INTERVENTIONS TO PREVENT UNINTENTIONAL INJURY IN CHILDREN ON THE ROAD

Report 1:

Systematic reviews of effectiveness and cost-effectiveness of road and street design-based interventions aimed at reducing unintentional injuries in children

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PRODUCED BY: Peninsula Technology Assessment Group (PenTAG), Peninsula Medical School, Universities of Exeter and Plymouth.

AUTHORS:
Kate Ashton, Associate Research Fellow, PenTAG
Tiffany Moxham, Information Specialist, PenTAG
Julie Frier, Specialist Registrar in Public Health, PenTAG
Gabriel Rogers, Research Fellow, PenTAG
Ruth Garside, Senior Research Fellow, PenTAG
Rob Anderson, Senior Lecturer, PenTAG

CORRESPONDENCE TO:
Kate Ashton
PenTAG, Noy Scott House, Barrack Road, Exeter, EX2 5DW
Kate.Ashton@pms.ac.uk

About the Peninsula Technology Assessment Group (PenTAG)

The Peninsula Technology Assessment Group is part of the Institute of Health Service Research at the Peninsula Medical School. PenTAG was established in 2000 and carries out independent Health Technology Assessments for the UK HTA Programme, systematic reviews and economic analyses for the NICE (Technology Appraisal and Centre for Public Health Excellence) and systematic reviews as part of the Cochrane Collaboration Heart Group, as well as for other local and national decision-makers. The group is multi-disciplinary and draws on individuals' backgrounds in public health, health services research, computing and decision analysis, systematic reviewing, statistics and health economics. The Peninsula Medical School is a school within the Universities of Plymouth and Exeter. The Institute of Health Research is made up of discrete but methodologically related research groups, among which Health Technology Assessment is a strong and recurring theme. Projects to date include:

- Barriers to and facilitators for the effectiveness of multiple risk factor programmes aimed at reducing cardiovascular disease within a given population: a systematic review of qualitative research (2009).
- Population and community programmes addressing multiple risk factors to prevent cardiovascular disease: a qualitative study into how and why some programmes are more successful than others (2009)
- Barriers to and facilitators of conveying information to prevent first occurrence of skin cancer: a systematic review of qualitative research (2009)
- The Effectiveness and Cost-Effectiveness of Cochlear Implants for Severe to Profound Deafness in Children and Adults: A Systematic Review and Economic Model (2008)
- The Effectiveness and Cost-Effectiveness of Methods of Storing Donated Kidneys from deceased donors: A Systematic Review and Economic Model (2008)
- Bevacizumab, sorafenib tosylate, sunitinib and temsirolimus for renal cell carcinoma: A systematic review and economic model (2008)
- The Effectiveness and Cost-Effectiveness of Cinacalcet for Secondary Hyperparathyroidism in end stage renal disease patients on dialysis. Systematic Review And Economic Evaluation (2007)
- The effectiveness and cost-effectiveness of Carmustine Implants and Temozolomide for the treatment of newly-diagnosed High Grade Glioma. Systematic Review And Economic Evaluation (2007)
- The Effectiveness and Cost-Effectiveness of Cardiac Resynchronisation Therapy for Heart Failure. Systematic Review and Economic Evaluation (2007)
- Inhaled Corticosteroids and Long-Acting Beta2-Agonists for The Treatment of Chronic Asthma in Adults and Children Aged 12 Years and Over: a Systematic Review and Economic Analysis (2007)
- Inhaled Corticosteroids and Long-Acting Beta2-Agonists for The Treatment of Chronic Asthma an Children Under the Age of 12 Years: a Systematic Review and Economic Analysis (2007)
- The Cost-Effectiveness of testing for hepatitis C (HCV) in former injecting drug users. Systematic Review And Economic Evaluation. (2006)
- Do The Findings Of Case Series Studies Vary Significantly According To Methodological Characteristics?(2005)

- The Effectiveness And Cost-Effectiveness Of Pimecrolimus And Tacrolimus For Atopic Eczema - A Systematic Review And Economic Modelling (2005)
- The Effectiveness And Cost-effectiveness Of Dual Chamber Pacemakers Compared To Single Chamber Pacemakers For Bradycardia Due To Atrioventricular Block Or Sick Sinus Syndrome - Systematic Review And Economic Evaluation (2005)
- The Effectiveness and Cost-Effectiveness Of Surveillance Of Barrett's Oesophagus: Exploring The Uncertainty (2005)
- The Effectiveness And Cost-Effectiveness Of Microwave And Thermal Balloon Endometrial Ablation For Heavy Menstrual Bleeding - A Systematic Review And Economic Modelling (2004)
- Systematic Review Of Endoscopic Sinus Surgery For Nasal Polyps (2003)
- The Effectiveness And Cost-Effectiveness Of Imatinib For First Line Treatment Of Chronic Myeloid Leukaemia In Chronic Phase (2003)
- The Effectiveness And Cost-Effectiveness Of Imatinib (STI 571) In Chronic Myeloid Leukaemia - A Systematic Review (2002)
- Screening For Hepatitis C Among Injecting Drug Users And In Genitourinary Medicine (GUM) Clinics - Systematic Reviews Of Effectiveness, Modelling Study And National Survey Of Current Practice (2002)
- The Effectiveness And Cost-Effectiveness Of Imatinib (STI 571) In Chronic Myeloid Leukaemia - A Systematic Review (2002)
- Screening For Hepatitis C Among Injecting Drug Users And In Genitourinary Medicine (GUM) Clinics - Systematic Reviews Of Effectiveness, Modelling Study And National Survey Of Current Practice (2002)

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Declaration of authors' competing interests

No authors have competing interests.

List of abbreviations

Abbreviation	Meaning
approx.	approximately
B&A	Before and after study
CHEC	A collaborative project led by researchers at the University of Maastricht, which developed a 'criteria list' for assisting with the systematic review of economic evaluations
DETR	Department of the Environment, Transport and the Regions (now DfT)
DfT	Department for Transport (for England)
EV	External validity
GATE	Graphical appraisal tool for epidemiological studies
GSCP	Gloucester Safer City Project
IV	Internal validity
KSI	Killed or seriously injured
km	Kilometre
kph	Kilometres per hour
LAAU	London Accident Analysis Unit
m	Metre
max.	Maximum
min.	Minimum
MLE	Maximum likelihood estimation
mph	Miles per hour
mth	month
NA	Not applicable
No.	Number
Non-RCT	Non-randomised controlled trial
NR	Not reported
OECD	Organisation for Economic Co-operation and Development
OR	Odds ratio
PenTAG	Peninsula Technology Assessment Group
PUIC	Prevention of unintentional injury to children
RaR	Rate ratio
RCT	Randomised controlled trial
RTM	Regression-to-mean
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (USA)
SE	Standard Error
SES	Socioeconomic status
SRTS	Safe Routes to School (generic acronym with international usage, but also specifically to distinguish the Federal STRS program in the US from the State-funded (SR2S) program
SR2S	Safe Routes to School (especially the State-funded program in the USA)
TfL	Transport for London
TRL	Transport Research Laboratory
TRRL	Transport and Road Research Laboratory
UK	United Kingdom
USA	United States of America
VISP	Village Speed Reduction Study
WMHTAC	West Midlands Health Technology Assessment Collaboration
y	years

Glossary

Term	Definition
20 mph zones	A zone where traffic-calming measures (spaced less than 100 metres apart) are used to limit at least average vehicle speeds to below 20 mph. The zones may be single roads or a number of roads in an area.
30kph	18.75mph
Base case (analysis)	The main deterministic analysis which uses the best (most plausible/justified) parameters and assumptions.
Benefit-cost ratio (BCR)	The monetary value of the additional benefits of an intervention, *divided by* the additional costs (measured or estimated for a given period, and discounted to a base year) i.e. if benefits exceed costs then the ratio is >1, and if costs exceed benefits the ratio is <1
Casualty	An individual that has sustained an injury (of any severity) or died. For the purposes of this review the injury/death would have occurred as the result of an accident that occurred on the road/street.
Cost-benefit analysis (CBA)	A type of economic evaluation in which the value of benefits is expressed in monetary units, and the cost of the intervention or programme is deducted from this amount (or monetary benefits are divided by costs to give a Benefit-Cost Ratio)
Cost-effectiveness analysis	A type of economic evaluation in which the incremental costs are compared with the incremental benefits (expressed in natural units), typically to produce an Incremental Cost-Effectiveness Ratio (e.g. £X,000 per additional unit of effectiveness)
Cost-utility analysis	A type of cost-effectiveness analysis in which consequences or benefits of the intervention are expressed in preference-based units that reflect both added/lost survival and increased/decreased health-related quality of life, to produce an Incremental Cost-Effectiveness Ratio (e.g. £X,000 per QALY)
Cost of illness study	A type of economic study in which the total cost impact of a particular disease (or its economic burden), usually in a particular country, is estimated. They do not therefore focus on specific interventions.
Crash-involved children	Number of children involved in motor-vehicle accidents/crashes as pedestrians or cyclists (= the outcome measure used in Blomberg et al. 2008 evaluations of Safe Routes to Schools programmes in the US). NB. does not strictly indicate whether the children were injured.
Deterministic analysis	Analysis which uses single values (point estimates) for each numerical assumption (in contrast to probabilistic analysis, which is based on sampling from a defined distribution of possible parameter values)
Discount rate	
First Year Rate of Return (FYRR)	The monetary value of the additional benefits of an intervention, divided by the additional costs (measured or estimated for the first year after a project or scheme's implementation, and discounted to a base year); usually expressed as a percentage. i.e. if benefits exceed costs then the ratio is >100%, and if costs exceed benefits the ratio is <1
Full economic evaluation	A comparative study which presents both the costs and the effectiveness or benefits of two or more alternative interventions or policies.
Gateways	A form of entry treatment to a traffic calmed area (term originally used for entrances to villages).
Green streets	The use of open spaces created by demolition of some properties.
Horizontal deflections / schemes	Measures that alter the horizontal alignment of the carriageway such as mini-roundabouts, build-outs and chicanes.
Injury accident	An accident that involves an injury to one or more of the people involved (one injury accident may involve more than one casualty).
'Linear' 20mph zones	20 mph zones that occupy single roads.
Narrowing	Any measure used as part of a speed management scheme to reduce the carriageway width available to moving traffic: pinch points, central hatching, traffic islands etc.
Net Present Value	The value of estimates of future streams of benefits less future streams of costs, when both are discounted to their value in the base year (i.e. the year of the analysis)

One-way sensitivity analysis	Examining how the results of an analysis (usually an economic analysis) vary when assumptions or parameters are varied one at a time
Probabilistic sensitivity analysis	A type of simulation based economic analysis which reflects the parameter uncertainty in all parameters simultaneously (by repeatedly sampling from pre-specified
Sensitivity analysis	The process of examining how the results of an analysis (usually an economic analysis) vary when assumptions or parameters are varied.
Time horizon	The length of time into the future (usually in years) over which an economic analysis assesses costs and benefits/effectiveness
Roundels	Speed limit signs that are painted onto the road.
STATS19	A database of road accident data held by the Department for Transport. The data is based on records completed by police officers on all reported road accidents. It contains information about the circumstances of each accident, including the date and time of day, road and vehicle characteristics and weather conditions; and also the age of the casualties, the grid reference of the location of the accident, whether the casualty was a pedestrian, the severity of injury, and the postcodes of residence of the drivers and casualties.
Sustrans	UK-based charity which campaigns for sustainable transport (www.sustrans.org.uk)
Vertical deflections / schemes	Any measure that alters the vertical profile of the carriageway, such as road humps and speed cushions.

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1. Summary

1.1. Introduction

NICE is developing a range of public health guidance to prevent unintentional injuries among children and young people aged under 15. This review (Report 1) focuses on the effectiveness and cost-effectiveness evidence related to interventions which prevent such injuries in the road or street environment using design- or engineering-based interventions such as traffic-calming. Two related reports have also been produced for this guidance. Report 2 contains a review of qualitative research and considers possible barriers to and facilitators of, the prevention of unintentional injury to children on the road. Report 3 contains a report of economic modelling assessing the cost-effectiveness and cost-benefit of 20mph zones and mixed priority routes.

In parallel with this work, NICE will also be developing public health intervention guidance during 2009 and 2010 on a number of child injury prevention areas:

- the prevention of unintentional injuries to children in the home (either by schemes involving free or discounted cost safety equipment and/or using home risk assessments);
- the prevention of unintentional injuries to children in external environments (e.g. designated play areas);
- the prevention of unintentional injuries to children on the road by using education and protective equipment to reduce road injuries (based on the same referral).
- the prevention of unintentional injuries to children on the road by using education and protective equipment to reduce road injuries (based on the same referral).

There will also be public health guidance (developed through the programme guidance development process) focusing on the broader legislative/regulatory and related strategic policy frameworks which aim to prevent unintentional injuries in children. NICE will also be preparing guidance that focuses on preventing unintentional road injuries among young people aged 15-24.

The studies contained within this report focus on local or regional interventions to reduce injuries in children aged under 15 by road/street design or by modifying the road/street environment and highway design.

1.2. Aim

This report presents two systematic reviews which aimed to identify, critically appraise, summarise and synthesise evidence relating to the effectiveness (review 1) and cost-effectiveness (review 2) of the specified types of road and street design-based interventions aimed at reducing unintentional injuries in children.

Review 1 (effectiveness)

a. What is the effectiveness (in terms of reducing unintentional injury in children) of design-based interventions aimed at reducing motorised traffic speeds and/or encouraging more careful driving

b. What is the effectiveness (in terms of reducing unintentional injury in children) of safe routes to school initiatives and cycle/walking routes/networks

c. What are the important factors which either enhance or reduce the effectiveness of such design-based interventions, safe routes to schools and cycle routes, or which help or hinder their implementation?

Review 2 (cost-effectiveness/cost-benefits)

a. What is the cost-effectiveness of such design-based interventions aimed at reducing speed, encouraging more careful driving, providing safe routes to schools and cycle routes?

b. What are the main causal relationships which seem to explain how the different combinations of resources (and levels of costs) of these interventions are related to intended outcomes?

1.3. Methods

Interventions

Papers or reports were sought which reported quantitative comparative evaluations of local or regional interventions to reduce injuries in children aged under 15 by road/street design or by modifying the road/street environment and highway design. These included the following either combined or delivered separately:

- traffic-calming
- 20 mph zones
- home zones
- international examples such as 'woonerven' in the Netherlands: streets or a group of streets that have been redesigned to slow traffic and promote non-motorised traffic
- 'naked streets' (or 'psychological traffic-calming') where road markings, lines, traffic lights, signs and curbs and so on are removed to create uncertainty in road users and encourage them to slow down
- 'quiet lanes' and other rural examples of traffic-calming schemes
- signing related to speed limits
- walking and cycling networks
- 'Safe Routes to Schools'

Outcomes of interest

Studies were included if they reported any of the following outcomes: rates of unintentional injuries in children; rates of hospital admissions and preventable child deaths related to unintentional injuries; severity of unintentional injuries in children. Study data on changes or differences in vehicle speeds or collisions (number and degree of impact) was only collected in studies where child injury data was also reported. Additionally, for the review of economic evaluations, studies were included if they reported incremental cost-effectiveness or cost-utility ratios, or summary measures of cost-benefit analysis (e.g. benefit cost ratios, net present value, first year rate of return) - or if these were calculable from cost and outcome data provided.

Search strategy

Relevant papers and reports were sought by an electronic search of relevant bibliographic databases (including safety- and transport-specific research databases), supplemented by searches of selected websites and communication with experts and/or organisations involved in the relevant research or transport policy areas. These were conducted by an experienced information specialist.

Inclusion and exclusion criteria (effectiveness review)

Inclusion criteria:

- Evaluations (prospective or retrospective) of relevant interventions that used comparative designs (randomised controlled trials, non-randomised controlled trials, before and after studies, or natural experiments)
- Studies reporting the relevant injury outcomes in children (or in both adults and children but with the outcomes for children reported separately). The ‘in children’ part of this inclusion criteria was only applied at full-text assessment stage.

Exclusion criteria:

- Empirical studies which only document schemes/interventions and related outcomes but without evidence regarding injury outcomes without the scheme/intervention (e.g. before its introduction, or in comparable towns or neighbourhoods).
- Empirical studies which do not separately report injury-related outcomes for children or young people.

Inclusion and exclusion criteria (cost-effectiveness review)

Inclusion criteria: Full economic evaluations of relevant types of intervention or scheme, and high quality costing studies conducted in the UK or countries of a similar level of economic development, patterns of transport use and urban environment.

Exclusion criteria: Cost-of-illness studies, or other studies which do not involve assessing the cost and related benefits/effectiveness of particular interventions (or class of intervention).

Data extraction and quality assessment

Standard study design details and study results were extracted to an MS-Access database (effectiveness review) or MS-Word tables (cost-effectiveness review). The quality of included effectiveness studies was assessed using the generic methodological checklist for quantitative intervention studies (Appendix F of 2nd edition of *Methods for the development of NICE public health guidance*, 2009). The quality of included economic evaluations was assessed using the 19-point ‘CHEC criteria list’. For both reviews, the applicability of included studies to current UK road and population settings was also assessed and recorded.

Syntheses of included studies

Meta-analysis (statistical pooling) of study results was not feasible in either of the two reviews, so study findings are summarised and synthesised through a mixture of tabulated study data and narrative description. Where study data allowed, effectiveness was expressed using the standard measure of a rate ratio (for uncontrolled before and after studies) and a ratio of rate ratios (for before and after studies with a control group).

1.4. Findings

The systematic review of **effectiveness studies** included **24** studies (reported in 26 papers). The interventions evaluated were: area wide traffic-calming (5 UK studies); single road traffic-calming (3 UK studies); 20mph zones (4 UK studies); home zones (3 UK studies); mixed priority route schemes (3 UK studies); cycle route (1 UK study); Safe Routes to Schools programmes (2 US studies); other (single component) traffic-calming measures (2 studies; 1 US, 1 Germany); and one evaluated a programme which combined several interventions encompassing engineering and education measures (1 study from Sweden). Most studies (17) were uncontrolled before and after studies, with the remainder being controlled before and after studies (4), case-control studies (2) and an ecological study.

The **systematic review of economic studies** included **12** studies, all of which were cost-benefit analyses. They were conducted according to the conventional methods of road safety and transport economics in which the cost of implementing the road infrastructure is deducted from the value of casualties or accidents saved. In the majority of cases they were reported in quite small sections in larger effectiveness evaluation reports, making judgements about the quality of methods used difficult. The interventions evaluated were: 20mph zones (2 UK studies); traffic-calming of single urban ('mixed priority') routes (3 UK studies); rural/village route traffic-calming (1 UK study) cycle & walking tracks (1 study in Norway); and several studies examining a wider range of area-wide, route and junction traffic-calming measures (2 UK studies, 2 in Norway and Sweden, and 1 in Australia).

Evidence Statements: effectiveness

Evidence Statement 1: Area-wide traffic-calming and child road safety outcomes

Five UK based studies evaluated area wide traffic-calming schemes. There was one controlled (Mackie et al, 1990 [+]) and 3 uncontrolled (Cloke et al, 1999 [-]; Department for Transport, 2001 [+]; Wheeler & Taylor 2000 [+]) before and after studies, and one ecological study (Jones et al, 2005 [+]). Within these studies, casualties, injury accidents and speed outcomes were reported.

1a There is moderate evidence from 2 uncontrolled before and after studies (both UK), that area wide traffic-calming may reduce **rates of KSI children** (Department for Transport, 2001 [+]; Wheeler & Taylor 2000 [+]). Both studies showed reductions in either KSI child casualties or KSI injury accidents involving child pedestrians or cyclists, but none of these were statistically significant.

1b There is moderate evidence from 1 uncontrolled before and after study and 1 ecological study (both UK), that area-wide traffic-calming may reduce **child road casualty rates of any severity** (Department for Transport, 2001 [+]; Jones et al, 2005 [+]). There is moderate evidence from 1 controlled and 2 uncontrolled before and after studies (all UK), that area-wide traffic-calming may reduce **child injury accident rates** of any severity (Cloke et al, 1999 [-]; Mackie et al, 1990 [+];Wheeler & Taylor 2000 [+]).

Of the 2 studies which reported **child casualty rates** one ecological study showed a statistically significant reduction (RaR= 0.777 for pedestrians in one of two cities studied, p= 0.002; Jones, 2005 [+]), whilst the results in the other city, and the uncontrolled before and after study are consistent with a reduction, but do not reach significance (Department for Transport, 2001 [+]).

The 3 studies which reported **child injury accident rates, (**1 controlled and 2 uncontrolled before and after studies, all UK) also show reductions, but only one approaches statistical significance when compared with a control group (RaR=0.524; 95% CI=0.258, 1.062 for child cyclists; Mackie et al, 1990 [+]) (Cloke et al, 1999 [-]; Wheeler & Taylor 2000 [+]).

1c There is weak evidence from 2 uncontrolled before and after studies that area wide traffic-calming may reduce traffic speeds (Cloke et al, 1999 [-]; Wheeler & Taylor 2000 [+]).

With the possible exception of the much older study by Mackie et al. (1990), this evidence is judged as directly applicable to similar roads and/or communities in the UK.

Evidence Statement 2: Single road traffic-calming and child road safety outcomes

Three UK based studies evaluated single road traffic-calming schemes. These were all uncontrolled before and after studies (Chorlton, 1990, [+]; Jones & Farmer, 1993 [+];

Mountain et al 2005, [+]). Within these studies, casualties, injury accidents and speed outcomes were reported.

2a There is weak evidence from 2 UK based uncontrolled before and after studies, to show that single road traffic-calming may reduce **child road casualty rates**. Only one of these studies showed a statistically significant reduction in child casualties from 12 to zero ($p<0.001$; Jones & Farmer, 1993 [+]). In the other study, numbers of casualties were too small (decreasing from 3 to zero) to be meaningful (Chorlton, 1990, [+]).

2b There is weak evidence from 1 UK based, uncontrolled before and after study that single road traffic-calming may reduce **child pedestrian injury accident rates** (RaR0.0381, $p<0.001$) while **child cyclist injury accident rates** were also reduced, but non-significantly (RaR=0.632, p=0.081; Mountain et al 2005, [+])

2c There is weak evidence from 2 uncontrolled before and after studies that single road traffic-calming may reduce traffic speeds (Jones & Farmer, 1993 [+]; Mountain et al 2005, [+]).

This evidence is judged as directly applicable to similar roads and/or communities in the UK, although the Chorlton evidence is dated.

Evidence Statement 3: 20mph zones and child road safety outcomes

Four UK based studies evaluated 20mph zones (mostly in urban areas). There was one controlled (Webster & Layfield, 2003 [+]) and 3 uncontrolled (Grayling et al, 2002 [+]; Grundy et al, 2008 [+]; Webster & Mackie, 1996 [+]) before and after studies, one of which was adjusted for background trends (Grundy et al, 2008 [+]). There is some overlap between studies. Two of the studies are of 20mph zones in London; one of which (Grundy et al, 2008 [+]) essentially updates the other (Webster & Layfield, 2003 [+]). There are also small overlaps between these London-based studies and the England-wide study (Webster & Mackie, 1996 [+]), and potentially between the England-wide study and the study based in Hull (Grayling et al, 2002 [+]). Within these studies, casualties and speed outcomes were reported.

3a There is moderate evidence from 2 uncontrolled before and after studies (1 adjusted for trends on background roads; both UK-based) that 20mph zones reduce **KSI child casualty rates** (RaR=0.242, to 0.859 depending on analysis and study, $p<0.05$ where recorded; Webster & Mackie, 1996 [+]; Grundy et al, 2008 [+]). One controlled before and after study also showed a reduction in **KSI child casualty rates** in the intervention group when compared to a control group, however, this reduction was non-significant (Webster & Layfield, 2003 [+]). It must be noted that this study also evaluated schemes in London, similarly to Grundy et al, 2008, and is essentially updated by this uncontrolled before and after study.

3b There is weak evidence from 1 uncontrolled before and after study (London-based), which was adjusted for trends on background roads, that 20mph zones may reduce **child pedestrian KSI casualty rates**. However this reduction is non-significant once the results had been adjusted for changes in background trends on outside roads (Grundy et al, 2008 [+]). One study also showed that 20mph zones may reduce **child pedestrian KSI casualty rates** (before and after data only reported for this outcome; RaR 0.394, $p<0.001$; Webster & Layfield, 2003 [+]). As noted above however, this study is essentially updated by the uncontrolled before and after study carried out by Grundy et al. (2008). The evidence shouldn't therefore be 'counted' twice.

3c There is weak evidence from one before and after study (controlled data only reported for this outcome) that 20mph zones may reduce **child pedal cyclist KSI casualty rates.** This reduction approaches statistical significance (RaR=0.399, $p=0.06$; Webster & Layfield, 2003 [+]).

3d There is moderate evidence from 3 UK-based uncontrolled before and after studies (one using adjusted analyses; Grundy et al, 2008 [+]), and one controlled before and after study of London schemes (Webster & Layfield, 2003 [+]), that 20mph zones may reduce **child road casualty rates overall**, and for child pedestrians and child pedal cyclists when analysed separately (Road casualty rates overall RaR=0.331 to 0.716 depending on analysis and intervention, $p<0.001$ where recorded; Grayling et al, 2002 [+]; Grundy et al, 2008 [+]; Webster & Layfield, 2003 [+]; Webster & Mackie, 1996 [+])

3e There is weak evidence from 2 studies that 20mph zones may reduce traffic speeds (Webster & Mackie, 1996 [+]; Webster & Layfield, 2003 [+]).

This evidence is judged as directly applicable to similar roads and/or communities in the UK, although the data from Webster & Mackie is rather dated.

Evidence Statement 4: Home zones and child road safety outcomes

Three UK-based studies evaluated home zone schemes (Layfield et al, 2005 [+]; Tilly et al, 2005 [+]; Webster et al, 2005 [+]). These were all uncontrolled before and after studies. Within these studies, casualties, injury accidents and speed outcomes were reported. These studies all reported low numbers of casualties/injury accidents both before and after the intervention (between 3 and 0).

4a There is moderate evidence from three UK-based, uncontrolled before and after studies, which show the impact of **child road casualty/injury accident rates** with Home Zones is consistent with no effect (Layfield et al, 2005 [+]; Tilly et al, 2005 [+]; Webster et al, 2005 [+]).

4b There is weak evidence from 3 studies that home zones may cause small reductions in traffic speeds (Layfield et al, 2005 [+]; Tilly et al, 2005 [+]; Webster et al, 2005 [+]).

This evidence is judged as directly applicable to similar roads and/or communities in the UK.

Evidence Statement 5: Mixed priority route schemes and child road safety outcomes

Three UK-based studies evaluated mixed priority route schemes (WSP Development and Transportation 2008a; 2008b; 2008c – all [+]). These were all uncontrolled before and after studies. Within these studies, casualties and speed outcomes were reported. These studies all reported low numbers of casualties both before and after the intervention (between 6 and 0).

5a There is moderate evidence from 3 UK-based, uncontrolled before and after studies that mixed priority route schemes may reduce **child road casualty rates** (WSP Development and Transportation 2008a; 2008b; 2008c – all [+]) – one study showed a significant reduction in child pedestrian casualties, while changes were consistent with no effect in one and increased in the other.

5b There is weak evidence from 3 studies that mixed priority route schemes may cause small reductions in traffic speeds (WSP Development and Transportation 2008a; 2008b; 2008c – all [+]).

This evidence is judged as directly/partially applicable to similar roads and/or communities in the UK.

Evidence Statement 6: Single component traffic-calming measures and child road safety outcomes

6a Speed humps

There is weak evidence from one case control study (US-based) that living near a speed hump may reduce a child's **risk of injury** on the road (unadjusted OR=0.50, 95%CI=0.27,0.89; Tester et al, 2004 [+]).

6b 30 kph speed limits

There is weak evidence from one case control study that living in an area with 0-5 streets with a speed limit of 30 kph may increase a child's **risk of injury** compared to a child living in an area with 15 or more streets with the same speed limit (OR=5.3, 95%CI=1.6,17.6; von Kries et al, 1998 [+]).

6c Pelican crossings

There is weak evidence from one case control study that living in an area with 0-2 pelican crossings/street may increase a child's **risk of injury** compared to a child living in an area with >3 pelican crossings/street (OR=2.3, 95%CI=1.2,4.5; von Kries et al, 1998 [+]).

Evidence Statement 7: Safe Routes to Schools Programmes and child road safety outcomes

There is moderate evidence from two controlled before and after (injury data time-series) studies (Gutierrez et al., 2008 [+]; Blomberg et al., 2008 [+]) in the USA, that Safe Routes to School (SRTS) programmes based predominantly on engineering measures may reduce the rates of crash-involved child pedestrians or cyclists, or the rate of child injury road accidents.

7a In 125 SRTS project areas across California, and after assuming modest (10%) increases in rates of walking and cycling to school due to the programmes (i.e. increased exposure), a mean reduction of 7% in the **all-injury collision rate with child pedestrians and cyclists** was estimated (14% for children aged 5 to 12) (Gutierrez et al. 2008 [+]). However, the estimated impact on **fatal or severe child injuries** was less conclusive (ranging from a 52% increase to a 24% reduction, again depending on assumed changes in levels of walking/cycling to school).

7b The evaluation of 53 projects in three unnamed US States (Blomberg et al., 2008 [+]) compared linear regression coefficients (giving 'T statistics') between the time-series trends of child injury data for the SRTS sites; these showed significantly greater reductions in

crash-involved child pedestrians and cyclists at SRTS sites when compared with at least two of the six 'control' time series in all three US states (NB. all of the 'T' values were negative, indicating that the reductions in crash outcomes in SRTS sites were always lower (if not always statistically significantly lower) than in the comparison time-series.)

This evidence from evaluations of SRTS programmes in the US is judged as partially applicable to similar localities in the UK.

Evidence Statement 8: Cycle routes and child road safety outcomes

8a There is weak evidence from 1 UK-based, uncontrolled before and after study of a largely off-road cycle route, that the impact of cycle routes is consistent with no effect on **child cyclist road casualty rates and KSI child cyclist rates**, although numbers were small. (Dean 1993 [+]).

This evidence is judged as partially applicable to off-road cycle routes in the UK, although the evidence is dated.

Evidence Statement 9: Combination interventions and child road safety outcomes

9a There is weak evidence from 1 controlled before and after study, that combined traffic-calming, safe routes to schools and education may reduce **child road casualty rates** when a before and after comparison was made (OR 0.722, p=0.007. Lindvquist et al 2001, [+]), however compared to the control group, the reduction was non-significant.

This Swedish evidence is judged as partially applicable to similar roads and/or communities in the UK.

Evidence Statements: effectiveness

Evidence Statement 10: Cost-benefit of area-wide traffic-calming

There is moderate evidence from 3 cost-benefit analyses of a variety of schemes in the UK (2 studies) and in Norway and Sweden (1 study), that show that even in the short-term (after 1 year) benefits are likely to exceed costs in most circumstances (Elvik, 2003 [+]; Gorell & Tootill, 2001 [+]; Mackie et al., 1990 [+]). However, there was considerable variation in First

Year Rates of Return both for different schemes within studies, and between the two UK studies (Mackie et al 1990 [+]: mean estimated FYRR across 5 schemes 30%-40%; Gorrell & Tootill 2001 [+]: mean estimated FYRR across 12 schemes 225%.

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.) This evidence is judged as partly applicable to the UK road setting as one of the two UK studies was very old, and another study was based on data from Norway and Sweden.

Evidence Statement 11: Cost-benefit of mandatory 20 mph zones and advisory 20 mph speed limits

There is moderate evidence from 1 cost-benefit analyses of **advisory 20 mph speed limits** in Scotland (75 sites, mainly comprising new signage) that shows that in the short-term (time horizon ~2-3 years; FYRR 48%) benefits are likely to exceed costs (Burns et al., 2001 [+]).

There is moderate evidence from 1 cost-benefit analyses of **mandatory 20 mph zones** in London that shows that in the medium to long-term (time horizon 5 and 10 years) benefits are likely to exceed costs in between 85% and 47% of schemes, depending on the exact time horizon of the analysis and the prior level of casualties at the location . However, across the 144 20mph zones evaluated, a mean net present value of £19,000 was achieved (over 5 years, or £67,000 over ten years post-implementation; 2005 £s) (Grundy et al., 2008 [+]).

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.). The evidence on 20 mph zones is judged as being directly applicable to other urban roads in England, whereas the applicability of the evidence on advisory speed limits in Scotland may have less applicability in England and Wales due to different road regulations relating to 20mph speed limits.

Evidence Statement 12: Cost-benefit of Mixed Priority Route schemes

There is moderate evidence from 3 cost-benefit analyses of a three very costly road improvement/safety schemes (construction costs of £2 to £2.2 million per km) in Manchester, Norwich and Crewe (England), that show that in the medium to long term (time horizon 3-10 years; FYRR range 11% to 34%) benefits are likely to exceed costs (Cheshire County Council & JE Jacobs, 2008 [+]; Manchester City Council & JE Jacobs, 2008 [+]; Norfolk County Council & JE Jacobs, 2008 [+]).

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.) This evidence on mixed priority routes is judged as being directly applicable to similar urban arterial roads in UK cities.

Evidence Statement 13: Cost-benefit of single route traffic-calming/safety schemes

There is moderate evidence from 1 cost-benefit analysis of a variety of schemes in the UK, that show that even in the short-term (time horizon 1 year) benefits are very likely to exceed costs (Gorell & Tootill, 2001 [+]). For various types of road safety treatment the First Year Rates of Return varied from 260% (for link-calming) to 520% (for 'routes') although the extent to which measures might be classed as design-based or focused on speed reduction is unclear.

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.) This evidence on single route safety schemes is judged as being directly applicable to similar roads in the UK, noting that many of the safety schemes were probably outside built-up areas.

Evidence Statement 14: Cost-benefit of rural/village traffic-calming

There is moderate evidence from 1 cost-benefit analysis of both village-specific traffic calming and major rural road schemes in the UK, that shows that in the short-term (time horizon ~2-3 years) benefits are likely to exceed costs (Wheeler & Taylor, 2000 [+]). The 24 village traffic calming schemes evaluated - which used gateway signing, physical measures, and new road markings achieved an estimated annual rate of return (=equivalent to FYRR) of 62%, while the more expensive major rural road schemes achieved an estimated annual rate of return of 39%.

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.) This evidence on village traffic calming and major rural road safety schemes is judged as being directly applicable to similar villages and rural roads in the UK.

Evidence Statement 15: Cost-benefit of accident 'black spot' safety treatments

There is inconsistent evidence from 1 cost-benefit analysis of a variety of accident 'black spot' safety treatments in Australia, which shows that in the long-term (time horizon 10 years) benefits exceeded costs for 7 of the 11 treatment types evaluated (Meuleners et al., 2008 [+]). Treatments were mainly of intersections, with benefit cost-ratios greater than one for: ban right turns (198.3); 'indented right island' (15.2); non-skid treatment (11.1); left turn slip (9.9); roundabouts – rural (9.8); 'traffic island on approach' (6.2); roundabouts – metro (4.4), and; median on existing road (1.4). The other black spot treatments, where costs exceeded estimated benefits were: the improvement or reinforcement of priority signs, nibs (kerb extensions), traffic control signals and 'seagull islands' (not defined). Treatments in rural areas had slightly higher benefit-cost ratios compared with those in metropolitan areas (mean 6.3 vs 4.3).

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.) This evidence on the safety treatment of high-accident road sections or junctions is judged as being partially applicable to similar roads in the UK, noting that many of the safety treatments were probably outside built-up areas, and also that other driving behaviours and road conditions and characteristics are likely to differ between the UK and Australia.

Evidence Statement 16: Cost-benefit of walking and cycling routes/networks

There is inconsistent evidence from 4 cost-benefit analyses of a wide variety of schemes in the UK (1 study), Norway (2 studies), and in Norway and Sweden (1 study), which show that over various time horizons (1, 10 or 25 years) benefits sometimes exceeded the cost of investments in the safety and mobility of cyclists and/or pedestrians (Gorell & Tootill, 2001 [+]; Erke & Elvik, 2007 [+]; Elvik, 2003 [+] Saelensminde, 2004 [++]).

16a For **cycle routes/networks** Gorrell & Tootill's (2001) study of 10 schemes in the UK estimated a FYRR of 522%, while a very comprehensive analysis of the impacts of combined walking and cycling networks in 3 Norwegian cities estimated benefit-cost ratios of 3, 4 and

14 (Saelensminde, 2004). In contrast, Erke and Elvik's (2007) estimated that combined pavement and cycle paths had benefit-cost ratios of between 0 and 0.82 (depending of traffic volumes), but the marking of cycle lanes gave negative benefit-cost ratios (i.e. negative 'benefits' due to increased time costs of motor vehicles).

16b For different **types of pedestrian crossing**, Erke and Elvik (2007) reported a range of benefit cost ratios from 2.16 to 0, again largely depending on traffic volumes. In contrast, Elvik 2003 estimated benefit-cost ratios of 1.14 to 2.07 for 'upgrading marked pedestrian crossings' and ratios of 1.44 to 6.03 for 'pedestrian bridges and underpasses' (in Norway and Sweden).

