the South East; provide affordable housing and tackle homelessness; address low demand and housing abandonment in parts of the north and midlands; ensure all social housing is at a decent standard by 2010; improve the local environment of all communities thus enhancing liveability; protect the countryside by ensuring most new housing is on previously developed land rather than greenfield sites. Also known as the Communities Plan.</p>
<p>Social Exclusion Unit (2003) <i>Making the Connections: Final Report on Transport and Social Exclusion</i></p>	<p>Examines the links between social exclusion, transport and the location of services. Sets out key policies on improving access, including accessibility planning by transport authorities; improved and more flexible public transport; ensuring accessibility is considered in land-use planning; making streets safer; measures to improve access to work, learning, healthcare and food shops.</p>

Table 2 continued

Wanless et al. (2004) <i>Securing Good Health for the Whole Population. Final Report</i>	An assessment of the resources required to provide high-quality health services in the future, focusing particularly on prevention and the wider determinants of health in England and on the cost effectiveness of action that can be taken to improve the health of the whole population and reduce health inequalities. Among issues covered are responsibilities for public health; information and research; targets; objective setting and delivery. Confirms that lifestyle changes such as increased physical activity could have a major impact on the level of health resources required in the future, and devotes a case study to the subject.
Chief Medical Officer (2004) <i>At Least Five A Week. Evidence on the Impact of Physical Activity and its Relationship to Health</i>	Sets out the available evidence from around the world for the impact of physical activity on public health. Discusses the cost and scale of the problem of physical inactivity in England and confirms recommendations on individual physical activity levels dating from 1996. Describes the health benefits across the life course of increased physical activity, highlighting the strength of the effect over a wide range of diseases.
Department for Transport (2004a) <i>Walking and Cycling: An Action Plan</i>	Aims to increase walking and cycling by creating places where people want to do these activities (eg through land-use and transport planning, improving liveability and tackling antisocial behaviour); providing high-quality facilities for safe walking and cycling; influencing travel behaviour through education, training, marketing and promotion; building skills and capacity; monitoring success through targets and indicators.
Department for Transport (2004b) <i>The Future of Transport – A Network for 2030</i>	Aspires to a transport network for 2030 with a more reliable and freer-flowing road network; a fast, reliable and efficient rail network; reliable, flexible and convenient bus services that are tailored to local needs; walking and cycling as a real alternative for local trips; more effective local and regional decision-making that links transport planning with housing and regeneration plans; improved road safety; respect for the environment. Builds on the 1998 white paper <i>A New Deal for Transport: Better for Everyone</i> and <i>Transport Ten Year Plan 2000</i> .
Office of the Deputy Prime Minister (2004a) <i>Planning Policy Statement 11: Regional Spatial Strategies</i>	The regional spatial strategy, incorporating a regional transport strategy, provides a spatial framework to inform the preparation of local development documents, local transport plans, and regional and sub-regional strategies and programmes that have a bearing on land-use activities.
Office of the Deputy Prime Minister (2004b) <i>Planning Policy Statement 12: Local Development Frameworks</i>	Sets out the government's policy on the preparation of local development documents comprising the local development framework. The local development framework, together with the regional spatial strategy, provides the essential framework for planning in the local authority area.
Department of Health (2004, 2005) <i>Choosing Health – Making Healthy Choices Easier and Choosing Activity: A Physical Activity Action Plan</i>	Aim to increase levels of physical activity in the population by ensuring that people know about the links between physical activity and better health and opportunities to be more active; encouraging activity in educational settings; providing opportunities for physical activity in the community in safe, attractive environments; providing advice and support through the NHS; and engaging employers to encourage people in the workplace.
HM Government (2005) <i>Securing the Future – Delivering UK Sustainable Development Strategy</i>	Sets out a new purpose and principles for sustainable development, and new shared priorities across the UK. Focuses on helping people make different choices; sustainable consumption and production; climate change and energy; protecting natural resources and enhancing the environment; creating sustainable communities in a fairer world.

Figure 3 Possible positive links between policies with a transport dimension and active travel outcomes



It has to be recognised that people are deterred from walking and cycling by the consequences of past policies. Despite policy makers' increasing use of techniques such as environmental, health and health inequalities impact assessment, some current policies (including those we have highlighted) may have unforeseen and unintended, but similarly negative and long-lasting effects. There is a question mark over the implications for active travel of improving public transport, a major goal of policy. However, there is evidence from transport surveys on the extent to which walking and cycling form a 'stage' of journeys using an essentially passive transport mode (Department for Transport 2005a). In 2002/03, for example, nearly two thirds of rail and underground trips, and just under a third of local bus trips, included a walking stage of 50 yards or more. (Twenty-eight per cent of all stages within journeys were on foot, although the proportion of stages on foot has fallen from 38% in 1989/91.)

Because they are high-level statements, policy documents tend not to explain causal (or assumed causal) links

between particular policy instruments and desired outcomes, such as increased cycling and walking. Transport is a field in which development of policy has outpaced development of the evidence base. The model in Figure 3 attempts to make more explicit some of the assumed positive connections between policy and outcomes. An additional purpose is to help make connections among relevant but diverse pieces of evidence.

In the model, the relevant **policy areas** are listed on the left. **Intermediate health outcomes** related to physical activity are on the right. In between, moving from left to right, are:

- an analysis of the range of **policy interventions** with potentially positive implications for active travel and physical activity
- the **decision factors** they create, assuming these interventions are effective.

Box 2 gives more detail about the policy interventions highlighted in Figure 3.

Box 2 Policy interventions with potential influence on physical activity

1 Changing attitudes to transport modes – ‘soft’ measures to provide:

- workplace and school travel plans
- personalised travel planning
- travel awareness campaigns
- information about public transport
- marketing (including individualised marketing) of public transport
- car-sharing schemes.

2 Local and regional spatial planning:

- regional and local transport strategies to complement regional and local spatial strategies: reciprocal relationship between land-use and transport planning
- planning objectives to include more sustainable transport choices; accessibility to jobs, shopping, leisure facilities and services by public transport, walking and cycling; reduced need to travel by car.

3 Improving public transport by promoting:

- more, and more reliable, bus services including demand-responsive services
- partnerships between passenger transport authorities and bus operators
- new powers for passenger transport authorities to develop services – quality contracts
- seamless integration of bus services and other travel networks
- integrated ticketing for different public transport modes and operators
- priority for buses – bus lanes (and enforcement), priority at traffic lights.

4 Reducing congestion and pollution by discouraging car use by:

- promoting walking and cycling
- allocating town centre space to pedestrians and cyclists
- introducing road pricing – including toll roads, congestion charges, ‘distance’ charges, charges for parking
- introducing taxation policies – fuel tax, vehicle excise duty
- promoting transport hierarchy.

5 Improving access to facilities and reducing social exclusion by:

- improving public transport (see 3 above)
- introducing concessionary fares for particular groups
- providing transport vouchers that can be used on different modes of transport
- focusing shops, leisure facilities and offices in town centres; promoting development in suitable places; considering the location of public services

- ensuring safer and more secure streets (see 6 and 8)
- providing appropriate travel advice (see 1).

6 Preventing road accidents:

- giving pedestrians and cyclists higher priority –
 - traffic calming
 - home zones and quiet lanes
 - cycle routes and lanes
 - pedestrianisation
 - National Cycle Network
- protecting pedestrians and cyclists from traffic –
 - drink–drive legislation and enforcement
 - speed limits and enforcement (eg 20 mph zones)
 - speed cameras
 - promoting use of bicycle helmets
 - designing vehicles to have a less damaging impact on pedestrians.

7 Developing cycling and pedestrian skills:

- road safety education, particularly for children
- cycle training.

8 Creating a functional, pleasing environment by:

- improving pedestrian links
- ensuring good quality, unobstructed pavements
- improving liveability – cleaner, greener, safer public spaces.

9 Creating a secure environment:

- designing for crime reduction (eg better street lighting)
- providing CCTV in public places
- promoting neighbourhood warden schemes
- taking measures against antisocial behaviour in public places.

10 Promoting social cohesion/capital:

- see 5 and 9 above.

11 Promoting health-related physical activity:

- improving understanding of the links between physical activity and better health, and of everyday opportunities to be active
- encouraging activity in early years, schools, and further and higher education
- extending the use of education facilities as a community resource for sport and physical activity
- creating and maintaining a wide range of opportunities for activity through sport
- ensuring high-quality, well targeted provision for walking and cycling
- making public spaces and the countryside more accessible and attractive
- providing more lifestyle advice for physical activity from health professionals and community support services
- encouraging physical activity in workplaces.

4 Review of the evidence on effectiveness of transport interventions: methodology

The standardised methodology developed by the HDA for the analysis and synthesis of review-level evidence (see the HDA's procedures and quality standards at www.nice.org.uk/page.aspx?o=518279) has been now adopted by NICE (2006). This methodology was applied here. The specific methodology used for the transport review is outlined below. We also took account of the methodology of the US Centers for Disease Control and Prevention's *Guide to Community Prevention Services* (Briss et al. 2000).

Model of transport, health and physical activity

The methodology included development of the working model for transport and physical activity (section 2). This model was intended to help:

- assemble and examine the research on the relationship and possible pathways between transport and physical activity
- assess the evidence on how far policies and interventions influence such pathways and promote patterns of cycling and walking that are safe, and that would have longer-term health benefits.

Transport interventions

As discussed in section 1, perhaps unsurprisingly there is little clarity about what constitutes a 'transport intervention' for increasing physical activity and, more specifically, promoting walking and cycling.

The review adopted a wide definition of 'transport interventions', encompassing transport policies, systems and initiatives that promote patterns of walking and cycling and/or increase the safety of walking and cycling.

This includes national, regional and local transport and land-use policies and schemes (upstream) as well as interventions focused on the individual level or on particular groups (downstream). It includes interventions that may not necessarily be viewed as 'public health' interventions, which are intended to achieve objectives other than active travel, physical activity or health improvement, but nevertheless have consequences for these areas.

Outcomes

Papers were included if they reviewed transport interventions in which walking and cycling and related outcomes or the economic costs were assessed. Outcome measures included both direct health outcomes (eg increased levels of physical activity, improved safety) and indirect health outcomes (eg increased levels of knowledge). Specifically, outcomes related to:

- increasing cycling and walking; improved safety for cyclists and pedestrians
- changes in knowledge, attitudes and beliefs (eg perceptions of risks and levels of safety).

We were also concerned to identify any significant adverse outcomes of such policies and interventions, such as injuries; and any differential impact of health benefits across different population groups that might increase health inequalities and limit effectiveness.

Search strategy

The following databases were searched.

Cochrane Library
DARE

Turning Research Into Practice (TRIP) database
 Health Technology Assessment (HTA) Database
 Scottish Intercollegiate Guidelines Network (SIGN)
 Health Evidence Bulletins Wales
 National Guideline Clearinghouse
 MEDLINE
 Transport database (Leeds University)
 National Coordinating Centre for Health Technology Assessment (NCCHTA) website
 NICE web pages
 Research Findings Electronic Register (ReFeR)
 National Research Register
 Clinical Evidence
 Excerpta Medica database (EMBASE), 1996–2002, week 51
 Sociological Abstracts (1963 to December 2002)
 PsycINFO (2000 to December 2002, week 4)
 Education Resources Information Center (ERIC) (1966 to December 2002)
 REGARD database
 Dialog online databases:

- EconLit
- Wilson Applied Science & Technology Abstracts
- Public Affairs Information Service (PAIS) International
- Environline
- Social SciSearch

The search strategy adopted is presented for MEDLINE in Appendix 1. This strategy was adapted for each of the databases.