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.) This evidence on different schemes to improve the popularity and safety of walking and cycling is judged as being partially applicable to similar roads in the UK.

2. Introduction

2.1. Context of these reviews

NICE is developing a range of public health guidance to prevent unintentional injuries among children and young people aged under 15. This review (Report 1) focuses on the effectiveness and cost-effectiveness evidence related to interventions which prevent such injuries in the road or street environment. Two related reports have also been produced. Report 2 contains a review of qualitative research and considers possible barriers to and facilitators of, the prevention of unintentional injury to children on the road. Report 3 contains a report of economic modelling assessing the cost-effectiveness and cost-benefit of 20mph zones and mixed priority routes.

In parallel with this work, NICE will also be developing public health guidance (also developed using the intervention development process) to prevent unintentional injuries in the home and in other external environments; and there is another piece of guidance relating to education and protective equipment to reduce road injuries, based on the same referral. There will also be public health guidance (developed through the programme guidance process) focusing on the broader legislative/regulatory and related activities which aim to prevent unintentional injuries in children.

In addition to this, NICE is also preparing guidance that focuses on preventing unintentional road injuries among young people aged 15-24.

The studies contained within this report focus on local or regional interventions to reduce injuries by road/street design or by modifying the road/street environment and highway design. While the interventions included will typically also prevent deaths and injuries to adults as well as children, the effectiveness review was restricted to studies which reported injury and injury accident outcomes for children.

2.2. Interventions to reduce unintentional injuries in children on the road

2.2.1. Traffic-calming

'Traffic-calming' is a term used to encompass a range of engineering strategies that are put in place with the aim of changing traffic patterns (including traffic speeds and flow) on a specific street or within a particular area. Although speed limit signs may be included within a traffic-calming scheme, it will not be the sole intervention, and will be accompanied by other modifications to the ‘usual’ road design, such as speed humps, street closures, chicanes, pinch-points, mini-roundabouts and other physical structures that aim to be self-enforcing, rather than requiring police enforcement. In this review traffic-calming interventions have been split into the following categories: area-wide traffic-calming, single road traffic-calming, and single component traffic-calming interventions. The more specific types of interventions, such as 20mph zones and mixed priority route schemes, have also been grouped separately. These specific intervention types are described below.

2.2.2. 20mph zones

20mph zones were originally designed with the intention of reducing child pedestrian injuries in and around residential areas, and as such were only implemented in such settings to start with. However, they have since also been used in town centres and rural areas, as well. The first UK 20mph zones were implemented in Sheffield, Kingston-upon-Thames and Norwich in 1991 (Department for Transport, 1999).

In contrast to roads that just have a 20mph speed limit (with repeated signs only), 20mph zones also incorporate self-enforcing road engineering measures to reduce traffic speeds. Zone entrances and exits are marked by terminal signs, but otherwise the design of such schemes varies across locations, taking into account the local environment, funding, cost benefit analysis, community needs and feedback from public consultation. Features may include a range of vertical and horizontal deflections, as well as other engineering measures such as gateways, surfacing, and road narrowing ([+]Grundy et al., 2008).

2.2.3. Home zones

Home zones are residential areas designed for maximising their use by people who walk and cycle, including children, as well as motorised traffic. This concept of ‘shared road space within a safe residential environment’ originated in the Netherlands as ‘woonerven’ (residential precincts). The aim of home zones is to improve the quality of life in residential areas by changing the way that streets are used and promoting the use of streets for a wider range of applications than just motorised traffic. The layout of streets within these schemes is designed to draw attention to the change of use and, in doing so, encourage drivers to consider other road users as priority. Care is taken to ensure that the design of individual home zones meets the needs of the local residents, and residents are encouraged to take 'ownership' of the area.

Home zones were suggested for the UK as a low cost measure to reduce casualties in young children in residential areas and allow them to play around their homes within a safe environment. Home zones are not principally about safety however, they are more about improving quality of life. None of the sites chosen for pilot home zones had particularly high vehicle flows and most had few accidents before implementation. The idea was to limit the need for conventional traffic-calming measures. In order to evaluate the effectiveness of home zones nine pilot schemes were established by the Department for Transport (DfT) in England and Wales. The pilot programme started in 1999. The Transport Act 2000 came into effect in February 2001 and makes provision for home zones in England and Wales, giving local authorities the power to designate home zones in their area, make orders about the specific use of roads and about measures to reduce speed within home zones, subject to regulations to be made by the Secretary of State (for England) or the National Assembly for Wales (Tilly et al., 2005).

2.2.4. Mixed priority routes

Mixed priority routes are high streets with a mixture of uses and users. They carry large volumes of traffic, but are also used by pedestrians, such as shoppers and school children, and cyclists. Consequently they are amongst the most unsafe of urban environments. There is a mixture of residential and commercial properties, and space is required for parking, as well as drop-off points for deliveries. As such, these streets do not naturally lend themselves to typical casualty-reducing interventions such as complete pedestrianisation or limited vehicle access schemes. Neither are the traditional engineering solutions in localised areas considered sufficient, given that accidents tend to be spread across a route (Department for Transportation, 2008). In addition to the concerns related to safety on these streets, there are also priorities related to the local economy and improving the environment for local communities. Such improvements require an integrated approach.

In order to facilitate an understanding of how to make improvements to safety and the surrounding environment on such streets, the Department for Transport (DfT) established the Mixed Priority Routes Demonstration Project (Department for Transport, 2008). This project involved the implementation of ten trial schemes. The schemes selected were spread throughout England, in: Crewe, Hull, two in London, Leamington Spa, Liverpool, Manchester, Norwich, Oxford, and St. Albans. The key modification characteristic of most schemes was the reallocation, or better use, of road space whilst minimising changes in vehicle access and traffic capacity. Consideration was given to all road users.

2.2.5. Quiet lanes

The Countryside Agency developed the Quiet Lanes initiative with support from the DfT. Quiet lanes have been defined as minor rural roads which are suitable for shared use by walkers, cyclists, horse riders and motor vehicles. The concept is not designed with the aim of producing traffic-calming results, or to prevent rat-running. It is intended for roads that already have low traffic flows and speeds, with the aim of encouraging maintenance and enhancement of these characteristics on such rural roads. The three key elements are:

- Involvement of the local community with the aim of encouraging a change in user behaviour
- An area-wide direction signing strategy
- Signs marking entry and exit to a Quiet Lane

Quiet Lanes are suitable for narrow single-track roads with very low traffic flows (not main access routes), no street lighting and with the national speed limit (except where 30mph speed limits exist though villages). The intention is that they form a network (rather than be applied to single roads) linking homes with public rights of way, shops, schools, public houses etc., creating an environment that is suitable for short trips from residents' homes to local amenities, in which non-motorised forms of transport can be used rather than cars. Routes should also be suitable for recreational use, such as for jogging, cycling, horse-riding, walking the dog etc. Diversions from the Quiet Lanes, to prevent through-traffic created by vehicles looking to avoid other busier roads, are also a key consideration. A guide has been developed by the Countryside Agency called 'Share with Care', which highlights this shared use concept (Kennedy et al., 2004a; Kennedy et al., 2004b).

Two pilot Quiet Lane projects have been set up in Norfolk and Kent (Kennedy et al., 2004a; Kennedy et al., 2004b). Evaluations of both of these have been included in the review of barriers and facilitators (Report 2); however, the studies did not report injury outcomes in children, and therefore were not eligible for inclusion in the current review of effectiveness (Report 1).

2.2.6. Cycle networks and routes

Cycle routes are relatively small scale projects when compared with other road engineering schemes; however, considerable effort can still be required to ensure the smooth running of all stages from planning to implementation.

Features of cycle routes may include:

- cycle tracks
- with-flow and contra-flow cycle lanes
- signalised cycle crossings
- shared pedestrian and cycle crossings
- shared use of routes by pedestrians and cyclists
- cycle/pedestrian bridges
- direction signing
- use of lightly trafficked streets

Ideally the final link of a cycle route should lead to parking facilities for cyclists that are close to amenities of interest (Department for Transport, 1995).

2.2.7. Safe Routes to School initiatives

In the UK, *Safe Routes to Schools* is the name of a public campaign to improve school travel options. It was pioneered by Sustrans in 1995 with several demonstration projects, following the example of national and local initiatives in Denmark, and schemes now exist in all four countries of the UK (Sustrans, 2009). The aim of the campaign is to increase the number of children travelling in ways which benefit their health and their environment by, amongst other things:

- Campaigning for, and sometimes creating, a safe environment for children to walk and cycle
- Supporting the implementation of ambitious school travel plans (e.g. to adopt targets which reduce car use by at least a third)

Today, *Safe Routes to Schools* projects in the UK increasingly take a holistic whole-school and community-wide approach, and may include a package of measures comprising, for example:

- Highway improvements
- Training in road safety skills for cyclists and pedestrians
- Walking buses
- Incentives and promotional activities
- Curriculum work
- New or improved facilities (e.g. cycle parking and waiting shelters)

Under Sustrans, Safe Routes to Schools initiatives are usually part of the development of a broader School Travel Plan

2.2.8. Interventions for which no relevant evidence was identified

The following types of intervention were also included in the scope for this suite of reviews (reviews of effectiveness and cost-effectiveness studies in this report; and the review of barriers and facilitators studies in report 2):

- international examples such as ‘woonerven’ in the Netherlands: streets or a group of streets that have been redesigned to slow traffic and promote non-motorised traffic
- ‘naked streets’ (or ‘psychological traffic-calming’) where road markings, lines, traffic lights, signs and curbs and so on are removed to create uncertainty in road users and encourage them to slow down
- walking networks and routes

However, no eligible studies of such interventions were identified for inclusion in any of the three reviews.

3. Aims

3.1. Objectives and Rationale

To identify, critically appraise, summarise and, where possible, synthesise evidence relating to the effectiveness (review 1) and cost-effectiveness (review 2) of the specified types of road and street design-based interventions aimed at reducing unintentional injuries in children.

3.2. Review Questions

3.2.1. Review 1 (Effectiveness)

a) What is the effectiveness (in terms of reducing unintentional injury in children) of design-based interventions aimed at reducing motorised traffic speeds and/or encouraging more careful driving?

b) What is the effectiveness (in terms of reducing unintentional injury in children) of 'Safe Routes to School' initiatives and cycle/walking routes/networks?

3.2.2. Review 2 (Cost-Effectiveness)

a) What is the cost-effectiveness of such design-based interventions aimed at reducing speed, encouraging more careful driving, providing 'Safe Routes to Schools' and cycle routes?

b) What are the main causal relationships which seem to explain how the different combinations of resources (and levels of costs) of these interventions are related to intended outcomes?

3.3. Factors and outcomes

Any potential explanatory factors (eg cultural, social, economic, environmental and organisational determinants/correlates) regarding the characteristics of individuals, families/households, or the places where they live or travel, which may be associated with unintentional injury in children and young people under 15 will be considered. A range of potential outcomes associated with unintentional childhood injury, as described in the scope, were considered:

Primary outcomes[a]:

- rates of unintentional injuries in children
- rates of hospital admissions and preventable child deaths related to unintentional injuries
- severity of unintentional injuries in children

Secondary outcomes[b]:

- vehicle speeds
- collisions (number and degree of impact)

Plus (for Review 2):

- costs and/or resource use
- cost-benefit estimates
- cost-effectiveness ratios

[a] Studies had to report at least one of the primary outcomes in order to be included in this review.

[b] Recorded only where a primary outcome is also reported.

4. Methods

Methods were pre-specified in the protocol shown in Appendix 1.

4.1. Identification of evidence

4.1.1. Relevant Interventions

The studies contained within this report focus on local or regional interventions to reduce injuries in children aged under 15 by road/street design or by modifying the road/street environment and highway design. These include the following either combined or delivered separately:

- traffic-calming
- 20 mph zones
- home zones
- international examples such as 'woonerven' in the Netherlands: streets or a group of streets that have been redesigned to slow traffic and promote non-motorised traffic
- 'naked streets' (or 'psychological traffic-calming') where road markings, lines, traffic lights, signs and curbs and so on are removed to create uncertainty in road users and encourage them to slow down
- 'quiet lanes' and other rural examples of traffic-calming schemes
- signing related to speed limits
- walking and cycling networks
- 'Safe Routes to Schools'

4.1.2. Search strategy

Methods for the search strategy were pre-specified in the search protocol shown in Appendix 2.

4.1.2.1. Background

While all reviews can pose challenges for finding research, the literature on road safety was discovered to contain additional challenges that shaped the searching methodology. We are not the first research team to have encountered such difficulties. Wentz et al, used word frequency analysis with hand searching as a gold standard in an attempt to devise search strategies that identified controlled evaluation studies of road safety interventions (Wentz et al., 2001). Despite being a team of experienced information professionals and researchers from the Cochrane Injuries Group using the indexed TRANSPORT database, however they were unable to device a strategy with acceptable sensitivity and specificity. Additionally, we were unable to access many potentially useful papers due to prohibitive cost, access difficulties [usually the British Library not buying certain reports], and unpublished reports unable to be sourced from their original funder or research organisation (n=48) (See Appendix 7 for complete list).

4.1.2.2. Search Methods

See Appendix 2 for full search methods and database search strategies.

A single strategy was used to identify relevant primary research for the effectiveness, cost-effectiveness, and qualitative research reviews. A search of the electronic bibliographic databases: Transport Research Information Service (TRIS), Medline, Medline In Process, PsycINFO, Social Science Citation Index, Health Management Information Consortium (HMIC), Applied Social Science Index and Abstracts (ASSIA), ERIC, SafetyLit, the EPPI CENTRE databases; TRoPHI, DoPHER, and Bibliomap, and the databases of the Centre for Review and Dissemination; Database of Abstracts of Reviews of Effects (DARE), National Health Service Economic Evaulations Database (NHSEED), and NHS Economic Evaluation Database (HTA) was undertaken.. A follow up `targeted` search was done in TRIS and Medline of specific named programmes and additional traffic-calming methods determined from the results of the original database searches.

Potentially includable papers from a parallel review for the CPHE programme on preventing unintentional injuries in children, “A systematic review of risk factors for unintentional injuries among children and young people aged under 15 years: Quantitative correlates review of unintentional injury in children”, were tagged during title/abstract screening for this review. Author suggestions, expert contacts, author citation, websites and an extensive search of references lists of reports and reviews were also used as search methods.

4.1.3. Inclusion/Exclusion criteria

4.1.3.1. Criteria common to all reviews:

Inclusion criteria

- Studies published from 1990
- Studies published in English language
- Studies conducted in OECD countries (see Appendix 3)

Exclusion criteria

- Conference proceedings / abstracts

4.1.3.2. Criteria specific to Review 1 (effectiveness):

Inclusion criteria:

- Evaluations (prospective or retrospective) of relevant interventions (see 4.1.1) that used comparative designs (randomised controlled trials, non-randomised controlled trials, before and after studies, or natural experiments)
- Studies reporting the relevant injury outcomes (see Primary outcomes in section 3.3) in children (or in both adults and children but with the outcomes for children reported separately). The 'in children' part of this inclusion criteria was only applied at full-text assessment stage. In other words, no papers were excluded on the basis of age at the title and abstract screening stage. *For the purposes of judging paper inclusion, papers were included if the relevant outcome information pertained to an age-grouping (e.g. 5 to 18 year-olds) where it was judged that the majority of people in that age-range are common with the intended age range for this NICE Guidance (i.e. children aged under 15 years).*

Exclusion criteria:

- Empirical studies which only document schemes/interventions and related outcomes but without evidence regarding injury outcomes without the scheme/intervention (e.g. before its introduction, or in comparable towns or neighbourhoods).

- Empirical studies which do not separately report injury-related outcomes for children or young people.

4.1.3.3. Criteria specific to Review 2 (cost-effectiveness):

Inclusion criteria:

- Full economic evaluations of relevant types of intervention or scheme, and high quality costing studies conducted in the UK or countries of a similar level of economic development, patterns of transport use and urban environment.

Exclusion criteria:

- Cost-of-illness studies, or other studies which do not involve assessing the cost and related benefits/effectiveness of particular interventions (or class of intervention).

4.1.4. Study selection

Assessment for inclusion was undertaken initially at title and/or abstract level (to identify potential papers/reports for inclusion) and then by examination of full papers. Inclusion decisions were made by a single reviewer (KA, RG or RA), and checked by a second reviewer where there was uncertainty (RA or RG; about 2% of all papers/reports at title and/or abstract level, and about 10% at the full-text level). Any disagreements or further uncertainty were settled by a third reviewer (RA or RG). A predefined checklist (see Appendix 4) was used to assess whether papers met the inclusion criteria. Papers/reports were screened for Report 1 and Report 2 at the same time, identifying those which were potentially includable for all three reviews - of effectiveness, cost-effectiveness or barriers and facilitators – at the same time.

4.2. Methods of analysis and synthesis

4.2.1. Review 1 (Effectiveness)

4.2.1.1. Data extraction

Data extraction and quality assessment was conducted into an Access database by a single reviewer (KA or RA), and checked by a second reviewer (JF) for around a 40% sample of the studies. Comments and suggestions were discussed and any amendments made where necessary.

4.2.1.2. Methods of quality appraisal

All included studies were quality assessed using the revised GATE checklist in the *Methods for the development of NICE public health guidance* (National Institute for Health and Clinical Excellence, 2009).

There are five sections of the revised GATE. Section 1 seeks to assess the key population criteria for determining the study's **external validity** – that is, the extent to which the findings of a study are generalisable beyond the confines of the study to the study's source population.

Sections 2 to 4 assess the key criteria for determining the study's **internal validity** – that is, making sure that the study has been carried out carefully, and that the outcomes are likely to be attributable to the intervention being assessed, rather than some other (often unidentified) factor. In an internally valid study, any differences observed between groups of patients allocated to receive different interventions may (apart from the possibility of random error) be attributed to the intervention under investigation. Biases are characteristics that are likely to make estimates of effect differ systematically from the truth. Each of the critical appraisal checklist questions covers an aspect of methodology that research has shown makes a significant difference to the conclusions of a study.

Checklist items are worded so that one of five responses is possible:

++	Indicates that for that particular aspect of study design, the study has been designed/conducted in such a way as to minimise the risk of bias
+	Indicates that either the answer to the checklist question is not clear from the way the study is reported, or that the study may not have addressed all potential sources of bias for that particular aspect of study design
-	Should be reserved for those aspects of the study design in which significant sources of bias may persist
Not reported (nr)	Should be reserved for those aspects in which the study under review fails to report how they have/might have been considered
Not applicable (na)	Should be reserved for those study design aspects which are not applicable given the study design under review (for example, allocation concealment would not be applicable for case control studies)

Each effectiveness study is then awarded an overall study quality grading for internal validity (IV) and a separate one for external validity (EV):

++	All or most of the criteria have been fulfilled. Where they have not been fulfilled the study conclusions are thought **very unlikely** to alter.
+	Some of the criteria have been fulfilled. Those criteria that have not been fulfilled or not adequately described are thought **unlikely** to alter the study conclusions.
-	Few or no criteria have been fulfilled. The study conclusions are thought **likely or very likely** to alter.

Within the evidence statements, specific terms were used to describe the strength of the evidence (quality, quantity and consistency). These were defined by the reviewers as follows:

Weak evidence: one study only, or two studies that show consistent results, but only one scores a [+] for internal validity.

Moderate evidence: two or more studies where at least two of them score a [+] for internal validity, and results are all consistent.

Strong evidence: not applicable to this review, as all studies were either controlled or uncontrolled before and after studies or case-control studies (no RCTs).

Inconsistent evidence: more than one study where the results do not agree.

4.2.1.3. Analysing and synthesising the findings

The majority of studies that were includable in this review were of a before and after study design, and therefore it was possible to compare the before and after rate ratios. Where these comparisons had not been reported, they were calculated by the reviewer, and tested for statistical significance using a 2-tailed unconstrained maximum likelihood estimate (MLE) (Gu et al., 2008). It should be noted here that, in the majority of cases, extracted data took the form of incidence rates (i.e. no. of events / no. of time periods). This type of data should be distinguished from dichotomous data (i.e. no. of cases / sample). Incidence rates may include multiple events relating to a single individual in the numerator, and the denominator is not dependent on a defined population size.

In uncontrolled studies the rate ratio is the ratio of event rates post and pre-intervention. It is given by the reduction in casualty/injury accident rate in the after period (or the intervention area) compared to the before period (or the control area). For example, a rate ratio of 0.5 indicates that casualty/injury accident rates have been halved.

Where control areas had been studied, a comparison of the changes in casualty/injury accident rate in the intervention and control areas was made. This is also referred to as the rate ratio, but is actually the ratio of rate ratios for the intervention and control areas. Standard errors for logarithms of rate ratios (and hence 95% confidence intervals) were calculated assuming that the numbers of observations in each period followed a Poisson Distribution (Bunn et al., 2003).

Due to the heterogeneity of the interventions studied, it was considered inappropriate to combine the studies statistically using a meta-analysis. Studies were therefore synthesized in a narrative review.

4.2.2. Review 2 (Cost-effectiveness)

4.2.2.1. Data extraction

Details of each included economic evaluation have been extracted to a table containing each study's design/methods, and another table to show the main results.

The **study design table** recorded the following details: author and publication year; type of economic evaluation (e.g. cost-benefit analysis or cost-effectiveness analysis), main data years (e.g. time period of before-and-after effectiveness study); country and setting; population and/or localities; interventions and comparators; perspective of the analysis; time horizon and discount rates used (if applicable); costs and savings included; type of cost-benefit estimate (e.g. Net Present Value or Benefit Cost Ratio), and; sensitivity analysis.

The **study results table** recorded the following details: the 'from' and 'to' intervention (i.e. the comparison); the cost of the intervention(s); the benefits associated with the intervention(s); the Benefit Cost Ratio (or other cost-effectiveness estimate).

4.2.2.2. Method of study quality appraisal

The assessment of study quality was informed by answering the questions in the CHEC criteria list to all included economic evaluations (Evers et al., 2005). Note that, as specified in the review's agreed protocol, we used the 19-point list as published in the 2005 paper by Evers et al., rather than the adapted checklist in the (2009) Second Edition of *Methods for the development of NICE public health guidance*.

As with the effectiveness studies, the economic evaluations were also given an overall score for study quality (mainly capturing internal validity and reporting standards).

4.2.2.3. Approach to judging the applicability of studies

Studies were judged as being directly applicable to current UK setting if they were from a recent (published 2000 onwards) UK-based economic evaluation with a reasonably well-described selection of sites. Older UK-based studies were deemed to be partially applicable. Studies from other countries were also deemed to be partially applicable, unless there was an obvious contrast in the intervention or with road or street settings between the study and the UK road environment.

4.2.2.4. Analysing and synthesising the findings

A narrative synthesis approach was adopted, in which:

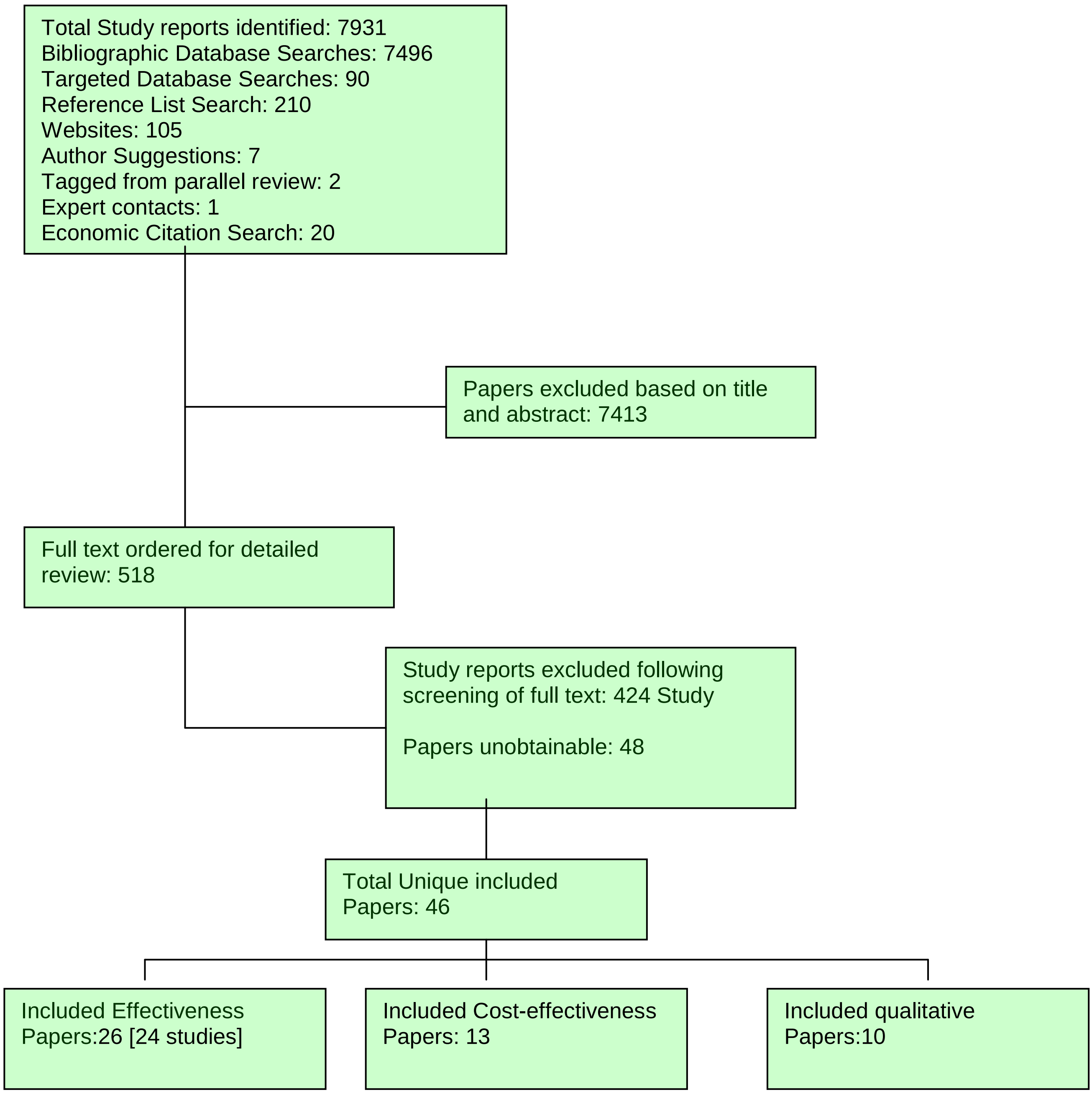
- studies were first grouped according to the type of intervention evaluated
- the key features of each study were described individually, and then
- notable similarities and differences in the methods and results across studies were described and interpreted

Particular emphasis was placed on comparing and contrasting any recent, good quality and UK-based studies.

5. Findings: Effectiveness

5.1. Study reports identified

Figure 1. Flow chart illustrating the process of study identification



5.2. Included studies

A total of 24 studies were included in this review, with data reported in 26 papers (papers with the majority of relevant data in them have been referred to as the main paper for that study). These studies fell into four main categories: traffic-calming, cycle routes, 'Safe Routes to School', and combination interventions. Traffic-calming schemes evaluated in the studies included in this review varied considerably in terms of scale, setting and nature of the intervention. For the purposes of this review they have therefore been split into smaller more comparable groups. The different types of traffic-calming studied were: area wide traffic-calming (5 studies reported in 7 papers) (Cloke et al., 1999; Department for Transport, 2001; Jones et al., 2005; Mackie et al., 1990; Wheeler et al., 1994; Wheeler & Taylor, 1999; Wheeler & Taylor, 2000); single road traffic-calming (3 studies) (Chorlton, 1990; Jones & Farmer, 1993; Mountain et al., 2005); 20mph zones (4 studies[c]) (Grayling et al., 2002; Grundy et al., 2008; Webster & Layfield, 2003; Webster & Mackie, 1996); home zones (3 studies) (Layfield et al., 2005; Tilly et al., 2005; Webster et al., 2005); mixed priority route schemes (3 studies) (WSP Development and Transportation, 2008a; WSP Development and Transportation, 2008b; WSP Development and Transportation, 2008c); and evaluations of other (single component) traffic-calming measures (2 studies) (Tester et al., 2004; von Kries et al., 1998). For a detailed description of all of the interventions see Appendix 7. One study evaluated the effectiveness of a cycle route (Dean, 1993); two were evaluations of 'Safe Routes to Schools' programmes (Blomberg et al., 2008; Gutierrez et al., 2008); and one studied a programme that combined several interventions, including engineering measures, a 'safe way to school' programme, and education (Lindqvist et al., 2001). Full details of all included studies can be found in Appendix 5 (*see separately bound document*). Details of the study interventions can be seen in Appendix 7.

The majority of eligible studies identified were uncontrolled before and after studies (n=17; one adjusted data for background trends). Four of the studies included a control comparison group (Blomberg et al, 2008; Gutierrez et al, 2008; Lindqvist et al, 2001; Mackie et al, 1990), one study was an ecological study (Jones et al, 2005), and two were case control studies

[c] It should be noted that several overlaps occur between the 20mph zone studies. Firstly, the study carried out by Grundy et al (2008) overlaps, and essentially updates, Webster and Layfield's (2003) study of London 20mph zones. Secondly, Webster & Mackie (1996) included data for five 20mph zones in London in their study, that were also included in Webster and Layfield's (2003) study. Hull's 20mph zones, evaluated by Grayling et al (2002) were also noted by Webster & Mackie (1996), however, data do not appear to have been analysed for these schemes in that study, presumably because insufficient 'after' data would have been available at that stage. Data from all of these studies have been extracted separately, but it must be noted that there are varying levels of overlap between them.

(Tester et al, 2004; von Kries et al, 1998). There were no RCTs; therefore the strength of the evidence is limited, to some degree, by study design. However, it is difficult to imagine how a conventional RCT could ever be feasible for study of these engineering based interventions. For full quality assessment details for all studies see Table 1 and Table 2.

Table 1: Quality assessment details for included studies (parts 1-2)

	Is the source area well described?	Eligible areas representative of the source areas of interest?	Does the selected area represent the eligible area?	Allocation to intervention (or comparison) groups - how was confounding minimised?	Interventions (and comparisons) well described and appropriate?	Allocation concealed?	Participants and/or investigators blind to exposure and comparison?	Exposure to intervention and comparison adequate?	Contamination acceptably low?	Were other interventions or their components similar in the areas compared?	All participants accounted for at study conclusion?	Did the setting reflect usual practice?	Did the intervention or control comparison reflect usual practice?
	1.1	**1.2**	**1.3**	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**	**2.6**	**2.7**	**2.8**	**2.9**	**2.10**
Blomberg et al. (2008)	NR	+	+	-	+	NA	+	NA	NA	NA	NA	+	+
Chorlton (1990)	++	NA	+	NA	++	NA	NA	NA	NA	+	NA	++	++
Cloke et al. (1999)	++	NA	+	NA	++	NA	NA	NA	NA	NR	NA	++	++
Dean (1993)	+	NA	-	NA	+	NA	NA	NA	NA	NR	NA	+	+
Department for Transport (2001)	++	NA	+	NA	++	NA	NA	NA	NA	+	NA	++	++
Grayling et al. (2002)	++	NA	+	NA	-	NA	NA	NA	NA	NR	NA	++	++
Grundy et al. (2008)	++	NA	+	NA	+	NA	NA	NA	NA	+	NA	++	++
Gutierrez et al. (2008)	+	+	+	NA	+	NA	++	NA	+	NA	NA	+	+
Jones & Farmer (1993)	++	NA	+	NA	++	NA	NA	NA	NA	NR	NA	++	++
Jones et al. (2005)	++	NA	+	NA	+	NA	NA	NA	NA	+	NA	++	++
Layfield et al. (2005)	++	NA	+	NA	++	NA	NA	NA	NA	+	NA	++	++
Lindqvist et al. (2001)	+	NA	-	NA	-	NA	NA	NA	NA	-	NA	+	+
Mackie et al. (1990)	++	NA	++	NA	++	NA	NA	NA	+	NR	NA	++	++
Mountain et al. (2005)	-	NA	+	NA	+	NA	NA	NA	NR	NR	NA	++	++
Tester et al. (2004)	++	NA	-	NA	-	NA	NA	NA	NA	NR	NA	++	++
Tilly et al. (2005)	++	NA	+	NA	++	NA	NA	NA	NA	+	NA	++	++
von Kries et al. (1998)	+	NA	-	NA	+	NA	NA	NA	NA	NR	+	+	+
Webster et al. (2005)	++	NA	+	NA	++	NA	NA	NA	NA	NR	NA	++	++
Webster & Layfield (2003)	++	NA	+	NA	++	NA	NA	NA	NA	NR	NA	++	++
Webster & Mackie (1996)	++	NA	++	NA	++	NA	NA	NA	NA	NR	NA	++	++
Wheeler & Taylor (2000)	++	NA	++	NA	++	NA	NA	NA	NA	NR	NA	++	++
WSP Development and Transportation (2008a)	++	NA	+	NA	++	NA	NA	NA	NA	+	NA	++	++
WSP Development and Transportation (2008b)	++	NA	+	NA	++	NA	NA	NA	NA	NR	NA	++	++
WSP Development and Transportation (2008c)	++	NA	+	NA	++	NA	NA	NA	NA	NR	NA	++	++

Table 2: Quality assessment details for included studies (parts 3-5)

	Outcome measures reliable?	Outcome measurement complete?	Were all important outcomes assessed?	Were outcomes relevant?	Similar timing of outcome measurements in exposure and comparison groups?	Was follow-up time meaningful?	Similar outcome measurement methods used in exposure and comparison groups?	Exposure and comparison groups similar at baseline? If not, were these adjusted?	Intention to treat analysis?	Estimates of effect size given or calculable?	Analytical methods appropriate?	Precision/uncertainty of intervention effects given or calculable? Were they meaningful?	Was the study sufficiently powered to detect an intervention effect (if one exists)?	Are the study results internally valid (ie unbiased)?	Are the findings generalisable to the source population (ie externally valid)?
	3.1	3.2	3.3	3.4	3.5	3.6	3.7	4.1	4.2	4.3	4.4	4.5	4.6	5.1	5.2
Blomberg et al. (2008)	NR	+	-	+	NA	-	++	NA	NA	+	+	+	NA	+	+
Chorlton (1990)	++	+	+	++	NA	+	NR	NA	NA	++	++	-	NA	-	+
Cloke et al. (1999)	++	-	-	++	NA	+	NR	NA	NA	+	+	+	NA	-	+
Dean (1993)	++	++	++	++	NA	+	++	NA	NA	++	++	+	NA	+	+
Department for Transport (2001)	++	-	++	++	NA	+	NR	NA	NA	++	++	++	NA	+	+
Grayling et al. (2002)	++	++	+	++	NA	++	++	NA	NA	++	++	+	NA	+	+
Grundy et al. (2008)	++	++	++	++	NA	++	++	NA	NA	++	++	++	NA	+	+
Gutierrez et al. (2008)	+	+	+	++	++	+	++	NA	NA	++	+	-	NA	+	+
Jones & Farmer (1993)	++	+	+	++	NA	++	+	NA	NA	++	+	++	NA	+	+
Jones et al. (2005)	++	++	+	++	NA	++	++	NA	NA	++	+	++	NA	+	+
Layfield et al. (2005)	++	+	++	++	NA	+	++	NA	NA	++	++	-	NA	+	+
Lindqvist et al. (2001)	++	++	+	++	++	+	++	+	NA	++	++	++	NA	+	-
Mackie et al. (1990)	++	-	+	++	++	++	NR	+	NA	++	++	++	NA	+	++
Mountain et al. (2005)	++	+	+	++	NA	++	++	NA	NA	++	++	++	NA	+	+
Tester et al. (2004)	++	++	+	++	++	+	++	++	NA	++	+	++	NA	+	-
Tilly et al. (2005)	++	+	++	++	NA	+	++	NA	NA	++	++	-	NA	+	+
von Kries et al. (1998)	++	+	++	++	++	NA	++	++	NA	++	+	++	NA	+	-
Webster et al. (2005)	++	+	++	++	NA	-	++	NA	NA	++	+	-	NA	+	+
Webster & Layfield (2003)	++	++	++	++	NA	+	++	NA	NA	++	++	++	NA	+	+
Webster & Mackie (1996)	++	++	++	++	NA	+	++	NA	NA	++	++	++	NA	+	++
Wheeler & Taylor (2000)	++	++	+	++	NA	+	++	NA	NA	++	++	-	NA	+	++
WSP Development and Transportation (2008a)	++	+	++	++	NA	+	+	NA	NA	+	+	-	NA	+	+
WSP Development and Transportation (2008b)	++	+	++	++	NA	+	+	NA	NA	++	++	-	NA	+	+
WSP Development and Transportation (2008c)	++	+	++	++	NA	+	+	NA	NA	+	+	-	NA	+	+

5.2.1. Applicability

Nearly all of the studies were based in the UK; three were in the United States (including the two 'Safe Routes to School' programmes); one was set in Germany; and the combination intervention was set in Sweden. The applicability of these studies to the policy area can therefore be considered pretty high, particularly with regard to the traffic-calming and cycle route interventions.

The remainder of this chapter discusses the studies within intervention type, providing details for each of the study characteristics, intervention characteristics, quality assessment and study results for area wide traffic-calming schemes, single road traffic-calming schemes, 20mph zones, home zones, mixed priority route schemes, safe routes to schools, cycle routes and combination interventions.