Inclusion and exclusion criteria

Papers were included if they:

- were published between 1996 and April 2005
- were published in the English language
- were reviews of human studies only
- were systematic reviews, meta-analyses, syntheses or review-level papers
- were reviews of transport interventions (defined above) that assessed health or health inequalities outcomes (defined above)
- described the intervention
- measured and reported the effectiveness of the intervention.

Papers were excluded if they examined:

- interventions solely aimed at reducing road accidents and casualties, including those that are alcohol-related – existing effectiveness briefings provide comprehensive reviews of the evidence in the areas of accidents and alcohol (section 1), so this review focused on interventions that improved safety or perceptions of safety of cyclists and pedestrians
- interventions improving air and noise pollution
- interventions improving access to public services, facilities and social networks
- transport interventions related to air, rail, river and sea travel
- screening and clinical interventions related to existing medical conditions, eg dementia and diabetes
- interventions related to reducing injuries from vehicle restraints and air bags
- interventions reducing post-accident outcomes
- interventions in developing countries
- if they were not review level (primary studies were not included).

Selection and filtering

The electronic search generated 1654 references. This included 126 papers identified via the specialist Transport database. These references were assessed for their suitability according to the inclusion criteria. Each paper was appraised independently by two reviewers in terms of:

- relevance
- transparency.

At this stage, 'relevance' included any paper that was relevant to the research question, fell potentially within the inclusion criteria and was a review-level analysis.

It became clear that virtually no papers addressed our review questions specifically. Most papers did not examine physical activity (walking and cycling) as outcomes. The majority of potentially relevant papers used injury and accidents as a primary health outcome. We judged that a total of 34 papers met our filtering inclusion criteria to some degree. The papers fell into two broad groups of interventions:

- transport and related land use
- safety of cyclists and pedestrians.

Critical appraisal

These 34 papers were appraised independently by two reviewers using the full critical appraisal tool (CAT; Appendix 2). Papers were assessed to determine whether they should be included in the evidence base. The 15 review papers that passed the CAT stage were judged to

be relevant and sufficiently systematic and transparent, and to apply the appropriate methods of analysis. These papers (Box 3) provide the basis for evidence statements. Appendix 3 presents a summary of the reviews.

The review papers excluded at the CAT stage are summarised in Appendix 4.

Box 3 Review papers included in the evidence base

Transport interventions promoting walking and cycling

Egan M, Petticrew M, Ogilvie D et al. (2003) New roads and human health: a systematic review. *American Journal of Public Health* 93(9):1463–71.

Handy S (2004) *Critical Assessment of the Literature on the Relationships among Transportation, Land Use and Physical Activity*. Prepared for the Transportation Research Board and the Institute of Medicine Committee on Physical Activity, Health, Transportation, and Land Use, Washington DC, USA. <http://trb.org/downloads/sr282papers/sr282Handy.pdf>

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5 Findings of the review of transport interventions and relationships to physical activity

This set of review-level papers cannot be regarded as comprehensive. The search of review-level papers relied primarily on electronic databases – a systematic search of websites, reviews of conference papers and access to a network of experts in this area may have identified other relevant evidence. The systematic search of appropriate sources is a methodological challenge for further review work. Nevertheless, this set of papers clearly indicates the limited and variable nature of evaluation research on the effectiveness of transport interventions on walking and cycling. The papers provide some evidence of sufficient quality to illustrate how transport and related forms of land use (particularly urban design) can change travel behaviour through interventions at different levels.

Interventions promoting walking and cycling

What are the most effective ways of improving population health through transport interventions? Morrison et al. (2003)

This study reviewed systematic review literature describing the effectiveness of transport interventions in improving population health. Twenty-eight systematic reviews were identified. The authors used a quality-index rating system ranging from 1 (major flaws) to 7 (minimal flaws). The reviews covered four categories of intervention: health promotion, engineering, environmental and legislative. Only six reviews (all of which were health promotion interventions) were rated as having minimal flaws. Notably, all reviews were concerned with injury prevention, and all but four were concerned with motor vehicle injury (although the authors did not use accident prevention as a primary search term).

For the purposes of this transport review, we judged that 13 of the studies reported fell within our inclusion criteria

and had bearing on safety conditions for pedestrians and cyclists. These studies covered use of bicycle helmets, safety education campaigns, traffic-calming measures, public lighting, speed limits, and accident prevention interventions among children and young people. The majority of these studies are covered within other reviews described in this section (Bunn et al. 2003; Klassen et al. 2000; Towner et al. 2001) and are not repeated here. Studies on public lighting and speed limits are not included elsewhere. The authors reached the following conclusions.

- Speed-limit zones are effective in reducing personal accidents and material damage. Creating raised road surfaces at crossroads may increase accidents, while noisy road surfaces (rumble strips) before crossroads are associated with reductions in accidents. Road humps and differential speed limits may reduce accidents locally, but increase them in surrounding areas.
- Public lighting reduced night-time accidents in all cases, but depended on the baseline risk and the proportion of night-time accidents.

The authors state that no evidence was found to suggest that any interventions will bring about a shift in the use of different modes of transport and consequently health in a broader way. Evidence on the effectiveness of transport interventions in relation to physical activity and other aspects of health is lacking.

Promoting walking and cycling as an alternative to using cars: systematic review. Ogilvie et al. (2004)

This publication aimed to review experimental or observational studies with a prospective or controlled retrospective design to assess what interventions were effective in promoting a population shift from using cars towards walking and cycling, and the health effects of such interventions.

The authors identified 22 studies. They categorised the studies according to the nature of the intervention as:

- targeted behaviour-change programmes – directed at motivated sub-groups
- publicity campaigns and agents of change – directed at groups undifferentiated by motivation or personal travel circumstances and, in some cases, making use of travel coordinators to promote changes in behaviour
- engineering measures
- financial incentives
- providing alternative services.

They looked for the following outcome measures: changes in the distribution of transport mode choice between cars and walking and cycling; effects on any measure of human health, fitness, health-related behaviour or wellbeing; and the distribution of effects among social groups.

The authors used a four-point scale to summarise the strength of modal shifts towards walking and cycling found in the studies: significant positive effect; positive effect of uncertain significance; inconclusive or no effect; negative effect of uncertain significance.

They graded the studies using a system of scoring for validity using 10 validity criteria. In each intervention category there were studies with both relatively high and relatively low validity scores.

Targeted behaviour-change programmes

- A self-help pack for commuters identified as contemplating changing, or actively preparing to change, their behaviour. The pack contained written interactive materials (eg advice on choosing routes, personal safety, safe cycle storage, an activity diary and a map) based on the transtheoretical model of behaviour change. There was a reported increase in mean time spent walking to work each week 1.93 times greater in the intervention group than in the control group. (Significant positive effect, validity score = 9.)
- TravelSmart pilots (three studies): individualised marketing of alternative modes of transport to households showing an interest in using them, using a tailored combination of, eg, public transport information, cycle-route maps, a walking information booklet with motivational challenge chart, and sometimes follow-up with home visits. There were net positive shifts towards walking and cycling ranging from 3.6 to 5.5%. (One site: significant positive effect,

validity score = 7; two sites: positive effect of uncertain significance, validity scores = 9.)

- Volunteer 'inveterate motorists' were invited to try to use bicycle and bus as much as possible in exchange for a free bicycle, a free bus pass and other accessories and information for 1 year. Participants reported a positive shift of 25% of all weekday trips after 11 months. (Positive effect of uncertain significance, validity score = 7.)
- Tailored feedback to households in two areas on their travel diaries, with suggestions on changing travel patterns, supported with customised information. Householders reported small changes in walking trips and larger but inconsistent changes in cycling trips after 1 month. (Inconclusive or no effect, validity score = 4.)

Publicity campaigns and agents of change

- Pupils in an intervention group of schools that received input for a year from a school travel coordinator were no less likely to travel to school by car than pupils in the control group of schools. (Inconclusive or no effect, validity score = 8.)
- Campaign using mass media and community activities to raise awareness of alternative modes of transport resulted in only one significant change – a decrease in cycling trips in the intervention area compared with the control area. (Inconclusive or no effect, validity score = 7.)
- Campaign using mass media and community activities to promote a voluntary no-drive-to-work day. Drivers' reports showed a positive shift of 1% of commuting journeys 7 months later. (Positive effect of uncertain significance, validity score = 5.)
- Promotion of alternative transport modes through workplace transport coordinators and transport fairs, free bus passes and rewards for staff using alternative modes. There was no evidence of a shift in employees' usual mode of travel to work after 9 months. (Inconclusive or no effect, validity score = 4.)

Engineering measures

- Upgrading and increasing the connectivity of a cycle-route network. Households in the intervention suburb reported a 3% increase after 3 years in the share of trips made by bicycle, with no change in the shares for walking and car use, whereas in the control area the frequency of car trips increased and the frequency of bicycle trips was unchanged. (Positive effect of uncertain significance, validity score = 7.)
- Bicycle-friendly demonstration project in two towns, mainly consisting of planning and building

improvements to cycle route networks. Households in one town reported a negative shift of 5% of all trips after 5 years; in the other town a zero shift. (Negative effect of uncertain significance, validity score = 6.)

- A new shared pedestrian and cycle route. School pupils reported a negative shift of 2% in their usual mode of travel to school after 17 months. (Negative effect of uncertain significance, validity score = 5.)
- Construction of bypasses accompanied by a variety of traffic-calming measures and enhanced walking or cycling facilities in six town centres. There was a negative shift of 3% in the main mode of travel of residents of bypassed towns to town centres. (Negative effect of uncertain significance, validity score = 3.)
- Construction of 20 mph zones in six towns, which were enforced using a range of engineering measures. There was no evidence for a change in travel patterns among residents of the towns. (Inconclusive or no effect, validity score = 5.)
- Car restriction, subsidised bus services and pedestrianisation of the central business district of a city. Office workers reported a positive shift of less than 1% of commuting journeys. (Positive effect of uncertain significance, validity score = 4.)

Financial incentives

- A subsidy for employees who commuted to work by modes other than driving at least equivalent to the cost to the employer of subsidising workplace parking. There was a positive shift at the intervention workplaces of 1% of commuting journeys after 1–3 years, compared with no significant change at the control workplace. (Significant positive effect, validity score = 8.)
- A toll ring for motor vehicles inbound towards a city centre between 06.00 and 17.00 on weekdays. An uncontrolled household panel study found a negative shift of 2.6% of all trips after 1 year. (Negative effect of uncertain significance, validity score = 7.)

Providing alternative services

- Neighbourhood-based car-sharing cooperative. Members were no more likely to report a positive shift after 9 months than aspiring members still waiting to join. The share of journeys made by car increased by a greater proportion than the combined walking and cycling modal share (17 and 3.7%, respectively). (Inconclusive or no effect, validity score = 7.)
- Opening a railway station in a commuter town. There was a positive shift of 5% of all trips after 1 year. (Significant positive effect, validity score = 7.)

- Voluntary use of neighbourhood telecommuting centres as an alternative to commuting to usual workplaces. There was a negative shift of 0.2% on telecommuting days compared with normal commuting days, with a 24% decrease in reported distance travelled on foot or by bicycle. (Negative effect of uncertain significance, validity score = 4.)

Only one of these studies – the self-help pack for commuters – showed effects on health after 6 months: significant net increases in sample mean scores on the mental health, vitality and general health sub-scales of the Short Form 36 (SF36) questionnaire, a commonly used tool for ascertaining subjective health status. The authors found insufficient data for any meaningful synthesis of the social distribution of effects.

The authors' overall conclusions were as follows.

- Targeted behaviour-change programmes can be effective in changing the transport choices of motivated sub-groups, but the social distribution of their effects, and their effects on the health of local populations, are unclear. Interventions of this kind might not be applicable to larger, less selected populations.
- Evidence that other types of intervention have been effective is inconsistent; of low validity, based on single highly contextual studies; or non-existent.

The authors identified the following gaps in research.

- There need to be evaluations of less targeted types of intervention to test the proposition that interventions engaging people in a participatory process and addressing factors of personal relevance are likely to be more effective than those aiming simply to raise awareness or impose changes in the physical and economic environments.
- Research is needed on whether successful targeted interventions conceal increasing disparities in levels of physical activity among social groups.
- Given variations in walking and cycling between populations both within and between countries that are greater than the effect size of the interventions considered, other reasons for these variations, such as attitudes towards cars and bicycles, need to be examined.
- There is a lack of evidence for the effectiveness of combining interventions in an integrated urban transport policy.
- Many transport policy interventions constitute natural experiments, in which effects on population health

could and should be evaluated using well designed prospective (and, where appropriate, controlled) studies. These studies should use varied methods of evaluation, providing multiple perspectives on the supposed causal relationship between a complex intervention and its alleged effects. They should assess changes in physical activity and wellbeing, as well as adverse effects such as injuries and the potential for widening social inequalities in health and determinants of health.

Transport and related land use

New roads and human health: a systematic review. Egan et al. (2003)

This review aimed to identify, assess and synthesise primary studies that focused on new roads and included measurements of effects on human health and wellbeing. A range of study designs were included. Thirty-two different studies were identified and critically appraised using critical appraisal tools 'from those recommended within the systematic review and transport methodological literature'.

The studies were concerned with injury reduction, disturbance and community severance. For the purposes of this transport review, we judged that the 12 studies concerned with injury prevention fell within our inclusion criteria. These studies covered: major urban roads (four studies), out-of-town bypasses (five studies) and major connecting roads between towns (three studies). Conclusions were as follows.

- New major urban roads resulted in variable and limited reductions in the incidence of injury accidents (1–8.5%). Improvements made to a single urban road in Norway was an exception, resulting in an estimated major decrease in accidental injuries of 51% (95% CI = 27, 68%). The nature of the improvements was atypical. The authors conclude that there is little evidence that new major urban roads significantly reduce the incidence of injury accidents.
- Out-of-town bypasses reduce the incidence of injury accidents on main routes through or around towns. (Two studies showed statistically significant reductions of 25 and 33%.)
- Major new roads connecting urban centres are associated with significant decreases in accident injuries. (Two studies showed statistically significant results ranging from 19 to 32%.)

Critical Assessment of the Literature on the Relationships among Transportation, Land Use and Physical Activity. Handy (2004)

This review was prepared for the Transportation Research Board and the Institute of Medicine Committee on Physical Activity, Health, Transportation and Land Use in the USA. The findings informed the recommendations of the Committee on Physical Activity and the Built Environment. It reviews theoretical perspectives in this field, as well as empirical evidence regarding the relationship between the built environment and physical activity behaviours. We focused on Handy's review of the empirical evidence, although we highlight some of the broader findings in other sections of this briefing.

Published review-level studies from both transport and physical activity literature were included, along with additional studies subsequent to these reviews. The author points out that most of the studies fall into the category of 'least suitable' for assessing the effectiveness of potential interventions according to the criteria used by the US Task Force on Community Prevention Services (ie cross-sectional studies).

A total of 22 studies from the travel behaviour literature were included. Almost all used cross-sectional design and relied on available sources of travel data. The studies used measures of walking or non-motorised modes of travel, while the measures of the built environment varied significantly, and included measures of land use (particularly population and/or employment density), land-use mix, transportation system, and accessibility. Few studies included measures of design. Some studies used classifications of neighbourhood type rather than measuring specific characteristics of urban form. Control variables covered household and individual characteristics including car ownership, income, age, gender, race etc.

A total of 28 cross-sectional studies from the physical activity literature were included. Nearly all studies drew on some form of theoretical model as a basis for the research design and conceptualisation of variables. Most studies relied on reported measures of physical activity and of the built environment. Measures of physical activity included measures of walking, other forms of physical activity, and total physical activity. Most studies used perceived measures of the built environment, focusing on accessibility to or convenience of facilities and opportunities for exercise, or on neighbourhood characteristics, or both. Many included individual and health-related variables.

Handy (2004) concludes that the studies from both the travel behaviour literature and the physical activity literature provide relatively consistent evidence for an association between the built environment and physical activity, and specifically that variables of urban form influence levels of walking and cycling. However there is 'unconvincing' evidence about what characteristics of the built environment are most strongly associated with physical activity. Handy also states that the studies do not establish causal relationships.

The review provides the following evidence on the relationship of specific aspects of transport and land use with walking and cycling.

- Accessibility is an important condition for physical activity. Distances to potential destinations had strong negative associations with physical activity.
- The importance of design variables is less clear. Design variables may prove more important for physical activity other than active travel, and distance may prove more important than design for active travel.
- The relative importance of attitudes and characteristics of the built environment in explaining active travel is unclear, and there are contradictory findings. For example, the environment may not provide a high level of support for individuals who are highly motivated to walk, but certain studies showed high levels of walking in areas rated as relatively low in terms of walkability.
- Car ownership is shown to be a mediating variable in the relationship between the built environment and physical activity. For example, individuals without access to a car for personal use were over four times as likely to have walked in the past 2 weeks as individuals who always had access to a car.

An update of recent evidence of the relationship between objective and self-report measures of the physical environment and physical activity behaviours. McCormack et al. (2004)

The purpose of this review was twofold:

- first, to update evidence on the association between the physical environment of neighbourhoods and physical activity behaviour in adults by reviewing quantitative studies published since 2000
- second, to examine the concept of context-specific physical activity behaviour by examining independently environmental factors that influence walking for recreation and transport; non-walking moderate and vigorous-intensity physical activity (where walking was

not examined specifically among other types of physical activity); and overall levels of physical activity.

The authors identified 34 studies meeting the following inclusion criteria.

- Any measure of physical activity as an outcome, correlate or predictor variable, regardless of its purpose, including self-report of participation in physical activity, frequency and/or duration of participation, and use of a facility, as well as objective measures using, eg pedometers or accelerometers.
- Self-reported or objectively measured (using geographical information systems and data from observers and audit processes) environment data, with which associations with physical activity measures had been made.
- In the case of studies that developed composite scores, a majority of the items forming the composite score related to the physical environment.

Studies fell into two main categories: those with objective environmental measures (12 studies) and those with self-reported measures (the majority), including a small number with both objective and self-reported measures.

The authors assessed the studies using a previously developed framework for categorising physical environmental attributes, comprising four main features:

- functionality – walking surface, street width, traffic and permeability
- safety – personal safety and safety from traffic
- aesthetics – streetscape and views
- destinations – existence of facilities.

They identified statistically significant associations between walking and other physical activity and the physical environment.

The authors found evidence from the studies suggesting that:

- both perceived and objectively measured physical environmental attributes of neighbourhoods were positively associated with walking; non-walking moderate and vigorous-intensity physical activity; and overall levels of physical activity
- the availability, accessibility and convenience of destinations and facilities, as well as the general functionality of the neighbourhood and its aesthetics, were positively associated with various levels of physical activity.

They found mixed evidence in relation to safety, and commented on the need to measure both personal safety and safety from traffic: people who perceived that there was busy or 'bothersome' traffic appeared more likely to walk, whereas there was evidence of a negative relationship between perceptions of crime and participation in physical activity.

The authors point out that causality cannot be inferred, as the majority of studies to date have been cross-sectional. It is not yet clear whether people choose environments that match their behaviour, or whether the environment shapes their behaviour.

The authors also identified several weaknesses in the studies and made recommendations on:

- the desirability of including both subjectively and objectively measured environmental data in the same studies
- examining physical activity performance in specific settings to strengthen associations between behaviour and environmental context
- using both aggregate-level and disaggregate-level environmental data to determine the level of influence of variables in composite measures
- using prospective study designs where possible
- examining how the environment moderates physical activity behaviour, given other known correlates of physical activity
- investigating the issue of objective and perceived safety, and how they may affect physical activity participation.

Understanding environmental influences on walking: review and research agenda. Owen et al. (2004)

The purpose of this review was to increase understanding of how local or neighbourhood environmental attributes can influence particular physical activity behaviours, through a review of quantitative studies examining the relationships of perceived and objectively assessed environmental attributes with the walking behaviour of adults.

The authors identified 18 studies that met their two criteria of using first, any type of walking (main outcome variable) and second, environmental attributes, whether measured objectively or by self-report (independent variables). Sixteen studies used a cross-sectional design, two a prospective design. Thirteen studies used measures of perceived environmental attributes, while 12 included at least one objective measure of environmental attributes.

Box 4 Examples of environmental attributes identified in studies reviewed

Aesthetically pleasing	Foul air
Convenience of facilities	No enjoyable scenery
Walking trail length	No walk/jog trails
Trail surface	High crime
Distance to trail	Access to open space
Metropolitan/county sprawl index	Access to beach
No sidewalks/pavements	Stores/shops within walking distance
Heavy traffic	Coastal location
Hills	Safety – personal and traffic
No streetlights	Weather
Unattended dogs	Traffic not a problem

The authors categorised the studies according to whether they examined environmental associations with walking for particular purposes: walking for exercise or recreation; total walking (particularly walking sufficiently to meet public health guidelines); walking to get to and from places; walking for pleasure.

The authors assessed the association found in each study between environmental attributes and walking outcomes as either significant or non-significant. The environmental attributes were numerous (Box 4), but the authors summarised categories of attributes as follows: aesthetic attributes; convenience of facilities for walking; accessibility of destinations; perceptions about traffic and busy roads.

The authors caution that it would be premature to state definitive conclusions from such a small number of studies specific to walking. However, they also argue that there is consistency in the patterns of association found.

Their assessment of the evidence was as follows.

- The pattern of findings shows a modest but consistent body of evidence indicating patterns of positive relationships between local or neighbourhood environmental attributes and walking for particular purposes. These were aesthetic attributes; convenience of facilities for walking (pavements, trails); accessibility of destinations (shops, park, beach); and perceptions about traffic and busy roads.