5.3. Findings

5.3.1. Area wide traffic-calming: Study Characteristics

Five studies were identified that quantitatively evaluated area wide traffic-calming (Cloke et al, 1999; Department for Transport, 2001; Jones et al, 2005; Mackie et al, 1990; Wheeler & Taylor, 2000). Four of these evaluated specific schemes and collected before and after data (Cloke et al, 1999; Department for Transport, 2001; Mackie et al, 1990; Wheeler & Taylor, 2000), one was an ecological study (Jones et al, 2005). All studies were based in the UK. All four studies of specific schemes included a wide variety of different traffic-calming features. Three of the studies involved some kind of public consultation (Cloke et al, 1999; Department for Transport, 2001; Mackie et al, 1990), and three involved some kind of police enforcement measure (e.g. speed cameras) (Department for Transport, 2001; Mackie et al, 1990; Wheeler & Taylor, 2000). The Gloucester Safer City Project also included some education, training and publicity, although the main focus was on the engineering measures (Department for Transport, 2001). See Table 3 for study characteristic details and Appendix 8 for detailed descriptions of the interventions.

Only one of these studies was a controlled before and after study (Mackie et al, 1990). This study evaluated the effectiveness of the Urban Safety Project in five English towns, collecting data for 5 years before the intervention and 2 years afterwards, and choosing areas with a large enough population to be sufficiently powered for a reduction in accidents to be measured. Further information regarding the individual schemes evaluated in this study were reported in several previous publications (Mackie et al., 1988; Walker & Gardner, 1989; Walker & McFetridge, 1989; Ward et al., 1989a; Ward et al., 1989b; Ward et al., 1989c). These studies were initially excluded from the review because they were published before 1990. It was however hoped that information from these studies could be used to add detail to the overarching study that has been included (Mackie et al, 1990); however, due the late arrival of these reports and limited available resources the reviewers were unable to use the publications in this way.

Three studies were uncontrolled before and after studies (Cloke et al, 1999; Department for Transport, 2001; Wheeler & Taylor, 2000). Two of these were based in an urban setting (Cloke et al, 1999; Department for Transport, 2001). The Gloucester Safer City Project was a project set up under the 'Safe Town Initiative' (Department for Transport, 2001). In order to be eligible for this grant the area again had to have a large enough population to be sufficiently powered for a reduction in accidents to be measurable. Data reported from before the intervention was the annual average over 5 years, and after data was for one year only, as results were only provisional (Department for Transport, 2001).

The second urban study was of a traffic-calming scheme implemented in a largely residential area (Leigh Park, Havant; Cloke et al, 1999). Data was collected over three years before the intervention and 20 months afterwards in this study. The third uncontrolled before and after study was of a number of village traffic-calming schemes (Wheeler & Taylor, 2000). The schemes evaluated in this study were spread across Great Britain and had been implemented in villages of a range of sizes, and with different speed reducing measures, traffic flows and main road classes. At least 5 years worth of data were collected before each of the schemes were implemented, and between 1.8 and 5 years worth of data were collected afterwards.

The remaining study was an ecological study of two cities with varying levels of traffic-calming measures that were assessed over three different 3 year time periods (Jones et al, 2005). For the purposes of this review, data from the first and the last time period have been recorded, and the assumption made that these would be the most comparable to the before and after periods of other studies assessed. The main aim of this study was a little different to the others, in that the authors were looking to determine firstly, whether area wide traffic-calming distribution reflects known inequalities in child pedestrian injury rates, and secondly, whether traffic-calming is associated with changes in childhood pedestrian injury rates. The two cities chosen had similar total populations and similar numbers of 4-16 year olds within that population. In City A about 43% of electoral divisions were in the most deprived fourth, where as in City B, only about 24% were. For all other characteristics measured, the two cities were fairly similarly, apart from the total road length was slightly higher in City B (~800km) compared to City A (~730km).

Two of the five studies scored a '++' for external validity because they evaluated a good spread of sites across the policy area (Mackie et al, 1990; Wheeler & Taylor, 2000); the others were restricted to one or two sites only. One of the studies scored a '-' for internal validity, mainly due to the lack of clarity of reporting of outcome data (Cloke et al, 1999). The rest of the studies scored a '+' for both internal and external validity. All studies were based in the UK, and can therefore be considered directly applicable to similar roads and/or communities in the UK, with the possible exception of the 1990 study by Mackie et al. where the evidence is around 20 years old.

Table 3: Area Wide Traffic-calming schemes: Study Characteristics

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
Jones et al. (2005) **Design:** Ecological study **Aim:** ▪ To determine whether area wide traffic-calming distribution reflects known inequalities in child pedestrian injury rates. ▪ To determine whether traffic-calming is associated with changes in childhood pedestrian injury rates. **Study years:** ▪ Implementation of intervention: mainly from the mid 1990s onwards ▪ Audit of traffic-calming measures: 2002 ▪ Data analysed: 3 year periods from 1992 to 2000 **Source of funding:** partly funded by a grant from the Chief Medical Officer for Wales. **Internal validity:** + **External validity:** +	**Area wide traffic-calming** ▪ UK ▪ Urban ▪ Two UK cities, 45 miles apart, with similar total populations (250-300,000), and similar 4-16 year old populations (35-50,000). ▪ City A: 42.9% of electoral divisions were in the most deprived fourth; total road length 733.1km; 61.5% of most deprived children walked to school; between 1991 and 2001, proportions of households without cars dropped from 37.3% to 29.7% ▪ City B: 23.8% of electoral divisions were in the most deprived fourth; total road length 798.7km; 64.2% of most deprived children walked to school; between 1991 and 2001, proportions of households without cars dropped from 34.6% to 28.5%	▪ Age of children: 4-16 ▪ Initially intended to use traffic-calming feature installation dates in before and after approach. Data not stored in a readily available format. Also, traffic-calming measures installed on different roads within the same electoral division over periods of months or years, precluding simple time series analysis. ▪ Analyses based on deprivation fourths because too few events occur within individual electoral divisions.	**Identified by author:** ▪ Lack of traffic-calming installation dates. ▪ Injury rate changes could be due to measured or unmeasured confounders. ▪ This type of n=2 ecological study suffers from lack of power and the potential for bias due to other simultaneous changes in intervention or control areas. ▪ Other potential biases: changing population and environmental exposures; changing traffic volumes and speeds; changing exposure to traffic or differences between the two cities. ▪ Generalising data to all 4-16 year olds and all journeys is not ideal and limits analyses. ▪ Limitations of STATS19.
Department for Transport (2001) **Design:** Uncontrolled B&A **Aim:** To gauge the early success of the Gloucester Safer City project (GSCP). **Study years:** ▪ Implementation of intervention: 1996-2001 ▪ Data analysed: Before data was annual average for 1991-95, after data was for 2000 **Source of funding:** DfT **Internal validity:** + **External validity:** +	**Area wide traffic-calming** ▪ UK ▪ Urban ▪ The city of Gloucester ▪ Population in 1991: 100,165 ▪ Virtually freestanding. ▪ Image is of a typical cathedral city and county town; however, it had extensive industry in the 19th century and was a major port. ▪ Car ownership rate: 439/1000 population (above the national average but lower than for the county as a whole). ▪ Ethnic minority population: 5.72%	▪ Age of children: 15 and under ▪ In order to be eligible for the 'Safe Town Initiative' grant, bidders had to satisfy the following criteria: - town/city ideally surrounded by countryside - population of ~100,000 to allow the effects to be statistically significant - ideally have a range of housing developments and road layouts. ▪ Data collected for the whole of Gloucester.	**Identified by author:** ▪ Only provisional results for 2000 available. ▪ Casualty figures are small, especially when disaggregated, and subject to random variation. Figures for fatalities are not high enough for reduction to be statistically significant. ▪ The project did not finish until the end of March 2001. In addition, the full benefits of the many works carried out in 2000 will not be reflected in that year's figures. ▪ The Gloucester experience will not necessarily transfer to all similar locations. Locations have different problems which they will need to remedy in different ways according to local circumstances.

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
Wheeler & Taylor (2000) **Design:** Uncontrolled B&A **Aim:** To study the impact on accidents of traffic-calming measures in villages. **Study years:** ▪ Implementation of intervention: from approx. 1991 ▪ Data analysed: at least 5y before, between 1.8 and 5y after **Source of funding:** DETR **Internal validity:** + **External validity:** ++	**Village traffic-calming schemes** ▪ UK ▪ Rural ▪ Schemes for evaluation selected to include a broad geographic spread (across Great Britain), a range of village size, main road class and traffic flow, and a range of speed-reducing measures.	▪ Age of children: Under 16 ▪ Sites where significant changes in traffic flow were reported during the study period were excluded from the study. No changes in flow, other than those occurring naturally due to national trends, were reported at the sites studied, although detailed information not always available.	**Identified by author:** NR **Identified by review team:** ▪ Numbers of injury accidents reported rather than actual number of casualties.
Cloke et al. (1999) **Design:** Uncontrolled B&A **Aim:** To evaluate the impact of a traffic-calming scheme on the physical environment (traffic speeds and flows, accident frequency, vehicle emissions, air quality and noise levels); and to assess the impact it has on the human environment in terms of public perception and acceptance of the scheme. **Study years:** ▪ Implementation of intervention: 1997 ▪ Data analysed: 3y before (1994-97), 20mths after (1997-98) **Source of funding:** DETR **Internal validity:** - **External validity:** +	**Area wide traffic-calming** ▪ UK ▪ Urban ▪ Area is a largely residential (about 70%) estate, with some recreational space, open space and light industry. ▪ Roads bounding the area cover ~5km, and within it ~15km ▪ Buses operate within the area. ▪ All single-carriageway roads with street lighting, and subject to a 30mph speed limit. ▪ High level of vulnerable road user casualties	▪ Age of children: NR	**Identified by author:** ▪ More time required before any meaningful conclusions can be drawn as to long term effect of the measures on accident frequency. **Identified by review team:** ▪ Age range of 'children' not specified ▪ Reporting of injury accident data in children not very clear.

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
Mackie et al. (1990) **Design:** Non-RCT **Aim:** To assess the overall accident changes achieved by the Urban Safety Project. **Study years:** ▪ Implementation of intervention: unclear ▪ Data analysed: 5y before, 2y after (except Reading - 21 mths - due to urgent major road works); dates unclear **Source of funding:** DfT and Local Authorities. **Internal validity:** + **External validity:** ++	**Area wide traffic-calming schemes** ▪ UK ▪ Urban ▪ Trial schemes in 5 English towns: Reading, Sheffield, Nelson, Bradford and Bristol. ▪ Areas chosen to: be of average accident risk; have a range of road network types; be large enough to show the interaction between main road and residential road traffic redistribution; be large enough to be able to achieve a statistically significant reduction in accidents ▪ Average size of each area: ~7m^2, with residential populations of 30-50,000.	▪ Age of children: NR ▪ One of the criteria for choosing sites was: to be large enough in total to establish with statistical confidence that the observed reduction in accidents had not occurred by chance. Target reduction: 10-15%, therefore overall total of ~1000 accidents in the after period in the five study areas needed. After period lasted 2 years, so areas chosen in the five towns to have approx. 100 injury accidents/year	**Identified by author:** NR **Identified by review team:** ▪ Age range of 'children' not specified ▪ Actual dates of data collection and implementation of the schemes are unclear. ▪ Numbers of injury accidents reported rather than actual number of casualties.

5.3.2. Area wide traffic-calming: Results

Child casualties

Two studies reported the number of child pedestrian casualties before and after the intervention (Jones et al, 2005; Department for Transport, 2001). Both reported a reduction in the number of child pedestrian casualties after (or with increased levels of) traffic-calming; however, only one of these was statistically significant in one of the cities studied (City A: RaR=0.777, SE 1.085, p=0.002) (Jones et al, 2005) (see Table 4). The 10% reduction in child casualties in City B was not statistically significant (RaR=0.897, SE 1.102, p=0.265). This apparent difference between cities may be due to the reported higher levels of deprivation in City A, and therefore suggest that traffic-calming may be more effective in more deprived areas; however, it may be that areas with higher levels of deprivation have also had more traffic-calming measures implemented in them over the years; and indeed the authors do note that changes in injury rates were significantly inversely correlated with density of traffic-calming features (number of features per km road length; r=-0.769, p=0.026). See Figure 2 at the end of this section for a graphical summary of the child casualty and injury accident results.

The Gloucester Safer City Project evaluation (Department for Transport, 2001) reported all child casualties, all KSI child casualties, and child pedestrian and cyclist casualties before and after traffic-calming, and although slight reductions were shown in all of these, they were again, not statistically significant (see Table 4). It must be noted that both of these studies were uncontrolled before and after studies, and therefore the changes noted do not take into account any confounding factors that may have changed during the study periods. This limitation will be considered in more detail in the discussion (see page 128).

Child injury accidents

Three of the studies reported frequencies of injury accidents involving children, rather than actual numbers of casualties (one injury accident may involve more than one casualty) (Wheeler & Taylor, 2000; Mackie et al, 1990; Cloke et al, 1999). One of these studies was a controlled before and after study (Mackie et al, 1990). The results from this study have been considered here in comparison to the other before and after studies, but an intervention-control comparison was also calculated (see

Table 5). Both the inter-arm, and the before and after comparison, showed non-significant reductions in child injury accident rates. However, the difference between the intervention and control areas in injury accidents involving child cyclists nearly reached significance (RaR=0.524, 95% CI=0.258, 1.062), but this is partly due to the apparent increase in child cyclist accidents in the control group, which the authors state is not reflected in national trends, and therefore may lead to an overestimate of the typical effects of the schemes.

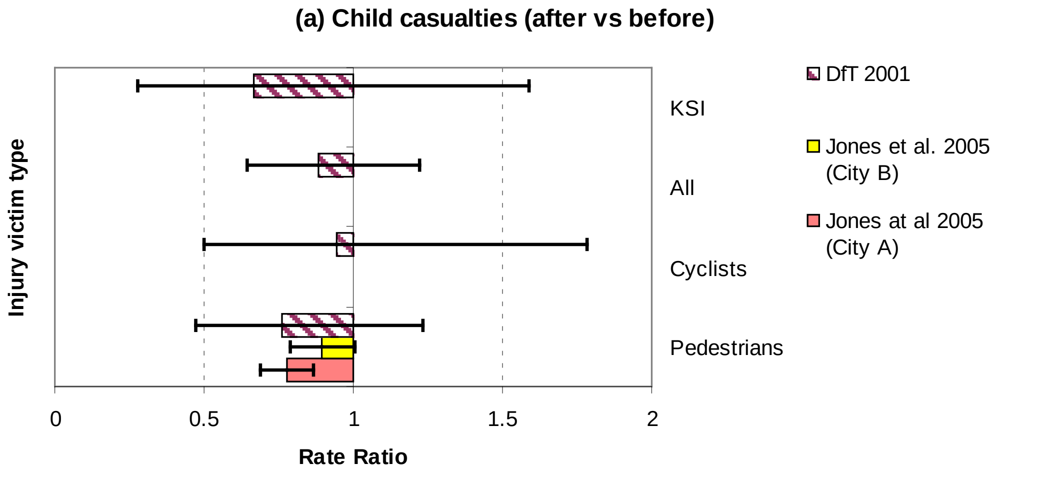
Injury accidents were also shown to be reduced in both of the other studies that reported this outcome. Wheeler & Taylor (2000) and Mackie et al (1990) reported separate outcomes for pedestrians and cyclists; and Wheeler & Taylor (2000) also reported KSI injury accidents separately; Cloke et al (1999) reported all injury accidents. None of the reductions were statistically significant. Observation frequencies were, however, quite low in two of these studies (Cloke et al, 1999; Wheeler & Taylor, 2000), which limits the meaningfulness of statistical comparison (see Table 6); and again, as these studies were uncontrolled before and after studies, the changes noted do not take into account possible changes in any confounding factors over the periods studied.

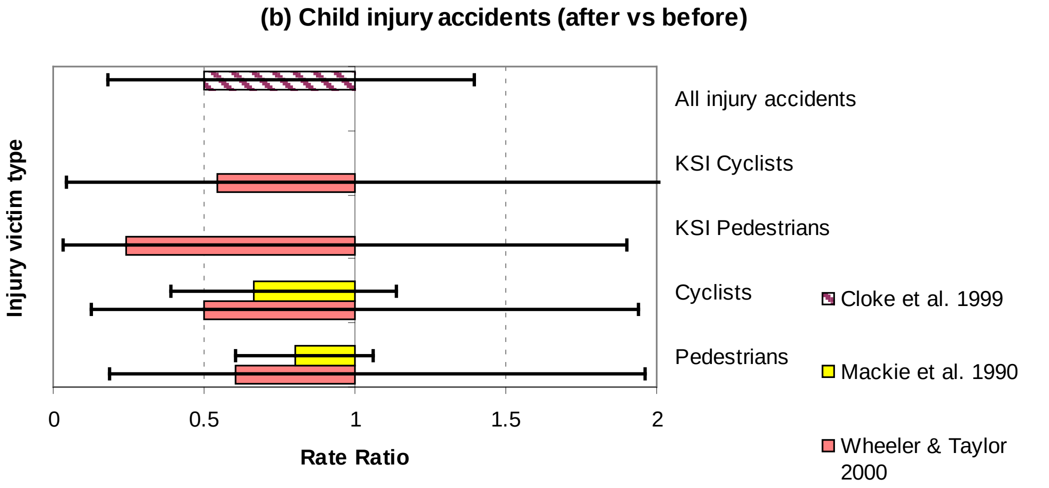
Traffic Speed

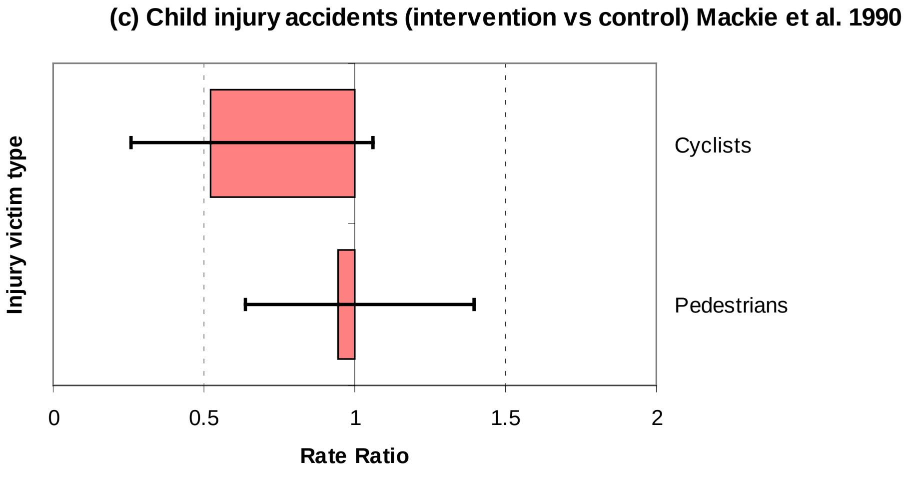
Traffic speed data were collected in two studies (Cloke et al, 1999; Wheeler & Taylor, 2000). Cloke et al (1999) reported that all of the measures had the effect of reducing speeds, and all speed reductions were significant ($p<0.05$). Speeds were reduced by up to 12mph, depending on the type of measure and location. Speed cushions, a raised junction, and a mini-roundabout appeared to be the most effective at reducing speeds, giving an average speed reduction of 11-12mph. Speed reduction at the pedestrian refuge was about 5mph. However, the authors state that this was not sufficient to reduce the mean speed to below 30mph.

Wheeler & Taylor (2000) did not report traffic speed data in their study, but it had been reported in previous publications of two studies of groups of village traffic-calming schemes that subsequently formed part of the this later larger study (Wheeler et al., 1994; Wheeler & Taylor, 1999). For completeness, data from these publications, which supplemented the main, later report, is given here. In the VISP study (Wheeler et al, 1994) changes in 85th percentile speeds were given. These ranged from small increases to a reduction of 13mph. There were 120 sites/times where 85th percentile speeds were measured, across 24 villages; speed reductions were noted at 98 of these. In the second study Wheeler & Taylor (1999) report that vehicle speeds were reduced almost everywhere, with the exception of one of the gateways (where speed increased), 85th percentile speeds decreased by between 3-15mph, both inbound at gateways and in the villages themselves. Mean speed reductions were generally up to about 2mph less than reductions in 85th percentile speeds. It is noted that a range of different measures have been used in combination, making it difficult to compare their effect, particularly as the circumstances in which they were installed varied considerably between villages.

Figure 2. Child casualty and injury accident rate ratios for area-wide traffic-calming: summary







Note: Lines represent 95% confidence intervals (calculated by reviewers)

Evidence Statement 1: Area-wide traffic-calming and child road safety outcomes

Five UK based studies evaluated area wide traffic-calming schemes. There was one controlled (Mackie et al, 1990 [+]) and 3 uncontrolled (Cloke et al, 1999 [-]; Department for Transport, 2001 [+]; Wheeler & Taylor 2000 [+]) before and after studies, and one ecological study (Jones et al, 2005 [+]). Within these studies, casualties, injury accidents and speed outcomes were reported.

1a There is moderate evidence from 2 uncontrolled before and after studies (both UK), that area wide traffic-calming may reduce **rates of KSI children** (Department for Transport, 2001 [+]; Wheeler & Taylor 2000 [+]). Both studies showed reductions in either KSI child casualties or KSI injury accidents involving child pedestrians or cyclists, but none of these were statistically significant.

1b There is moderate evidence from 1 uncontrolled before and after study and 1 ecological study (both UK), that area-wide traffic-calming may reduce **child road casualty rates of any severity** (Department for Transport, 2001 [+]; Jones et al, 2005 [+]). There is moderate evidence from 1 controlled and 2 uncontrolled before and after studies (all UK), that area-wide traffic-calming may reduce **child injury accident rates** of any severity (Cloke et al, 1999 [-]; Mackie et al, 1990 [+];Wheeler & Taylor 2000 [+]).

Of the 2 studies which reported **child casualty rates** one ecological study showed a statistically significant reduction (RaR= 0.777 for pedestrians in one of two cities studied, p= 0.002; Jones, 2005 [+]), whilst the results in the other city, and the uncontrolled before and after study are consistent with a reduction, but do not reach significance (Department for Transport, 2001 [+]).

The 3 studies which reported **child injury accident rates, (**1 controlled and 2 uncontrolled before and after studies, all UK) also show reductions, but only one approaches statistical significance when compared with a control group (RaR=0.524; 95% CI=0.258, 1.062 for child cyclists; Mackie et al, 1990 [+]) (Cloke et al, 1999 [-]; Wheeler & Taylor 2000 [+]).

1c There is weak evidence from 2 uncontrolled before and after studies that area wide traffic-calming may reduce traffic speeds (Cloke et al, 1999 [-]; Wheeler & Taylor 2000 [+]).

With the possible exception of the much older study by Mackie et al. (1990), this evidence is judged as directly applicable to similar roads and/or communities in the UK.

Table 4: Area wide traffic-calming – Results: Child casualties

		Before		After			
Study Name	**Child casualties**	**Years**	**No. of casualties**	**Years**	**No. of casualties**	**Before-after comparison (or equivalent)**	**p**
Jones et al. (2005)	Pedestrians: City A	3	345	3	268	RaR=0.777 (SE 1.085)	0.002[d]
	Pedestrians: City B	3	224	3	201	RaR=0.897 (SE 1.102)	0.265
Department for Transport (2001)	All	1	79	1	70	RaR=0.886 (SE 1.178)	0.461
	Pedal cyclist	1	19	1	18	RaR=0.947 (SE 1.389)	0.869
	Pedestrian	1	38	1	29	RaR=0.763 (SE 1.280)	0.272
	All KSI	1	12	1	8	RaR=0.667 (SE 1.578)	0.371[d]

Table 5: Area wide traffic-calming – Results: Child injury accident data (intervention-control comparison)

			Before		After			
Study name	**Study arm**	**Injury accidents**	**Years**	**No. of injury accidents**	**Years**	**No. of injury accidents**	**Before-after comparison[e]**	**Intervention-control comparison**
Mackie et al. (1990) [f]	Traffic-calming	Pedestrians	1	111	1	89	RaR=0.802 (SE 1.153)	RaR=0.944 (95% CI=0.639, 1.393)
	Control	Pedestrians	1	113	1	96	RaR=0.850 (SE 1.149)	
	Traffic-calming	Cyclists	1	33	1	22	RaR=0.667 (SE 1.317)	RaR=0.524 (95% CI=0.258, 1.062)
	Control	Cyclists	1	33	1	42	RaR=1.273 (SE 1.262)	

[d] Calculated by reviewer using raw casualty frequency data. MLE hypothesis test used.

[e] All RaR's were calculated by the reviewer using raw casualty frequency data.

[f] 'Before' and 'after' data for the intervention group is also presented in Table 6 with the 'before' and 'after' data for the non-controlled studies.

Table 6: Area wide traffic-calming – Results: Child injury accident data

		Before		After			
Study Name	**Injury accidents involving children**	**Years**	**No. of injury accidents**	**Years**	**No. of injury accidents**	**Before-after comparison (or equivalent)**	**p**
Wheeler & Taylor (2000)	Pedestrians[g]	1	6.6	1	4	RaR=0.606 (SE 1.884)	0.425
	Cyclists	1	5.4	1	2.7	RaR=0.500 (SE 2.107)	0.343
	KSI Pedestrians[g]	1	3.3	1	0.8	RaR=0.242 (SE 3.477)	0.217
	KSI Cyclists[g]	1	1.1	1	0.6	RaR=0.545 (SE 4.977)	0.701
Cloke et al. (1999)	All[h]	1	10	1	5	RaR=0.500 (SE 1.729)	0.197
Mackie et al. (1990)[i]	Pedestrians	1	111	1	89	RaR=0.802 (SE 1.153)	0.120
	Cyclists	1	33	1	22	RaR=0.667 (SE 1.317)	0.138

[g] Data is for 56 villages. No. of injury accidents are per year for villages combined (mean of 7.2 years before and 5.3 years after accident data).

[h] The number of injury accidents before the intervention was not actually reported, but the authors state that: ‘accidents to children [have] been halved, to 5 per year’

[i] Interarm comparison data is presented in

Table 5 for this controlled study.

5.3.3. Single road traffic-calming: Study characteristics

Three UK based studies evaluated traffic-calming schemes that were implemented on single road(s) (Chorlton 1990; Jones & Farmer 1993; Mountain et al, 2005). The quality of the evidence for this type of intervention is limited by the fact that all of these studies had an uncontrolled before and after study design. The scale of each of these studies was quite different (Chorlton 1990; Jones & Farmer 1993; Mountain et al, 2005). See Table 7 for study characteristic details, and Appendix 8 for detailed descriptions of the interventions.

Mountain et al (2005) compared the impact of 71 engineering schemes of various types with 79 safety camera schemes implemented on 30mph roads at various locations throughout Great Britain. However, no indication of the setting for these schemes (e.g. urban/rural) was given, and therefore a score of '+' was given to this study for external validity (as well as internal validity). Data was collected for 3 years before the schemes had been implemented and for an average of two and a half years afterwards.

Jones & Farmer (1993) conducted a before and after study of the effect of 'pedestrian ramps'[j] on a busy dual carriageway, less than 1km in length, adjacent to a shopping centre. The road had quite high pedestrian crossing flows and a poor accident record before implementation of the intervention. Data were collected for 3 years before the intervention and 31 months afterwards (internal validity '+', external validity '+').

Chorlton (1990) reported before and after data for a pilot traffic-calming scheme on quite a different type of single road (also less than 1km long) in Devon. This road formed the main artery of an extensive council estate, bounded by slightly older private properties, where pedestrian and cyclist accidents were a problem, particularly among children travelling to and from school. The road was used for a number of different purposes, including acting as a short cut, forming part of a distributor road system, a bus route, a school route, and an area in which children play, and people shop and relax. A variety of measures were implemented, including cycle tracks in both directions and features to enhance the local environment. The

[j] 'Pedestrian ramps' are described in this study as: about 5.5m wide and flat-topped; they raise the road to the level of the kerb by a slope of 1 in 6; the approach face is marked with white triangles; each end is marked with a white line; signage was used; ramps were installed at 6 of the 8 partially covered ways; in between ramps, railings and other features were used to discourage pedestrians from crossing, however, crossing is still possible. These would appear to be similar to the 'flat-top road humps', 'footway cross-overs' or 'threshold treatments' described in other studies, and shouldn't be confused with slopes that allow people with mobility difficulties to avoid stairs (another possible interpretation of 'Pedestrian ramps').

intervention also involved consultation with local people and contribution from local children. The clarity of reporting was such that it was given a '-' for internal validity. However, Chorlton does state that it was too early at that stage to draw any clear conclusions about the reduction in accidents. Chorlton (1990) collected data for 5 years before the intervention and 18 months afterwards.

Table 7: Single Road Traffic-calming – Study Characteristics

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
Mountain et al. (2005) **Design:** Uncontrolled B&A **Aim:** To compare the impact of speed enforcement cameras and engineering measures on accidents and vehicle speeds and to establish the nature of any relationship between speed changes and accident changes. **Study years:** ▪ Dates unclear ▪ Data for: 3y before, average of 2.5y after **Source of funding:** Engineering and Physical Sciences Research Council. **Internal validity:** + **External validity:** +	**Single road traffic-calming schemes** ▪ UK ▪ Unclear whether urban or rural ▪ 150 speed management schemes implemented on 30mph roads at various locations throughout Great Britain	▪ Age of children: NR ▪ Child specific data only available for 56/71 engineering scheme sites, and 74/79 safety camera sites. ▪ Sample size limited by availability of sufficiently detailed speed and flow data (not routinely collected for all speed management schemes)	**Identified by author:** ▪ Observed changes in accidents will include changes arising due to RTM and trend. Not possible to correct the observed changes involving vulnerable road users, due to absence of predictive models for cyclist and pedestrian accidents or data for control sites. **Identified by review team:** ▪ Age range of 'children' not specified ▪ Actual dates of data collection are unclear. ▪ Numbers of injury accidents reported rather than actual number of casualties.
Jones & Farmer (1993) **Design:** Uncontrolled B&A **Aim:** To examine the effect of pedestrian ramps on accidents; on pedestrian flows, delay, crossing behaviour; on vehicle flows, behaviour, speeds; and on bus journey times. Also, to describe the results of a survey of people's attitudes to, and understanding of, the ramps. **Study years:** ▪ Implementation of intervention: 1988 ▪ Data analysed: 3y before (1985-88), 31mths after (1988-91) ▪ Speed data collected: immediately before, immediately after, and again about a year later ('follow-up' data). **Source of funding:** DfT **Internal validity:** + **External validity:** +	**Pedestrian ramps** ▪ UK ▪ Urban ▪ Central Milton Keynes. ▪ A dual carriageway road used by many customers and workers to reach the main shopping centre ▪ Poor accident record ▪ Carries all buses serving the shopping centre and much of the private vehicle traffic ▪ Also a large entertainments centre and 2 supermarkets in the vicinity ▪ Quite high pedestrian crossing flows - up to ~4,500 pedestrians/hour, mostly in about a 400m stretch of the road ▪ Straight road, length <1km, with a speed limit of 30mph. ▪ Moderately busy with up to ~1000 vehicles/hour on a weekday; and up to ~1200	▪ Age of children: 14 and under	**Identified by author:** ▪ A possible distorting influence on comparison of accidents might have been change in traffic volumes. However, on average, the traffic flows in the 'before' and 'after' periods are similar. In the 3 years before the installation of the ramps, traffic on Midsummer Boulevard increased by about 15%. In the 11 months after it fell by possibly as much as 12%. ▪ Not possible to test for the likely size of the effect of RTM in this study, but the scale of the change in accidents is such that it seems highly unlikely to be due entirely to this.

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
	vehicles/hour on a Saturday.		
Chorlton (1990) **Design:** Uncontrolled B&A **Aim:** To outline the design, development and construction of the Burnthouse Lane Traffic-calming scheme and to give details of the extensive before and after studies associated with the scheme. **Study years:** ▪ Implementation of intervention: 1988 ▪ Data analysed: 5y before, 18mths after; dates unclear **Source of funding:** paper produced by commission of Michael Hawkins OBE, County Engineer and Planning Officer of Devon County Council. **Internal validity:** + **External validity:** +	**Single road traffic-calming scheme** ▪ UK ▪ Urban ▪ A pilot demonstration scheme. ▪ Burnthouse Lane forms part of an intermediate ring road lying between the Inner Bypass and the 'famous' Exeter bypass. ▪ Main artery of an extensive council estate, bounded by slightly older private properties. ▪ Pedestrians and cyclists accidents were a problem (particularly children travelling to/from school) ▪ 3 schools and a nursery are situated on the road ▪ Also shops, a surgery, village hall, churches and a public house ▪ Functioned at a number of different levels: fast, short-cut or rat run; part of a distributor road system enabling access to home or work; school route; bus route; an area in which children play; an area where people shop and relax; and the communal centre for a much wider area.	▪ Age of children: 10 and under	**Identified by author:** ▪ Too early to draw any clear conclusions about the reduction in accidents.

5.3.4. Single road traffic-calming: Results

See Table 8 and Figure 3 (next page) for a graphical summary of the results relating to child casualties and child injury accidents.

Child casualties

Two of the studies report child casualty rates before and after the intervention (Chorlton, 1990; Jones & Farmer, 1993). In Jones & Farmer's study (1993) child pedestrian casualties were reduced from 12 over 3 years before, to zero over 31 months after the intervention (RaR=0, $p<0.001$). However, as with all of the studies of single road traffic-calming schemes, caution needs to be taken when interpreting the results, as they are all uncontrolled before and after studies, and are therefore open to a number of confounding factors. Chorlton (1990) also reports a reduction in the annual rate of child (aged under 11) casualties from three to zero. However, the numbers are too small to interpret anything meaningful from these results (see Table 8).

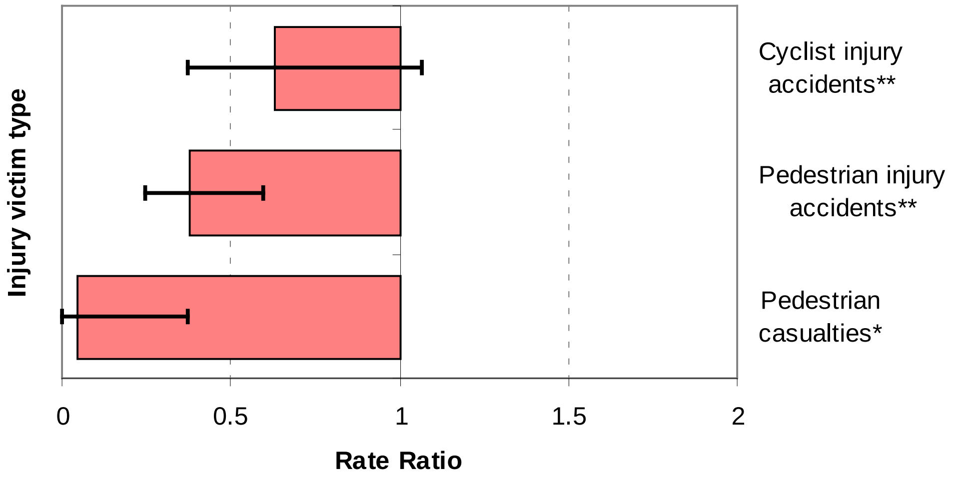
Child injury accidents

One of the studies of single road traffic-calming reported child injury accidents rather than casualties as an outcome (Mountain et al, 2005). With a larger number of sites, and therefore frequency of observations, Mountain et al (2005) report a significant reduction (around 60%) in injury accidents involving child pedestrians (RaR=0.381, SE1.259, $p<0.001$) and also a reduction in injury accidents involving child cyclists, although this is not statistically significant (Table 9). Reductions in injury accident rates were also seen at safety camera intervention sites; however these were not statistically significant.

Traffic speed

Two of the studies of single road traffic-calming schemes report speed data (Jones & Farmer, 1993; Mountain et al, 2005). Mountain et al (2005) report reductions in mean traffic speeds (mph) for both 'vertical' and 'horizontal' traffic-calming schemes, and report that traffic speed reductions were significantly greater ($p<0.05$) at 'vertical' schemes (-8.4mph, SE 0.94) compared to both 'horizontal' schemes (-3.3mph, SE 0.94) and safety camera sites (-4.1mph, SE 0.32). (see Table 10). Jones & Farmer report a reduction in mean speed from 26mph to 13mph with the installation of 'pedestrian ramps'.

Figure 3. Child casualty and injury accident rate ratios for single route traffic-calming: summary



Note: Lines represent 95% confidence intervals (calculated by reviewers)
* from Jones & Farmer 1993
**from Mountain et al. 2005

Evidence Statement 2: Single road traffic-calming and child road safety outcomes

Three UK based studies evaluated single road traffic-calming schemes. These were all uncontrolled before and after studies (Chorlton, 1990, [+]; Jones & Farmer, 1993 [+]; Mountain et al 2005, [+]). Within these studies, casualties, injury accidents and speed outcomes were reported.

2a There is weak evidence from 2 UK based uncontrolled before and after studies,to show that single road traffic-calming may reduce **child road casualty rates**. Only one of these studies showed a statistically significant reduction in child casualties from 12 to zero ($p<0.001$; Jones & Farmer, 1993 [+]). In the other study, numbers of casualties were too small (decreasing from 3 to zero) to be meaningful (Chorlton, 1990, [+]).

2b There is weak evidence from 1 UK based, uncontrolled before and after study that single road traffic-calming may reduce **child pedestrian injury accident rates** (RaR0.0381, $p<0.001$) while **child cyclist injury accident rates** were also reduced, but non-significantly (RaR=0.632, $p=0.081$; Mountain et al 2005, [+])

2c There is weak evidence from 2 uncontrolled before and after studies that single road traffic-calming may reduce traffic speeds (Jones & Farmer, 1993 [+]; Mountain et al 2005, [+]).

This evidence is judged as directly applicable to similar roads and/or communities in the UK, although the Chorlton evidence is dated.

Table 8: Single Road Traffic-calming – Results: Child casualties

		Before		After			
Study Name	**Child casualties**	**Years**	**No. of casualties**	**Years**	**No. of casualties**	**Before-after comparison (or equivalent)**	**p**
Chorlton (1990)	All	1	3	1	0	Not reported here because of small numbers.	
Jones & Farmer (1993)	Pedestrian	3	12	2.58	0	RaR=0	<0.001

Table 9: Single Road Traffic-calming – Results: Child injury accidents

		Before		After			
Study Name	**Injury accidents involving children**	**Years**	**No. of injury accidents**	**Years**	**No. of injury accidents**	**Before-after comparison (or equivalent)**	**p**
Mountain et al. (2005)	Pedestrians (engineering schemes)[k]	2.98	77	2.54	25	RaR=0.381 (SE 1.259)	<0.001
	Cyclists (engineering schemes)	2.98	39	2.54	21	RaR=0.632 (SE 1.311)	0.081
	Pedestrians (speed cameras)[l]	*2.99*	*134*	*2.42*	*94*	*RaR=0.867 (SE 1.144)*	*0.284*
	Cyclists (speed cameras)	*2.99*	*49*	*2.42*	*39*	*RaR=0.983 (SE 1.239)*	*0.938*

[k] Data is for 56 engineering scheme sites

[l] Data is for 74 speed camera sites

Table 10: Single Road Traffic-calming – Results: Traffic Speed

Study Name	Subgroup Name	Mean speed before (mph)	Mean speed after (mph)	Mean difference in speed (mph)
Mountain et al. (2005)	Horizontal deflections (30 schemes)			-3.3 (SE 0.53)[m]
	Vertical deflections (36 schemes)			-8.4 (SE 0.94) [n]
	Speed cameras (74 sites)			*-4.1 (SE 0.32)*[m]
Jones & Farmer (1993)		26	13	-13[o]

[m] Significantly different from vertical schemes ($p<0.05$)

[n] Significantly different from horizontal schemes ($p<0.05$)

[o] Mean difference calculated by reviewer.

5.3.5. 20mph zones: Study characteristics

Four studies evaluated 20mph zones, all in the UK (Grayling et al, 2002; Grundy et al, 2008; Webster & Mackie, 1996; Webster & Layfield, 2003). However, all of them potentially overlap with at least one other to different extents, and care must therefore be taken when interpreting the results. Nevertheless, data from all of these studies have been extracted separately, but it must be noted that there are varying levels of overlap between them. See Table 11 for study characteristics and Appendix 7 for detailed descriptions of the interventions.

Grundy et al. (2008) carried out the most recent study which focussed on 20mph zones in London. They collected data over a 20 year period and conducted a time series analysis. They also conducted a before and after analysis on a restricted number of zones (using 3 years of ‘before’ data and 3 years of ‘after’ data) for comparison (as this is the more traditional approach taken by other studies), and within this they adjusted for background trends on outside roads using two different methods. The authors note that the numbers of pedestrian casualty rates in London are declining, although remain relatively high compared to the rest of the country (perhaps reflecting the higher numbers of pedestrians in London). This study essentially updates the previous study of 20mph zones in London carried out by Webster & Layfield (2003), and as such should be the main focus in terms of observing the effects of 20mph zones in London. Webster & Layfield carried out a controlled before and after study using unclassified roads in London and a control group. Data were collected for 5 years before implementation of the 20mph zones, and between 1 and 5 years afterwards.

The other two studies were uncontrolled before and after studies (Grayling et al, 2002; Webster & Mackie, 1996). Webster & Mackie (1996) carried out a review of 20mph zones across England, scoring ‘++’ for external validity. In this study they evaluated a mixture of urban and rural zones in a variety of settings, including residential areas, shopping streets and town centres. They also included five of the London 20mph zones; however, out of 72 zones, the overlap with the studies by Grundy et al (2008) and Webster & Layfield (2003) is nevertheless quite small. Data were collected for at least 3 years before the intervention, and at least 1 year afterwards for each zone. The other uncontrolled before and after study focussed on 20mph zones in Hull (Grayling et al, 2002). These schemes were also noted by Webster & Mackie (1996), however, data do not appear to have been analysed for these Hull schemes in that study, presumably because insufficient 'after' data would have been available at that stage. It is noted in this study that Hull is an area with a relatively high level of deprivation compared to the rest of England. Data were collected for 3 years before and after the interventions had been implemented.

All four studies scored '+' for internal validity, and with the exception of Webster & Mackie's (1996) study, they scored a '+' for external validity as well.

Table 11: 20 mph zones - Study Characteristics

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
Grundy et al. (2008) **Design:** Uncontrolled B&A (but adjusted for background trends) **Aim:** To provide an assessment of the effectiveness and cost effectiveness of 20mph zones on casualty reduction and to identify implications for road safety policy in London. **Study years:** ▪ Implementation of intervention: 1991-2008 ▪ Data analysed: data collected for the years 1986-2006 for time series analysis; and for before and after analysis - 3y before, 3y after (restricted to zones implemented between 1991-2003 to ensure that enough 'after' data available) **Source of funding:** TfL **Internal validity:** + **External validity:** +	**20mph zones in London** ▪ UK ▪ Urban ▪ Area covered: 121km^2; 2006km of roads within London. ▪ Size of zones varies greatly, from a single stretch of road 0.07km to an area covering 37km of roads. ▪ Majority of roads included and adjacent to the zones are minor roads. ▪ There has been a shift in location of zones from the more affluent areas to the more deprived areas. ▪ Not all zones were implemented in an area with high casualty rates, some implemented around schools or areas with potential for high casualty frequencies. ▪ 252 zones contain a school and most have one within 100m. ▪ London's pedestrian casualty rates are declining, but remain comparatively high compared to the England average. This may however reflect the higher number of pedestrians in London.	▪ Age of children: 15 and under ▪ Time series regression analysis used as the main method of analysis - allowing adjustment for background changes and potential borough level effects. ▪ Before and after analysis also done to see whether this would provide similar results.	**Identified by author:** ▪ Could not include data on risk exposure. There might have been a change in the amount and modality of traffic associated with the introduction of 20mph zones. ▪ There are potentially roads that have ceased to be 20mph zones, as some traffic-calming measures have been removed over the time period of the study (relatively rare). ▪ Not able to take into account other road safety initiatives that may have occurred during the study period (e.g. safety cameras).

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
Webster & Layfield (2003) **Design:** Non-RCT **Aim:** To review the performance of 20mph zones in London **Study years:** ▪ Implementation of intervention: from approx. 1989 ▪ Data analysed: 5y before, between 1 and 5y after **Source of funding:** LAAU **Internal validity:** + **External validity:** +	**20mph zones in London** ▪ UK ▪ Urban ▪ London Boroughs	▪ Age of children: NR ▪ Information obtained for 115/137 zones identified, however only 78 analysed (only these in place long enough for at least 1y after data to be available). ▪ Change in speed data only available for 14/78 zones.	**Identified by author:** ▪ Insufficient data readily available with regard to scheme costs, scheme design, traffic flows and speeds before and after installation, and road user type, in order to identify any relationships between zone design and effectiveness. **Identified by review team:** ▪ Age range of 'children' not specified ▪ Some errors apparent in data reported.
Grayling et al. (2002) **Design:** Uncontrolled B&A **Aim:** To deepen understanding of the relationship between deprivation and child pedestrian casualties and to examine the impact of local and national transport policies. (The section of interest for this review is a case study within the report) **Study years:** ▪ Implementation of intervention: 1996-97 ▪ Data analysed: 3y before, 3y after; dates unclear **Source of funding:** financial support from the Guild of Experienced Motorists (GEM) and the Ree Jeffreys Road Fund and additional funding from the Polden Puckham Trust and Laing's Charitable Trust. **Internal validity:** + **External validity:** +	**20mph zones in Hull** ▪ UK ▪ Urban ▪ The city of Kingston-upon-Hull ▪ Population: ~1/4 million ▪ Relatively high level of deprivation (3/20 electoral wards among the 100 most deprived in England; all in the 30% most deprived)	▪ Age of children: Unclear. Assumed that children are defined as 15 years and under (the age range specified for 'children' in unrelated data presented earlier in the report).	**Identified by author:** NR **Identified by review team:** ▪ Age range of 'children' not specified ▪ Actual dates of data collection are unclear. ▪ Some errors apparent in data reported.

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
Webster & Mackie (1996) **Design:** Uncontrolled B&A **Aim:** To review all of the 20mph zones schemes resulting from the 20mph Zone initiative introduced by the Department for Transport in December 1990. **Study years:** ▪ Implementation of intervention: from approx. 1989 ▪ Data analysed: at least 3y before, at least 1y after (time periods as stated by authors, although data appears inconsistent) **Source of funding:** DfT **Internal validity:** + **External validity:** ++	**20mph zones** ▪ UK ▪ Mixture of urban and rural ▪ 20mph zones in England that had been installed for at least 12 months. Set in a mixture of environments including residential areas, shopping streets, town centres and single road schemes.	▪ Age of children: 15 and under ▪ Information obtained regarding 240 zones in England, including permanent, temporary and proposed zones, and also including different phases of the same zone, however only 72 schemes analysed (in place sufficiently long enough to provide an average of 30mths after data). ▪ Change in speed data only available for 32/72 zones.	**Identified by author:** NR **Identified by review team:** ▪ Lengths of data collection periods in tables do not always appear to match up with the defined minimums or maximums stated in the text. ▪ The words 'casualty' and 'accident' appear to be used interchangeably.

5.3.6. 20mph zones: Results

Child casualties

Both of the London studies (Grundy et al, 2008; Webster & Layfield, 2003) attempted to control for background changes in casualty rates for selected outcomes. Grundy et al (2008) carried out a time series analysis, and also adjusted their before and after data for changes on outside roads using two different methods. They report reductions in all and KSI child casualties overall, as well as all and KSI child pedestrian casualties. All of these reductions were statistically significant (at least at the 95% level, where reported), with the exception of KSI child pedestrians when the before and after analysis was adjusted for trends on background roads (see Table 13). Webster & Layfield (2003) reported data for unclassified roads in London as a control (see Table 12). They report reductions in all child casualties and child KSI casualties, but only the reduction in all casualties was significantly different from the control area (RaR=0.579; 95% CI=0.405, 0.829).

All four studies showed a statistically significant reduction in 'all' child casualties after implementation of 20mph zones (using a before and after comparison; see Table 13). Similarly, significant reductions were seen in child pedestrian casualties in the three studies that reported this outcome (Grayling et al, 2002; Grundy et al, 2008; Webster & Layfield, 2003). Child cyclist casualties, in the two studies that reported these, were also significantly reduced, although the change was at a lower level of significance (p=0.029) in the Hull study (Grayling et al, 2002), compared with the London study (p<0.001; Webster & Layfield, 2003), perhaps not surprising given the differences in scale and number of observations in each of the studies.

Reductions in KSI child casualties were also shown in the three studies that reported them. Reductions in all KSI child casualties were all statistically significant. Webster & Layfield (2003) reported child pedestrian and child cyclist KSI casualties separately (this level of detail wasn't reported for the control group, and therefore only a before and after comparison can be made), but only the reduction in child pedestrian KSI casualties was statistically significant.

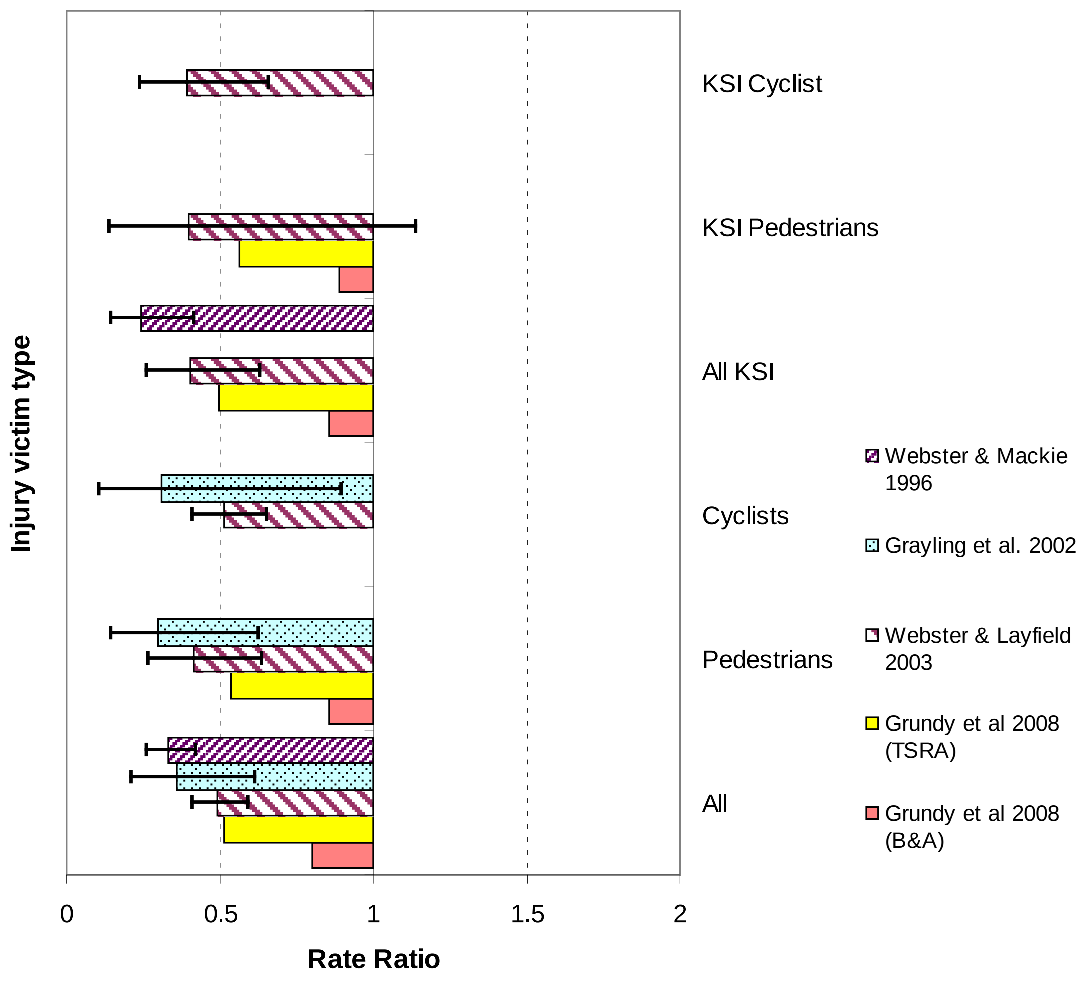
It must be emphasised again that the studies that rely on uncontrolled data are open to several potential confounders which will be considered in the discussion section of this report.

Traffic speed

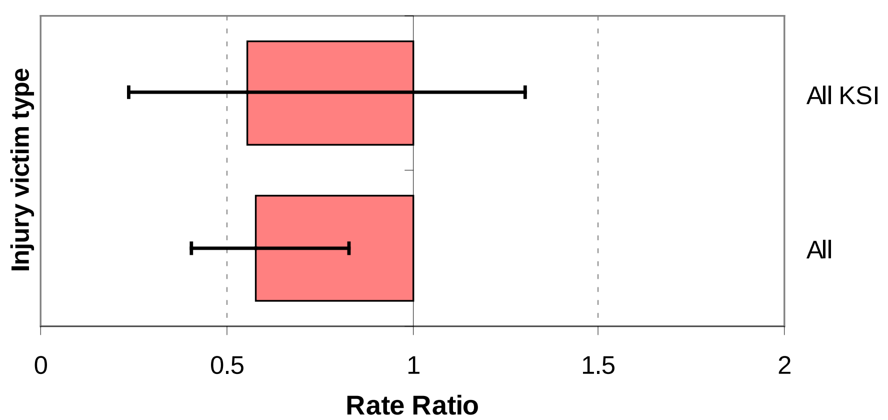
Two studies reported data on speed reductions with 20mph zones. Speed reductions of around 9mph were noted in both the earlier London study (Webster & Layfield, 2003) and the England wide study (Webster & Mackie, 1996) (Table 14).

Figure 4. Child casualty and injury accident rate ratios for 20 mph zones: summary

(a) Child casualties (after vs before)



(b) Child casualties (intervention vs control) Webster & Layfield 2003



Note: lines represent 95% confidence intervals (calculated by reviewers – except for Grundy et al 2008, because data periods and absolute counts not reported)

Evidence Statement 3: 20mph zones and child road safety outcomes

Four UK based studies evaluated 20mph zones (mostly in urban areas). There was one controlled (Webster & Layfield, 2003 [+]) and 3 uncontrolled (Grayling et al, 2002 [+]; Grundy et al, 2008 [+]; Webster & Mackie, 1996 [+]) before and after studies, one of which was adjusted for background trends (Grundy et al, 2008 [+]). There is some overlap between studies. Two of the studies are of 20mph zones in London; one of which (Grundy et al, 2008 [+]) essentially updates the other (Webster & Layfield, 2003 [+]). There are also small overlaps between these London based studies and the England-wide study (Webster & Mackie, 1996 [+]), and potentially between the England-wide study and the study based in Hull (Grayling et al, 2002 [+]). Within these studies, casualties and speed outcomes were reported.

3a There is moderate evidence from 2 uncontrolled before and after studies (1 adjusted for trends on background roads; both UK-based) that 20mph zones reduce **KSI child casualty rates** (RaR=0.242, to 0.859 depending on analysis and study, $p<0.05$ where recorded; Webster & Mackie, 1996 [+]; Grundy et al, 2008 [+]). One controlled before and after study also showed a reduction in **KSI child casualty rates** in the intervention group when compared to a control group, however, this reduction was non-significant (Webster & Layfield, 2003 [+]). It must be noted that this study also evaluated schemes in London, similarly to Grundy et al, 2008, and is essentially updated by this uncontrolled before and after study.

3b There is weak evidence from 1 uncontrolled before and after study (London-based), which was adjusted for trends on background roads, that 20mph zones may reduce **child pedestrian KSI casualty rates**. However this reduction is non-significant once the results had been adjusted for changes in background trends on outside roads (Grundy et al, 2008 [+]). One study also showed that 20mph zones may reduce **child pedestrian KSI casualty rates** (before and after data only reported for this outcome; RaR 0.394, $p<0.001$; Webster & Layfield, 2003 [+]). As noted above however, this study is essentially updated by the uncontrolled before and after study carried out by Grundy et al. (2008). The evidence shouldn't therefore be 'counted' twice.

3c There is weak evidence from one before and after study (controlled data only reported for this outcome) that 20mph zones may reduce **child pedal cyclist KSI casualty rates.** This reduction approaches statistical significance (RaR=0.399, $p=0.06$; Webster & Layfield, 2003 [+]).

3d There is moderate evidence from 3 UK-based uncontrolled before and after studies (one using adjusted analyses; Grundy et al, 2008 [+]), and one controlled before and after study of London schemes (Webster & Layfield, 2003 [+]), that 20mph zones may reduce **child road casualty rates overall**, and for child pedestrians and child pedal cyclists when analysed separately (Road casualty rates overall RaR=0.331 to 0.716 depending on analysis and intervention, $p<0.001$ where recorded; Grayling et al, 2002 [+]; Grundy et al, 2008 [+]; Webster & Layfield, 2003 [+]; Webster & Mackie, 1996 [+])

3e There is weak evidence from 2 studies that 20mph zones may reduce traffic speeds (Webster & Mackie, 1996 [+]; Webster & Layfield, 2003 [+]).

This evidence is judged as directly applicable to similar roads and/or communities in the UK, although the data from Webster & Mackie is rather dated.

Table 12: 20 mph zones– Results: Child casualty data (intervention-control comparison)

			Before		After			
Study name	**Study arm**	**Child casualties**	**Years**	**No. of casualties**	**Years**	**No. of casualties**	**Before after comparison**[e]	**Intervention-control comparisons**[e]
Webster & Layfield (2003)[p]	20mph Zones	All	5	475	3.13	146	RaR=0.491 (SE 1.099)	RaR=0.579 (95% CI=0.405, 0.829)[q]
	Unclassified roads in London	All	5	7718	3	3926	RaR=0.848 (SE 1.020)	
	20mph Zones	All KSI	5	95	3.13	24	RaR=0.404 (SE 1.257)	RaR=0.554 (95% CI=0.235, 1.304)[q]
	Unclassified roads in London	All KSI	5	1486	3	650	RaR=0.729 (SE 1.048)	

[p] Before' and 'after' data for the intervention group is also presented in Table 13 with the 'before' and 'after' data for the non-controlled studies.

[q] Observations were converted to annual rates in order to standardize them for calculation of the intervention-control comparisons.

Table 13: 20 mph zones – Results: Child casualty rates

		Before		After			
Study Name	**Child casualties**	**Years**	**No. of casualties**	**Years**	**No. of casualties**	**Before-after comparison (or equivalent)**	**p**
Grundy et al. (2008)	All[r]					RaR=0.515 (SE 0.033)	NR
	All[s]					RaR=0.534	<0.0001
	All[t]					RaR=0.716	<0.0001
	All[u]					RaR=0.803	<0.0001
	Pedestrian					RaR=0.538 (SE 0.047)	NR
	Pedestrian					RaR=0.587	<0.0001
	Pedestrian					RaR=0.807	<0.0001
	Pedestrian[u]					RaR=0.859	<0.001
	All KSI[r]					RaR=0.498 (SE 0.066)	NR
	All KSI[s]					RaR=0.360	p<0.0001
	All KSI[t]					RaR=0.782	p<0.05
	All KSI[u]					RaR=0.859	p<0.05
	KSI Pedestrians[r]					RaR=0.561 (SE 0.089)	NR
	KSI Pedestrians[s]					RaR=0.589	p<0.001
	KSI Pedestrians[t]					RaR=0.903	NS
	KSI Pedestrians[u]					RaR=0.888	NS
Webster & Layfield (2003)[v]	All[w]	5	475	3.13	146	RaR=0.491 (SE 1.099)	<0.001
	Pedal cyclist	5	97	3.13	25	RaR=0.412 (SE 1.251)	<0.001
	Pedestrian	5	291	3.13	94	RaR=0.516 (SE 1.126)	<0.001
	All KSI	5	95	3.13	24	RaR=0.404 (SE 1.257)	<0.001
	KSI Cyclists	5	16	3.13	4	RaR=0.399 (SE 1.749)	0.060
	KSI Pedestrians	5	73	3.13	18	RaR=0.394 (SE 1.301)	<0.001
Grayling et al. (2002)	All[x]	3	50	3	18	RaR=0.360 (SE 1.316)	<0.001
	Pedal cyclist	3	13	3	4	RaR=0.308 (SE 1.771)	0.029
	Pedestrian	3	30	3	9	RaR=0.300 (SE 1.462)	<0.001
Webster & Mackie (1996)	All[y]	3.53	369	2.43	84	RaR=0.331 (SE 1.129)	<0.001
	All KSI[y]	3.53	90	2.43	15	RaR=0.242 (SE 1.322)	<0.001

[r] Calculated using time series regression analysis

[s] Calculated using unadjusted before and after analysis restricted to the 152 zones implemented between 1991 and 2003

[t] Calculated using before and after analysis, adjusted for background trends on outside roads by calculating the % change that occurred between two 6 year periods. Restricted to the 152 zones implemented between 1991 and 2003.

[u] Calculated using before and after analysis, adjusted for background trends on outside roads by calculating a different trend (% change in casualties) for each year using the total number of casualties in the 3y previous compared to the total number in the 3y after that year; restricted to the 152 zones implemented between 1991 and 2003

[v] Interarm comparison data is presented in Table 12 for this controlled study.

[w] Data is for 78 zones

[x] Data is for 13 zones

[y] Data is for 72 zones

Table 14: 20 mph zones – Results: Traffic speed

Study Name	Subgroup Name	Mean difference in speed (mph)
Webster & Layfield (2003)	(14 zones)	-9.1
Webster & Mackie (1996)	(32 zones)	-9.3

5.3.7. Home zones - Study Characteristics

The three studies of home zones were all produced by TRL in 2005 as part of a contract placed by the DfT (Layfield et al, 2005; Tilly et al, 2005; Webster et al, 2005). All reports follow the same format and are of pilot home zone schemes in the UK; they are therefore all of similar quality (internal validity +, external validity +). Data were collected for at least 5 years before the interventions were implemented in each study area; however, the time period for data collected after was somewhat less, ranging from 5 months (Webster et al, 2005) to 2 years (Tilly et al, 2005).

In the selection of the pilot home zone schemes, the working group aimed to include schemes of varying types and from a variety of geographical locations. Two of the schemes were based in rural settings, although are otherwise seemingly quite different: Magor village is a conservation area with about 60 dwellings that has merged with the neighbouring community of Undy due to residential development (Layfield et al, 2005); and Cavell Way is a housing estate with 122 family dwellings and distinct boundaries (only one road provides access into and out of the estate). It is in a pocket of relative deprivation within a wider more affluent area (Webster et al, 2005). The other scheme was based in the urban setting of Northmoor (Manchester), a well-defined residential area containing about 1400 dwellings. A combination of environmental, social and economic factors has led to decline in the area (Tilly et al, 2005). This area had received some traffic-calming measures prior to implementation of the home zone.

The interventions implemented in all areas involved public consultation of varying types; in one area this included a visit to Holland for five residents in order for them to experience a Dutch home zone (Webster et al, 2005). In the Magor village home zone area a consortium of local authorities was already looking at transport issues in the area prior to implementation of the home zone (Layfield et al, 2005). A study of routes and mode of travel to school was being carried out, and a ‘Safer routes to school’ strategy was being developed. All areas appeared to have relatively high proportions of children.

In one of the home zone schemes the more typical traffic-calming measures, such as 20mph signing, gateway treatments, narrowings and road humps appeared to play a major part, and environmental and visual enhancements were also incorporated (Layfield et al, 2005). The other two seemed to focus more on the ‘shared space/surface’ concept, where visual and environmental enhancements played a key part, although traffic-calming measures, such as chicanes were also incorporated (Tilly et al, 2005; Webster et al, 2005). See Table 15 for study characteristic details and Appendix 7 for detailed descriptions of the interventions.

Table 15: Home zones – Study characteristics

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
Tilly et al. (2005) **Design:** Uncontrolled B&A **Aim:** The aim of all of the Pilot Home Zone Scheme reports is to assess the effectiveness of pilot home zone schemes in achieving the aim of home zones; to come to a view on the need for additional legislation; and to identify and disseminate good practice. **Study years:** ▪ Implementation of intervention: 2001 (phase 1) ▪ Data analysed: 5y before (1995-2000), just less than 2y after (2001-03) **Source of funding:** DfT **Internal validity:** + **External validity:** +	**Home zone** ▪ UK ▪ Urban ▪ Northmoor, Manchester ▪ A number of regeneration programmes taking place throughout the city ▪ Northmoor was declared a Housing Renewal Area in December 1998. The home zone forms an essential part of the concept plan. ▪ Well-defined residential area containing about 1400 dwellings. ▪ Main spine road through the home zone has been used as a 'racetrack' for stolen cars and as a 'rat-run' by vehicles avoiding congestion ▪ Combination of environmental, social and economic factors (e.g. high levels of unemployment, increasing drug use and vandalism, a deteriorating physical environment) led to decline. ▪ Children make up a relatively high proportion of the population (27%). ▪ The residential streets are quite repetitive, with made up surfaces and no soft landscaping; houses have no front gardens; small children tend to play in the streets; car ownership is low; and crime is a problem.	▪ Age of children: 15 and under or identified as a 'child' (ages of casualties were given individually in most cases) ▪ Over 30 local authorities in England and Wales put forward around 50 schemes for inclusion in the pilot programme. ▪ Priority given to schemes with: innovative ideas, strong support for residents' associations, transferable results and a commitment to complete implementation of the scheme within the study time scale. ▪ The working group tried to include a variety of scheme types and geographical areas.	**Identified by author:** ▪ Time periods are short. ▪ Low accident numbers unlikely to give a statistically significant result. **Identified by review team:** ▪ Home zone sites generally had low vehicle flows and few accidents, and therefore changes in accidents were not a primary focus of the intervention.
Webster et al. (2005) **Design:** Uncontrolled B&A **Aim:** The aim of all of the Pilot Home Zone Scheme reports is to assess the effectiveness of pilot home zone schemes in achieving the aim of home zones; to come to a view on the need for additional legislation; and to identify and disseminate good practice. **Study years:**	**Home zone** ▪ UK ▪ Rural ▪ Cavell Way, Sittingbourne ▪ A 'retro fit' home zone (a home zone being introduced to an existing housing estate). ▪ Clearly definable area with distinct boundaries. Only one road providing access	▪ Age of children: 15 and under or identified as a 'child' (ages of casualties were given individually in most cases) ▪ Over 30 local authorities in England and Wales put forward around 50 schemes for inclusion in the pilot programme. ▪ Priority given to schemes with: innovative ideas, strong support for residents' associations, transferable results and a	**Identified by author:** ▪ Time periods are short. ▪ Low accident numbers unlikely to give a statistically significant result. **Identified by review team:** ▪ Home zone sites generally had low vehicle flows and few accidents, and therefore changes in accidents were not a primary focus

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
▪ Implementation of intervention: 2000-03 ▪ Data analysed: 5y before (1995-99), 5mths after (2003) **Source of funding:** DfT **Internal validity:** + **External validity:** +	into and out of the estate. ▪ 122 family dwellings ▪ Mixture of age groups, although relatively high proportion of children. ▪ In a pocket of relative deprivation, within a wider more affluent area. ▪ Borders directly onto a Single Regeneration Budget area. ▪ There is a play area. ▪ There is concern for the safety and security of children walking / cycling alone along the streets.	commitment to complete implementation of the scheme within the study time scale. ▪ The working group tried to include a variety of scheme types and geographical areas.	of the intervention.
Layfield et al. (2005) **Design:** Uncontrolled B&A **Aim:** The aim of all of the Pilot Home Zone Scheme reports is to assess the effectiveness of pilot home zone schemes in achieving the aim of home zones; to come to a view on the need for additional legislation; and to identify and disseminate good practice. **Study years:** ▪ Implementation of intervention: 2001-02 ▪ Data analysed: 7y before (1994-2001), 9mths after (2002-03) **Source of funding:** DfT **Internal validity:** + **External validity:** +	**Home zone** ▪ UK ▪ Rural ▪ Magor Village, Monmouthshire ▪ Population: ~5000. ▪ ~22% adults surveyed had children under 17. ▪ Little direct employment in the village, and so Magor, and the abutting community of Undy (merged with Magor due to residential development), are effectively a dormitory settlement for the nearby towns of Newport, Cardiff and Bristol. ▪ Conservation area. Primarily residential with ~60 dwellings, 20 small shops, a church, restaurants and public houses. ▪ Primary School and an area of open space nearby. Vehicular access to these is via the home zone. ▪ 3 off-street public car-parks close to the village centre.	▪ Age of children: 15 and under or identified as a 'child' (ages of casualties were given individually in most cases) ▪ Over 30 local authorities in England and Wales put forward around 50 schemes for inclusion in the pilot programme. ▪ Priority given to schemes with: innovative ideas, strong support for residents' associations, transferable results and a commitment to complete implementation of the scheme within the study time scale. ▪ The working group tried to include a variety of scheme types and geographical areas.	**Identified by author:** ▪ Time periods are short. ▪ Low accident numbers unlikely to give a statistically significant result. **Identified by review team:** ▪ Home zone sites generally had low vehicle flows and few accidents, and therefore changes in accidents were not a primary focus of the intervention.

5.3.8. Home zones - Results

Child casualty and injury accident rates

All three areas had very low numbers of child casualties/injury accidents before and after the implementation of home zones (in two of the studies there were no observations either before or after within the home zone areas; Layfield et al, 2005; Webster et al, 2005), meaning that even when a reduction in all casualties was shown (from three over 5 years, to zero over nearly 2 years; Tilly et al, 2005), it is very difficult to say whether this reduction can be attributable to the home zone scheme (see Table 16 and
Table 17).

Traffic speed

Reductions in mean traffic speeds were noted at all locations where it was measured before and after the home zones were implemented (ranging between -1.7 and -7.7mph), apart from on one road with low humps and cushions where the mean speed increased from 14 to 18 mph, and on an untreated road where a very slight increase was noted (0.4mph) (
Table 18). Mean speeds generally appeared to be low before the implementation of home zones (most reported were below 20mph) and were generally not reduced to below ~12mph, with the exception of one road where a mean speed of ~9mph was reported after the intervention; however, no data are reported for the before period for this particular road.

Evidence Statement 4: Home zones and child road safety outcomes

Three UK based studies evaluated home zone schemes (Layfield et al, 2005 [+]; Tilly et al, 2005 [+]; Webster et al, 2005 [+]). These were all uncontrolled before and after studies. Within these studies, casualties, injury accidents and speed outcomes were reported. These studies all reported low numbers of casualties/injury accidents both before and after the intervention (between 3 and 0).

4a There is moderate evidence from three UK-based, uncontrolled before and after studies, which show the impact of **child road casualty/injury accident rates** with Home Zones is consistent with no effect (Layfield et al, 2005 [+]; Tilly et al, 2005 [+]; Webster et al, 2005 [+]).

4b There is weak evidence from 3 studies that home zones may cause small reductions in traffic speeds (Layfield et al, 2005 [+]; Tilly et al, 2005 [+]; Webster et al, 2005 [+]).

This evidence is judged as directly applicable to similar roads and/or communities in the UK.

Table 16: Home zones – Results: Child casualties

		Before		After			
Study Name	Child casualties	Years	No. of casualties	Years	No. of casualties	Before-after comparison (or equivalent)	p
Tilly et al. (2005)	All	5	3	1.92	1	RaR=0.868 (SE 3.173)	0.899
	KSI Cyclists	5	0	1.92	0		
	KSI Pedestrians	5	0	1.92	0		
TRL (2005)	All	7	0	0.75	0		

Table 17: Home zones – Results: Child injury accidents

Study Name	SubgroupName	Injury accidents involving children	Years	No. of injury accidents	Years	No. of injury accidents	Before-after comparison (or equivalent)	p
Webster et al. (2005)		All[a]	5	0	0.42	0		

[a] After accident data are preliminary data only and weren't yet validated

Table 18: Home zones – Results: Traffic speed

Study Name	Subgroup Name	Mean speed before (mph)	Mean speed after (mph)	Mean difference in speed (mph)
Tilly et al. (2005)	Road with low height humps and cushions	14.7	17.9	3.2[a]
	Treated road 1	16	12.6	-3.4
	Treated road 2	17.4	11.5	-5.9
	Treated road 3		9.4	
	Untreated road	17.5	17.9	0.4
Webster et al. (2005)		21.1[b]	13.4[c]	-7.7[d]
TRL (2005)	Location 1 (near speed hump)	13.9	12.2	-1.7[p]
	Location 2(near speed hump)	16.4	13.9	-2.5[p]
	Location 3 (no measures, just outside home zone)	25.8	21.9	-3.9[p]

[a] Mean difference calculated by reviewer

[b] 'Before' speed data was only collected for 2 of the sites.

[c] 'After' speed data are overall data for all 4 locations.

[d] Speed 'change' data are overall data for all 4 locations, calculated from the average 'before' and 'after' data for each of the locations; however, 'before' data wasn't collected for 2 of the sites.

5.3.9. Mixed priority route schemes – Study Characteristics

The three studies of mixed priority route schemes were all produced by WSP Development and Transportation (2008a; 2008b; 2008c) who were commissioned by the DfT. All reports follow the same format and are of mixed priority route schemes in the UK; they are therefore all of similar quality (internal validity +, external validity +).

Each scheme was selected on its potential merits for providing different challenges and barriers to overcome in order to deliver the project. All three schemes reviewed here were located on busy city routes with a mixture of shops, restaurants and bars that lead to heavy pedestrian and/or cyclist flow at both day and night. They also have residential areas in the local vicinity. The route in Oxfordshire was one of the most severely constrained, with particularly narrow carriageways through the central section and issues of parking and traffic management posing particular challenges (WSP Development and Transportation, 2008a). One of the challenges envisaged with the Hull scheme was the potential conflicting priorities in an area of social deprivation (WSP Development and Transportation, 2008b).