- Most studies have found environmental attributes to be associated with walking for exercise, recreation, or 'total walking'.
- While there is some overlap, the environmental attributes found to be associated with walking to get to and from places differed from those associated with walking for exercise and recreation. For example, the aesthetic nature of the environment was not associated with walking to get to and from places.

The authors discuss the research opportunities for understanding environmental influences on walking, pointing to the need to go beyond identifying environmental correlates of walking, as in this review. They recommend investigation of causation by means of multi-level studies that include the strongest individual- and social-level influences on physical activity, such as self-efficacy and social support, ideally using prospective study designs.

The authors also identified, in addition to the issue of causality, the following key elements of the research agenda:

- reliability: the need for reliable measures of environmental attributes
- validity: tools for objectively verifying rated and self-reported environmental attributes
- conception: refining of conceptual models and theories to underpin research.

Environmental correlates of walking and cycling: findings from the transportation, urban design and planning literatures. Saelens et al. (2003)

This paper aimed to review the findings from transportation studies that explored the relationship between neighbourhood characteristics and non-motorised transport (walking and cycling), and also consider the implications for future research. (This study was included in Handy's broader review, described previously. The study of Saelens et al. is presented here to demonstrate the nature of evidence from transport literature.)

The authors defined two categories of study according to their design and methodology.

- Ten neighbourhood-comparison studies, comparing the behaviour of residents in highly walkable/bikeable neighbourhoods with that of residents in low-walkable and bikeable neighbourhoods. Highly walkable/bikeable neighbourhoods have a traditional design characterised by high population density, a good mixture of land

use, high connectivity, and adequate walk/bike design (eg continuous pavements). These neighbourhoods are compared with those having lower population density, more uniform land use (eg only residential), poorer street connectivity, and inadequate pedestrian and bike facilities that are defined as low-walkable/bikeable. The findings from this type of study showed that residents in highly walkable neighbourhoods reported approximately twice as many walking trips per week than residents of low-walkable neighbourhoods. The variance across the range of studies depended in part on the purpose of the walking trip. Walking to work and walking for errands appear more likely in highly walkable than low-walkable neighbourhoods. The authors comment that the lack of individual or composite reliable and valid walkability measures makes it difficult to compare neighbourhoods and walking/cycling rates across studies. Walking/cycling rates provided in most neighbourhood comparison studies were not adjusted for potential individual-level confounding variables.

- Four correlation analyses of neighbourhood characteristics and non-motorised transport, controlling for either or both individual and neighbourhood socio-demographic variables (eg age, income, automobile ownership). Overall, these studies demonstrate consistent associations of neighbourhood walkability factors with walking and cycling. Correlation analyses showed that population density, employment density and land-use mix (especially close proximity to housing of shopping, work and other non-residential land use) were important factors associated with walking and cycling. One study showed that better pedestrian infrastructure, including pavements and street lighting, was related to increased non-car travel, particularly for non-work trips originating from home. The findings showed that environmental variables appear to add to variance accounted for beyond socio-demographic predictors of walking/cycling.

Importantly, the authors consider the potential population impact of the findings. The estimated mean difference in level of walking between highly walkable and low-walkable neighbourhoods amounted to 1–2 km, or about 15–30 minutes more walking per week. The authors state that, although this effect appears modest, when extrapolated to entire populations in target neighbourhoods it may compare very favourably with the population effects of more traditional approaches to individual behaviour change.

Interventions promoting the safety of cyclists and pedestrians

Area-wide traffic calming for preventing traffic related injuries. Bunn et al. (2003)

This publication sought to evaluate the effectiveness of area-wide traffic calming in preventing traffic-related crashes, injuries and deaths. No RCTs were identified. Sixteen controlled before-and-after trials met the inclusion criteria. Seven studies were carried out in Germany; six in the UK; two in Australia; and one in the Netherlands. Areas covering a number of different streets, including residential and main roads treated with traffic-calming measures, were included. The interventions included were area-calming measures designed to discourage the use of residential streets for through travel and to create an environment where residential streets are safe. Eligible schemes included those that involved a number of specific changes to the road layout, road hierarchy or road environment, such as vertical and horizontal shifts in traffic, optical measures, redistribution of traffic or alterations to road hierarchy, and changes to the road environment.

Certain studies were excluded: those that focused solely on evaluating the enforcement of legal interventions; educational programmes aimed at altering driver or pedestrian behaviour; studies on effects of improved public transport facilities; and studies describing interventions separating different road users or investigating the effect of alterations to road signs or traffic lights alone.

Eight studies reported the number of road traffic crashes resulting in deaths with a pooled rate ratio of 0.63 (95% CI, 0.14–2.59). Sixteen studies reported the number of road traffic crashes resulting in injuries (fatal and non-fatal) with a pooled rate ratio of 0.89 (95% CI, 0.80–1.00). Nine studies reported the total number of road traffic crashes with a pooled rate ratio of 0.95 (95% CI, 0.81–1.11). Thirteen studies reported the number of pedestrian–motor vehicle collisions with a pooled rate ratio of 1.00 (95% CI, 0.84–1.18). Significant heterogeneity was found in the total number of crashes, deaths and injury outcomes. The results suggest that area-wide traffic calming in towns and cities may be a promising intervention for reducing the number of road traffic injuries and deaths. However, the authors suggest that further rigorous evaluations are needed.

Safety education of pedestrians for injury prevention. Dupperrex et al. (2002)

This systematic review sought to quantify the effectiveness of pedestrian education programmes in preventing pedestrian motor vehicle collisions and changing the behaviour, attitude and knowledge of pedestrians. Randomised controlled trials only were eligible for inclusion in the review. Fifteen RCTs were identified, but all were of generally poor methodological quality. Eight trials were conducted in the UK, three in the USA, one in Australia, one in Germany, one in Canada, and one in Japan. No trials were conducted in a developing country and there were none on pedestrian safety training in older people. The total number of participants was 3754. Study participants were children in 14 studies and institutionalised adults in one.

Interventions targeting any pedestrians of all ages were eligible for inclusion. Also, any pedestrian safety education (PSE) programmes were eligible for inclusion in the review. None of the trials assessed the effect of pedestrian safety education on the occurrence of pedestrian injury, but six assessed the effect on observed behaviour.

Eight studies involved direct education of participants; seven used parents as educators.

The results indicated that pedestrian safety education can improve knowledge and change observed road-crossing behaviour. However, it is difficult to predict what effect this might have on reducing the risk of pedestrian–motor vehicle collision and injury. The authors found evidence that changes in safety knowledge and observed behaviour decline over time, suggesting that safety education must be repeated at regular intervals.

Interventions for increasing pedestrian and cyclist visibility for the prevention of death and injuries. Kwan and Mapstone (2002)

This systematic review aimed to assess the effects of different visibility aids on the occurrence of pedestrian– and cyclist–motor vehicle collisions (primary objective), and on drivers' detection and recognition responses (secondary objective). Only RCTs and before-and-after studies, and any studies comparing all types of daytime or night-time visibility aids used on bicycles and by pedestrians/cyclists, were included. Nineteen trials were conducted in the USA, five in the UK, three in Australia, three in the Netherlands, three in South Africa, and the remainder from Israel, Canada, Sweden and Finland. The

study designs eligible for inclusion were:

- any visibility aid vs no visibility
- comparison of different visibility aids such as active vs passive visibility aids
- comparison of positioning of visibility aids such as 'biomotion' vs no 'biomotion' marking.

A total of 882 participants aged between 17 and 77 were included. Observers inside a vehicle, and observers of slides or video simulation of a car journey or driving scene, were also included. The number of observers in the trials ranged from 4 to 645.

No studies addressing the primary objective were identified; 37 trials were identified in relation to the secondary objective. The reported results in a narrative synthesis were combined according to the type of intervention in terms of daytime and night-time visibility aids.

The results indicated that visibility aids have the potential to increase visibility and enable drivers to detect pedestrians and cyclists earlier, but the effect of visibility aids on pedestrian and cyclist safety remains unknown. Fluorescent materials in yellow, red and orange were found to improve detection and recognition in the daytime, while for night-time visibility lamps, flashing lights and retro-reflective materials in red and yellow colours increase detection and recognition. The authors suggest that studies collecting data on more meaningful outcomes are required.

Bicycle helmets

Bicycle helmet efficacy: a meta-analysis. Attewell et al. (2001)

This meta-analysis assessed the efficacy of bicycle helmets in reducing risk of injury to cyclists, and identified 16 studies with 17,289 participants. The studies were surveys and case-control studies, and there was heterogeneity in study design and populations. Nine studies were conducted in the USA, four in Australia, two in Canada, and one in the UK. Interventions targeting child-only, adult-only, or all cyclist populations were included. The stated outcomes were head, brain and facial injury. However, several of the studies included contained information on neck and fatal injuries, which were also analysed.

Studies were combined to calculate estimates of odds ratios (ORs) and 95% confidence intervals (CIs). A

random-effects model for each outcome was used if a statistical test of heterogeneity was significant. Statistically significant heterogeneity was found for head injury ($Q = 52$, $df = 11$, $P < 0.001$); brain injury ($Q = 22$, $df = 7$, $P = 0.002$); and facial injury ($Q = 11$, $df = 5$, $P = 0.04$), as well as for potential publication bias. For fatal injury, there was no evidence of heterogeneity ($Q = 3.5$, $df = 5$, $P = 0.6$), and there was no strong evidence for heterogeneity in three studies used to compute an efficacy estimate for neck injury ($Q = 2.5$, $df = 2$, $P = 0.3$).

The use of helmets was found to reduce the risk of head injury (13 studies, $OR = 0.40$, 95% $CI = 0.29-0.55$); brain injury (eight studies, $OR = 0.42$, 95% $CI = 0.26-0.67$); facial injury (eight studies, $OR = 0.53$, 95% $CI = 0.39-0.73$); and fatal injury (six studies, $OR = 0.27$, 95% $CI = 0.10-0.71$). The authors of the review concluded that there were clear benefits to wearing a cycle helmet in terms of injury risk and, despite possible publication bias, they stated that the association between helmet use and injury risk was compelling.

Bicycle Helmets – A Review of their Effectiveness: A Critical Review of the Literature. Towner et al. (2002)

This systematic review investigated (a) the effectiveness of bicycle helmets in reducing injuries; (b) the promotion of bicycle helmets; (c) bicycle helmet legislation. The review was based on an update of Towner et al. (2001).

Bicycle helmet efficacy

The aim of this part of the review was to assess the effectiveness of bicycle helmets in reducing injuries, using comparative observational studies. Sixteen studies were identified but 15 were included as two were from the same data set. As no inclusion criteria were reported, studies assessing the efficacy of any bicycle helmet appear to have been eligible for inclusion. Eight studies were conducted in the USA, four in Australia, two in Canada, and one in the UK. There was considerable heterogeneity in the studies relating to definitions of head and brain injury, choice of controls, target group, and context in which cycling takes place. Very little evidence was found for helmet use and bicycling style.

The results indicated that bicycle helmets are effective in reducing the incidence and severity of injuries to the head, brain and upper face. Bicycle helmets were also found to be effective in reducing head injury for users of all ages, especially for children. However, there was equivocal evidence relating to the link between helmet use and neck injury.