Data was collected for at least 3 years before each of the interventions (5 years worth of data was collected in the before period for the Hull study; WSP Development and Transportation, 2008b); but only between 10 months and 1 year afterwards. All studied areas incorporated a range of different measures within their schemes, including various traffic-calming features and environmental enhancements. They also all involved public consultation. In Oxfordshire (WSP Development and Transportation, 2008a) there was an agreement to include cycle awareness in bus driver training and to include speed monitoring on buses. In the Oxfordshire study it was also noted that some environmental enhancements and measures to improve safety and pedestrian provision had been carried out previously. See Table 19 for further details of study characteristics and Appendix 8 for detailed descriptions of the interventions.

Table 19: Mixed priority route schemes – Study characteristics

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
WSP Development and Transportation (2008a) **Design:** Uncontrolled B&A **Aim:** To provide an interim evaluation of the Mixed Priority Scheme in Oxfordshire, and also to disseminate the success of the project. **Study years:** ▪ Implementation of intervention: 2005 ▪ Data analysed: 3y before, 1y after; dates unclear **Source of funding:** DfT **Internal validity:** + **External validity:** +	**Mixed Priority Route scheme** ▪ UK ▪ Urban ▪ Cowley Road (Oxfordshire), a radial route from the south-east of the city with a typical flow of around 10,000 vehicles. ▪ Mix of retail, restaurants and bars/clubs creating a busy day and night-time environment. ▪ High density housing bounds the route ▪ Diverse and somewhat transient population ▪ Important bus corridor with over 650 buses per day ▪ Busy cycle route with flows >3000 cyclists/day	▪ Age of children: 15 and under ▪ Each authority was chosen for funding for a scheme on its' potential merits of providing different challenges and barriers to overcome in order to deliver the project. ▪ Selection of second tranche authorities was influenced by the first round selection with the aim of having two 'matched' schemes (similar in terms of the physical and political environments)	**Identified by author:** NR **Identified by review team:** ▪ Actual dates of data collection are unclear.
WSP Development and Transportation (2008c) **Design:** Uncontrolled B&A **Aim:** To provide an interim evaluation of the Mixed Priority Scheme in Liverpool, and also to disseminate the success of the project **Study years:** ▪ Implementation of intervention: 2004-05 ▪ Data analysed: 3y before (2001-04), 10mths after (2005-06) **Source of funding:** DfT **Internal validity:** + **External validity:** +	**Mixed Priority Route scheme** ▪ UK ▪ Urban ▪ Berry Street and Renshaw Street (Liverpool) ▪ Among the busiest roads in the city ▪ Route is lined with major shops, restaurants, clubs, pubs and fast food outlets. ▪ Roads heavily used by pedestrians at all times of the day. ▪ University halls of residence and a number of further residential developments located in the area.	▪ Age of children: 15 and under ▪ Each authority was chosen for funding for a scheme on its' potential merits of providing different challenges and barriers to overcome in order to deliver the project. ▪ Selection of second tranche authorities was influenced by the first round selection with the aim of having two 'matched' schemes (similar in terms of the physical and political environments)	**Identified by author:** NR
WSP Development and Transportation (2008b) **Design:** Uncontrolled B&A **Aim:** To provide an interim evaluation of the Mixed Priority Scheme in Hull, and also to	**Mixed Priority Route scheme** ▪ UK ▪ Urban ▪ Newland Avenue is a local distributor road	▪ Age of children: NR ▪ Each authority was chosen for funding for a scheme on its' potential merits of providing different challenges and barriers to overcome in order to deliver the project.	**Identified by author:** NR **Identified by review team:** ▪ Age range of 'children' not specified.

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
disseminate the success of the project. **Study years:** ▪ Implementation of intervention: 2004-05 ▪ Data analysed: 5y before (1998-2003), 1y after (2005-06) **Source of funding:** DfT **Internal validity:** + **External validity:** +	approx. 2 miles north of Hull city centre ▪ Bound by high density housing, with relatively low traffic and parking demand ▪ High cycle and pedestrian flows. ▪ Everyday shopping facilities as well as a variety of independent retailers attracting visitors from the wider area. ▪ Cafes/ bars, a school and access to housing on surrounding streets provided ▪ Length: 900m ▪ Residential areas include large areas of student housing. ▪ An area of social deprivation	▪ Selection of second tranche authorities was influenced by the first round selection with the aim of having two 'matched' schemes (similar in terms of the physical and political environments)	

5.3.10. Mixed priority route schemes – Results

Child casualty rates

Only one statistically significant reduction in child casualty numbers was seen across all three studies, and that was in child pedestrian casualties in the Hull scheme (p=0.025) (WSP Development and Transportation, 2008b). However the numbers were so small (five over the 5 years before, and zero during the year after) that this result needs to be treated with caution. There were in fact slight increases in casualty frequencies in some categories in all locations. Again, the numbers are too small to allow any meaningful interpretations (Table 20).

Traffic speed

Speed reductions were noted on all routes; however they were generally quite small. Traffic speed data were collected at 42 sites/times across seven locations within the Hull scheme; speed reductions were noted at 35 of these, ranging from -0.2 to -9mph. (WSP Development and Transportation, 2008b) (See Table 21).

Evidence Statement 5: Mixed priority route schemes and child road safety outcomes

Three UK based studies evaluated mixed priority route schemes (WSP Development and Transportation 2008a; 2008b; 2008c – all [+]). These were all uncontrolled before and after studies. Within these studies, casualties and speed outcomes were reported. These studies all reported low numbers of casualties both before and after the intervention (between 6 and 0).

5a There is moderate evidence from 3 UK-based, uncontrolled before and after studies that mixed priority route schemes may reduce **child road casualty rates** (WSP Development and Transportation 2008a; 2008b; 2008c – all [+]) – one study showed a significant reduction in child pedestrian casualties, while changes were consistent with no effect in one and increased in the other.

5b There is weak evidence from 3 studies that mixed priority route schemes may cause small reductions in traffic speeds (WSP Development and Transportation 2008a; 2008b; 2008c – all [+]).

This evidence is judged as directly/partially applicable to similar roads and/or communities in the UK.

Table 20: Mixed priority route schemes – Results : Child casualty rates

		Before		After			
Study Name	Child casualties	Years	No. of casualties	Years	No. of casualties	Before-after comparison (or equivalent)	p
WSP Development and Transportation (2008a)	Pedestrian	3	2	1	0	RaR=0	0.157
	Pedal cyclist	3	0	1	1		
	KSI Pedestrians	3	0	1	0		
	KSI Cyclists	3	0	1	0		
WSP Development and Transportation (2008c)	Pedestrian	3	3	0.83	1	RaR=1.549 (SE 3.173)	0.878
	Cyclists	3	0	0.83	1		
	KSI Pedestrian	3	0	0.83	1		
	KSI Cyclists	3	0	0.83	1		
WSP Development and Transportation (2008b)	All	5	6	1	2	RaR=1.667 (SE 2.263)	0.593
	Pedestrian	5	5	1	0	RaR=0	0.025
	Cyclists	5	0	1	0		

Table 21: Mixed priority route schemes – Results : Mixed priority route schemes – Results : Traffic speed

Study Name	Mean difference in speed (mph)
WSP Development and Transportation (2008a)	-1.7
WSP Development and Transportation (2008c)	-1.94

5.3.11. Single component traffic-calming interventions

Two studies evaluated single component traffic-calming features. One of these was carried out in the US (Tester et al, 2004); and one in Germany (von Kries et al 1998). See Table 22 for study characteristic details and Appendix 8 for details of the interventions.

Both studies were of a case control design. The most recent was carried out to determine whether children who had been hit by a vehicle (cases) were any less likely to live near a speed hump than their peers who lived in the same city and visited the emergency room that day for another reason (controls) (Tester et al, 2004). This study was given a '-' for external validity as it is was carried out in the US, and it is unclear how transferable the findings would be to a UK setting (internal validity '+'). Tester et al (2004) found that children hit by a vehicle within their neighbourhood were significantly less likely to live near a speed hump than their controls (14% vs 23%; unadjusted OR=0.50; 95% CI=0.27,0.89); and as a subset, those hit on the block in front of their home were even less likely (12% vs 24%; unadjusted OR=0.38; 95% CI=0.15, 0.90).

von Kries et al (1998) conducted a case control study to assess the separate impact of 30kph streets, pelican crossings and playgrounds on the risk for pedestrian and cyclist injuries amongst school children. Playgrounds are not an intervention of interest in this review, and therefore the data for these has not been reported here. This study was given a '-' for external validity as it is was carried out in the Germany, and it is unclear how transferable the findings would be to a UK setting (internal validity '+'). They found that the injury risk for a child living in an area with 0-5 streets with a speed limit of 30kph was about 5 times higher than that for a child living in an area with 15 or more streets with the same speed limit (OR=5.3; 95% CI=1.6,17.6). They also found that the injury risk for children living in areas with 0-2 pelican crossings/street was more than two times higher compared with children living in areas with four or more pelican crossings (OR=2.3; 95% CI=1.2,4.5).

Evidence Statement 6: Single component traffic-calming measures and child road safety outcomes

6a Speed humps

There is weak evidence from one case control study (US-based) that living near a speed hump may reduce a child's **risk of injury** on the road (unadjusted OR=0.50, 95%CI=0.27,0.89; Tester et al, 2004 [+]).

6b 30kph speed limits

There is weak evidence from one case control study that living in an area with 0-5 streets with a speed limit of 30kph may increase a child's **risk of injury** compared to a child living in an area with 15 or more streets with the same speed limit (OR=5.3, 95%CI=1.6,17.6; von Kries et al, 1998 [+]).

6c Pelican crossings

There is weak evidence from one case control study that living in an area with 0-2 pelican crossings/street may increase a child's **risk of injury** compared to a child living in an area with >3 pelican crossings/street (OR=2.3, 95%CI=1.2,4.5; von Kries et al, 1998 [+]).

Table 22 Single Component Traffic-calming Interventions – Study Characteristics

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
Tester et al. (2004) **Design:** Case control study **Aim:** To determine whether children who had been struck by automobiles in Oakland were any less likely to live near a speed hump than their peers. **Study years:** Implementation of intervention: 1995-2000 Data analysed: as above. **Source of funding:** NR	**Speed Humps** US Urban The Oakland Pedestrian Safety Project implemented on residential streets. Oakland has historically been one of the most dangerous cities in California to be a pedestrian.	Age of children: 14 and under; also suggest that children under 5 years were excluded because injuries in this age group were not usually related to the flow of street traffic (although this is unclear)	**Identified by author:** The authors note several methodological limitations: Limiting measurement to speed humps on a child's street ignores the potential protective effect of speed humps around the corner from a child's house (relevant rate of exposure to intervention may be underestimated, affecting estimation of intervention's protective impact) Study sample: injuries not reported to the emergency medical services would have been missed. Therefore lower acuity injuries underrepresented. Possible that significant confounding factors were not addressed (e.g. the presence of sidewalks). Factors used to approximate SES (census tract household income and medical insurance status) may have been inappropriate proxies.
von Kries (1998) **Design:** Case control study **Aim:** To assess the impact of potentially modifiable environmental factors on the risk for pedestrian and cyclist injuries among school age children in Düsseldorf. **Study years:** Data analysed: January 1993 – March 1995 **Source of funding:** supported by the BMFT	**30kph streets / pelican crossings** Germany Urban Population of school age children in Düsseldorf (population 570,000) in the west of Germany	Age of children: 6-14	**Identified by author:** Potential random misclassification of the children's neighbourhood areas. Could not control for socioeconomic factors Traffic volume could not be measured. Not clear which components of the possible interventions are most relevant.

5.3.12. 'Safe Routes to School' programmes – study characteristics

Only two studies were found which quantitatively evaluated the child injury or child injury collision impacts of Safe Routes to Schools Programmes (Blomberg et al., 2008; Gutierrez et al., 2008). Both were from the United States, and evaluated State-funded SR2S programs in four states implemented prior to 2005 (that is, before the federally funded SRTS program, introduced following the passing of SAFETEA-LU federal legislation in 2005). We also identified an unpublished report for the Department for Transport for England (from 2004), which assessed the impact of School Travel Plans in the UK, and presents before-and-after data from several case study areas; however, it did not provide sufficient detail on these case studies to warrant the report's inclusion as a quantitative comparative evaluation in its own right (Cairns et al., 2009). This limited UK data on the potential child injury reduction effects of SRTS programmes is considered in the Discussion section of this report (see page 128).

Both of the included US studies used time series and geographical location data on child injury accidents (Gutierrez et al., 2008), or 'crash-involved pedestrians/cyclists' (Blomberg et al., 2008), for 8 or 9 years spanning the introduction of state-funded SRTS programs, choosing schemes which had been established long enough for sufficient post-intervention accident/injury data to be available. The evaluation of SRTS schemes in California by Gutierrez (with supplementary information from Orenstein et al. 2007) was of 125 projects covering 350 schools (mostly elementary schools), while that by Blomberg was of 53 projects in 30 cities across three states. In California, the SRTS programs were dominantly based on engineering measures (such as pavement/sidewalk upgrades (in 71%), and new/upgraded intersection crossings (41%)) while the programs in the 3-State Blomberg study appeared more likely to include education (76%), encouragement (70%) and enforcement (64%) activities alongside engineering measures (82% of programs; although this 82% includes some engineering *surveys* without infrastructure changes)

Both US studies also used time series injury data from defined 'control areas' without SRTS programs (either the rest of state (Blomberg, 2008), or other intersections in same cities as the SRTS schemes but not included in designated SRTS zones (Gutierrez, 2008)). However, as well as comparisons based upon geographically-defined 'control area' data, the Blomberg study also compared the pattern of reduction in pedestrian/cyclist child injury rates in SRTS zones (at school travel times and dates) with trends in the annual injury rate in: the rest of the state; at all dates and times of the day; for children not of elementary school age (less than three years, and over 13 years of age), and amongst child vehicle passengers.

This yielded a number of regression analysis coefficients for each time series, for each state, nearly all of which showed a reduction in child injuries over the time period. To estimate the 'effect size' of the SRTS program therefore, these coefficients were then compared with the regression coefficients for pedestrian/cyclist injuries within SRTS zones at school travel times, for 4 to 12-year-old children.

While exhibiting different patterns of weaknesses in study design and reporting, both studies were judged to be of moderate quality (+) in terms of both internal validity and their generalisability to their respective populations/settings in the US. Their applicability to the UK is difficult to assess given the very different nature of the urban and suburban environment in the USA, and in particular the historical prominence given to the car in the design and layout of North American cities, and also the likely different focus and scale of current UK SRTS schemes, as fostered by Sustrans and further encouraged by the *School Travel Plans* policy (Cairns et al., 2009). See Table 23 for study characteristic details and Appendix 8 for detailed descriptions of the interventions.

Evidence Statement 7: Safe Routes to Schools Programmes and child road safety outcomes

There is moderate evidence from two controlled before and after studies (using time-series injury data) (Gutierrez et al., 2008 [+]; Blomberg et al., 2008 [+]) in the USA, that Safe Routes to School (SRTS) programmes based predominantly on engineering measures may reduce the rates of crash-involved child pedestrians or cyclists, or the rate of child injury road accidents.

7a In 125 SRTS project areas across California, and after assuming modest (10%) increases in rates of walking and cycling to school due to the programmes (i.e. increased exposure), a mean reduction of 7% in the **all-injury collision rate with child pedestrians and cyclists** was estimated (14% for children aged 5 to 12) (Gutierrez et al. 2008 [+]). However, the estimated impact on **fatal or severe child injuries** was less conclusive (ranging from a 52% increase to a 24% reduction, again depending on assumed changes in levels of walking/cycling to school).

7b The evaluation of 53 projects in three unnamed US States (Blomberg et al., 2008 [+]) compared linear regression coefficients (giving 'T statistics') between the time-series trends of child injury data for the SRTS sites; these showed significantly greater reductions in **crash-involved child pedestrians and cyclists** at SRTS sites when compared with at least two of the six 'control' time series in all three US states (NB. all of the 'T' values were negative, indicating that the reductions in crash outcomes in SRTS sites were always lower (if not always statistically significantly lower) than in the comparison time-series.)

This evidence from evaluations of SRTS programmes in the US is judged as partially applicable to similar localities in the UK.

Table 23: Safe routes to school – Study characteristics

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
Blomberg et al. (2008) **Design:** Non-RCT **Aim:** ▪ To determine the feasibility of conducting a systematic and practically meaningful crash-based evaluation of SRTS programs. ▪ (If feasibility is shown) To conduct a study to examine the safety effects of implementing legacy SRTS programs **Study years:** State 1: 1996-2004 (9 years) State 2: 1996-2004 (9 years) State 3: 1996-2003 (8 years) **Source of funding:** National Highway Traffic Safety Administration (USA) **Internal validity:** + **External validity:** +	**SRTS** ▪ US ▪ Most SRTS programs appeared to be within cities. ▪ Main crash data presented is from 3 US states (states not identified). State 1: 29 SRTS programs in 21 different cities. State 2: 14 SRTS programs in 7 cities. State 3: 10 programs in 2 cities.	▪ Age of children: 4-12 ▪ Of the 130 'legacy' SRTS programs included in the overall report, 53 were in the three States for which crash outcome data were analysed.	**Identified by author:** ▪ No standard methods for reporting either the process or the outcomes of the programs. ▪ Heterogeneity of SRTS programs evaluated (size, focus and duration); for 'a large proportion' crash reduction was not primary objective. ▪ Not all elementary schools within the defined SRTS program sites were involved in the local SRTS program. ▪ Had to assume that the desired modal shift (to increased walking and cycling) took place; otherwise, any measured reductions in crash-involved pedestrians and cyclists could be due to reduced exposure. ▪ Possibility of spill-over effects beyond immediate SRTS program sites, and possibility of SRTS program sites in same state which did not participate in this study - would affect comparisons with statewide crash trend data. **Identified by review team:** ▪ Unclear what the key comparison should be, given the large number of comparisons made (i.e. there is a concern over multiple significance testing which has not apparently been accounted for)
Gutierrez et al. (2008) **Design:** Non-RCT **Aim:** (Inferred) To evaluate the impact of the California Safe Routes to School program on the safety of child pedestrians and cyclists **Study years:** 1998-2005 (8 years). Mean pre-construction period = 283 weeks (5.4 years). Mean post-	**SR2S** ▪ US ▪ Unclear whether mostly urban or urban/rural mix ▪ 350 schools (especially elementary schools) and their surrounding areas	▪ Age of children: 5-17 ▪ Projects (i.e areas) chosen if: funded in the first 3 SR2S funding cycles; construction improvements had been completed by end of December 2005; relevant agency returned a questionnaire with enough information; and no significant overlap of school or collision data. Led to inclusion of 125/570 projects funded to date.	**Identified by author:** ▪ Lack of good data (state or school/project level) for changes in volumes of pedestrian, cyclist and vehicle traffic. ▪ Rarity of collisions, leading to uncertainty in estimates of change. ▪ Omission of wider safety impacts of SR2S projects, such as near-misses, perceptions of safe travel, and impact amounts of motorised

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
construction period = 102 weeks (2 years). **Source of funding:** California Department of Transportation (Caltrans) **Internal validity:** + **External validity:** +			traffic. **Identified by review team:** ▪ Numbers of injury accidents reported rather than actual number of casualties.

5.3.13. 'Safe Routes to School' programmes – Results

Although not directly comparable, because of the different methods of analysis used, both studies indicate a probable reduction in child injuries due to the SRTS program. The Gutierrez et al 2008 study, assuming a modest (and plausible - given other evidence within the report) 10% increase in rates of walking and cycling to school at the SRTS sites, estimates a 7% relative reduction in the rate of collisions with child pedestrians and cyclists (age 5 to 17 years) or a 14% relative reduction amongst those of elementary school age (age 5 to 12 years, which is where most (68%) SRTS projects were based). However, most of this estimated reduction is of 'minor injuries or complaint of injury' rather than fatal or serious injury, and no uncertainty bounds are presented for these main results.

The Blomberg et al 2008 study results are harder to interpret because of the multiple comparisons made between the different time-series control data. However, there is a general tendency in all three states for the SRTS sites to show greater decreases in the rates of crash involvement of child pedestrians and cyclists than the reductions observed State-wide. Statistically significantly ($p < 0.06$) greater reductions in crash involvement at the SRTS sites (for 4- to 12-year-old pedestrians and cyclists at school travel times and dates) were shown when they are compared with most of the other control data time-series (e.g. for: child *passengers* for SRTS sites at school travel times and dates; *child passengers Statewide* at school travel times, and: child *pedestrians or cyclists of non-elementary school age* (<3 and 13+ years) Statewide at all times of the day or week). See Table 24 for results.

Table 24: Safe Routes to Schools - Results: Child injury accident data

Study Name	Injury accidents involving child	Assumed background changes	Before-after comparison (or equivalent)	p
Gutierrez et al. (2008)	Pedestrians or cyclists (age 5-17)	Change in walking/cycling: +100%	RaR=0.51	NR
		Change in walking/cycling: +50%	RaR=0.68	NR
		Change in walking/cycling: +25%	RaR=0.82	NR
		Change in walking/cycling: +10%	RaR=0.93	NR
		Change in walking/cycling: none	RaR=1.02	NR
	KSI pedestrians or cyclists (age 5-17)	Change in walking/cycling: +100%	RaR=0.76	NR
		Change in walking/cycling: +50%	RaR=1.01	NR
		Change in walking/cycling: +25%	RaR=1.21	NR
		Change in walking/cycling: +10%	RaR=1.38	NR
		Change in walking/cycling: none	RaR=1.52	NR
	Pedestrians or cyclists (age 5-12)	Change in walking/cycling: +100%	RaR=0.47	NR
		Change in walking/cycling: +50%	RaR=0.63	NR
		Change in walking/cycling: +25%	RaR=0.75	NR
		Change in walking/cycling: +10%	RaR=0.86	NR
		Change in walking/cycling: none	RaR=0.94	NR

Table 25: Safe Routes to Schools - Results: Number of child pedestrians/cyclists involved in crashes

Study name	Intervention data	Control time series data	Subgroup Name	T-value[ee]	p
Blomberg et al. (2008)	Pedestrians/Cyclists age 4-12 at SRTS Sites and school trip times & dates	Passengers age 4-12 at SRTS Sites and school trip times & dates	State 1	-3.527	0.003
		Passengers age 4-12 Statewide at school trip times & dates		-6.97	0.000
		Pedestrians/Cyclists age 0-3 & 13+ at SRTS Sites and school trip times & dates		-5.966	0.000
		Pedestrians/Cyclists age 0-3 & 13+ Statewide & All times & dates		-6.828	0.000
		Pedestrians/Cyclists age 4-12 Statewide at All times & dates		-1.838	0.087
		Pedestrians/Cyclists age 4-12 Statewide at school trip times & dates only		-1.97	0.069
		Passengers age 4-12 at SRTS Sites and school trip times & dates	State 2	-2.082	0.056
		Passengers age 4-12 Statewide at school trip times & dates		-4.895	0.000
		Pedestrians/Cyclists age 0-3 & 13+ at SRTS Sites and school trip times & dates		-1.096	0.292
		Pedestrians/Cyclists age 0-3 & 13+ Statewide & All times & dates		-3.161	0.007
		Pedestrians/Cyclists age 4-12 Statewide at All times & dates		-1.943	0.072
		Pedestrians/Cyclists age 4-12 Statewide at school trip times & dates only		-1.349	0.199
		Passengers age 4-12 at SRTS Sites and school trip times & dates	State 3	-3.446	0.004
		Passengers age 4-12 Statewide at school trip times & dates		-2.161	0.049
		Pedestrians/Cyclists age 0-3 & 13+ at SRTS Sites and school trip times & dates		-0.988	0.340
		Pedestrians/Cyclists age 0-3 & 13+ Statewide & All times & dates		-2.139	0.051
		Pedestrians/Cyclists age 4-12 Statewide at All times & dates		-0.902	0.382
		Pedestrians/Cyclists age 4-12 Statewide at school trip times & dates only		-1.101	0.290

[ee] The T value is the difference between the linear regression coefficients of the different time series data for the groups described (Coefficient A – Coefficient B) divided by $\sqrt{(\text{Standard error A})^2+(\text{Standard error B})^2}$

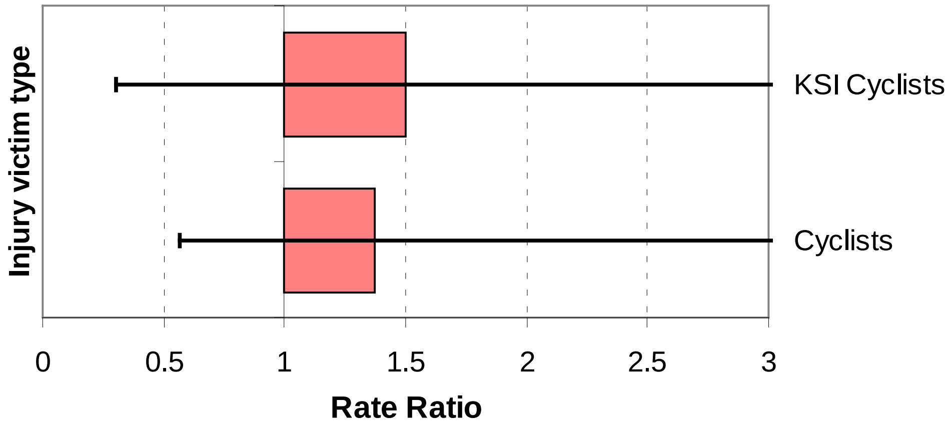
5.3.14. Cycle routes

One uncontrolled before and after study evaluated an off-road cycle route that was implemented in Stockton (County of Cleveland, UK) in 1985 (Dean, 1993) (see Table 26 and Appendix 8). This 4km route runs along the line of a disused railway, linking residential districts with the town centre. Injury data was collected for an 18 month period before the intervention and an 18 month period afterwards for the catchment area of the cycle route. The study scored a '+' for both internal and external validity. See Figure 5 below for a graphical summary of the study's main child cyclist casualty results.

Study results implied that the cycle route had been unsuccessful in reducing injuries in children, and actually showed a slight increase in child cyclist injuries, from eight in the 18 months before to 11 in the 18 months after (not statistically significant). There was also a slight increase in child KSI casualties; however, the numbers were too small to be able to tell whether this was the true effect of the intervention. No traffic speed data were reported (see Table 27).

As with a lot of the studies included in this review caution must be taken when interpreting these results as this uncontrolled study may be influenced by several confounding factors that have not been taken into account. Data were reported for an area outside of the catchment area of this cycle route in this study, but it is unclear how these data are intended to be used. Also noted in this study is that 'before' and 'after' time periods used were not particularly comparable, in that the 'before' period contained two winters (a season when cyclist accidents are expected to be at their lowest), and the 'after' period only contained one.

Figure 5. Child cyclist casualty rate ratios (before vs after the cycle route in Stockton)



Note: lines represent 95% confidence intervals (calculated by reviewers)

Evidence Statement 8: Cycle routes and child road safety outcomes

8a There is weak evidence from 1 UK-based, uncontrolled before and after study of a largely off-road cycle route, that the impact of cycle routes is consistent with no effect on **child cyclist road casualty rates and KSI child cyclist rates**, although numbers were small. (Dean 1993 [+]).

This evidence is judged as partially applicable to off-road cycle routes in the UK, although the evidence is dated.

Table 26: Cycle routes –Study characteristics

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
Dean (1993) **Design:** Uncontrolled B&A **Aim:** To provide an objective assessment of the Stockton Cycle route based on data collected before and after the route was opened. **Study years:** ▪ Implementation of intervention: 1985 ▪ Data analysed: 18mth before (1983-85), 18mth after (1985-86) **Source of funding:** TRRL **Internal validity:** + **External validity:** +	**Cycle Route** ▪ UK ▪ Mixed urban/rural ▪ The Stockton (County of Cleveland) Cycle Route ▪ ~4km route; runs along the line of a disused railway, linking residential districts with the town centre. ▪ Females make up a very small percentage of the total cyclists in the Stockton-on-Tees area.	▪ Age of children: 14 and under	**Identified by author:** ▪ Data collection periods too short to reach firm conclusions. ▪ 'Before' period contained 2 winters, where it would be expected that cyclist accidents would be at their lowest. The 'after' period had only 1 winter period.

Table 27: Cycle routes – Results: Child casualties

		Before		After			
Study Name	**Child casualties**	**Years**	**No. of casualties**	**Years**	**No. of casualties**	**Before-after comparison (or equivalent)**	**p**
Dean (1993)	Cyclists	1.5	8	1.5	11	RaR=1.375 (SE 1.591)	0.491
	KSI Cyclists	1.5	2	1.5	3	RaR=1.500 (SE 2.491)	0.655

5.3.15. Combination interventions

One controlled before and after study evaluated a community based injury prevention programme that combined traffic-calming, a 'Safe way to school' programme and education (Lindvquist et al, 2001) (See Table 28 and Appendix 8 for study characteristic details and a more detailed intervention description). This study scored a '-' for external validity as it is was carried out in the Sweden, and it is unclear how transferable the findings would be to a UK setting (internal validity '+'). In contrast to the other before and after studies included in this review, that use the length of time over which observations were made as the denominator, this study actually reported children injured per person at risk (i.e. residents) in the study and control areas. It must be noted that this is not comparable to the rate ratios report for other studies, in that the same person could be injured in more than one accident, and yet would still only count as one injured person.

Lindvquist et al (2001) showed a significant reduction in injured children from 176 out of 8566 children at risk to 124 out of 8315 children at risk (OR=0.722; SE 1.126; *p*=0.007) (See

Table 29) when a before and after comparison in the intervention area was made. However, although a reduction in child casualties was shown in the intervention group when compared to the control group, this difference was not significant. No speed data were collected.

Evidence Statement 9: Combination interventions and child road safety outcomes

9a There is weak evidence from 1 controlled before and after study, that combined traffic-calming, safe routes to schools and education may reduce **child road casualty rates** when a before and after comparison was made (OR 0.722, p=0.007. Lindvquist et al 2001, [+]), however compared to the control group, the reduction was non-significant.

This Swedish evidence is judged as partially applicable to similar roads and/or communities in the UK.

Table 28: Combination interventions – Study characteristics

Study Details	Intervention type + Setting	Data collection / analysis notes	Limitations
Lindqvist et al. (2001) **Design:** Non-RCT **Aim:** To examine the effect of a community-based injury prevention programme (the WHO Safe Community Program) on traffic injuries. **Study years:** ▪ Implementation of intervention: 1987-1988 ▪ Data analysed: 1y before (1983-4), 1y after (1989) **Source of funding:** supported by grants from the Swedish National Institute of Public Health, the Swedish MTO program, and Östergötland County Council. **Internal validity:** + **External validity:** -	**Combined area wide intervention: traffic-calming, 'safe way to school', and education.** ▪ Sweden ▪ Urban ▪ The WHO Safe Community program in Motala municipality. ▪ Focussed on local neighbourhoods. ▪ Children and the elderly are the main 'inhabitants' of the local neighbourhood during the daytime	▪ Age of children: 15 and under	**Identified by author:** The authors note limitations related to study design: ▪ Single-pedestrian injuries were classified as traffic injuries and included in the program. This may limit comparability with other studies, which have followed more strictly the ICD definition of traffic injury. ▪ Psychological sequelae (e.g. post-traumatic stress disorder) not included in the severity ratings ▪ Calculations of odds ratios in a cohort study may be questioned. The incidence of injuries was, however, in the optimal interval (<10%) to avoid overestimations. ▪ To rule out random fluctuations, the study would have ideally been extended to several years before and after intervention.

Table 29: Combination interventions – Results: Child casualties

			Before		After				
Study name	Arm Name	Casualties	Individuals at risk	No. of injured individuals	Individuals at risk	No. of injured individuals	Before-after comparison[ff]	p	Intervention-control comparisons[gg]
Lindqvist et al. (2001)	Study area	All	8566	176	8315	124	OR=0.722 (SE 1.126)	0.007	Ratio of ORs=0.811 (p=0.32)[hh]
	Control	All	5543	73	5196	61	OR=0.890 (SE 1.191)	0.562	

[ff] Calculated by reviewer using raw casualty frequency data.

[gg] All comparisons were calculated by the reviewer using raw casualty frequency data.

[hh] There was uncertainty over the correct hypothesis test to use.

	area								

6. Findings: Cost-effectiveness

6.1.1. Study reports identified

Papers/reports were flagged from the main searches as being potentially includable economic evaluations or cost analyses. These were obtained in full text for assessment against the inclusion criteria for the cost-effectiveness review. In addition, some reports were obtained in full text as studies for possible inclusion in the review of effectiveness studies, but were discovered to also contain a section describing a cost-benefit analysis. Copies of these were also forwarded to the review team's health economist for assessment against the cost-effectiveness review's inclusion criteria.

In all 19 reports/papers were identified as potentially includable economic evaluations or cost analyses and obtained in full text version. Of these seven were excluded, on the basis of:

- Interventions not relevant (e.g. traffic signals and road markings only, paved shoulders on rural Australian roads, street lights only – primarily to prevent injury to adults late at night)
- Settings not included/applicable (e.g. a review of cost-effectiveness studies in lower and middle income countries)
- Study focus and design outside scope (e.g. a review of accident simulation models, a cost analysis in New Zealand, a cost-of-illness study)

These studies are listed in Appendix 10.

6.1.2. Included studies

Thirteen studies were identified which met our inclusion criteria of either being full economic evaluations or UK-based cost analyses of the relevant interventions. They were all cost-benefit analyses, mainly conducted using the established conventions from transport economics for conducting such analyses (in their respective jurisdictions). All placed a value on casualties and/or fatalities avoided, but none (in the economic analyses) distinguished between injuries sustained by, or involving, children versus adults.

The 13 studies were all cost-benefit analyses in which the costs of implementing the schemes were set against the savings attributable to casualties avoided. They all only compared the schemes or measures of interest with the absence of those measures, typically based on uncontrolled before and after studies. The traffic-calming and other schemes/measures evaluated by the studies included:

- 20mph zones (2 UK studies)
- Traffic-calming of single urban routes (3 UK studies)
- Rural/village route traffic-calming (1 UK study)
- Cycle & walking tracks (1 study in Norway)
- Several studies examining a wider range of area-wide, route and junction traffic-calming measures (3 UK studies, 2 in Norway and Sweden, and 1 in Australia)

Despite all the studies being cost-benefit analyses, the results were expressed in a variety of ways: First Year Rate of Return (7 studies, all in the UK), Benefit Cost Ratio (3 studies), Net Present Value (1 study), and Average Annual Rate of Return (1 study). A brief description of these measures, and how they are calculated and interpreted is shown in Table 31 (on p.111). Only one study presented any incremental cost-effectiveness ratios ('expenditure per accident saved per year'), and none compared intervention costs with either life-years or quality-adjusted life-years saved - which would be the typical measures of effectiveness used in economic evaluations of health care interventions. Only one study was based on an explicit decision model (Grundy et al 2007) and in this case it was an extremely simple one, mainly to facilitate a probabilistic sensitivity analysis.

Apart from one very early economic evaluation of area-wide traffic-calming in five English cities and towns (Mackie et al. 1990), the included studies were published between 2000 and 2009. All but two of the study reports/papers (Elvik 2003, Saelensminde 2004) were primarily effectiveness evaluations, including a relatively small cost-benefit or 'value for money' chapter or report section. (The separate publication of economic evaluations seems to be much less common in the road safety and transport economics field than in health.) Therefore, in assessing the quality of the included economic evaluations, an assessment of poor study quality - by the standards of health economic evaluations - is typically a reflection of minimal reporting rather than poor study design or conduct *per se*.

One recent economic study, the evaluation of the impact of Local Safety Schemes on casualty reductions (published by the department for Transport in April 2009) was identified too late for full data extraction and quality assessment (Atkins (on behalf of DfT), 2009). It is similar in many respects to the 2001 analysis of road safety schemes in the MOLASSES database (Gorell & Tootill, 2001), so may be regarded as a study of similar quality. The findings of the 2009 Atkins study is summarised in the relevant findings sections.

Table 30. Relevant published economic evaluations of traffic-calming and related road safety measures: Study designs [a]

Author, year	Analysis type, data	Country, setting	Population, data	Interventions or comparators	Perspective	Time horizon, discounting	Costs & savings included	Statistic estimated	Sensitivity analyses
Gorell & Tootill, 2001	Cost Benefit Analyses & Cost-Effectiveness Analysis <u>Data years:</u> 1991-1999 <u>Base year:</u> 1999	United Kingdom	Local Authority Safety Schemes in TRL's 'MOLASSES' database <u>Data:</u> before and after data on approx. 2200 schemes in 49 Authorities (local or highway)	Area-wide Route[35] Link Cycle scheme Pedestrian facility Priority junction Signalised junction[1] Roundabout Bend[1]	None stated	3 years (= conservative estimate of service life of schemes); No discounting.	Cost of implementing the scheme Savings for each 'Personal Injury Accident' avoided (in 1999, £69,390)	Expenditure per accident saved per annum First year rate of return	Separate analyses for older schemes and newer schemes (i.e. monitoring periods 1996-1999 pre-treatment)
Burns et al. 2001	Cost-Benefit Analysis <u>Data years:</u> 1998-2000 <u>Base year:</u> 1999	Scotland	75 trial sites in 27 participating councils (relating to 1,525km of carriageway and 31,000 households) NB. cost data from 68 sites; before and after data from 59	20mph advisory speed limits, using 4 alternative signage strategies (and some with local publicity campaign)	None stated	1 year (implicit in use of first year rate of return) No discounting	Planning and design Works Annual maintenance Publicity monitoring (=enforcement?) Savings: per 'slight accident' avoided	First year rate of return	None
Grundy et al. 2008	Cost-Benefit Analysis <u>Data years:</u> 2002/3 to 2008 <u>Base year:</u> 2005	London, United Kingdom	144 20mph zones (of 399 in main evaluation) for which cost data were available (and after excluding those associated with a home zone (5) and those which were upgrades of pre-existing traffic-	20mph zones (from single 0.07km stretches of road to areas covering 37km of road; 252 of the 399 zones contained a school; plus 93 have a school within 100m; nearly all minor roads)	None stated	5 and 10 years Value of savings from casualty reductions discounted at 3.5% per year	Consultation costs Building costs From the 144 zones which were dominantly 20mph zones and had cost data Savings: for fatal, serious and slight accidents	Net Present Value	Results presented separately for zones in 'low casualty' and 'high casualty' frequency locations Also, probabilistic sensitivity

[35] may include safety schemes which do not include road engineering measures (e.g. include all action of speed cameras or red-light cameras)

Author, year	Analysis type, data	Country, setting	Population, data	Interventions or comparators	Perspective	Time horizon, discounting	Costs & savings included	Statistic estimated	Sensitivity analyses
			calming schemes (10)						analysis conducted
Manchester City Council, 2008	Cost-Benefit Analysis Data years: 2000 to 2007 Base year: 2005	England, Manchester	Traffic-calming and refurbishment of a 1.2km primary route into the city centre	Final scheme included: Carriageway re-alignment, new crossings, traffic signals, bus lanes, pedestrian stages and cycle advance stop lines, pedestrian refuge islands, parking rationalisation, widened footways, footway resurfacing, carriageway resurfacing, new street lighting, themed street furniture	None stated	1 year (first year rate of return)	Construction costs Project management, public consultation, design and supervision fees, parking survey. Savings associated with casualties avoided	First year rate of return	None
Cheshire County Council, 2008	Cost-Benefit Analysis Data years: 2000/1 – 2007 Base year: 2005	England, Crewe	Traffic-calming of an approx 1km section of a major route (single carriageway) into the town centre, including two major junctions	Final scheme included: Upgrading of traffic signals, 20mph speed limit with speed humps and carriageway redesign, extension and remodelling of footways, build-outs, system of one-way streets, new signing strategy, cycle lanes and facilities at all junctions, new bus stops	None stated	1 year (first year rate of return)	Construction costs Project management, public consultation, monitoring, design and contract supervision Savings associated with casualties avoided	First year rate of return	None

Author, year	Analysis type, data	Country, setting	Population, data	Interventions or comparators	Perspective	Time horizon, discounting	Costs & savings included	Statistic estimated	Sensitivity analyses
Norfolk County Council, 2008	Cost-Benefit Analysis Data years: Base year: 2005	England, Norwich	Traffic-calming of an approx 0.5km section of a major one-way route (most dual carriageway, very few junctions) in the city centre, which is also a key corridor for pedestrians between the main railways station and the city centre. Dominant land use is night time leisure scene	Final scheme included: Signal-controlled pedestrian crossings, uncontrolled pedestrian crossings, new Puffin crossings, carriageway redesign with curb buildouts, removal of central reservation, widening of footways, reduced on-street parking, Saxon paving, variable message and static car park signing, 'public realm improvements' (e.g. street trees, new design bins and bollards)	None stated	1 year (first year rate of return)	Construction costs Project management, public consultation, monitoring, design and contract supervision Savings associated with casualties avoided	First year rate of return	None
Mackie et al 1990 (= TRL Research Report 263)	Cost-Benefit Analysis Data years: not stated (but before period was 4–5 years, after = 2 years) Therefore study data probably from 1981/2 to 1988/9 Base year: 1987	England, 5 cities or towns (Reading, Sheffield, Nelson, Bradford, Bristol)	Large areas in these cities, without an evident poor accident record	Area-wide schemes incorporating some or all of the following measures: Mini-roundabouts, banned right turns, road closures/no entry orders, sheltered parking, right turn bays, central refuges, 'threshold treatments' (footway crossovers), pinch points, speed control humps.	None stated	5 years No discounting	Implementation costs Design & management, costs Increased vehicle operating costs Increased journey times Savings from accidents avoided	First Year Rate of Return	Analysis with 'worst case' and 'best case' assumptions, and excluding Sheffield effectiveness data (atypically large reduction in accidents)
Wheeler & Taylor, 2000 *Village Speed Reduction Study (VISP) (= TRL Research Report 452)	Cost-Benefit Analysis Data years: 1992 to 2008 Base year: 1998	Great Britain	24 'VISP'* village traffic-calming schemes) and 9 major road (rural) traffic-calming schemes	Various levels of traffic-calming in and around villages, including: Gateway signing, physical measures, minor or significant signing & markings	None stated	None (annual rate of return) No discounting	Consultation costs Building costs Savings: for KSI and slight accidents	Average annual rate of return	Results for VISP schemes and major road schemes reported separately

Author, year	Analysis type, data	Country, setting	Population, data	Interventions or comparators	Perspective	Time horizon, discounting	Costs & savings included	Statistic estimated	Sensitivity analyses
Sælensminde, 2004	Cost-Benefit Analysis Data year: various Base year: 2003	Norway, 3 cities (Troudheim, Hamar, Horrsund)	Walking and cycling networks in the three cities	Walking and cycling networks	None stated Societal/community (inferred)	25 years, discounting 5% pr year	Capital costs Maintenance costs 'Tax-cost factor' ** Reduced insecurity for pedestrians and cyclists Reduced costs for transporting school children Costs related to diseases and ailments External ('spill-over') costs of transport Parking costs for employers	Benefit-Cost ratio	Various 1-way: Pedestrian and cycle traffic Number of accidents Cost estimates Discount rate
Erke & Elvik 2007	Cost-Benefit Analysis	Norway	Norwegian roads with different motor vehicle volume	Variety of cycle paths/lanes, pedestrian crossings	None stated Societal/community (inferred)	Not stated Not stated	Safety (reduction of numbers and/or severity of injuries) Mobility (travel time) Health effects of walking and cycling Environmental impacts Comfort and security	Benefit-Cost ratio	One-way, by motor vehicle traffic volume
Elvik 2003	Cost Benefit Analysis	Norway & Sweden	No specific locations within the countries	Very wide range of different road safety measures, and for each, their current or optimal use (if data available)	None stated Societal/community (inferred)	10 years Not stated	Safety impact (reduction of numbers and/or severity of injuries)	Benefit cost ratio	Current use vs Optimal use

Author, year	Analysis type, data	Country, setting	Population, data	Interventions or comparators	Perspective	Time horizon, discounting	Costs & savings included	Statistic estimated	Sensitivity analyses
Meuleners et al. 2008	Cost Benefit Analysis Data years: 2000-2002 or up to 2003 (unclear) Base year: 2003	Australia, Western Australia	Various road/junction locations in Western Australia (WA Road Injury Database)	Treatment types: 150 sites (including 134 intersections): Roundabouts (metro, rural), Traffic control signals, Non-skid treatment, Traffic island on approach, Seagull island, left turn slip, Median on existing road, Nibs, Ban right turns, Indented right island, Improve/ reinforce priority signs	Not stated. But implicit societal (community) perspective	10 years, 5% per year discount rate	Programme costs (both capital costs and maintenance/ operating costs) Cost savings due to any reductions in crashes; including human costs of treating injuries Productivity losses Vehicle repair & related costs 'General' crash costs (not clear) All crashes (including both injury crashes and property only crashes) (NB. 5 years pre-treatment data; 6 months to 3 years post-treatment) Crash rates analyzed using Poisson regression GEE of crash rates over whole time period	Benefit Cost Ratio	One-way: Rural vs Metropolitan areas Life of treatments 5-15 years Discount rates

* may include safety schemes which do not include road engineering measures (e.g. include all action of speed cameras or red-light cameras)

6.1.2.1. Quality appraisal

Quality appraisal was assessed using the 19-item CHEC Criteria list (which has many items in common with the more well-known ‘Drummond checklist’) (Evers et al., 2005). It has some advantages over the Drummond checklist because (a) it has been developed and validated through a review of previous checklists and an international consensus process, and because (b) key questions about the identification, measurement and valuation of costs and consequences are asked separately for costs and consequences/effects.

However, because most of the cost-benefit analyses were reported so briefly, as part of much broader evaluations of the effectiveness and implementation of relevant schemes, the level of detail available to judge many of the study quality criteria was lacking. Also, the quality assessment checklist used - being specifically designed to assess stand-alone publications of health care economic evaluations – may often lead (possibly unfairly) to judgements of poor study quality in the area of transport economics and road safety evaluation, where different methodological and reporting conventions seem to apply.

6.1.2.2. Applicability

Amongst the very many factors which determine the applicability of cost-effectiveness and cost-benefit estimates, the two important basic determinants are:

- The country where the interventions were implemented and evaluated
- The number of years since the intervention was implemented and evaluated

Therefore, we have assumed that the studies of most relevance to a UK setting are seven economic evaluations published using UK data on UK schemes from 2000 onwards (three on major urban routes, one on rural traffic-calming, and two on 20mph zones).

However, it should also always be borne in mind that even within a specific type of scheme within a particular country (e.g. 20mph zones in England) there is a very large possible variety of the scale of schemes, as well as variations in the specific combination and quality (cost) of included engineering and other components, together with differing local contexts (e.g. motorised traffic levels, population density, pedestrian and cyclist traffic levels, degree of safety/accident levels of existing road network/route/junction) and processes of implementation (e.g. with different levels of local consultation). These differences will generally impact on both the cost and the benefit side of an evaluation, so broad and unqualified conclusions about the cost-effectiveness of traffic-calming and other design-based road safety measures are unlikely.

6.1.3. Findings

Before describing the findings of each economic evaluation in turn, Table 31 below provides a brief description of the various estimates of the efficiency which were reported in the included studies. As already noted, in the road safety and transport field investment decisions at a local authority and other levels of government are often based on relatively short-term cost-benefit estimates such as the First Year Rate of Return. This is despite both the physical duration of the infrastructure/engineering changes, and the effective life of the infrastructure changes, often being many years.

Table 31. Description and interpretation of alternative cost-benefit estimates

Measure (abbreviation)	Description	Interpretation of values
Benefit-Cost Ratio (BCR)	The monetary value of the additional benefits of an intervention, divided by the additional costs (measured or estimated for a given period, and discounted to a base year)	Values: >1 when benefits exceed costs; <1 when costs exceed benefits
First Year Rate of Return (FYRR)	Same as BCR, but only for the costs and benefits in the first year after implementation, and usually expressed as a percentage	Values: >100% when benefits exceed costs; < 1 when costs exceed benefits
Annual Average Rate of Return	Same as BCR, but expressed as a percentage.	Values: >100% when benefits exceed costs; < 1 when costs exceed benefits
Net Present Value (or Net Monetary Benefit)	The monetary value of the additional benefits of an intervention, less the additional costs (measured or estimated for a given period, and discounted to a base year)	Values in £: Positive values when benefits exceed costs.

Table 32. Relevant published economic evaluations of traffic-calming and related road safety measures: Results [a]

Author, Year	Intervention(s)		Cost of the intervention		Benefits associated with the intervention			Cost-Benefit estimate	
Gorell & Tootill, 2001	Absence of scheme compared with:	The following schemes: Whole database (1992-1999):	No. of schemes (with cost data)	Average cost of scheme (1999 £s)	No. of schemes (with 'after' data)	% change in accidents per year	Average annual accidents saved	Expenditure per accident saved per annum	Average first year rate of return (%)
	Cycle scheme		12	59,155	12	-65	3.79	15607	444
	Area-wide		12	79,312	12	-31	1.86	30720	225
	Route		69	22,419	77	-43	1.51	13331	520
	Link-calming		63	39,612	78	-48	1.48	26764	260
	Signalised junction		159	35,206	195	-37	1.43	26128	266
	Bend		265	10,753	304	-48	1.14	8958	722
	Roundabout		164	40,502	188	-33	1.09	39415	176
	Pedestrian facility		250	27,296	317	-32	1.02	28036	246
	Link (overall)		435	28,391	674	-25	1.00	25072	276
	Link-general		398	27,333	636	-26	0.90	26262	266
	Priority junction		468	11,930	519	-34	0.87	13231	523
Gorell & Tootill, 2001 continued	Schemes monitored from 1996-1999:		No. of schemes (with cost data)	Average cost of scheme (1999 £s)	No. of schemes (with 'after' data)	% change in accidents per year	Average annual accidents saved	Expenditure per accident saved per annum	Average first year rate of return (%)
	Cycle scheme		10	64,706	10	-65	3.96	16,347	522
	Area-wide		9	78,843	9	-51	2.69	29,261	236
	Route		21	25,709	21	-38	1.38	18,622	372
	Link-calming		32	51,815	32	-55	1.57	32,655	210
	Signalised junction		72	35,675	78	-34	1.35	27,053	256
	Bend		98	6,046	108	-60	1.22	4,822	1434
	Roundabout		81	30,132	82	-30	1.22	31,268	276
	Pedestrian facility		110	31,544	119	-30	1.00	34,336	213
	Link (overall)		164	27,068	168	-33	1.26	21,096	328
	Link-general		149	24,740	153	-34	1.18	20,605	336
	Priority junction		295	8,795	297	-33	0.83	10,227	678
Burns et al. 2001	All 68 sites with cost data		All in 1999 £s: Planning & design cost: £1,304 Works: £3,496 Annual maintenance: £418 Publicity: £379 Mean cost per trial site: £4,650 (range £1150 to £15,700) Cost of implementing all schemes = £369,315		Estimated reduction of 13 slight accidents per year Equates to £177,690 of estimated savings (across the 59 sites with before and after data)			48% First Year Rate of Return (across all sites with data)	

Author, Year	Intervention(s)		Cost of the intervention		Benefits associated with the intervention	Cost-Benefit estimate	
			Installation cost per km (1999 £s)	Installation cost per household (1999 £s)			
	All 20mph zone trial sites		208	10			
	green signs + repeat roundels		229	14			
	white signs + repeat roundels		199	10			
	White signs + green roundels + repeat roundels		195	12			
	On street name signs + repeat roundels		319	7			
Grundy et al. 2008	20 mph zones in:	Time horizon	Consultation and building cost per km (2005 £s)		Casualty-reduction benefits per km (2005 £s, with standard deviation)	Net Present Value	% of zones with positive NPV
	'Low casualty' roads/streets	5 years	59,461		23,344 (3,668)	-36,117	41%
		10 years	59,461		37,278 (5,905)	-22,183	53%
	'High casualty' roads/streets	5 years	59,993		78,940 (14,660)	18,947	74%
		10 years	59,993		127,299 (24,232)	67,306	85%
Manchester City Council, 2008		Traffic-calming of the 2.2 km route	£2.545 million (construction costs) + other initial costs of £0.588 million = £3.135 million (= approx £2.2 million construction cost per km)		15.5 casualties avoided per year, at £44,920 savings each = £696,000 per year	First Year Rate of Return = 22%	
Cheshire County Council, 2008		Traffic-calming of the 1km route (incl. 2 junctions)	£1.689 million (construction costs) + other initial costs of £0.444 million = £2.133 million (= approx £2.1 million construction cost per km)		5.1 casualties avoided per year, at £46,838 savings each = £238,874 per year	First Year Rate of Return = 11.2%	
Norfolk County Council, 2008		Traffic-calming of the 0.5km route	£1 million (construction costs) + other initial costs of £0.259 million = £1.259 million (= approx £2 million construction cost per km)		9.6 casualties avoided per year, at £44,920 savings each = £431,000 per year	First Year Rate of Return = 34%	
Mackie et al 1990 (= TRL Research Report 263)		All 5 area-wide schemes involved in the Urban Safety Project	Mean installation costs of £250,000 per scheme Plus estimated design and management costs of £250,000 =£500,000 per scheme Plus vehicle operating costs and value of time (vale not stated)		Annual reduction in accidents at all sites = 25 = 131 (before) – 106 (after) Savings of £16,410 per injury accident Inflated each year by 2.5% (for 5 years)	First Year Rate of Return = 65% (range from 'worst' case to 'best case' = 10% to 340%) Based only on 4 schemes (excluding sheffield) = 30% to 40%	
Wheeler & Taylor, 2000	Rural traffic-calming		(1998 £s)		Reduction across the whole sample of villages Adjusted injuries per year (unadjusted)		

Author, Year	Intervention(s)	Cost of the intervention			Benefits associated with the intervention				Cost-Benefit estimate
					KSI	Slightly injured	Value of injuries avoided		Average annual rate of return:
	Schemes across all villages				18.3 (8.7)	13.0 (14.1)	= £2.02 million (= £36,128 per scheme		NR
	VISP schemes	£25,500			1.7 (5.3)	1.4 (1.0)	= £0.37 million (= £15,578 per scheme		0.62 per VISP scheme
	Major rural road schemes	£138,000			2.3 (4.1)	0.7 (0.5)	= £0.49 million (= £54,100 per scheme)		0.39 per major road scheme
Sælensminde, 2004		Horrsund	Hamar	Trendheim		Hokrsmd	Hamar	Trendheim	Benefit-cost ratio: Horrsund: 4.09 Hamar: 14.34 Trendheim: 2.94
	Capital	23.6	15.8	600.0	Savings in 2003 NOK millions:				
	Maintenance	1.6	1.0	39.5	Reduced insecurity for peds & cyclists	4.2 9.5 0.5 3.5	2.7 6.1 0.4 2.3	107.6 398.2 13.7 100.7	
	'Tax-cost factor'	5.0	3.4	127.9	School transport	2.6	1.1	3.6	
	TOTAL COSTS (2003 NOK million)	30.2	20.1	767.4	Less severe diseases	16.7	35.4	269.2	
					Severe diseases	97.7	206.6	1572.4	
					Motorised transport & parking	9.4 9.5	20.0 34.6	124.4 433.4	
					TOTAL SAVINGS	153.7	309.1	3023.3	
Erke & Elvik 2007		Cost (NOK million, 2005)			Motor vehicle volume				Benefit cost ratio
	Combined sidewalk and cycle path	6.0 per km			35,000				0.82
					19,000				0.39
					8,000				0.00
	Grade-separated crossing for pedestrians and cyclists	1.6 – 22.0 per location			35,000				2.04
					19,000				0.32
					8,000				0.00
	Traffic signals at pedestrian crossings	0.5 – 1.0 per crossing facility			35,000				-15.28
					19,000				-3.10
					8,000				-1.38
	Improvement of pedestrian crossings	0.15 – 2.3 per crossing facility			35,000				0.51
					19,000				2.16
					8,000				0.05

Author, Year	Intervention(s)	Cost of the intervention	Benefits associated with the intervention		Cost-Benefit estimate	
	Marking of cycle lane	0.5 per km	35,000		-2.12	
			19,000		-1.21	
			8,000		-0.78	
Elvik 2003	Selected measures:	(NB. only cost-benefit ratios reported; no separate costs and savings/benefits):	Cost-Benefit Ratios In Norway		Cost-Benefit Ratios In Sweden	
			Current use	Optimal use	Current	Optimal
	Area-wide urban traffic-calming		3.18	3.05	-0.50	Inappl.
	Walking speed streets (7km/h streets)		-2.61	Inappl.	-0.76	Inappl.
	Traffic signal control of pedestrian crossings		0.87	Inappl.	0.66	Inappl.
	Adoption of optimal speed limits		Not used	4.47	Not used	1.00
	Speed humps on residential roads		-8.75	Inappl.	No data	No data
	Upgrading marked pedestrian crossings		2.07	1.75	1.46	1.14
	Variable message signs		1.45	1.33	Not used	1.13
	Pedestrian bridges or underpasses		6.03	3.73	1.57	1.44
	Roundabouts		1.52	2.26	1.70	1.90
	Staggered junctions		0.51	Inappl.	0.28	Inappl.
	Roadside safety treatment		Not used	Inappl.	1.28	1.28
	General rehabilitation of roads		0.61	Inappl.	0.55	Inappl.
	Guard rails on the roadside		1.18	1.18	0.69	Inappl.
	Horizontal curve treatment		6.55	5.75	1.90	1.90
Meuleners et al. 2008	Type of road treatment:	Present value of treatment (A$, 2003)	All crash reduction (%)	Present value of crash cost saving (A$, 2003)		
	Roundabouts - Metro	3,436,891	21.3	15,239,880	4.4	
	Roundabouts – Rural	1,092,179	60.2	10,739,977	9.8	
	Traffic control signals	1,000,269	21.2	-4,779,484	-4.8	
	Non-skid treatment	679,169	6.7	7,515,224	11.1	
	Traffic island on approach	657,191	18.7	4,061,624	6.2	
	'Seagull island' (not defined)	628,974	-5.7*	-896,126	-1.4	
	Left turn slip	506,763	11.1	4,996,963	9.9	
	Median on existing road	353,458	8.2	498,977	1.4	
	Nibs (Kerb extensions)	136,697	58.7	-2,143,128	-15.7	
	Ban right turns	28,670	52.0	5,685,393	198.3	
	Indented right island	183,194	49.6	2,786,441	15.2	
	Improve/reinforce priority signs	18,942	16.0	2,335,800	-123.3	
	All State Roads	381,239	3.5	-5,374,343	-14.1	

* negative crash reduction = an increase in crashes

Area-wide traffic-calming

Estimates of the cost-effectiveness of area-wide traffic-calming are available from one quite old study in five English cities (Mackie et al., 1990), and two more recent studies which focused on the cost-effectiveness of a wide range of different road safety measures in the UK, and in Norway and Sweden (not at specific localities) (Elvik, 2003; Gorell & Tootill, 2001).

The study by Mackie et al (TRL Research Report 263) was primarily a controlled before and after **evaluation of five area-wide traffic-calming schemes in the late 1980s in Sheffield, Bristol, Reading, Bradford and Nelson** which were part of the 'Urban Safety Project' (Mackie et al., 1990). The treatments in the areas comprised a better definition of the road hierarchy, with upgraded routes and other changes to redistribute traffic, plus a range of traffic-calming measures to improve conditions for vulnerable road users (e.g. pinch points, entry treatments [i.e. footway cross-overs], central refuges and wide islands, roundabouts, staggered parking bays, rumble strips and speed control humps). Measured speed reductions were mostly attributed to the use of speed humps. The estimated accident reduction effect sizes in the different schemes ranged from -4% (part of Reading scheme) to -25% (part of Bristol scheme) with a mean across all schemes of -13%. The schemes covered large areas of these cities and did not target specific accident problem areas. Estimates of first year rates of return ranged from 10% (in the worst case) to 340% in the best case (average 65% for all schemes). However, excluding the conspicuously high estimate of accident reductions from the Sheffield scheme, the authors believed that "a more typical but still substantial" first year rate of return of between 30% and 40% was more representative.

However, although studying actual UK schemes, being so old (1987 base year for analysis), and also being based on very crude estimates of the cost the schemes (£250,000 installation costs, plus £250,000 design and management costs), the relevance of these cost-benefit estimates to policy-making in the UK today is very doubtful.

Also in the UK, Gorrell and Tootill examined the cost-effectiveness and cost-benefit of **a range of UK Local Authority Safety Schemes** (1991-1999) recorded in the large MOLASSES database (Gorell & Tootill, 2001). Of the over a thousand schemes evaluated (mainly link-roads, routes, junctions and bends), only 12 were classed as area-wide schemes, and these had an average cost of approximately £80,000 (1999 £s; range or variance not reported) per scheme, but yielded an annual reduction in personal injury accidents of 31% (or -1.86 accidents per scheme). Therefore, the estimated expenditure per accident saved (with only a one-year time horizon) was £30,720, and the estimated average first year rate of return (from placing a monetary value on casualties avoided) was 225%.

As part of an exercise in estimating the cost-effectiveness of a wide range of road safety measures, under different policy-making scenarios, Elvik also estimated the cost-benefit of **area-wide urban traffic-calming in Norway and Sweden**, but their analysis was not apparently based on particular schemes at specific localities (Elvik, 2003). In contrast to the above estimates, they estimated the benefit-cost ratio of area-wide traffic-calming to be 3.18 in Norway but -0.50 in Sweden (if implemented at current levels). Unfortunately, this contrasting result (highly cost-effective in Norway, but not cost-effective in Sweden) is not discussed or explained in the paper (it is one of over 130 road safety measures covered in the review paper).

A much more recent (April 2009) report from the UK, by the consultancy Atkins, has evaluated the **casualty reduction impacts of Local Safety Schemes** (Atkins (on behalf of DfT), 2009). This analysed either numbers of casualties saved or numbers of collisions avoided (where a collision is a road traffic crash that results in a recorded personal injury) over 300 road safety schemes including 55 traffic-calming schemes (25 of which were 20 mph zones). First Year Rates of Return were calculated under a number of different assumptions, for roads in built-up and non-built-up areas, and for schemes of different cost.

Evidence Statement 10: Cost-benefit of area-wide traffic-calming

There is moderate evidence from 3 cost-benefit analyses of a variety of schemes in the UK (2 studies) and in Norway and Sweden (1 study), that show that even in the short-term (after 1 year) benefits are likely to exceed costs in most circumstances (Elvik, 2003 [+]; Gorell & Tootill, 2001 [+]; Mackie et al., 1990 [+]). However, there was considerable variation in First Year Rates of Return both for different schemes within studies, and between the two UK studies (Mackie et al 1990 [+]: mean estimated FYRR across 5 schemes 30%-40%; Gorrell & Tootill 2001 [+]: mean estimated FYRR across 12 schemes 225%.

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.)

This evidence is judged as partly applicable to the UK road setting as one of the two UK studies was very old, and another study was based on data from Norway and Sweden.

20mph zones

Two fairly recent economic evaluations of the use of 20mph zones have been conducted, one in Scotland (Burns et al., 2001) and one in London (Grundy et al., 2008). However, it should be noted that the advisory 20mph speed limits in Scotland had no engineering traffic-calming features, in contrast to the mandatory 20mph zones in England where traffic-calming components are a required feature.

A large and relatively recent study of a national trial (75 trial sites) in **Scotland**, evaluated the introduction of **20mph advisory speed limit zones** of various size, with various signage strategies and also different degrees of publicity and enforcement (Burns et al., 2001). The related cost-benefit analysis involved off-setting the estimated cost savings due to accidents avoided from the initial (design, planning, works and publicity) and ongoing maintenance costs of the scheme. In 61 of the 68 trial areas who provided cost data the installation cost of the scheme was lower than the saved costs of one 'slight' accident avoided. Furthermore, by their estimation, the cost of all 75 schemes across the whole of Scotland (£369,315 in 1999 £s) was considerably lower than the cost of one fatal accident (£1.182 million).

Even basing the analysis on just the cost savings due to the thirteen slight accidents avoided across schemes, produces a First Year Rate of Return of 48%. This compares with an estimated First Year Rate of Return of engineering solutions to speed reduction in similar urban areas of 24% (based on data from TRL 215 Report).

Another more recent study evaluated the costs and benefits of 144 **mandatory 20mph zones** across **London**, using data from 2002/3 to 2008 (Grundy et al., 2008). The related cost-benefit analysis involved off-setting the estimated cost savings due to accidents avoided, from the initial consultation and building costs of the scheme. This was the only one of the 11 included economic evaluations which was based on a (very simple) decision model and which conducted a probabilistic sensitivity analysis, and one of the few which used a time horizon of over 5 years (10 years). They also separately presented the cost-benefit analyses for schemes implemented in low casualty and high casualty roads/streets.

When introduced into 'high casualty' areas and considered either over a 5- or a 10-year time horizon, the 20mph zones produced positive mean net present values (NPVs) of approximately £19,000 and £67,000 respectively. However, these mean NPVs conceal very wide variations in the relative size of costs and benefits for individual schemes. Over the 5-year time horizon 26% of schemes had a negative NPV (i.e. costs exceeded benefits) and even over ten years, 15% of schemes had negative NPV. The equivalent proportions of schemes in implemented in 'low casualty' areas where costs exceeded benefits were 41% and 53%.

Interestingly, the cost per km of the 20mph zones in London (at just under £60,000 per km, in 2005 £s) is far higher than the installation cost per km from the earlier study of advisory 20mph zones in Scotland (range: £195 to £319 per km). This almost certainly reflects the greater use of physical measures (e.g. speed humps, gateways, and carriageway alterations) as part of the London schemes, in contrast to the (slightly older) Scottish advisory speed limit zones which almost exclusively appeared to involve just new signage.

Evidence Statement 11: Cost-benefit of mandatory 20 mph zones and advisory 20 mph speed limits

There is moderate evidence from 1 cost-benefit analyses of **advisory 20 mph speed limits** in Scotland (75 sites, mainly comprising new signage) that shows that in the short-term (time horizon ~2-3 years; FYRR 48%) benefits are likely to exceed costs (Burns et al., 2001 [+]).

There is moderate evidence from 1 cost-benefit analyses of **mandatory 20 mph zones** in London that shows that in the medium to long-term (time horizon 5 and 10 years) benefits are likely to exceed costs in between 85% and 47% of schemes, depending on the exact time horizon of the analysis and the prior level of casualties at the location . However, across the 144 20mph zones evaluated, a mean net present value of £19,000 was achieved (over 5 years, or £67,000 over ten years post-implementation; 2005 £s) (Grundy et al., 2008 [+]).

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.). The evidence on 20 mph zones is judged as being directly applicable to other urban roads in England, whereas the applicability of the evidence on advisory speed limits in Scotland may have less applicability in England and Wales due to different road regulations relating to 20mph speed limits.

Safety treatment of urban mixed priority routes

Three recent evaluation studies, conducted as part of the same series of linked evaluations of 'Mixed Priority Routes' (see also sections 2.2.4 and 5.3.9), have evaluated traffic-calming of specific sections of main road in Manchester (Manchester City Council & JE Jacobs, 2008), Norwich (Norfolk County Council & JE Jacobs, 2008) and Crewe (Cheshire County Council & JE Jacobs, 2008). (NB. Other evaluation reports in this series reported that there was insufficient data on which to base a cost benefit comparison.) While all three studies were judged as 'good' [+] quality economic evaluations, it should be noted that the description of the methods and results of the cost-benefit analysis was extremely minimal (one or two sentences citing the DfT's Highways Economic Note 2005 document, and also only reporting a single base case First Year Rate of Return estimate) .

The **traffic-calming and road/street refurbishment of Wilmslow Road in Manchester** during 2003/4 (Manchester City Council & JE Jacobs, 2008) was a large engineering project involving extensive public consultation, and also serving a number of environment regeneration and economic development objectives in addition to safety goals. It incorporated a wide range of both traffic-calming measures, and other physical changes to the streetscape to improve the environment for shoppers, residents and other pedestrians (see Table 30 above for more detail). The 2.2km section of major arterial route was improved at a total cost of £3.135 million (2005 £s), or a stated £2.2 million per kilometre. When compared with the estimated annual savings from reduced casualties (using DfT recommended valuations) this equates to a First Year Rate of Return of 22%. That is, without discounting and extrapolating the same casualty reductions into the future the cost of the schemes would be exceeded by the value of the benefits after 5 years. This might be regarded as an under-estimate of the scheme's true cost-effectiveness, as it attaches no value to the various other non-safety-related benefits which it was intended to achieve, and which would have added to the scheme's cost.

The **traffic-calming of Prince of Wales Road in Norwich** during 2003/4 was a road engineering project mainly to improve safety on a short (0.5km) section of city centre dual carriageway through an area which has high night time leisure activity (pubs and clubs), as well as being the main pedestrian route between the city centre and the main railways station (Norfolk County Council & JE Jacobs, 2008). It incorporated a wide range of traffic-calming measures, although has few junctions (see Table 30). The 0.5km section of major arterial route was improved at a total cost of £1.259 million (2005 £s), or a stated £2 million per kilometre. When compared with the estimated annual savings from reduced casualties (again, using DfT recommended valuations) this equates to a First Year Rate of Return of 34%. That is, without discounting and extrapolating the same casualty reductions into the future the cost of the schemes would be exceeded by the value of the benefits (at £431,000 per year) after only 3 years.

The **traffic-calming of Nantwich Road in Crewe** during 2004/5 was a road engineering project mainly intended to improve safety on a short (1km) section of single carriageway including two major junctions (Cheshire County Council & JE Jacobs, 2008). It incorporated a wide range of traffic-calming measures, including carriageway alterations and 20mph speed limit with speed humps (see Table 30). The 1km section of arterial route was improved at a total cost of £2.133 million (2005 £s), or a stated £2.1 million per kilometre. When compared with the estimated annual savings from reduced casualties (again, using DfT recommended valuations) this equates to a First Year Rate of Return of 11%. That is, without discounting, and extrapolating the same casualty reductions into the future, the cost of the schemes would be exceeded by the estimated value of the benefits (at £238,874 per year) after approximately 10 years.

Given the different range of safety and broader non-safety objectives of the schemes in Manchester, Norwich and Crewe, and the different detailed content and scale of their designs, as well as different implementation processes (e.g. different levels of public consultation, use of parking surveys, speed hump trials), it is remarkable that they ultimately all had a similar construction cost per km, of around £2 million. Thus the main reason for variation in the estimated First Year Rate of Return between these schemes is the per kilometre reduction in casualties. Before and after casualty data for the Norwich scheme suggests it achieved a reduction equivalent to approximately 19 casualties per year per km, compared with a reduction of approximately 7 per year per km in Manchester, and 5 per year per km in Crewe.

Evidence Statement 12: Cost-benefit of Mixed Priority Route schemes

There is moderate evidence from 3 cost-benefit analyses of a three very costly road improvement/safety schemes (construction costs of £2 to £2.2 million per km) in Manchester, Norwich and Crewe (England), that show that in the medium to long term (time horizon 3-10 years; FYRR range 11% to 34%) benefits are likely to exceed costs (Cheshire County Council & JE Jacobs, 2008 [+]; Manchester City Council & JE Jacobs, 2008 [+]; Norfolk County Council & JE Jacobs, 2008 [+]).

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.) This evidence on mixed priority routes is judged as being directly applicable to similar urban arterial roads in UK cities.

Other single route safety schemes

The study by Gorrell and Tootill, already discussed above in relation to area-wide traffic-calming, examined the cost-effectiveness and cost-benefit of **a range of UK Local Authority Safety Schemes** (1991-1999) recorded in the large MOLASSES database (Gorell & Tootill, 2001). As part of this analysis they were able to assess the cost-benefit of: 'link-calming', 'routes', 'links (overall)' and 'links (general)' - although the specific features of these categories of road safety scheme were not further described. Nevertheless, they all achieved impressive average First Year Rates of Return: 260% for link calming (63 schemes); 520% for routes (69 schemes); 276% for links-overall (435 schemes); 266% for links-general (398 schemes). However, due to the lack of fuller descriptions of these scheme types it is not clear to what extent these safety schemes would be classed as traffic-calming (e.g. aiming to reduce driver speeds) versus those aimed at reducing the likelihood or severity of accidents in other ways. Nor was a sub-group analysis provided for routes in built-up areas, or (for example) in areas close to schools.

Evidence Statement 13: Cost-benefit of single route traffic-calming/safety schemes

There is moderate evidence from 1 cost-benefit analysis of a variety of schemes in the UK, that show that even in the short-term (time horizon 1 year) benefits are very likely to exceed costs (Gorell & Tootill, 2001 [+]). For various types of road safety treatment the First Year Rates of Return varied from 260% (for link-calming) to 520% (for 'routes') although the extent to which measures might be classed as design-based or focused on speed reduction is unclear.

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.) This evidence on single route safety schemes is judged as being directly applicable to similar roads in the UK, noting that many of the safety schemes were probably outside built-up areas.

Rural/village traffic-calming

Only one of the included studies exclusively evaluated traffic-calming outside urban areas, specifically in British villages (Wheeler & Taylor, 2000). However, it is also likely that many of the schemes evaluated as part of the MOLASSES database in the UK (Gorell & Tootill, 2001), and as part of the evaluation of Black Spot programmes in Western Australia (see next section) were also in non-urban locations.

Wheeler & Taylor's (2000) report evaluated both the **24 village traffic-calming schemes (Vehicle Speed Reduction Study, or 'VISP')**, and also **9 other major rural road safety schemes**. The Vehicle Speed Reduction Study traffic-calming villages were mainly treated using gateway signing, physical measures, and new road markings, both within and on approach roads to villages. The average scheme cost (in 1998 £s) was £25,000, which on average achieved a reduction (national time trend-adjusted) of 1.7 killed or seriously injured per year, and of 1.4 slightly injured per year. These equate to a value of around £15,500 in related savings to society, giving an annual rate of return of 0.62 per village traffic-calming scheme. The major road schemes were, on average, over five times as expensive (£138,000) as the village schemes, but achieved slightly higher reductions in the number of people killed or seriously injured. Comparing this cost per scheme with estimated injury savings per road scheme of £54,100 gives an annual rate of return of 0.39. Therefore, given the likely durability of the signage and other physical infrastructure involved, on average the benefits would exceed the costs of these schemes within only two to three years of their completion.