Bicycle helmet promotion

Nineteen studies were identified that assessed the effectiveness of bicycle helmet-promotion interventions. Six studies were RCTs, nine were controlled trials without random allocation, one was before-and-after, and three were other types. Studies on the promotion of bicycle helmets were eligible for inclusion in the review. Nine studies were conducted in the USA, five in Canada, two in the UK, one in Sweden, and one in New Zealand. Considerable heterogeneity was found between the studies.

The results indicated that most bicycle helmet educational campaigns were targeted at children. It was found that these campaigns can increase the use of helmets, and that younger children and girls showed the greatest effects from the campaigns. The evidence also showed that reducing the costs of helmets through discounts and give-away programmes facilitates the uptake and use of helmets.

Bicycle helmet legislation

Thirteen studies were identified that assessed the efficacy of bicycle helmet legislation. Nine were before-and-after studies, three were controlled studies, and one was a survey. Studies that assessed the effectiveness of bicycle helmet legislation were eligible for inclusion in the review. Six studies were conducted in the USA, four in Australia, two in Canada, and one in New Zealand.

The results indicated that bicycle helmet legislation is associated with reductions in head injuries. Legislation, combined with educational activities, was found to be an effective means of increasing observed helmet use. Results also indicated that compulsory helmet wearing may lead to decreased bicycle use.

Prevention of road injuries in childhood and adolescence

Social deprivation and the prevention of unintentional injury in childhood: a systematic review. Dowswell and Towner (2002)

This systematic review assessed the effectiveness of health promotion interventions in preventing unintentional injuries in childhood and young adolescents, with a specific focus on social deprivation. All interventions were targeted at children under the age of 15, and addressed issues of social deprivation. Eligible studies had to describe an intervention aimed at either preventing accidents or reducing the severity of injuries. Of the 32 studies that

addressed issues of social deprivation, 16 studies assessing interventions in the road environment are relevant to this evidence briefing. These studies consisted of six RCTs, eight controlled trials, and two before-and-after studies. Ten studies were conducted in the USA, five in Canada, and one in the UK.

For road injuries, there is a paucity of evidence relating to social deprivation issues. Evaluations generally seemed to target individual behaviour rather than environmental change. The review indicates that the paucity of evidence makes it difficult for those involved in health promotion to know how best to target their efforts and design interventions to reduce inequalities in child injury rates.

The authors suggest that much more evidence is needed regarding the impact of community campaigns, broader policy change and strategies to increase the reach of health promotion campaigns on socially deprived groups.

Community-based injury prevention interventions. Klassen et al. (2000)

This systematic review sought to evaluate the impact of community-based injury prevention interventions on childhood injuries, safety behaviours and the adoption of safety devices. Studies were eligible only if they included a control group that received no intervention. Thirty-two studies were included; 24 of these that address interventions in the road environment are relevant to this evidence briefing. Eleven studies were conducted in the USA, seven in Canada, and one in each of the UK, New Zealand, Sweden, Australia, Japan and the Netherlands.

Studies targeting children aged between 0 and 19 years were eligible for inclusion in the review. Also, communication-based interventions aimed at preventing childhood injuries or changing safety behaviour were eligible for inclusion. Interventions targeted schools, municipalities and cities. Interventions of interest were reviewed under the headings: bicycle injury-prevention studies (12); child motor vehicle restraint studies (5); pedestrian injury prevention studies (4); alcohol-use and vehicle safety studies (3).

The results indicate that community-based interventions are effective in increasing some safety practices, such as increased bicycle helmet use and car seat use for children. This review found that the common themes for successful community-based interventions appeared to be as follows:

- the use of multiple strategies grounded in the theory of behaviour change

- integration of interventions with the community
- community stakeholders included in the development of strategies
- randomised controlled designs used to maximise reliability of the results.

What Works in Preventing Unintentional Injuries in Children and Young Adolescents? An Updated Systematic Review. Towner et al. (2001)

Interventions in the road environment, home environment and leisure environment, and community-based studies were assessed in this systematic review. The review by Dowsell and Towner (2002), summarised above, is a sub-section of this full review. The section on the road environment is relevant to this evidence briefing, and has been categorised into general interventions, pedestrian injury prevention, bicycle injury prevention, car passenger interventions, and bus passenger interventions. The first sub-sections are relevant here. The review addressed the prevention of all unintentional injuries, but only interventions in the general road environment or pedestrian injury prevention studies are considered here.

Studies targeting children under the age of 15 and studies assessing the effectiveness of a range of interventions in the road environment were eligible for inclusion in the review. A total of 155 studies were identified for the whole review. Of these, 29 are appraised here as they are relevant to this briefing. Five were RCTs, eight before-and-after studies, and 16 controlled studies without randomisation. Thirteen studies were conducted in the UK, five in the USA, three in the Netherlands, two in Denmark, two in Australia, two in Canada, one in Japan, and one in Sweden. Primary prevention measures designed to prevent accidents, or secondary prevention measures designed to reduce the impact of accidents, were included. The interventions appraised are transport policies, traffic-calming measures, pedestrian skills training, pedestrian education, and other traffic education programmes.

The results relevant to this evidence briefing were as follows.

- There was one study on transport policy, and there was little evidence in this area.
- One study showed some evidence that school-crossing patrols reduce road traffic accidents.
- Six studies on traffic calming indicated good evidence to suggest that engineering schemes and traffic-calming measures reduce accidents. Area-wide

engineering schemes were found to be cost effective. Some evidence was found for cycle tracks in reducing cycle injuries, but further research is needed.

- Results from 10 studies on pedestrian skills training showed that training programmes improve children's skills, such as timing and crossing the road in a safe place. Practical roadside experience was found to be essential, and more evidence was needed to show if pedestrian skills training reduces childhood injuries.
- Results from five studies on pedestrian education/traffic clubs indicated that school-based programmes are not effective. Children's traffic clubs promoting parental teaching have shown good evidence for behaviour change and there is evidence for casualty reduction, but more research is needed.
- Results from seven studies on other traffic education programmes indicated that road safety programmes combining educational and environmental measures show some potential, but further research is needed. Also, it was found that some measures may be counter-productive and more user involvement during programme design could be of use.

6 Conclusions: evidence and gaps

The findings of the analysis are presented as evidence statements, which we have grouped into three categories: planning and environmental factors and active travel; promoting active travel; making active travel safer. We also discuss areas of common ground and of contradiction revealed by these evidence statements.

Evidence statements

Planning and environmental factors, and walking and cycling

There is review-level evidence that variables in urban form influence levels of walking and cycling. However there is unconvincing evidence about which specific characteristics of the built environment are most strongly associated with physical activity (Handy 2004). There are important confounding factors:

- the relative importance of attitudes and characteristics of the built environment in explaining active travel is unclear and contradictory, eg individuals who are highly motivated to walk may choose to do so regardless of whether the area is attractive for walking
- car ownership is a mediating variable in the relationship between the built environment and physical activity. Individuals without access to a car for personal use are more likely to walk for transportation.

There is review-level evidence on the relationship between environmental attributes at the neighbourhood level and walking. This indicates that:

- there may be positive associations between certain neighbourhood environmental attributes (both perceived and objectively measured) and walking behaviour (Owen et al. 2004; McCormack et al. 2004), non-walking physical activity, and overall physical activity (McCormack et al. 2004)

- the neighbourhood environmental attributes associated with walking may vary according to the reason for walking: whether walking is for exercise or recreation, for getting to and from places, for pleasure, or to meet public health guidelines (Owen et al. 2004)
- the availability, accessibility and convenience of destinations and facilities, as well as the general functionality of the neighbourhood and its aesthetics, are positively associated with various levels of physical activity (McCormack et al. 2004).

Promoting active travel

Behaviour-change programmes promoting walking and cycling and targeted at motivated sub-groups

There is review-level evidence that programmes based on the transtheoretical model of behaviour change, which target people who are motivated to change their transport behaviour through individualised marketing, are effective in achieving a shift from car use to walking and cycling (Ogilvie et al. 2004).

Publicity campaigns, including those using travel coordinators to promote behaviour change

The review-level evidence is inconclusive on the effectiveness of publicity campaigns directed at groups in the population undifferentiated by motivation or personal travel circumstances in achieving a shift from car use to walking and cycling – including campaigns using travel coordinators as ‘agents of change’ (Ogilvie et al. 2004).

Engineering measures

The review-level evidence is inconclusive on the effectiveness of engineering measures – such as creating or improving cycle routes, constructing bypasses, traffic calming, or combinations of these – in achieving a shift from car use to walking and cycling (Ogilvie et al. 2004).

Financial incentives

The review-level evidence is inconclusive on the effectiveness of financial incentives – such as employer subsidies to employees who commute by modes other than driving, and tolls for commuters in cars – in achieving a shift from car use to walking and cycling (Ogilvie et al. 2004).

Providing alternative services

The review-level evidence is inconclusive on the effectiveness of providing alternative services – such as car-sharing cooperatives, access to rail services, and neighbourhood telecommuting centres – in achieving a shift from car use to walking and cycling (Ogilvie et al. 2004).

Making active travel safer

Traffic calming

There is review-level evidence to suggest that area-wide traffic calming in towns and cities may be a promising intervention for reducing the number of road traffic injuries and deaths. However, further rigorous evaluations are needed (Bunn et al. 2003).

There is review-level evidence to suggest that engineering schemes and traffic-calming measures reduce accidents. Area-wide engineering schemes are cost effective. There is also some review-level evidence that cycle tracks reduce cycle injuries. However, further research is needed (Towner et al. 2001).

Impact of new urban roads on safety (accident injuries)

There is review-level evidence showing that new major urban roads have statistically insignificant effects on injury incidence, and that out-of-town bypasses and major new roads connecting urban centres can result in more substantial decreases in accident injuries.

Speed limits

There is review-level evidence showing that speed-limit zones are effective in reducing personal accidents and material damage. Creating raised road surfaces at crossroads may increase accidents, while noisy road surfaces (rumble strips) before crossroads are associated with reductions in accidents. Road humps and differential speed limits may reduce accidents locally, but increase them in surrounding areas.

Street lighting

There is review-level evidence showing that public lighting can reduce night-time accidents (but dependent on baseline risk and proportion of night-time accidents).

Bicycle helmets

There is review-level evidence to suggest that the use of bicycle helmets reduces the risk of head, brain, facial and fatal injuries, but the evidence is unclear or equivocal for neck injuries (Attewell et al. 2001; Towner et al. 2002), and there is very little evidence relating to helmet use and bicycling style (Towner et al. 2002).

Health promotion interventions promoting use of cycle helmets

There is review-level evidence to suggest that bicycle helmet promotion interventions can increase the use of helmets; the greatest effects are shown in younger children and girls. There is further evidence that reducing the costs of helmets through discounts and give-away programmes facilitates uptake and use of helmets (Towner et al. 2002).

There is review-level evidence of sufficient quality that shows school-based education and public/parent education programmes encouraging the use of helmets by children can reduce accident injuries. Health promotion and community-based programmes promoting helmet use (among 15–25 year olds) can also reduce accident injuries.