Evidence Statement 14: Cost-benefit of rural/village traffic-calming

There is moderate evidence from 1 cost-benefit analysis of both village-specific traffic calming and major rural road schemes in the UK, that shows that in the short-term (time horizon ~2-3 years) benefits are likely to exceed costs (Wheeler & Taylor, 2000 [+]). The 24 village traffic calming schemes evaluated - which used gateway signing, physical measures, and new road markings achieved an estimated annual rate of return (=equivalent to FYRR) of 62%, while the more expensive major rural road schemes achieved an estimated annual rate of return of 39%.

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.) This evidence on village traffic calming and major rural road safety schemes is judged as being directly applicable to similar villages and rural roads in the UK.

Accident 'Black Spot' treatments (Australia)

Meuleners and colleagues used an established state-wide road injury database to evaluate the effectiveness and cost-effectiveness of a wide range of treatments of identified **high accident frequency locations ('Black Spots') throughout Western Australia - mostly road intersection treatments** (Meuleners et al., 2008). In contrast to most of the other included economic evaluations, this study adopted a more plausible time horizon (10 years) and used discounting of future benefits and costs (at 5%), including maintenance/operating costs. Also, taking an (implicit) societal perspective the cost-benefit analysis included crash costs unrelated to injuries, such as vehicle repair and other crash costs. The estimated benefit-cost ratios varied from a highly cost-effective 198.3 (for banned right turns) to 1.4 (for medians on existing roads). However, some types of treatment produced extra costs because they were assessed to have increased rather than reduced the estimated injury crashes (these were reported as negative benefit cost ratios). Of the 11 types of road or intersection treatment seven were shown to be cost-effective over the ten year time horizon, the exceptions being: traffic control signals, 'seagull islands', and 'nibs' (kerb extensions), and the priority signs already mentioned; see full results in Table 30 above). Black Spot treatments in rural areas, on average, had a slightly higher cost-effectiveness (mean benefit-cost ratio of 6.3) compared with treatments in metropolitan areas (ratio of 4.3).

Evidence Statement 15: Cost-benefit of accident 'black spot' safety treatments

There is inconsistent evidence from 1 cost-benefit analysis of a variety of accident 'black spot' safety treatments in Australia, which shows that in the long-term (time horizon 10 years) benefits exceeded costs for 7 of the 11 treatment types evaluated (Meuleners et al., 2008 [+]). Treatments were mainly of intersections, with benefit cost-ratios greater than one for: ban right turns (198.3); 'indented right island' (15.2); non-skid treatment (11.1); left turn slip (9.9); roundabouts – rural (9.8); 'traffic island on approach' (6.2); roundabouts – metro (4.4), and; median on existing road (1.4). The other black spot treatments, where costs exceeded estimated benefits were: the improvement or reinforcement of priority signs, nibs (kerb extensions), traffic control signals and 'seagull islands' (not defined). Treatments in rural areas had slightly higher benefit-cost ratios compared with those in metropolitan areas (mean 6.3 vs 4.3).

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.) This evidence on the safety treatment of high-accident road sections or junctions is judged as being partially applicable to similar roads in the UK, noting that many of the safety treatments were probably outside built-up areas, and also that other driving behaviours and road conditions and characteristics are likely to differ between the UK and Australia.

Interventions to improve the safety and popularity of walking and cycling

Two fairly recent evaluations, both in Norway, involved the explicit evaluation of measures to reduce injuries to pedestrians (Erke & Elvik, 2007), and/or to analyse the safety and other wider societal benefits and costs of walking and cycle path networks) (Saelensminde, 2004).

Erke and Elvik's (2007) study of the cost-effectiveness of preventing pedestrian accidents evaluated (amongst other schemes) the cost-benefit of **shared pedestrian/cycle paths, cycle lane markings and three types of pedestrian/cycle crossing (in Norway)**. The estimated benefit-cost ratios were highly sensitive to the volume of motor vehicles on the targeted road. In relation to **cycle paths**, whereas 'combined sidewalk and cycle path' had benefit-cost ratios of 0.39 and 0.82 (NB time horizon not stated), the marking of cycle lanes (which was 12 times cheaper per km) actually achieved negative benefit-cost ratios. The authors state that this is "mainly because of the increased time costs of motor vehicles" (p.38) which outweighed the positive value of injury reductions.

Amongst the three safety measures for pedestrians, **grade-separated crossings (for pedestrians and cyclists)** and **'improvement of pedestrian crossing'**, achieved benefit cost ratios greater than one, but only if installed on (respectively) roads with high and medium traffic volumes. Finally, **traffic signals at pedestrian crossings** were estimated to give negative high benefit cost ratios (again because of the increased time costs to motor vehicles). However, judgement of the quality of this study, and its applicability to the UK setting, is hampered by the very brief (5 page) description of their methods and results.

Sælensminde's 2004 study of the benefits and costs of **walking and cycling track networks in three Norwegian cities**, estimated the most comprehensive range of societal cost and benefit impacts of all the included economic evaluations in this review. It included these tracks': capital costs; maintenance costs; and the value of reduced insecurity (i.e. increased sense of safety) for pedestrians and cyclists; reduced costs of child transportation to school; costs related to both severe and milder diseases and ailments (avoided through greater physical activity); and external (e.g. environmental) costs of road transport (CO_2, noise, congestion). The overall estimated benefit-cost ratios for the networks in each city varied from 3 and 4 (in Trondheim and Hokksund) to as high as 14 in Hamar, using (the author claims) “high but realistic” scheme cost estimates, and conservative estimates of benefits.

Despite these impressive and favourable benefit-cost ratios, it should be noted that many of the costs were “preliminary estimates” and there was “limited knowledge of many of the benefits” (p.604). Such uncertainty was partially explored using some one-way sensitivity analyses, including exploration of the potential impact of increased levels of accidents amongst pedestrians and cyclists with the cycling and walking networks. Taking into account (provisional) estimates of the likely cost of increased accidents to pedestrians and cyclists would reduce the value of benefits in each city by approximately 30%; therefore, not by enough to alter the overall favourable balance of costs and benefits.

In the UK, Gorrell and Tootill’s analysis of the MOLASSES local authority safety scheme data (Gorell & Tootill, 2001) estimated the cost-benefit of 10 ‘**cycle schemes**’ (implemented from 1996-1999; scale and content not described). They cost approximately £65,000 each, yielding an estimated annual saving of 3.96 accidents, and giving a First Year Rate of Return of 522%. The same study also evaluated the cost-benefit of 110 ‘**pedestrian facilities**’ but it is unclear whether these may have included walking/pedestrian routes, or were mainly pedestrian crossings etc.. The average First Year Rate of Return for these safety schemes for pedestrians (1996-1999, in 1999 £s) was 213%, and 292% when over a hundred earlier schemes were included.

Evidence Statement 16: Cost-benefit of walking and cycling routes/networks

There is inconsistent evidence from 4 cost-benefit analyses of a wide variety of schemes in the UK (1 study), Norway (2 studies), and in Norway and Sweden (1 study), which show that over various time horizons (1, 10 or 25 years) benefits sometimes exceeded the cost of investments in the safety and mobility of cyclists and/or pedestrians (Gorell & Tootill, 2001 [+]; Erke & Elvik, 2007 [+]; Elvik, 2003 [+] Saelensminde, 2004 [++]).

16a For **cycle routes/networks** Gorrell & Tootill’s (2001) study of 10 schemes in the UK estimated a FYRR of 522%, while a very comprehensive analysis of the impacts of combined walking and cycling networks in 3 Norwegian cities estimated benefit-cost ratios of 3, 4 and 14 (Saelensminde, 2004). In contrast, Erke and Elvik’s (2007) estimated that combined pavement and cycle paths had benefit-cost ratios of between 0 and 0.82 (depending of traffic volumes), but the marking of cycle lanes gave negative benefit-cost ratios (i.e. negative 'benefits' due to increased time costs of motor vehicles).

16b For different **types of pedestrian crossing**, Erke and Elvik (2007) reported a range of benefit cost ratios from 2.16 to 0, again largely depending on traffic volumes. In contrast, Elvik 2003 estimated benefit-cost ratios of 1.14 to 2.07 for 'upgrading marked pedestrian crossings' and ratios of 1.44 to 6.03 for 'pedestrian bridges and underpasses' (in Norway and Sweden).

(There have been no cost-effectiveness or cost-utility analyses which compare the incremental costs with the incremental health gains due to injuries prevented.) This evidence on different schemes to improve the popularity and safety of walking and cycling is judged as being partially applicable to similar roads in the UK.

7. Discussion

7.1. Review 1 (Effectiveness)

7.1.1. Statement of principal findings

A total of 24 studies which evaluated the impact of neighbourhood, design-based interventions on the prevention of unintentional injuries to children in the road environment were included in this review. The interventions assessed were area-wide traffic-calming (five studies, all UK); single road traffic-calming (three studies, all UK); 20mph zones (four studies, albeit relating to overlapping interventions, all in the UK); home zones (three studies, all UK); mixed priority route schemes (three studies, all UK); single component traffic-calming interventions (two studies, one from the USA, one German); safe routes to school (two studies, both USA); cycle routes (one study, UK); and combination interventions (one study, Sweden). Most studies used uncontrolled before and after designs.

Although we searched for them, no eligible studies were found about international examples such as 'woonerven' in the Netherlands; 'naked streets' (or 'psychological traffic-calming') or walking networks and routes.

The best evidence for a reduction in injuries in children through road environment intervention identified by this review is for 20mph zones, where statistically significant reductions were reported across a range of outcomes in all studies. Even here, however, the evidence is based on a limited number of studies (three uncontrolled before and after studies and one non-randomised controlled trial), which overlapped with each other to some degree (geographically, in terms of schemes covered), and in which not all reported reductions reached levels usually regarded as statistically significant.

For other interventions, despite apparent reductions in child injury rates, few outcomes reached levels which could be regarded as statistically significant ($\alpha = 0.05$ level). For example, overall, the results for area wide traffic-calming interventions (based on five studies) suggest that they may lead to reductions in rates of KSI, child road casualty rates, child injury accident rates, and speed. However, statistically significant results were only seen for one of the two studies which reported child casualty rates (and there in only one of two cities studied – the more deprived location) and for one of the three studies reporting child injury accident rates. All other results were non significant. Given the consistency of direction, we have tended to interpret these results as indicative of possible positive effect, although they can be interpreted as indicative of no effect. There is the suggestion that these interventions may be more effective in more deprived areas but insufficient evidence to investigate this possibility with any certainty.

7.1.2. Limitations of the review

7.1.2.1. Review methods

This review focussed on reducing injury in children and studies were excluded if fatalities, injuries or injury accidents were not reported. As noted below, interventions in the road environment may have a number of health, social and environmental aims, not limited to injury, so our review provides information that is necessarily partial in terms of the range of potential benefits from such interventions. In particular, included information about the impact of the included interventions on traffic speed should be treated with caution. This is because this review has not systematically identified all the research available about the impact of road environment interventions on vehicle speeds, as those studies reporting this outcome in the absence of injury data have been excluded. In addition, among those studies we have included, many do not report basic details such as the variance in speed changes or the baseline speeds prior to the intervention, further limiting interpretation.

We have made statements about the applicability of evidence to the UK studies based on crude understandings of the differences in road environment and driving or other key road safety behaviours (e.g. street-crossing) between the UK and other European or American countries. Specialists in the field may have a more sophisticated understanding of the ways in which particular aspects of design may translate to the UK.

This review included many reports which are available as local agency reports and other forms of grey literature. Applying systematic review methods developed in the health field to transport literature was problematic in a number of ways. As previous researchers have found (Bunn et al, 2003), it was difficult to develop search strategies of appropriate sensitivity and specificity. Transport specific databases were difficult to navigate and use. Many studies did not supply an abstract, or did not provide enough information in the abstract to allow us to make inclusion decisions at this stage. We ordered over 500 papers full text in order to identify the relevant 24 papers for this effectiveness (as well as 13 for the cost-effectiveness review, and 10 in the review of qualitative research (Report 2)). Finally, a large number of studies were found o be unobtainable, either due to prohibitively high costs, or because we were unable to locate or contact the relevant person or agency who could supply the document. In other cases, this process was so long that we were unable to incorporate the study for practical, time reasons. These problems may increase publication and other selection biases that are always of concern in any systematic review.

7.1.2.2. Nature of the interventions

Traffic-calming schemes, and their components, are very heterogeneous, making it difficult to compare them, and ill advisable to pool results. Consequently, our conclusions about the effectiveness of most of the interventions are equivocal.

Variation between the interventions include differences in:

- scale (such as short stretch of roads *vs*. several interconnected streets)
- the specific types and number of engineering components (including speed humps/cushions, signalised crossings, changes to signage, changes to road alignment and curb-line)
- the type and number of features to enhance the environment for pedestrians and cyclists.

Since there are a very limited number of studies about any particular type of scheme, and within each there may be large variation in the nature of the individual schemes, it has not been possible to draw any conclusions about how such heterogeneity in design might impact on heterogeneous study results.

In addition, interventions may be accompanied by educational or promotional activities within the community, or other community engagement activities, which have not been assessed here, and we do not know if the impact of engineering solutions is affected by such combinations.

In addition, traffic-calming measures vary in terms the characteristics of the location of the scheme, and how it was chosen to be traffic calmed. Influences on such decisions may include:

- public pressure (possibly in response to specific accidents or perceived clusters of accidents/near misses),
- available data on (for example) accident rates, traffic volumes and speeds at different locations, or
- formal “safety audits” of selected areas or streets (e.g. perhaps as part of a Safe Routes to School programme).

In several studies, the number of injuries to children prior to the intervention being introduced was low, or even zero, suggesting that the choice of area was influenced by priorities other than existing rates of injury and accident. Similarly, the aims of some traffic-calming schemes, notably home zones and ‘Safe Routes To School’, are not primarily aimed at reducing injuries, focussing instead on other health or social priorities. These include improving quality of life by making environmental enhancements and causing a modal shift in transport use to increase walking and cycling, with the overall aim of increasing physical activity and reducing carbon emissions and congestion.

We note that, although most of the studies were conducted in the UK, the only two studies to examine Safe Routes to Schools were from the USA, limiting their applicability.

7.1.2.2.1. Study designs

Most of the included studies (17 of 24) were uncontrolled before and after studies. They are subject to a range of possible confounding factors including regression to the mean, changing background trends in accidents, population changes, traffic and accident migration, and changes in traffic flows. One study (Wheeler & Taylor, 2000) excluded sites where significant changes in traffic flows were noted during the study period however, detailed information about this was not always available. In most cases, studies did not investigate or try to control for potential confounders which limits the validity of the findings.

Small numbers, particularly small numbers of deaths, during the periods before the intervention increase the possibility of a type II error. Many intervention zones also showed low initial speeds and numbers of casualties which may limit the applicability of studies to specific locations, as well as reduce the study’s ability to identify true reductions in key outcomes. Small numbers of relevant outcomes also limit subgroup analysis. Some studies did supply information about subgroups such as age groups or sex and we did extract this data into the evidence tables. They were not, however, discussed in the body of the report as the very small numbers in each group render the, already marginal, statistical analyses meaningless.

Across the studies different age ranges for “children” were used; some did not state the age range that they used to define this group.

In some cases, studies reported data for adjacent areas, but it was unclear from this report whether these were meant to be considered as controls (for example Dean, 1993). Adjacent areas may anyway suffer from contamination effects.

Finally, traffic-calming and cycle route interventions are generally not primarily aimed at children. We did not exclude papers for this reason where we had only screened title and abstract, and ordered full text papers where they reported relevant interventions. In the event, 76 papers were excluded at this stage because they did not report injury outcomes in children separately. In reality, it is likely that traffic-calming will impact on injury rates in children even where this information is not explicitly reported.

7.2. Research recommendations

There is a clear need for more controlled studies to measure effect. These studies also need to have longer follow-up periods and/or larger samples of sites if there is to be sufficient statistical power to assess differential effectiveness (either in subgroups of people – e.g. children – or subgroups of treatment types or locations – e.g. deprived areas).

Given the wide variation in results for many of the interventions in the effectiveness studies reviewed (either between studies or between sites within studies), the presumption that randomised controlled trials cannot be conducted for local road-design changes and traffic calming seems unwarranted. We can see no ethical or practical reasons why the possibility of conducting randomised controlled trials in this research field should not be re-visited.

In particular, UK home zones need to be properly evaluated across the full range of their intended impacts.

7.3. Review 2 (Cost effectiveness)

7.3.1. Strengths of the review

This systematic review has been based on explicit policy-relevant review questions, and used search strategies developed by an information specialist, which were specifically designed to identify potentially relevant studies. A wide range of electronic databases was searched, including some which are specific to the areas of transport policy/research and safety policy/research. These searches have also been supplemented by other targeted searches, and searches of relevant websites and the reference lists of included studies.

The review has been conducted by a health economist who is experienced in both conducting economic evaluations and in conducting systematic reviews of economic evaluations.

7.3.2. Limitations of the review

Limitations of the systematic review

Due to unavoidable time and other resource constraints, this systematic review was largely conducted by one person (the team's health economist). There was therefore no second reviewer available for checking study inclusion/exclusion choices or for checking data extraction and study quality assessment.

The initial searches were not restricted by study design, so the identification of economic evaluations (or UK-based cost analyses) relied upon them either being identified in the initial search results (i.e. by title and abstract), or on retrieval of full-text effectiveness studies (some of which turned out to incorporate an economic analysis). However, in our view, given the preponderance of economic studies within institutional or governmental reports *of effectiveness* (rather than academic journal papers), this strategy is less likely to miss potentially includable studies than a dedicated search for economic evaluation studies.

Main limitations of the included studies

- Extremely brief descriptions of economic analysis methods used, in most studies. This is partly due to the widely accepted use of standardised methods for conducting economic analyses of transport interventions (including, especially in the UK through

DfT methods guidance, widely accepted estimates of the societal value of fatalities or casualties avoided). It is also to do with the economic evaluations, in many cases, being a part of a report largely focusing on effectiveness evaluation and implementation issues.

- In addition to the restricted choice of evaluation sites - to those which had sufficient periods of after and before accident or injury data collection - most of the cost-benefit analyses were conducted on an even smaller subset of sites for which the costs of implementing the scheme were available. This cost was often not broken down further; where it was, it was only disaggregated into construction and other costs (e.g. project management, public consultation, design).
- Most of the included economic analyses had unusually short time horizons (1 or 3 years), especially given the likely durability of the (mostly) physical measures evaluated. The exceptions were: Sælensminde 2004 (25yrs), Meuleners et al. 2008 (10yrs), Elvik, 2003 (10 yrs), Grundy et al. 2008 (5 & 10 yrs) and Mackie et al. 1990 (5yrs). There was a corresponding lack of use of discounting in those studies with short time horizons.
- No or very limited sensitivity analyses (only one study conducted a probabilistic sensitivity analysis) (Grundy et al. 2008). This study was also the only decision model-based analysis (although it was an extremely basic one).
- On the benefits side, most studies (and especially those from the UK) did not deduct any valuation of the cost to society of increased journey times or other external (or ‘spillover’ costs). Exceptions were the studies by Sælensminde 2004, and Mackie et al. 1990. UK studies tended to only place a benefit value on casualties or accidents avoided.

7.3.3. Methodological considerations

All of the economic evaluations which we found on the interventions of interest were conducted using the approaches favoured by transport economists, that is: cost-benefit analyses, often with quite short time horizons. Only one study reported incremental cost-effectiveness ratios (cost per accident saved per annum), alongside first year rate of return. Also, even amongst those studies which used a cost-benefit approach there was some variety in choice of cost-benefit estimate, with many reporting First Year Rates of Return, but others reporting benefit-cost ratios for other lengths of time or Net Present Values. Compared with economic evaluation in health care, where it is virtually standard to follow outcomes for the lengths of people's lives, and for the likely duration of the technology, it seems incongruous to assess the balance of the benefits and costs of such (generally) durable changes to the road environment using such short time horizons for analysis.

The later (2000 onwards) UK studies in this review had adhered to the suggested methods of the Department for Transport's *Highways Economic Note 1*, but the earlier studies also adopted similar methods including standard monetary values for road casualties or road accidents avoided. The reliability of the original sources of these values, which were based on willingness to pay exercises conducted in the early 1990s, and which have been inflated over the years, is open to question (NB. they are currently being re-evaluated).

Traffic-calming and related measures to reduce injuries on the road, or to increase the uptake of walking or cycling, are - in a very important sense - highly variable and complex interventions. They:

- Are multi-component (comprising a mixture of different physical elements – such as speed humps, signage, road markings, carriageway redesign, signalised crossings etc.)
- Exist at a variety of scales (from one short street section, to areas covering whole networks of streets and junctions) and can be implemented at different levels of intensity within areas,
- Are placed in a variety of localities (each with, for example, a different: prior record or actual risk of accidents, motorised traffic levels, pedestrian and cyclist activity levels,
- Are (or may be) effective in large part, because of people's behavioural responses to the measures – rather than the measures per se.
- Are subject to "non-specific effects" (i.e. effects not due to the eventual traffic-calming measures themselves, but due to other activities which accompanied the measures; such as changed behaviour due to public consultation, or road safety education programmes at local schools.

For these reasons, unequivocal general statements about the cost-effectiveness or cost-benefits of traffic-calming and related road safety schemes should not be expected.

7.4. Research recommendations

There is a clear need for more high quality (especially controlled) evaluations to have economic evaluations conducted alongside the main effectiveness evaluation. Fuller reporting of the detailed methods of such economic evaluations would be useful.

The cost-effectiveness or cost-benefit of certain types of road design-based intervention appear not to have been conducted anywhere yet, e.g Home Zones, ‘quiet lanes’, mandatory 20mph speed limits (i.e. without traffic calming features).

There appears to be a paucity of cost-effectiveness analyses of traffic calming and other road safety interventions. The long-term quality of life and public sector cost impact of non-fatal road injuries, in adults or children, requires more research (see economic modelling, Report 3)

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Appendices

Appendix 1 Research protocol

Clarification of scope

Populations

Groups that will be covered

Children and young people aged under 15

Parents and carers of children and young people aged under 15

Groups that will not be covered

Anyone aged 15 or older, except the parents or carers of children and young people aged under 15 (where they are the focus of research about their children, or where they are targeted as key agents to reduce unintentional injuries in their children).

Interventions /Activities that will be covered

Activities

Activities/measures that will be covered

NICE is developing a range of public health guidance to prevent unintentional injuries among children and young people aged under 15. This protocol relates to producing evidence about interventions which prevent such injuries in the road or street environment.

In parallel with this work, NICE will also be developing public health guidance (also developed using the intervention development process) to prevent unintentional injuries in the home and in other external environments. There will also be public health guidance (developed through the programme guidance process) focusing on the broader legislative/regulatory and related activities which aim to prevent unintentional injuries in children. The present guidance will complement these publications and will focus on:

- Local or regional interventions to reduce injuries in children aged under 15 by road/street design or by modifying the road/street environment and highway design. These will include the following either combined or delivered separately:

– traffic-calming
– 20 mph zones
– home zones
– international examples such as ‘woonerven’ in the Netherlands: streets or a group of streets that have been redesigned to slow traffic and promote non-motorised traffic
– ‘naked streets’ (or ‘psychological traffic-calming’) where road markings, lines, traffic lights, signs and curbs and so on are removed to create uncertainty in road users and encourage them to slow down
– ‘quiet lanes’ and other rural examples of traffic-calming schemes
– signing related to speed limits
– walking and cycling networks
– ‘Safe Routes to Schools’

Activities/measures that will not be covered

a) National legislation or regulation, including in relation to blood alcohol concentration and other driver legislation.

b) Enforcement of legislation, including speed limits, speed cameras, speed limiters (technology that prevents a vehicle being driven at certain speeds) alcohol testing, enforcing driver legislation and policing policies.

c) Primary prevention to reduce the risk of collisions which use education of drivers, cyclists and pedestrians (including national and local media campaigns, leaflets and promotional activities), mandatory training, re-testing and post-offence training, visibility for vehicles and visibility for cyclists and pedestrians such as daytime lights and high visibility clothing, and those that aim to reduce risk through passive methods (such as anti-lock breaks or skid resistant surfaces).

d) Secondary prevention measures that aim to reduce the severity of or occurrence of injury following collision (e.g. seat belt and safety seat use promotion, helmets)

e) Tertiary prevention, including emergency services, treatment and rehabilitation.

Key questions and outcomes

Below are the overarching questions that will be addressed along with some of the outcomes that would be considered as evidence:

Question 1: What types of road design or modification to the road and street environment are effective and cost-effective in reducing road injuries among children and young people aged under 15?

Question 2: What are the barriers and facilitators to implementing environmental modifications and road/street designs relating to the reduction of road injuries?

Expected outcomes: Changes in injuries and deaths in children and young people aged under 15, including changes in injury severity, vehicle speeds, collisions, knowledge and attitudes and estimates of the cost of specific interventions relative to the outcomes achieved.

Steps will be taken to identify ineffective as well as effective interventions and approaches (e.g. through the review of grey literature).

Reports

Report 1 will include Reviews 1 (effectiveness) and 2 (cost-effectiveness). Report 2 will include Review 3 (barriers and facilitators) if it is to be included as a separate review. Report 3 will include an economic analysis of a selected type of intervention (if deemed feasible and useful).

Reviews

Aims, key review questions and key outcomes

Report 1: Systematic review of effectiveness and cost-effectiveness studies

a) Aim

To identify, critically appraise, summarise and synthesise evidence relating to the effectiveness (review 1) and cost-effectiveness (review 2) of the specified types of road and street design-based interventions aimed at reducing unintentional injuries in children.

b) Key review questions

Review 1 (effectiveness)

What is the effectiveness (in terms of reducing unintentional injury in children) of design-based interventions aimed at reducing motorised traffic speeds and/or encouraging more careful driving

What is the effectiveness (in terms of reducing unintentional injury in children) of safe routes to school initiatives and cycle/walking routes/networks

What are the important factors which either enhance or reduce the effectiveness of such design-based interventions, safe routes to schools and cycle routes, or which help or hinder their implementation?

Review 2 (cost-effectiveness)

What is the cost-effectiveness of such design-based interventions aimed at reducing speed, encouraging more careful driving, providing safe routes to schools and cycle routes?

What are the main causal relationships which seem to explain how the different combinations of resources (and levels of costs) of these interventions are related to intended outcomes?

c) Factors and outcomes

Any potential explanatory factors (eg cultural, social, economic, environmental and organisational determinants/correlates), regarding the characteristics of individuals, families/households, or the places where they live or travel which may be associated with unintentional injury in children and young people under 15 will be considered. A range of potential outcomes associated with unintentional childhood injury, as described in the scope, are listed below:

Primary outcomes:

- rates of unintentional injuries in children
- rates of hospital admissions and preventable child deaths related to unintentional injuries
- severity of unintentional injuries in children
- Secondary outcomes:
- vehicle speeds
- collisions (number and degree of impact)
- Plus (for Review 2):
- costs and/or resource use
- cost-benefit estimates
- cost-effectiveness ratios

Report 2: Systematic review of evidence about 'barriers and facilitators'

Production of a separate review of barriers and facilitators is conditional upon (a) the amount of studies identified for inclusion in the effectiveness and cost-effectiveness reviews (the "main reviews"); and (b) the number of studies eligible for inclusion in a "barriers and facilitators" review. If the production of a set of high quality reviews under each of these three headings is deemed unmanageable given the time and resources available, then a separate review of barriers and facilitators will not be conducted. However, in order to still answer the "barriers and facilitators" review question – it is proposed that relevant observations from the 'Discussion' and 'Conclusion' sections of all the included effectiveness papers will be extracted as part of that review (e.g. where authors try to explain why their evaluated outcomes differed from others, or differed from what they expected).

a) Aim

To identify, critically appraise, summarise and synthesise qualitative and/or quantitative evidence relating to contextual or other factors which either enhance or reduce the effectiveness of such design-based interventions, safe routes to schools and cycle routes, or which help or hinder their implementation.

b) Key review questions

What are the important factors which either enhance or reduce the effectiveness of such design-based interventions, safe routes to schools and cycle routes, or which help or hinder their implementation?

Methods

1.1 Overview

An electronic search of relevant bibliographic databases, and also selected websites, will be conducted in order to identify relevant primary research (to be supplemented by communication with experts and/or organisations involved in the relevant research or transport policy areas).

1.2 Search process and methods

To review published literature, and relevant unpublished/grey literature, as far as time and other resources allow.

To include all relevant primary research that meet minimum quality criteria (see below). Searches will be conducted in the following databases:

From the "core databases":

- ASSIA (Applied Social Science Index and Abstracts)
- Database of Abstracts of Reviews of Effectiveness (DARE); NHS EED; HTA (all in the CRD database)

- EconLit
- HMIC (or Kings Fund catalogue and DH data)
- MEDLINE
- PsycINFO
- Social Science Citation Index

From the topic-specific databases:

- ERIC
- SafetyLit
- EPPI Centre databases
- The Campbell Collaboration
- Transport Research Information Service via the TRIS online free access at: http://ntlsearch.bts.gov/tris/index.do hosted by the National Transportation Library
- International Transport Research Documentation (ITRD) via STN desk connection pay as you use service hosted by STN international at: http://www.stn-international.de

Search terms – To be agreed separately, and appended to this protocol)

The websites of the various relevant organisations will also be searched for relevant publications; these will include the following:

UK Department for Transport (DfT)

Transport Research Laboratory (TRL)

Sustrans

Public Health Observatory website(s) for the South West (lead on Injuries; http://www.swpho.nhs.uk/) and South East (lead on Transport; http://www.sepho.org.uk/)

Nottingham School of the Built Environment

CAST (Staffordshire University)

UCL Centre for Transport Studies

University of Leeds Institute of Transport Studies

University of Westminster Transport Studies Group

And may include some of the following, should time and resources allow:

Ministries of Transport in selected countries (e.g. Netherlands) – where the website is available in English

Royal Town Planning Institute (www.rtpi.org.uk/)

Institute of Highway Incorporated Engineers (http://www.ihie.org.uk/)

Living Streets (http://www.livingstreets.org.uk/)

National Technical Information Service

Institution of Civil Engineers (www.icenet.org.uk)

Scottish Executive

Welsh Assembly Government

Expert contacts in the relevant policy/practice areas (e.g. highway engineering, urban design/town planning) as well as key researchers of these types of intervention will also be consulted

1.3 Study selection

Inclusion criteria (common to all reviews):

Studies published from 1990

Studies published in English language

Criteria specific to Review 1 (effectiveness):

Inclusion criteria:

Evaluations (prospective or retrospective) using comparative designs (randomized controlled trials, non-randomized controlled trials, before and after studies, or natural experiments)

Studies reporting the relevant injury outcomes in children (or in both adults and children but with the outcomes for children shown separately). This inclusion criteria will only be applied at full-text assessment stage. In other words, no papers will be excluded on the basis of age at the title and abstract screening stage. *For the purposes of judging paper inclusion, papers will be included if the relevant outcome information pertains to an age-grouping (e.g. 5 to 18 year-olds) where it is judged that* *the majority of people in that age-range are common with the intended age range for this NICE Guidance (i.e. children aged under 15 years)*

Exclusion criteria:

Empirical studies which only document schemes/interventions and related outcomes but without evidence regarding injury outcomes without the scheme/intervention (e.g. before its introduction, or in comparable towns or neighbourhoods).

Empirical studies which do not separately report injury-related outcomes for children or young people.

Criteria specific to Review 2 (cost-effectiveness):

Inclusion criteria:

Full economic evaluations of relevant types of intervention or scheme, and high quality costing studies conducted in the UK or countries of a similar level of economic development, patterns of transport use and urban environment.

Exclusion criteria:

Cost-of-illness studies, or other studies which do not involve assessing the cost and related benefits/effectiveness of particular interventions (or class of intervention).

Criteria specific to Review 3 (barriers & facilitators):

Inclusion criteria:

Primary qualitative research involving the analysis of written or spoken speech/evidence, regarding attitudes towards, or experiences of, the relevant interventions; OR

Quantitative or qualitative surveys of attitudes towards, or experiences of the relevant interventions.

Exclusion criteria:

Research which does not involve the collection and analysis of qualitative data using established qualitative research methods.

Assessment for inclusion will be undertaken initially at title and/or abstract level (to identify potential papers/reports for inclusion) by a single reviewer (and a sample checked by a second reviewer), and then by examination of full papers.

1.4 Quality assessment and data extraction

All included studies will be quality assessed using the checklists in the *Methods for development of NICE public health guidance 2006* where these are appropriate (so if, for example, one is not available for a particular included study design we will seek a valid checklist from other sources such as CRD or CASP). Any departure from the methods manual will be discussed and agreed with the NICE CPHE Team. Data extraction and quality assessment will be conducted by a single reviewer, and checked by a second reviewer for a sample of studies, as agreed with the NICE CPHE team.

1.5 Data synthesis and presentation, including evidence statements

Data synthesis and presentation, including evidence statements will be conducted according to the procedures outlined in the *Methods for development of NICE public health guidance 2006*. Key choices in how to synthesise the included evidence, or in how to develop evidence statements, will be discussed with the relevant analysts at CPHE.

Report 3: Economic analysis of a selected type of intervention

(IF FEASIBLE AND USEFUL)

a) Aim

For a specific type/s of scheme/s/intervention/s, to assess the relationship between the amounts and combinations of resources and costs, and the levels of resulting benefits and/or effectiveness (related to avoiding unintentional injuries to, and death in, children).(ie. To look at the costs and benefits of all impacts of an intervention in relation to unintentional injuries including death in children.

b) Perspective

The analysis will adopt both a health and Personal Social Services perspective, and a broader public sector perspective in relation to costs (as in the NICE CPHE methods Guide, 2006). Injury-related health outcomes will be expressed in terms of QALYs or life-years gained/lost wherever possible. If good data are available, and where appropriate, impacts in terms of other outcomes, such as lost school days may also be part of a broader cost-consequence approach to analysis. Also, if sufficient good data are available, outcomes may be expressed in monetary terms and an assessment of whether benefits exceed costs made.

Protocol Reference

Wallace A, Croucher K, Quilagars D, & Baldwin S. 2004. Meeting the challenge: developing systematic reviewing in social policy. Policy and Politics 32: 4; 455-470.

Appendix 2 Search Strategy

Searches were performed to find relevant primary research using a comparative design, qualitative studies, and cost-effectiveness studies. Database protocol driven searching, targeted searching, author suggestions, expert input, citation searching, named website searches, and citations from a parallel review were utilised.

All searches were limited to those published in English since 1990 where possible.

Bibliographic Databases:

The following databases were searched between 29 Jan, 2009 and 17 February, 2009

- ASSIA (Applied Social Science Index and Abstracts) via CSA
- Database of Abstracts of Reviews of Effectiveness (DARE); NHS EED; HTA all via the Centre for Reviews and Dissemination database
- EconLit via EBSCO
- HMIC via Search 2.0
- Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1950 to Present
- PsycINFO 1806 to February Week 2 2009 via OVID online
- ISI Web of Knowledge Social Sciences Citation Index (SSCI)--1956-present
- ERIC via Dialog Datastar
- SafetyLit (online)
- EPPI Centre databases: TRoPHI, DoPHER, and Bibliomap (online)
- The Campbell Collaboration (online)
- Transport Research Information Service (TRIS) via TRIS online

Bibliographic Databases Search Strategy

The Medline search strategy example follows and was “translated” according to the appropriate thesaurus terms for each individual database. Where a database did not have a thesaurus or does not have a search facility to incorporate thesaurus searching, text words only were used. All searches where possible were limited to English language and from 1990-current.

Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1950 to Present

Search Date: 29012009

1. safe route*.mp.
2. (walk* adj3 bus*).mp.
3. traffic club*.mp.
4. (woonerven or woonerf).mp.
5. 1 or 2 or 3 or 4
6. ((walk* or Pedestrian*) adj2 (network* or path* or route* or footpath or sidewalk or verge)).mp.
7. ((cycle* or bicycle or walk*) adj2 (track* or trail* or network* or route* or lane*)).mp.
8. ((safe* adj2 cycl*) or (safe* adj2 walk*)).mp.
9. cycle* path*.mp.
10. Bicycling/
11. Walking/
12. (cycl* or bicycl* or walk* or play* or travel*).mp.
13. 6 or 7 or 8 or 9 or 10 or 11 or 12
14. (injur* or accident* or death* or fatal* or collision or crash*).tw.
15. (road* or street* or highway* or traffic*).tw.
16. 14 and 15
17. 13 and 16
18. ((traffic or pedestrian or home) adj2 zone*).tw.
19. (20 mph or 20 mi per hr).mp. or 20mi/hr or 20m/hr or 20 miles per hour.mp. or 20 mi ph.mp.
20. 30km.mp.
21. ((30 km and (hour or hr)) or (30 kilo meter* and (hour or hr)) or ((30 kilometre or 30 kilometer) and (hour and hr))).mp.
22. ((street* or road* or lane*) and (quiet or naked)).ti,ab.
23. ((speed or road or street) and (humps or bumps or lumps)).ti,ab.
24. (sleeping adj policeman).ti,ab.
25. (central adj2 (refuge* or reservat*)).tw.
26. (hierarchy and (road* or street* or highway*)).tw.
27. ((road* or street* or highway or traffic) adj3 (design or environment* or manage* or layout or lay out)).tw.
28. (chicane* or speed cushion or rumble or jiggle bars).tw.
29. (cross* adj2 (pelican* or zebra or puffin or signal*)).tw.
30. (traffic adj2 calm*).tw.
31. (traffic adj4 (flow or restraint* or engineer* or security)).tw.
32. or/18-31
33. 32 and 14
34. (urban or suburb* or residential or (limited adj access) or pedestrian or neighbourhood).tw.
35. (sign* and (reduc* or restrict* or limit* or prevent*)).tw.
36. Accident Prevention/ and (reduc* or restrict* or limit* or prevent*).tw.
37. "Location Directories and Signs"/
38. Environment Design/
39. Accidents, Traffic/
40. ((speed* or volume*) and (reduc* or restrict* or limit* or prevent*)).tw.
41. or/34-40
42. 41 and 16
43. (reduc* or restrict* or limit* or prevent*).tw.
44. 42 and 43
45. (animals not humans).sh.
46. 5 or 17 or 33 or 44
47. 46 not 45
48. limit 47 to (english language and yr="1990 - 2009")

Targeted Bibliographic Database Searches

After screening the results from the protocol driven search strategy, a "targeted" search of specific named programmes and additional traffic-calming terms was done in the bibliographic databases on the 31 March 2009:

- Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1950 to Present
- Transport Research Information Service (TRIS) via TRIS online
- Below is the Medline strategy for the targeted search.