There is review-level evidence on the effectiveness of cycle helmet legislation for reduction in head injuries; when combined with educational activities, legislation is an effective means of increasing observed helmet use. However, compulsory helmet use may lead to decreased bicycle use (Towner et al. 2002).

Visibility aids

There is review-level evidence that visibility aids can increase visibility and enable drivers to detect pedestrians and cyclists earlier, but there is a lack of evidence for the effect of visibility aids on pedestrian and cyclist safety (Kwan and Mapstone 2002).

Inequalities

There is a lack of review-level evidence for the effectiveness of interventions to reduce inequalities in road injury rates in children under the age of 15 (Dowswell and Towner 2002).

Road safety training and education programmes

There is review-level evidence that training programmes improve children's skills, such as timing and crossing the road in a safe place. Also, practical roadside experience is essential (Towner et al. 2001).

There is review-level evidence to suggest that school-based pedestrian education programmes are not effective, but children's traffic clubs promoting parental teaching are effective in behaviour change. The evidence also shows casualty reduction, but more research is needed (Towner et al. 2001).

There is review-level evidence that road safety programmes combining educational and environmental measures show some potential for reducing childhood accidents, but further research is needed (Towner et al. 2001).

There is review-level evidence to suggest that safety education can improve children's knowledge and can change observed road-crossing behaviour, but it is difficult to predict what effect this might have on risk of pedestrian injury. The evidence also indicates that behaviour change and knowledge decline over time, suggesting that safety education must be repeated at regular intervals (Dupperex et al. 2002).

Community-based interventions with multiple strategies

There is review-level evidence to suggest that community-based interventions are effective in increasing some safety practices, such as increased bicycle helmet use and use of car seats for children (Klassen et al. 2000).

Common ground, missed opportunities and contradictions in the evidence

The relationship between active travel and the actual and perceived safety of cycling and walking is one of the focuses of this briefing. It is noteworthy that similar interventions have been used to achieve different aims: eg, engineering measures such as traffic calming, cycle routes and lanes, and bypasses have been used both to reduce accidents and encourage walking and cycling. Unfortunately, this review has found that intervention studies have tended to concentrate on only one set of outcomes. Generally, opportunities have also been missed to investigate whether road safety interventions might also have an impact on travel behaviour, whether positive

or negative. For example, there is evidence quoted above that a safety intervention – compulsory cycle helmet use – may lead to decreased bicycle use.

Gaps in the evidence

There is very little review-level evidence of sufficient quality that addresses the specific research questions:

- what transport interventions are effective in increasing active travel, specifically walking and cycling?
- what transport interventions are effective in increasing the safety of walking and cycling?

This reflects, in part, the very limited amount of primary evaluation research on the impact of developments and changes in transport systems with respect to health and physical activity. There are very few primary studies of sufficient quality on the effectiveness of 'transport' interventions on walking and cycling in the general population or different population groups. The majority of studies in this area are based on observational designs, and have not identified physical activity, specifically walking and cycling, as outcome measures. The impact of changes in transport systems has been evaluated using injuries and accidents as the principal outcome measures.

The research agenda in this field is therefore significant. Although research interest and efforts are growing, this agenda needs to be addressed through cross-discipline collaboration between transport, planning and public health.

Based on this review of reviews, the following research priorities are identified.

- A common theoretical framework is required for identifying transport and related environmental characteristics, and their influence on physical activity, specifically walking and cycling; and for the design and evaluation of 'transport interventions' that promote increases in walking and cycling.
- This should make clear what constitutes a 'transport intervention', including the potential health consequences of various modes of travel involved in different types of journey.
- Research is required to determine what transport and related environmental attributes and interventions are important in influencing different types of travel and physical activity, at a population level and with respect to different population groups. This should include

work to define more systematically the rather disparate environmental attributes identified in studies to date (Box 4, page 23).

Bauman (2005) speculates that future research, with better measurement of environmental attributes (both objective and subjective) and better analytical methods, will serve to reinforce identified associations between walking and physical activity, and perhaps show better evidence of causality through longitudinal studies. But the limitations of such studies need to be addressed: lack of evidence of causality, likelihood of self selection, activity substitution, and lack of standardisation of measures (Ewing 2005).

Study designs need to be considered that can address areas of bias and confounding, and that can investigate decisions about residential location, car ownership, and the role of preferences and perceptions – including attitudes to cars and bicycles – on these decisions. There needs to be a move towards the use of quasi-experimental designs for evaluation of transport and related environmental interventions.

Transport policy is ahead of the evidence base on what works in promoting walking and cycling. A range of transport policies and initiatives have the explicit or implicit aim of increasing levels of walking and cycling, as well as achieving other health, social and economic outcomes. It is important that the impact of such policies and initiatives on walking and cycling is evaluated. Many of these transport policy interventions constitute natural experiments. Their effects on population health – particularly their impact on walking and cycling – should be evaluated using well designed prospective (and, where appropriate, controlled) studies. Box 2 (page 14) provides examples of opportunities for such natural experiments, and the potential to examine health outcomes as well as other social and economic consequences. Examples of important research questions include:

- What is the impact of new city-wide transport policies and plans, which incorporate anti-congestion measures, on modes of active travel (walking and cycling)?
- To what extent do measures to reduce road accidents increase the actual and perceived safety of pedestrians and cyclists?
- What features of more attractive urban environments and different neighbourhood designs are effective in increasing levels of walking and cycling?

- What is the impact on travel and physical activity of improvements in transport systems as part of regeneration initiatives, including their differential impact across population groups and communities?

Transport policies should be subject to more systematic use of health impact assessment. The negative consequences, such as those highlighted in section 3, should be averted or minimised.

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Appendix 1 Search strategy

Safety and active travel

The search strategy adopted is presented for MEDLINE, and was adapted accordingly for each database.

- 1 ACCIDENTS, TRAFFIC/
- 2 ((prevent\$ or decreas\$ or reduc\$ or minimi\$) adj4 (traffic or road or vehicle?) adj4 (accident\$ or injur\$ or death? or morbidity)).mp.
- 3 ((prevent\$ or decreas\$ or reduc\$ or minimi\$) adj4 hospital admission?).mp.
- 4 ((increas\$ or enhanc\$ or improv\$ or develop\$) adj4 (traffic or road or vehicle?) adj4 safety).mp.
- 5 (safe adj3 sound).mp. [mp = title, abstract, subject headings, drug trade name, original title, device manufacturer, drug manufacturer name]
- 6 ((prevent\$ or decreas\$ or reduc\$ or minimi\$) adj4 (dangerous driver\$ or dangerous driving)).mp.
- 7 ((improv\$ or enhanc\$) adj4 (driver or drivers)).mp.
- 8 (seatbelt? or seat belt? or car seat\$).mp.
- 9 ((increas\$ or enhanc\$ or improv\$) adj4 road marking?).mp.
- 10 ((increas\$ or enhanc\$ or improv\$) adj4 (street lights or street lighting)).mp.
- 11 (home zone or home zones or safer routes).mp.
- 12 ((road or railway) adj crossing).mp.
- 13 (speed adj4 (restrict\$ or camera\$ or bump or bumps or limit or limits or zone or zones)).mp.
- 14 (danger adj4 (road or rail or transport or traffic)).mp.
- 15 (drink driving or (driving adj4 alcohol\$)).mp. [mp = title, abstract, subject headings, drug trade name, original title, device manufacturer, drug manufacturer name]
- 16 road space.m. [mp = title, abstract, subject headings, drug trade name, original title, device manufacturer, drug manufacturer name]
- 17 traffic calming.m.
- 18 or/1-17

- 19 (metaanalys\$ or meta-analys\$ or meta analys\$ or cochrane).ti,ab.
- 20 (review\$ or overview\$).ti.
- 21 review.pt.
- 22 (synthes\$ adj4 (literature\$ or research\$ or studies or data)).ti,ab.
23. pooled analys\$.ti,ab.
- 24 (medline or medlars or embase or cinahl or scisearch or psychinfo or psycinfo or psychlit or psyclit).ti,ab.
- 25 ((hand or manual or database\$ or computer\$) adj4 search\$).ti,ab.
- 26 ((electronic or bibliographic\$) adj4 (database\$ or database\$)).ti,ab.
- 27 ((review\$ or overview\$) adj4 (systematic\$ or methodologic\$ or quantitativ\$ or research or literature\$ or studies or trial\$ or effective or effectiveness)).ab.
- 28 or/19-27
- 29 18 and 28
- 30 exp ASIA/
- 31 exp AFRICA/
- 32 exp South America/
- 33 exp Developing Countries/
- 34 or/30-33
- 35 29 not 34
- 36 limit 35 to (human and english language and yr = 1996-2005)

Walking/cycling

- 1 ((promot\$ or encourag\$ or increas\$ or enhanc\$ or improv\$ or develop\$) adj4 (safety or safe) adj4 (cycle or cyclist? or cycling or bicycle or bicyclist or bicycling or pedestrian? or walk or walking)).mp.
- 2 (cycle path\$ or cycle lane? or cycle route?).mp.
- 3 (sidewalk? or pavement?).mp.

4 ((walk or walking or pedestrian?) adj4 (strategy or strategies or policy or policies or initiative? or scheme? or program\$ or legislation or service?)).mp.

5 ((cycle or cyclist? or cycling or bicycle or bicyclist or bicycling) adj4 (strategy or strategies or policy or policies or initiative? or scheme? or program\$ or legislation or service?)).mp.

6 health walk\$.mp.

7 ((prevent\$ or decreas\$ or reduc\$ or discourag\$) adj4 (cycle or cyclist? or cycling) adj4 (accident\$ or injur\$)).mp.

8 ((prevent\$ or decreas\$ or reduc\$ or discourag\$) adj4 (pedestrian? or walk or walking) adj4 (accident\$ or injur\$)).mp.

9 (((prevent\$ or decreas\$ or reduc\$ or discourag\$) adj4 (obesity or weight)) and (cycling or walking)).mp. [mp = title, abstract, subject headings, drug trade name, original title, device manufacturer, drug manufacturer name]

10 (((prevent\$ or decreas\$ or reduc\$ or discourag\$) adj4 (heart disease or stroke)) and (cycling or walking)).mp.

11 ((education or awareness or campaign\$ or training) adj4 (cyclist? or pedestrian?)).mp.

12 or/1-11

13 (metaanalys\$ or meta-analys\$ or meta analys\$ or cochrane).ti,ab.

14 (review\$ or overview\$).ti,ab.

15 review.pt.

16 (synthes\$ adj4 (literature\$ or research\$ or studies or data)).ti,ab.

17 pooled analys\$.ti,ab.

18 (medline or medlars or embase or cinahl or scisearch or psychinfo or psycinfo or psychlit or psyclit).ti,ab.

19 ((hand or manual or database\$ or computer\$) adj4 search\$).ti,ab.

20 ((electronic or bibliographic\$) adj4 (database\$ or database\$)).ti,ab.

21 ((review\$ or overview\$) adj4 (systematic\$ or methodologic\$ or quantitativ\$ or research or literature\$ or studies or trial\$ or effective or effectiveness)).ab.

22 or/13-21

23 12 and 22

24 exp ASIA/

25 exp AFRICA/

26 exp South America/

27 exp Developing Countries/

28 or/24-27

29 23 not 28

30 limit 29 to yr = 1996-2005

31 limit 30 to (human and english language)

• references followed up	Yes	No	Unsure
• experts consulted	Yes	No	Unsure
• grey literature searched	Yes	No	Unsure
• search terms specified	Yes	No	Unsure
• inclusion criteria described	Yes	No	Unsure
Is it worth continuing?	Yes	No	Why/why not?

Quality

Did the authors assess the quality (rigour) of the studies included? Yes No Unsure

Consider whether the following are used:

- | | | | |
|--------------------------|-----|----|--------|
| • a rating system | Yes | No | Unsure |
| • more than one assessor | Yes | No | Unsure |

If study results have been combined, was it reasonable to do so? Yes No Unsure

Consider whether the following are true:

- | | | | |
|--|-----|----|--------|
| • are the results of included studies clearly displayed? | Yes | No | Unsure |
| • are the studies addressing similar research questions? | Yes | No | Unsure |
| • are the studies sufficiently similar in design? | Yes | No | Unsure |
| • are the results similar from study to study (test of heterogeneity)? | Yes | No | Unsure |
| • Are the reasons for any variation in the results discussed? | Yes | No | Unsure |

What is the overall finding of the review? Consider:

- how the results are expressed (numeric, relative risks, etc)
- whether the results could be due to chance (p-values and confidence intervals)

Are sufficient data from individual studies included to mediate between data and interpretation/conclusions? Yes No Unsure

Does this paper cover all appropriate interventions and approaches for this field (within the aims of the study)? Yes No Unsure

If no, what?

Relevance to UK

Can the results be applied/are they generalisable to a UK population/population group? Yes No Unsure

Are there cultural differences from the UK? Yes No Unsure

Are there differences from the UK in healthcare provision? Yes No Unsure

Is the paper focused on a particular target group (age, sex, population sub-group, etc)? Yes No Unsure

Accept for inclusion onto HDA Evidence Base? Yes No Refer to third party

Additional comments:

Appendix 3 Characteristics of review-level papers included in the evidence base

Author (year)	Objective	Number and type of studies included	Setting	Participants	Intervention	Findings
Morrison et al. (2003)	To review systematic review literature that describes the effectiveness of transport interventions in improving population health	28 systematic reviews, published and unpublished, in any language, measurement of health effects of any mode of transport intervention Health effects included social, psychological, and physical effects	Not stated	Specific to individual reviews	Any mode of transport or transport policy with effects on health: health promotion engineering environmental legislative All reviews were concerned with injury prevention; all but four were concerned with prevention of motor car injuries	Three reviews (quality rated at least 6) fell within our inclusion criteria and had bearing on conditions for safe cycling and walking. These reviews showed: school-based and public/parent education encouraging use of bicycle helmets reduced hospital in-patient rates for bicycle injuries by up to 0.2% more than the control group bicycle and motorcycle helmets reduced head and other injuries (15–25 year olds); motorcycle legislation was followed by a 30% reduction in fatalities and its repeal by an increase of 25–40% area-wide traffic-calming reduces the number of accidents by a mean of 15% in the whole area affected by the measures (main roads and local roads combined); effects relatively constant in different countries and different years no evidence to suggest any interventions will bring about a shift in the use of different modes of transport and consequently health in a broader way

Author (year)	Objective	Number and type of studies included	Setting	Participants	Intervention	Findings
Ogilvie et al. (2004)	To review experimental or observational studies in order to assess what interventions are effective in promoting a population shift from using cars towards walking and cycling, and the health effects of such interventions	22 studies; published and unpublished in any language, experimental or observational studies with prospective or controlled retrospective design Effects include changes in the distribution of choice of transport mode; effects on health, fitness, health-related behaviour or wellbeing; and distribution of effects among social groups	Scotland, England, Denmark, Norway, Netherlands, Germany, Australia, USA	Various defined populations and population sub-sets specific to each study (including a motivated sub-group of commuters; commuters to particular workplaces; households; school pupils; people in urban neighbourhoods and small towns)	Targeted behaviour-change programmes (directed at motivated sub-groups); publicity campaigns plus agents of change; engineering measures; financial incentives; providing alternative services	Studies showed that behaviour change programmes targeted at motivated sub-groups can be effective: a self-help pack for commuters identified as contemplating or actively preparing to change their behaviour resulted in a reported increase in mean time spent walking to work each week (1.93 times greater in intervention group than in control group) three interventions involving individualised marketing of alternative modes of transport to households showing an interest in using them resulted in a net positive shift towards walking and cycling ranging from 3.6 to 5.5% volunteer motorists invited to try to use bicycle and bus as much as possible in exchange for a free bicycle, free bus pass and other accessories and information for 1 year reported a positive shift of 25% of all weekday trips after 11 months tailored feedback to households in two areas on changing travel patterns resulted in reported small changes in walking trips, and larger but inconsistent changes in cycling trips, after 1 month Evidence on the effectiveness of the following types of intervention is inconsistent, of low validity based on single highly contextual studies, or non-existent: publicity campaigns, including those using travel coordinators to promote behaviour change; engineering measures; financial incentives; providing alternative services

Author (year)	Objective	Number and type of studies included	Setting	Participants	Intervention	Findings
Egan et al. (2003)	To systematically review primary (observational) studies of health effects of construction of new roads	32 studies, any language, range of study designs Studies 1962–2002	UK, Australia, Norway, New Zealand, Denmark, Germany, Sweden	Affected local residents	New road construction interventions concerned with injury reduction, disturbance and community severance None of the studies examined impact on access to healthcare, health inequalities or physical activity	12 studies concerned with injury prevention fell within our inclusion criteria; these covered major urban roads (four), out-of-town bypasses (five), major connecting roads between towns (three) The studies showed that: new major urban roads resulted in variable and limited reductions in the incidence of injury accidents (1–8.5%), with the exception of improvements made to a single urban road in Norway that estimated a major decrease in accident injuries of 51% (95% CI = 27, 68%) out-of-town bypasses reduce incidence of injury accidents on main routes through or around towns (two studies showed statistically significant reduction of 25 and 33%) major new roads connecting urban centres are associated with significant decreases in accident injuries (two studies showed statistically significant results ranging from 19–32%)
Handy (2004)	To provide a theoretical framework and to review and evaluate empirical evidence on the relationship between the built environment and physical activity behaviours	22 studies from travel behaviour literature and 28 from physical activity literature Most studies used cross-sectional design Not experimental in the main; bias a major issue	Wide range of developed countries	Majority of studies not specific interventions but focusing on associations between transport/land use and physical activity and potential design features for promoting physical activity, including walking and cycling	Relationship between measures of travel behaviour and measures of the built environment Relationship between measures of physical activity and measures of the built environment	Accessibility is a strong correlate of away-from-home physical activity Importance of design measures in the built environment ambiguous, may be more important for physical activity nearer home Individual and interpersonal factors potentially more important than the built environment in explaining physical activity Supportive built environment not enough on its own to ensure physical activity, but does facilitate physical activity

Author (year)	Objective	Number and type of studies included	Setting	Participants	Intervention	Findings
McCormack et al. (2004)	To update evidence on the association between the physical environment and physical activity behaviour To examine the concept of context-specific physical activity behaviour by examining independently environmental factors that influence walking for recreation and transport; non-walking moderate and vigorous-intensity physical activity; and overall levels of physical activity	34 quantitative studies; study design unspecified; dating from 2000 Studies with any measure of physical activity as an outcome, correlate or predictor variable, regardless of the behaviour's purpose Studies had to have collected self-reported or objectively measured environmental data having associations with physical activity measures	Unspecified but predominantly USA	Unspecified neighbourhoods	Range of physical environmental attributes summarised as: functionality safety aesthetics destinations	Evidence from 34 studies suggests that: both perceived and objectively measured physical environmental attributes of neighbourhoods are positively associated with walking; non-walking moderate and vigorous-intensity physical activity; and overall levels of physical activity availability, accessibility and convenience of destinations and facilities, as well as general functionality of the neighbourhood and its aesthetics, are positively associated with various levels of physical activity mixed evidence in relation to safety, suggesting a need to measure both personal safety and safety from traffic: people who perceived that there was busy or 'bothersome' traffic appeared more likely to walk; evidence for a negative relationship between perceptions of crime and participation in physical activity
Owen et al. (2004)	Review of quantitative studies examining relationships of perceived and objectively assessed local or neighbourhood environmental attributes with the walking behaviour of adults	18 quantitative studies of either cross-sectional (16) or prospective design (2); using any type of walking as the main outcome variable, if the independent variables included environmental attributes, whether measured objectively or by self-report Types of walking include 'neighbourhood walking' (for exercise or recreation); 'total walking' (sufficient to meet public health guidelines); walking to get to and from places; and 'social walking' (for pleasure)	Unspecified but predominantly USA	Unspecified neighbourhoods	Range of environmental attributes relating to aesthetic attributes, convenience of facilities for walking, accessibility of destinations, perceptions about traffic and busy roads	Assessment of 18 studies: modest but consistent body of evidence indicating patterns of positive relationships between local or neighbourhood environmental attributes and walking for particular purposes most studies found environmental attributes to be associated with walking for exercise, recreation, or total walking while there is some overlap, environmental attributes found to be associated with walking to get to and from places differed from those associated with walking for exercise and recreation

Author (year)	Objective	Number and type of studies included	Setting	Participants	Intervention	Findings
Bunn et al. (2003)	To evaluate the effectiveness of area-wide traffic calming in preventing traffic-related crashes, injuries and deaths	No RCTs located 16 before-and-after studies were found, all were deemed to be of adequate quality Databases searched in 2000/01	Germany (seven) UK (six) Australia (two) Netherlands (one)	Areas covering a different number of streets, including residential and main roads treated with traffic-calming measures, eligible for inclusion	Area-wide traffic-calming measures designed to discourage use of residential streets for through travel, eg: vertical and horizontal shifts in traffic optical measures redistribution of traffic/ alteration to road hierarchy changes to road environment Interventions such as enforcement of legal interventions or effects of public transport excluded	No RCTs identified. Area-wide traffic-calming measures are promising for reducing road traffic injuries and deaths; however, further (rigorous) research is required For pooled rate ratios see page 31 Significant heterogeneity present for total number of crashes, deaths and injuries outcomes
Dupperrex et al. (2002)	To quantify the effectiveness of pedestrian education programmes in: preventing pedestrian-motor collisions and changing behaviour, attitude and knowledge of pedestrians	Only RCTs eligible for inclusion: 15 were identified, all of generally poor methodological quality Databases searched to May 2003	UK (eight) Australia (one) Germany (one) USA (three) Japan (one) Canada (one)	N = 3754 (plus one extra study with numbers not reported) Interventions targeted at any pedestrians, of all ages, eligible for inclusion Participants in 14/15 RCTs identified were children	Any pedestrian safety education programmes eligible for inclusion	Pedestrian safety education can result in improvement in knowledge and change in observed road-crossing behaviour. It is difficult to predict what effect this might have on pedestrian injuries. There is evidence that behaviour change and knowledge decline over time, so education programmes should be repeated at regular intervals
Kwan and Mapstone (2002)	To assess the effect of visibility aids on the occurrence of pedestrian and cyclist-motor vehicle collisions (primary objective) and on drivers' detection and recognition responses (secondary objective)	Studies included only if an RCT or a controlled before-and-after study 37 trials included that addressed the secondary objective; no trials were found assessing the effect of visibility aids on rates of pedestrian or cyclist-motor collisions or injuries Databases searched to 2001	USA (19) UK (five) Australia (three) Netherlands (three) South Africa (two) Israel (two) Canada (one) Sweden (one) Finland (one) Six studies were laboratory-based, the remaining 31 road-based simulations	Studies including any pedestrians, cyclists or drivers eligible for inclusion. Studies of observers inside a vehicle or observers of slides or video simulation of a car journey also eligible. 882 participants aged 17-77. The smallest trial included four observers; the largest, 645 observers	Any studies comparing daytime or night-time visibility aids used on bicycles and by pedestrians/cyclists The following study designs were eligible: any visibility aid vs none comparison of different visibility aids comparison of positioning of visibility aids	No studies were identified that addressed the primary objective of this review. 37 other trials were identified in relation to the secondary objective. Results reported in a narrative synthesis combined according to type of intervention: daytime visibility aids; night-time visibility aids. The results suggest that visibility aids have the potential to increase visibility and enable drivers to detect pedestrians and cyclists sooner. The effect of visibility aids on the safety of pedestrians and cyclists remains unknown. Studies that collect data on more meaningful outcomes are required

Author (year)	Objective	Number and type of studies included	Setting	Participants	Intervention	Findings
Attewell et al. (2001)	To quantify the efficacy of bicycle helmets in preventing serious injury to cyclists	Studies had to: be in English in a peer-reviewed journal, include sufficient detail to construct a 2x2 table, exclude laboratory or population studies (design not specified) 16 studies included (1987–98): case-control studies, surveys and data set analyses Databases searched to 1999	Australia (four) USA (nine) UK (one) Canada (two)	N = 17,289 Mixture of interventions targeted at child-only, adult-only, or all cyclist populations No inclusion/exclusion criteria reported	Cycle helmets in preventing serious injury to the head, face and brain. Neck injuries and fatalities were also reported in some studies and subsequently analysed in the review	Evidence demonstrates that cycle helmets prevent serious injury and death. Helmet use is 'sub-optimal' and use for all bicycle riders should be encouraged. For odds ratios see page 32 Random effects model was used for each outcome. Statistically significant heterogeneity was found for head, brain and face outcomes, as well as potential publication bias
Towner et al. (2002)	To assess the effectiveness of cycle helmets in reducing injuries (using observational studies) Based on an update of Towner et al. (2000)	Comparative observational studies included to assess the efficacy of bicycle helmets A total of 16 studies identified but two were from the same data set, therefore 15 were included	USA (eight) Australia (four) Canada (two) UK (one)	No specific inclusion criteria with relation to participants. Studies assessing efficacy of bicycle helmets for any cyclists eligible	No specific inclusion criteria relating to the interventions reported Studies assessing the efficacy of any bicycle helmet were eligible	Results presented as a narrative synthesis Observational studies demonstrated evidence that bicycle helmets are effective in reducing incidence and severity of injuries to the head, brain and upper face Bicycle helmets are effective in reducing injury rates for people of all ages, especially children There is equivocal evidence in relation to helmet use and neck injury rates
Towner et al. (2002)	To assess the effectiveness of cycle helmet promotion interventions Based on an update of Towner et al. (2000)	A variety of study designs assessing interventions were used A total of 19 studies included: six RCTs, nine controlled trials, one before-and-after, three 'other'	USA (nine) Australia (one) Canada (five) UK (two) Sweden (one) New Zealand (one)	Studies targeting children under the age of 15 and adults eligible for inclusion	Studies relating to promotion of bicycle helmets eligible	Most helmet promotion interventions were targeted at children Campaigns can increase the use of helmets; younger children and girls showed the greatest effects from the campaigns There is evidence that reducing the cost of helmets or using give-away programmes increases uptake and use of helmets
Towner et al. (2002)	To assess the effectiveness of cycle helmet legislation Based on an update of Towner et al. (2000)	A variety of study designs assessing interventions were used A total of 13 studies included: nine before-and-after, three controlled trials, one survey	USA (six) Australia (four) Canada (two) New Zealand (one)	Studies targeting children under the age of 15 and adults were eligible for inclusion	Studies assessing the effectiveness of bicycle helmet legislation were eligible	Evidence suggests that helmet legislation has been associated with reductions in head injuries Legislation in combination with educational activities is an effective way to increase observed helmet use Compulsory helmet wearing may lead to decreased bicycle use

Author (year)	Objective	Number and type of studies included	Setting	Participants	Intervention	Findings
Dowswell and Towner (2002)	To answer the question: 'How effective are health promotion interventions in preventing unintentional injuries in childhood and young adolescence', with particular reference to social deprivation Based on a subset of studies from Towner et al. (2000)	16 studies evaluated interventions in the road environment and are relevant here Studies had to be in English and published between 1975 and 2000 describe an intervention aiming either to prevent accidents or reduce the severity of injuries Six RCTs, eight controlled trials, two before-and-after studies included Databases searched until June 2000	UK (one) Canada (five) USA (10)	All programmes were targeted at children under the age of 15 and addressed issues of social deprivation	Studies describing a primary intervention aimed to prevent accidents occurring, or a secondary intervention aimed to prevent or reduce the severity of injuries	32 studies addressed issues of social deprivation – of these 16 are relevant to this review For injuries in the road there is a paucity of evidence on social deprivation issues. The limited evaluations generally target individual behaviour change rather than environmental change
Klassen et al. (2000)	To evaluate the impact of community-based injury-prevention interventions on childhood injuries, safety behaviours and the adoption of safety devices	Studies were included only if they included a control group that received no intervention: 32 RCTs and non-RCTs were included, 24 of which are relevant here Databases searched to 1998	Canada (seven) USA (11) UK (one) New Zealand (one) Sweden (one) Australia (one) Japan (one) Netherlands (one)	Interventions targeted at children between 0 and 19 years of age eligible for inclusion	Any communication-based intervention aimed at preventing childhood injuries or changing safety behaviour Interventions of interest were reviewed under the headings: bicycle injury-prevention studies (12) child motor-vehicle restraint studies (five) pedestrian injury-prevention studies (four) alcohol-use and vehicle safety studies (three)	Results suggest that community-based interventions are effective in increasing some safety practices such as increased bicycle helmet use and car-seat use for children. Common themes for successful community-based interventions: use of multiple strategies grounded in the theory of behaviour change integration of interventions with the community community stakeholders included in development of strategies RCT designs used to maximise reliability of results

Author (year)	Objective	Number and type of studies included	Setting	Participants	Intervention	Findings
Towner et al. (2001)	To answer the question: How effective are health promotion interventions in preventing unintentional injuries in childhood and young adolescence? Addressed prevention of all unintentional injuries; only interventions in the general road environment or pedestrian injury prevention studies are considered here	A variety of study designs assessing interventions used to assess the effectiveness of interventions in the road environment A total of 155 studies identified for the whole review, of which 29 are appraised here: five RCTs, eight before-and-after studies, 16 controlled studies (without randomisation)	UK (13) USA (five) Netherlands (three) Denmark (two) Australia (two) Canada (two) Japan (one) Sweden (one)	Studies targeting children under the age of 15 were eligible for inclusion	Studies assessing the effectiveness of a variety of interventions in the road environment were eligible Primary prevention measures designed to prevent accidents, or secondary prevention measures designed to reduce the impact of accidents, included Studies assessing the following interventions are appraised here: transport policies; traffic-calming measures; pedestrian skills training; pedestrian education (traffic clubs); other traffic education	Transport policies (one study): there is very little evidence in this area; only one study demonstrated some evidence that school-crossing patrols have reduced road traffic accidents Traffic calming (six studies): there is good evidence that engineering schemes and traffic-calming measures reduce accidents; area-wide engineering schemes are cost effective; there is some evidence that cycle tracks reduce cycle injuries, however further research is needed Pedestrian skills training (10 studies): training programmes improve children's skills such as timing and crossing the road in a safe place; practical roadside experience is essential; more evidence is needed to show if pedestrian skills training reduces child injuries Pedestrian education-traffic clubs (five studies): school-based programmes have not been shown to be effective; children's traffic clubs promoting parental teaching have shown good evidence of behaviour change; there is evidence of casualty reduction, but more research is needed Other traffic education (seven studies): road safety programmes that combine educational and environmental measures show some potential, but further research is needed; some measures may be counter-productive; more user involvement during programme design could be of use

Appendix 4 Summary of critical appraisal findings of papers excluded from the briefing

Author (date)	Stage 1						Stage 2					
	Specifies clear, relevant aim or research question	Identifies appropriate range of source databases	Undertakes additional search strategies	Specifies search terms	Specifies inclusion/exclusion criteria	Rigour of individual studies assessed	Individual studies' findings presented clearly and consistently	Individual studies' findings analysed clearly and consistently	Conclusions presented relate to individual studies' findings			
Centers for Disease Control and Prevention (2001)	X (guidance for prevention of unintentional injuries in general)	X	X	X	X	-	-	-	-			
Coffman (2003)	X (does not meet inclusion criteria)	✓	X	X	X	-	-	-	-			
Crane (2000)	✓	X	X	X	X							
Dowd et al. (2002)	X (not systematic review)	X	X	X	X	-	-	-	-			
Ewing (2001)	✓	X	X	X	X							
Frank (2004)	✓	X	X	X	X							
Hamilton and Stott (2004)	X (not systematic review)	X	X	X	X	-	-	-	-			
Jacobsen (2003)	X (not a review; an analysis of five data sets)	X	X	X	X	-	-	-	-			
Koepsell et al. (2002)	X (does not meet inclusion criteria)	X	X	X	X	-	-	-	-			
Kwan and Mapstone (2004)	X (repeat of 2002 paper included in evidence base)	✓	✓	✓	✓	✓	✓	✓	✓			

Author (date)	Stage 1						Stage 2				
	Specifies clear, relevant aim or research question	Identifies appropriate range of source databases	Undertakes additional search strategies	Specifies search terms	Specifies inclusion/exclusion criteria	Rigour of individual studies assessed	Individual studies' findings presented clearly and consistently	Individual studies' findings analysed clearly and consistently	Conclusions presented relate to individual studies' findings		
Margolis et al. (2000)	X (does not meet inclusion criteria)	X	X	X	X	-	-	-	-		
Peek-Asa and Zwerling (2003)	X (not systematic review)	X	X	X	X	-	-	-	-		
Retting (1999)	X (not systematic review)	X	X	X	X	-	-	-	-		
Retting et al. (2003)	X (does not meet inclusion criteria)	X	X	✓	✓	-	-	-	-		
Rivara et al. (1998)	X (not systematic review)	X	X	X	X	-	-	-	-		
RoSPA (2001)	X (not systematic review)	X	X	X	X	-	-	-	-		
Steer Davies Gleave (2001)	✓	X	X	X	X						