1	neighbourhood road safety initiative.tw.
2	leigh park*.tw.
3	play it safe.tw.
4	child pedestrian injury prevention project.tw.
5	CPIPP.tw.
6	streetwise kids club.tw.
7	streetwise kids club*.tw.
8	street-wise kids club.tw.
9	school travel plan.tw.
10	school travel plan*.tw.
11	school safety zones.tw.
12	feet first a step ahead.tw.
13	vision zero.tw.
14	LATM.tw.
15	danish bun*.tw.
16	dynamic striping.tw.
17	local area traffic management.tw.
18	dynamic road marking.tw.
19	SUNflower.ti.
20	injur*.tw.
21	20 and 19
22	verkehrsberuhigung.tw.
23	liveable street*.tw.
24	cut your garden hedge.tw.
25	SAFE WAY TO SCHOOL.tw.
26	free foot spaces.tw.
27	11 or 21 or 7 or 26 or 17 or 2 or 22 or 1 or 18 or 23 or 16 or 13 or 25 or 6 or 3 or 9 or 12 or 14 or 15 or 8 or 4 or 24 or 10 or 5

Websites:

The following organisation's websites were searched for relevant publications:

- UK Department for Transport (DfT) (http://www.dft.gov.uk/)
- Transport Research Laboratory (TRL) (http://www.trl.co.uk/)
- Public Health Observatory website for the South West (lead on Injuries; http://www.swpho.nhs.uk/)

- Public Health Observatory website for the South East (lead on Transport; http://www.sepho.org.uk/)
- Every Child Matters (http://www.dcsf.gov.uk/everychildmatters/)
- Institute of Highway Incorporated Engineers (http://www.ihie.org.uk/)
- Transport 2000 (http://www.transport2000.org/)
- Safe Routes to School (http://saferoutesinfo.org/)
- (http://depts.washington.edu/hiprc/practices/topic/pedestrians/environment.html)

Review of References

Due to the difficulties of finding primary research as described in the methods section. References lists of reports and reviews were searched in order to utilise the contacts and database access that other research groups may have had available.

Citation Searching

- Citation searches were done in ISI Web of Knowledge Social Sciences Citation Index (SSCI) on key authors.

Author Suggestions

Staff of Sustrans (UK) and the National Center for Safe Routes to School (USA) were contacted along with experts in the field of transport policy evaluation [see page 3 for a full list].

Expert Contacts

Staff of Sustrans (UK) and the National Center for Safe Routes to School (USA) were contacted along with experts in the field of transport policy evaluation.

Parallel review

References from a parallel review for the CPHE programme on preventing unintentional injuries in children, “A systematic review of risk factors for unintentional injuries among children and young people aged under 15 years: Quantitative correlates review of unintentional injury in children", considered potentially includable for this review were tagged at time of screening.

Appendix 3 List of OECD Countries

Austria
Australia
Belgium
Canada
Czech republic
Denmark
Finland
France
Germany
Greece
Hungary
Iceland
Ireland
Italy
Japan
Korea
Luxembourg
Mexico
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

Source: http://www.oecd.org/

Appendix 4 Screening checklists

Checklist for abstract and full text screening

	Title/abstract criteria
1	Not addressing primary prevention of unintentional injuries on the road OR admissions to hospital or preventable deaths related to unintentional injuries on the road OR the costs associated with interventions to prevent such outcomes OR barriers & facilitators to such interventions.
2	Not a comparative design OR full economic evaluation OR high quality costing study OR primary qualitative research OR survey of attitudes/experiences
3	Intervention not related to road/street design OR road/street environment OR walking/cycling networks OR 'Safe Routes to School'
4	Not set in an OECD country
5	Published prior to 1990
6	Not in English
7	Duplicate
8	Maybe
9	Does not address one of our primary outcomes (e.g. only measures vehicle speeds, number or severity of collisions etc.)
A	Applicability fatally flawed (e.g. setting completely inappropriate)
B	Simulation modelling
C	Conference proceeding/abstract
RR	Review for refs [this must be applied in addition to an exclusion criteria]
	Criteria at full text stage
1	Outcomes not reported separately for children under 15 years (or where the majority are under 15 years)
2	Not a comparative design OR economic evaluation OR high quality costing study OR findings do not relate to barriers and facilitators
3	Unobtainable
4	Not addressing primary prevention of unintentional injuries on the road OR admissions to hospital or preventable deaths related to unintentional injuries on the road OR the costs associated with interventions to prevent such outcomes OR barriers & facilitators to such interventions.
5	Intervention not related to road/street design OR road/street environment OR walking/cycling networks OR 'Safe Routes to School'
6	Does not address one of our primary outcomes (e.g. only measures vehicle speeds, number or severity of collisions etc.)
7	Applicability fatally flawed (e.g. setting completely inappropriate)
8	Conference proceeding/abstract
9	Published prior to 1990
A	Duplicate
B	Not in English
C	Not set in an OECD country

(Criteria in rows that are shaded grey are not exclusion criteria but were needed as options for use when screening references)

Appendix 5 Evidence Tables (Review 1 –Effectiveness) SEE SEPARATE DOCUMENT

See separate document.

Appendix 6 Studies excluded at full text stage and unobtainable studies (Review 1)

Reference Citations	Reason for exclusion
Abbott PG, Hartley S, Hickman Sea. The environmental assessment of traffic management schemes: a literature review. 1995.	Inappropriate study design
Abdelghany A. Above-Ground Actuated Yellow Crosswalk Lights at Uncontrolled Pedestrian Crossings. NTIS, 2005.	Does not address one of the primary outcomes
Adams AK. Reducing the toll of road traffic accidents. Journal of the Royal Society of Medicine 2004;97(3):157.	Inappropriate study design
Adams D. Road sense. Police Review; 1 Jan 1999 ;():30.	Inappropriate study design
Allsop RE. Safety of pedestrians and cyclists in urban areas. Brussels: European Transport Safety Council, 1999.	Inappropriate study design
Amundsen AH & Elvik R. Effects on road safety of new urban arterial roads. Accident Analysis & Prevention 2004; 36(1):115-23.	Outcomes not reported separately for children or not related to injury prevention in children
Anon. A league table of child deaths by injury in rich nations. Florence - Piazza SS Annunziata 12 50122 Florence, Italy: UNICEF Innocenti Research Centre 2001;():n. pag..	Inappropriate study design
Anon. Child accident prevention: an integrated approach to road safety: plans and progress within one highway authority. London: Child Accident Prevention Trust - (28 Portland Place, London, W1N 4DE) 1991;():n. pag..	Inappropriate study design
Anon. COMMUNITY PARTICIPATION IN ROAD SAFETY: BARRIERS AND ENABLERS. Journal of Community Health, 2001;26(4):257-70.	Inappropriate study design
Anon. Injury prevention. Public health approaches to improved road safety. Weekly Epidemiological Record 1993;68(9):60-61.	Inappropriate study design
Anon. Mean Streets: Pedestrian Safety and Reform of the Nation's Transportation Law. Washington, DC: Surface Transportation Policy Project, 1997.	Inappropriate study design
Anon. Portland City. Portland's city-wide speed bump study: seeing the big picture. Public Works 2000;13():22-26.	Outcomes not reported separately for children or not related to injury prevention in children
Anon. Realising 'Vision Zero': Sweden's drive to slash road traffic deaths has led it to invest in Europe's largest ISA demonstration project to date. ITS International 2000;6(3):53-54.	Inappropriate study design
Anon. Students' Perception of the Level of Traffic Safety Provided in School Areas. 2009.	Inappropriate study design
Anon. Zein, S.R.;Geddes, E.;Hemsing, S.,. Transportation Research Record, 2009.	Does not address one of the primary outcomes
Appleyard B. planning safe routes to school. 2003.	Inappropriate study design
Ashaari Y, Collins EC, Thambipillai JKR. Neighbourhood Traffic Management in Mount St. Thomas.	Outcomes not reported separately for children or not related to injury prevention in children
Association of British Drivers. ABD's response to the 20mph speed limit consultation. London, 1999.	Inappropriate study design
Austin K & White P. Reducing pedestrian and vehicle conflicts at pelican crossings. TEC, 1997.	Does not address one of the primary outcomes
Balzani M, Balzani Mbi, Borgogni Aai. The Body Goes to the City project: Research on safe routes to school and playgrounds in Ferrara. [References]. Garcia Mira, Ricardo (Ed); Sabucedo Cameselle, Jose M (Ed); Romay Martinez, Jose (Ed) -326;(2003):Hogrefe.	Inappropriate study design
Barker J & Helliar-Symons RD. Count-down signs and roundel markings trials. TRL, 1997.	Outcomes not reported separately for children or not related to injury prevention in children
Barker J. Trials of rural road safety engineering measures. TRL, 1997.	Inappropriate study design
Beeck EF, Borsboom GJJ, Mackenbach JP. Economic development and traffic accident mortality in the industrialized world, 1962-1990. International Journal of Epidemiology 2000;29(3):503-09.	Inappropriate study design
Ben-Joseph E. Changing the residential street scene: adapting the shared street (Woonerf) concept to the suburban environment. Journal of the American Planning Association; 61 (4) Autumn 95 1995;():15.	Inappropriate study design
Ben-Joseph E. Residential Street Standards and Neighborhood Traffic Control: A Survey of Cities' Practices and Public Officials' Attitudes. Working paper 95-1. Berkeley, CA: Institute of Transportation Studies, University of California at Berkeley, 1995.	Inappropriate study design
Bertus L & Fortuijn GH. Pedestrian and Bicycle-friendly Roundabouts; Dilemma of Comfort and Safety.	Does not address one of the primary outcomes
Birdsall MS. International Safe Routes to School Programs: Examining a Charity's Efforts Across the United Kingdom. ITE Journal 2008;78(9):43-45.	Inappropriate study design

Reference Citations	Reason for exclusion
Bishai D, Mahoney P, Defrancesco S, Guyer B, Carlson GA. How willing are parents to improve pedestrian safety in their community? Journal of Epidemiology & Community Health 2003;57(12):951-55.	Inappropriate study design
Bishai DM & Hyder A. Modeling the cost effectiveness of injury interventions in lower and middle income countries: opportunities and challenges. Cost Effectiveness and Resource Allocation 2006;4(2):n. pag..	Not set in an OECD country
Boarnet MG, Day K, Anderson C, McMillan T, Alfonzo M. California's Safe Routes to School program: impacts on walking, bicycling and pedestrian safety. Journal of the American Planning Association 2005;71(3):301-17.	Does not address one of the primary outcomes
Bolam B, Hodgetts D, Chamberlain K, Murphy S, Gleeson K. 'Just do it': an analysis of accounts of control over health amongst lower socioeconomic status groups. Critical Public Health 2003;13(1):15-31.	Does not address prevention of unintentional injuries in humans on the road etc.
BOWERS SP. A Safer Routes to School Project incorporating the use of speed sensitive (vehicle actuated) signs. HIGHWAYS & TRANSPORTATION 2001;48(5):9-13.	Does not address one of the primary outcomes
Brenda J.Wigmore CPBWBWaPHB. School journey safety: a comparative study of engineering devices. 2001.	Inappropriate study design
Brennan DT. Evaluation of residential traffic-calming: a new multi-criteria approach. Traffic Eng Control 1994;35(1):19-24.	Inappropriate study design
Brilon W & Blanke H. Area-wide Traffic-calming Measures and Their Effects on Traffic Safety in Residential Areas.	Outcomes not reported separately for children or not related to injury prevention in children
Brilon W & Blanke H. Traffic safety effects from traffic-calming. VTI Rapport 1990;363A():133-48.	Not in English
Brindle R. Local street speed management in Australia--is it 'traffic-calming'? Accident Analysis & Prevention 1992;24(1):29-38.	Inappropriate study design
Brindle R. Traffic-calming in Australia - more than neighborhood traffic management.	Inappropriate study design
Brindle RE. Traffic-calming in Australia: more than neighbourhood traffic management. ITE Journal 1997;67(7):26-33.	Duplicate
Brown MD. Reducing traffic-accident-related trauma among children. Kansas Medicine 1992;93(4):123-24.	Intervention not related to road/street design etc.
Brude U & Larsson J. What roundabout design provides the highest possible safety? Nordic Road Transport Research 2000;12():17-21.	Outcomes not reported separately for children or not related to injury prevention in children
Cairns S, Davis A, et a, Newson C. Making School Travel Plans Work: Research Report. London: Report for the Department for Transport by: Transport 2000, University College London, Adrian Davis Associates, Sustrans, Cleary Hughes Associates and Transport for Quality of Life, 2000.	Inappropriate study design
Carson J & Mannering F. The effect of ice warning signs on ice-accident frequencies and severities. Accident Analysis & Prevention 2001;33(1):99-109.	Inappropriate study design
Carsten OMJ, Sherbourne DJ, Rothengatter JA. Intelligent traffic signals for pedestrians: evaluation of trials in three countries. Trasnportation Research Part C, 1998.	Does not address one of the primary outcomes
Carver A, Salmon J, Campbell K, Garnett S, Baur L, Crawford D. Perceptions of the local neighborhood and walking and cycling among adolescents. American Journal of Health Promotion 2005;20(2):139-47.	Inappropriate study design
Cavill N, Kahlmeier S, Rutter H. Economic analyses of transport infrastructure and policies including health effects related to cycling and walking: A systematic review. Transport Policy 2008;15(5):n. pag..	Does not address prevention of unintentional injuries in humans on the road etc.
Centre for Health Training - National Highway Traffic Safety Administration. Safe Routes to School: Practice and Promise. Centre for Health Training - National Highway Traffic Safety Administration, 2008.	Inappropriate study design
Centres for Disease Control and Prevention. Barriers to children walking to or from school - United States 2004. Morbidity and Mortality Weekly Report 2005;54(38):949-52.	Inappropriate study design
CEREPRI & Apollo. Success Factors and Barriers of Implemented Good Interventions for the Prevention of Injuries. Center for Research and Prevention of Injuries(CE.RE.PR.I) for Apollo-WP3 project (DG SANCO), 2007.	Inappropriate study design
Charlton R & Smith G. How to reduce the toll of road traffic accidents. Journal of the Royal Society of Medicine 2003;96(10):475-76.	Inappropriate study design
Chick C. An integrated approach to traffic-calming, road safety and environmental improvements in the London borough of Hounslow.	Outcomes not reported separately for children or not related to injury prevention in children
Chinn L, Guy J, Stothart G, Thomson J, Tolmie A. The effects of traffic-calming on child pedestrian skills development. TRL, 2004.	Inappropriate study design
Chua CS & Fisher AJ. Performance measurements of local area traffic management: a case study. Australian Road Research 1991;21(2):16-34.	Outcomes not reported separately for children or not related to injury prevention in children
Clarke A & Domfield MJ. Traffic-calming, Auto-Restricted Zones and Other Traffic	Inappropriate study design

Reference Citations	Reason for exclusion
Management Techniques: Their Effects on Bicycling and Pedestrians. FHWA, U.S. Department of Transportation, 1994.	
Clarke A & Tracy L. Bicycle safety-related research synthesis. 2009.	Inappropriate study design
Clarke S. Sustrans Safe Routes to Schools Project û An Evaluation. Sustrans, 1997.	Inappropriate study design
Clifton KJ & Kreamer-Fults K. Role of Environmental Attributes in Explaining Pedestrian - Vehicular Crashes near Public Schools.	Inappropriate study design
Coetzer R. Reducing speed limit to 20 mph in urban areas. Long term sequelae of road traffic accidents must not be underestimated. BMJ 2001;322(7277):50-51.	Inappropriate study design
Collins DC & Kearns RA. Geographies of inequality: child pedestrian injury and walking school buses in Auckland, New Zealand. Social Science & Medicine 2005;60(1):61-69.	Intervention not related to road/street design etc.
Corben BF, Ambrose C, Wai FC. Evaluation of accident black spot treatments. Montash University, Melbourne, Australia: Accident Research Centre, 1990.	Outcomes not reported separately for children or not related to injury prevention in children
Cosgrove C. Walking and Bicycling to School: Making it Safe. Traffic Safety Centre Online Newsletter 2006;3(4):n. pag..	Inappropriate study design
Cottrell WD, Kim N, Martin PT, Perrin HJ. Effectiveness of traffic management in Salt Lake City, Utah. Journal of Safety Research 2006;37(1):27-41.	Outcomes not reported separately for children or not related to injury prevention in children
Crane EO, Augustine A, Tait GR. The M77 Highway: saving lives and money. Injury 2008;39(9):1071-74.	Outcomes not reported separately for children or not related to injury prevention in children
Cynecki MJ, Sparks JW, Grote JL. Rumble strips and pedestrian safety. ITE Journal 1993;63(8):18-24.	Outcomes not reported separately for children or not related to injury prevention in children
DALEY M. All dressed up and nowhere to go? A qualitative research study of the barriers and enablers to cycling in inner Sydney. Road & Transport Research: Journal of Australian and New Zealand Research and Practice 2007;16(4):42-52.	Outcomes not reported separately for children or not related to injury prevention in children
Daniels F, Moore W, Conti C, Norville Perez LC, Gaines BM, Hood RG, et al. The role of the African-American physician in reducing traffic-related injury and death among African Americans: consensus report of the National Medical Association. Journal of the National Medical Association 2002;94(2):108-18.	Inappropriate study design
Daniels S, Nuyts E, Wets G. The effects of roundabouts on traffic safety for bicyclists: an observational study. Accident Analysis & Prevention 2008;40(2):518-26.	Outcomes not reported separately for children or not related to injury prevention in children
Danish Road Directorate. DUMAS TOWN STUDY REPORT. 2000.	Outcomes not reported separately for children or not related to injury prevention in children
Davidson LL, Durkin MS, Kuhn L, Oconnor P, Barlow B, Heagarty MC. The Impact of the Safe Kids Healthy Neighborhoods Injury Prevention Program in Harlem, 1988 Through 1991. American Journal of Public Health 1994;84(4):580-86.	Intervention not related to road/street design etc.
Davis A. Livable streets and perceived accident risk: quality of life issues for residents and vulnerable road-users. Traffic Engineering and Control 1992;33(6):374-79.	Inappropriate study design
De BB & Vereeck L. Safety effects of roundabouts in Flanders: signal type, speed limits and vulnerable road users. Accident Analysis & Prevention 2007;39(3):591-99.	Outcomes not reported separately for children or not related to injury prevention in children
De BB, Nuyts E, Vereeck L. Road safety effects of roundabouts in Flanders. Journal of Safety Research 2005;36(3):289-96.	Outcomes not reported separately for children or not related to injury prevention in children
Debell C. White lines - study shows their absence may be a safety plus. Traffic Engineering and Control 2003;44(9):316-17.	Inappropriate study design
Defrancesco S, Gielen AC, Bishai D, Mahoney P, Ho S, Guyer B. Parents as advocates for child pedestrian injury prevention: what do they believe about the efficacy of prevention strategies and about how to create change? American Journal of Health Education 2003;34():48-53.	Inappropriate study design
D'Elia A, Newstead S, Cameron M. Overall impact of speed-related initiatives and factors on crash outcomes. Annual Proceedings/Association for the Advancement of Automotive Medicine 2007;51():465-84.	Intervention not related to road/street design etc.
Denney RC. Reducing the toll of road traffic accidents. Journal of the Royal Society of Medicine 2003;96(12):617.	Inappropriate study design
Department for Transport. Home Zones: Challenging the Future of our Streets. Department for Transport, 2005.	Inappropriate study design
Department for Transport. Local Transport Note 1/04: Planning and Design for Walking and Cycling - Consultation Draft. London: TSO, 2004.	Inappropriate study design
Department for Transport. Mixed Priority Routes: Practitioners' Guide. 2008.	Does not address one of the primary outcomes
Department for Transport. Travelling to School Initiative: Report on the Findings of the Initial Evaluation. 2005.	Does not address one of the primary outcomes

Reference Citations	Reason for exclusion
Department for Transportation. Mixed Priority Routes Road Safety Demonstration Project: Summary Scheme Report. 2008.	Does not address one of the primary outcomes
Department for Transportation. Tomorrow's roads: safer for everyone. 1900.	Inappropriate study design
Department of Transport Local Government and the Regions. A Road Safety Good Practice Guide. London: DTLR, 2001.	Outcomes not reported separately for children or not related to injury prevention in children
Department of Transportation. High street renaissance: Delivering û Renewing û Improving. 2009.	Inappropriate study design
Doldissen A & Draeger W. Environmental traffic management strategies in Buxtehude, West Germany. In: Anon., ed. The greening of urban transport, London: Bellhaven, 1990. pp.266-84.	Outcomes not reported separately for children or not related to injury prevention in children
Douglas M & Thomson H. Health Impact Assessment of Transport Initiatives: a guide. Edinburgh: NHS Health Scotland, MRC Social & Public Health Sciences Unit, Institute of Occupational Medicine, 2007.	Inappropriate study design
Dumbaugh E & Frank L. Traffic safety and Safe Routes to Schools - Synthesizing the empirical evidence. Transportation Research Record 2007;(2009):89-97.	Inappropriate study design
Dyson C. CONTRASTING VIEWS WITHIN AUSTRALIA ON WHICH FACTORS DRIVE THE REDUCTION IN NUMBERS OF SERIOUS ROAD CASUALTIES.	Inappropriate study design
Eco-Logica Limited. Safe Routes to Schools and School Travel Plans: An Overview. World Transport Policy & Practice 2008;14(1):8-14.	Inappropriate study design
Elvik R. A meta-analysis of evaluations of public lighting as an accident countermeasure. Transportation Research Record 1995;1485():112-24.	Inappropriate study design
Elvik R. Effects on road safety of converting intersections to roundabouts. Transportation Research 2003;10(Paper No. 03-2106):1-10.	Inappropriate study design
Elvik R. Evaluations of road accident blackspot treatment: a case of the Iron Law of Evaluation Studies? Accident Analysis & Prevention 1997;29(2):191-99.	Inappropriate study design
Elvik R. Road safety management by objectives: a critical analysis of the Norwegian approach. Accident Analysis & Prevention 2008;40(3):1115-22.	Inappropriate study design
Engel U & Thomsen LK. Safety effects of speed reducing measures in Danish residential areas. Accident Analysis & Prevention 1992;24(1):17-28.	Outcomes not reported separately for children or not related to injury prevention in children
European Transport Safety Council. Reducing Traffic Injuries Resulting from Excess and Inappropriate Speed. Brussels: ETSC, 1995.	Inappropriate study design
Evans SA & Kohli HS. Socioeconomic status and the prevention of child home injuries: a survey of parents of preschool children. Injury Prevention 1997;3(1):29-34.	Intervention not related to road/street design etc.
Evers S, Goossens M, de Vet H, van Tulder M, Ament A. Criteria list for assessment of methodological quality of economic evaluations: Consensus on Health Economic Criteria. International Journal of Technology Assessment in Health Care 2005;21(1):240-45.	Inappropriate study design
Ewing R & Kooshian C. U.S. experience with traffic-calming. ITE Journal 1997;67(8):28-33.	Inappropriate study design
Ewing R. Traffic-calming: State of the Practice.	Outcomes not reported separately for children or not related to injury prevention in children
Fairlie RB & Taylor MAP. Evaluating the safety benefits of local area traffic management.	Outcomes not reported separately for children or not related to injury prevention in children
Faure A & De NA. Safety in urban areas: the French program 'safer city, accident-free districts'. Accident Analysis & Prevention 1992;24(1):39-44.	Outcomes not reported separately for children or not related to injury prevention in children
Federal highway Administration. Analyses of Successful Provincial, State and Local Bicycle and Pedestrian Programs in Canada and the United States: Case Study 18, National Bicycling and Walking Study. Washington, DC, 1993.	Inappropriate study design
Fitch J & Crum N. Dynamic Striping in Four Towns Along Vermont Route 30 - Final Report. Vermont Agency of Transportation; Federal Highway Administration, 2007.	Does not address one of the primary outcomes
Frantzeskakis j & Pitsiava-Latinopoulou m. TRAFFIC MANAGEMENT AND SAFETY IN TWO GREEK CITIES. THE DUMAS PROJECT.	Conference Proceeding / Abstract
Frantzeskakis JM & Pitsiava-Latinopoulou m. SAFETY EVALUATION OF PEDESTRIANISATION IN MEDIUM-SIZE TOWNS -THE DUMAS EU PROJECT.	Outcomes not reported separately for children or not related to injury prevention in children
Fuller R. Constructing safety. Irish Journal of Psychology ;15(4):1994-523.	Inappropriate study design
Garber S & Grahman JD. The effects of the new 65 mile-per-hour speed limit on rural highway fatalities: a state-by-state analysis. Accident Analysis & Prevention 1990;22(2):137-49.	Intervention not related to road/street design etc.
Garder P, Leden L, Pulkkinen U. Measuring the safety effects of raised bicycle crossings using a new research methodology. Transportation Research Record 1998;1636():64-70.	Outcomes not reported separately for children or not related to injury prevention in children
Garling A & Garling T. Parents' residential satisfaction and perceptions of children's accident risk. Journal of Environmental Psychology; 10 (Mar 90) p 27-36	Inappropriate study design

Reference Citations	Reason for exclusion
1990;():366-36.	
Geoplan Town Planning. Neighbourhood Road Safety and Amenity: A look at barriers to the implementation of local area traffic management schemes and strategies to overcome these. Geoplan Town Planning, 1990.	Inappropriate study design
Gervais M & Concha N. WORKING WITH COMMUNITIES TO REDUCE ROAD TRAFFIC INJURY INEQUALITIES IN LONDON : EVALUATION OF DEMONSTRATION PROJECTS. ETHNOS Research & Consultancy, 2008.	Inappropriate study design
Gill T. Home zones in the UK: history, policy and impact on children and youth. Children, Youth and Environments 2006;16(1):90-103.	Inappropriate study design
Gill T. Home zones: policy review. Children and Society; 11 (4) Dec 1997 1997;():70.	Inappropriate study design
Golding J & Jones L. Factors to be considered in devising an effective programme for the reduction of road traffic accidents. West Indian Medical Journal 1994;43(3):69-70.	Inappropriate study design
Gorman D, Douglas M, Noble P, Patton G. Reducing speed limit to 20mph in urban areas: both advisory and mandatory speed limits are being introduced in Edinburgh. BMJ 2001;322(51):n. pag..	Inappropriate study design
Green J. Evidence, epistemology and experience: evidence based health care in the work of accident alliances. Sociology of Health and Illness 2009;22():453-76.	Inappropriate study design
Gregory M & Jarrett DF. The long-term analysis of accident remedial measures at high-risk sites in Essex. Traffic Engineering and Control 1994;35():8-11.	Outcomes not reported separately for children or not related to injury prevention in children
Grundy C, Steinbach R, Edwards P, Green J, Wilkinson P. The Effect of 20 mph zones on Inequalities in Road Casualties in London : A report to the London Road Safety Unit. 2009.	Outcomes not reported separately for children or not related to injury prevention in children
Gunnarsson S & Hagson A. Traffic Management For a Swedish Historical Town [Visby Innerstad]. TFB-RAPPORT 1992;():1-62.	Not in English
Guria J. An economic evaluation of incremental resources to road safety programmes in New Zealand. Accident Analysis & Prevention 1999;31(1-2):91-99.	Intervention not related to road/street design etc.
Hakim S, Shefer D, Hakkert AS, Hocherman I. A critical review of macro models for road accidents. Accident Analysis & Prevention 1991;23(5):379-400.	Inappropriate study design
Hamilton-Baillie B & Jones B. Improving traffic behaviour and safety through urban design. Civility Engineering 2005;158():39-47.	Inappropriate study design
Harris L & Parkwood Research Associates. PATHWAYS FOR PEOPLE. 4635 Crackersport RoadAllentown, PA 18104(610) 481-0102: RODALE PRESS, 1995.	Inappropriate study design
Harvey T. A Review of Current Traffic-calming Techniques. Leeds: Institute for Transport Studies, University of Leeds, 1992.	Inappropriate study design
Hass-Klau C, Nold I, Bocker G, Crampton G. Civilised Streets: A Guide to Traffic-calming. Brighton, United Kingdom: Environmental and Transport Planning, 1999.	Duplicate
Hass-Klau C. Civilized Streets: A Guide to Traffic-calming, Environment and Transport Planning. Brighton, England: Brighton Press, 1992.	Duplicate
Hass-Klau C. Civilized Streets: A Guide to Traffic-calming. Brighton: Environment and Transport Planning, 1992.	Inappropriate study design
Hass-Klau C. The Theory and Practice of Traffic-calming. Brighton: Environmental and Transport Planning, 1990.	Inappropriate study design
Hatfield J, Murphy S, Job RF. Beliefs and behaviours relevant to the road safety effects of profile lane-marking. Accident Analysis & Prevention 2008;40(6):1872-79.	Does not address one of the primary outcomes
Haworth N, Ungers B, Vulcan P, Corben B. Evaluation of a 50 km/h default urban speed limit for Australia. Melbourne: National Road Transport Commision, 2001.	Outcomes not reported separately for children or not related to injury prevention in children
Herbel SBE & Herbel SB. Safety conscious planning in small and medium-sized MPOs and rural planning agencies: Results of a domestic scan. Journal of Safety Research ;36(5):2005-4775.	Inappropriate study design
Herrstedt L. Traffic-calming design--a speed management method. Danish experiences on environmentally adapted through roads. Accident Analysis & Prevention 1992;24(1):3-16.	Inappropriate study design
Hijar M, Vasquez-Vela E, Arreola-Rissa C. Pedestrian Traffic Injuries in Mexico. Injury Control & Safety Promotion 2003;10():37-43.	Outcomes not reported separately for children or not related to injury prevention in children
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Appendix 7 Study intervention descriptions

RefID	Study	Arm No.	Type of intervention	What delivered	Details of other components of scheme/intervention
10332	Blomberg et al. (2008)	1	Safe Routes to School	Pedestrians/Cyclists age 4-12 at SRTS Sites and school trip times & dates	-
		2	No intervention	Passengers age 4-12 at SRTS Sites and school trip times & dates	-
		3	No intervention	Pedestrians/Cyclists age 4-12 Statewide at All times & dates	-
		4	No intervention	Pedestrians/Cyclists age 4-12 Statewide at school trip times & dates only	-
		5	No intervention	Passengers age 4-12 Statewide at school trip times & dates	-
		6	No intervention	Pedestrians/Cyclists age 0-3 & 13+ at SRTS Sites and school trip times & dates	-
		7	No intervention	Pedestrians/Cyclists age 0-3 & 13+ Statewide & All times & dates	-
10489	Chorlton (1990)	1	Before intervention	-	-
		2	Traffic-calming	**Traffic-calming scheme** Length of the scheme: 0.6km. Traffic-calming measures included: reduction in main carriageway width from 12.5m to 5.5m; cycle tracks in both directions; sheltered parking between speed tables; sheltered access for cycle tracks at both ends of the scheme; speed tables on all side roads entering the scheme and either side of each junction on the scheme itself; accesses to private drives laid in grey concrete blocks across the pavement; raised planters with trees and other foliage; road alignment changed; two types of street lighting; additional footway and planters provided outside one of the schools instead of further sheltered parking.	Consultation with local councillors, the heads of local schools, the appropriate officers of the City Council, and the school governors of local schools. A Community Liaison Group was also set up. At one of the meetings it was agreed to introduce a road safety education programme for the school children. It is unclear whether this actually took place. Leaflets An official opening of the scheme with unveiling of plaques and planting of trees. Children from the local school planted two raised gardens outside the school.
10308	Cloke et al. (1999)	1	Before intervention	Pelican crossings already in place.	-

RefID	Study	Arm No.	Type of intervention	What delivered	Details of other components of scheme/intervention
		2	Traffic-calming	**Traffic-calming scheme** installed in 2 phases. Traffic-calming measures included: speed cushions; staggered pairs of cushions, used in conjunction with pedestrian refuges at some locations; pelican crossings already in place converted to humped pelican crossings - a raised junction with red surfacing was installed; mini-roundabouts; pedestrian refuges and traffic islands incorporating illuminated bollards; gateways and build-outs featuring non-illuminated bollards, and cross-hatching, to deter parking in unsatisfactory locations.	Extensive public consultation
10603	Dean (1993)	1	Before intervention	-	-
		2	Cycle routes/networks	**Cycle route** 2 sections: along line of a disused railway; ~2.1km long runs from the disused railway along an existing footway between a school and a college, continues to town centre via two roads and existing pedestrian tunnel; 2.2km long Provision made for pedestrians as well as cyclists to use route	-
		3	Control	Data provided for areas outside the catchment area of the cycle route, but within Stockton-on-Tees.	-
		4	As above.	As above.	-
10346	Department for Transport (2001)	1	Before intervention	-	-
		2	Traffic-calming	**Gloucester Safer City Project (GSCP)** City-wide intervention. Information on the existing accident problem used to develop scheme Roads within the city were divided into 3 main categories: a network of roads that remain through routes; mixed use roads; access only roads. City-wide measures included: narrowing and highlighted signs and boundaries at gateways (entrances) to the city; anti-skid surfacing at junctions. Measures implemented in specific areas / on specific routes included: narrowings; vertical deflection; bus and cycle lanes; improved cycle routes; traffic islands; increased size of pedestrian holding areas in centre of road; central ladder hatching; new/modified pedestrian crossings; improved timings at pedestrian crossings; transponders at traffic lights triggering a green phase for buses; widened pavements; 20mph speed limits; vehicle activated speed limit signs; signs to draw driver attention to cyclists; advanced warning signs of possible queues;	The focus of the GSCP was on engineering, however the following interventions were also included as part of the package: Education, training and publicity including: courses for offending drivers; the Safer City forum; local education; special campaigns organised with the police to coincide with national TV advertising; posters Consultation Enforcement: increased numbers of speed camera sites and use of mobile camera

RefID	Study	Arm No.	Type of intervention	What delivered	Details of other components of scheme/intervention
				pedestrianised areas; roads designated to buses and cyclists only; altered entrance geometry at roundabouts; crossing facilities at roundabouts	and in-car video equipment
10351	Grayling et al. (2002)	1	Before intervention	-	-
		2	Traffic-calming	**20mph zones** in Hull A generic description of 20mph zones is given rather than a description of exactly what was implemented in Hull: Combination of the lower speed limit with humps or speed cushions and other changes to the road layout. In Hull: children at local primary schools designed the customised signs for each zone.	-
10515	Grundy et al. (2008)	1	Before intervention	-	-
		2	Traffic-calming	152 **20mph zones** 20mph zone features include: terminal signs at the entrance and exit of the zone; vertical deflections; horizontal deflections; narrowing; and other engineering measures such as gateways and surfacing.	Each 20 mph zone is designed individually, taking into account local area characteristics, funding, cost benefit analysis, community needs and public consultation.
		3	Control 1	Data provided for areas adjacent to 20mph zones. These areas may be subject to other remedial measures.	-
		4	As above.	As above.	-
		5	Control 2	Data provided for annual background changes.	-
		6	As above.	As above.	-
10334	Gutierrez et al. (2008)	1	Safe Routes to School	School **SR2S** areas Most projects were had multiple components: 71% included pavement upgrades or installation; upgrading of intersection crossings, 41%; traffic-calming and speed reduction, 21%; traffic signals, 20%; bicycle paths and other facilities, 12%.	Only five broad types of infrastructure could be funded (see 'what delivered')
		2	No intervention	Control areas	-
592	Jones et al. (2005)	1	Before intervention	**City A: 1992-1994** Installation of traffic-calming measures may have started.	-

RefID	Study	Arm No.	Type of intervention	What delivered	Details of other components of scheme/intervention
		2	Traffic-calming	**City A: 1998-2000** 891 traffic-calming features Traffic-calming features audited were: speed humps, road narrowings, and road closures. Average distance between features: 0.82km Traffic-calming density per km road length: 1.22	-
		3	Before intervention	**City B: 1992-1994** Installation of traffic-calming measures may have started.	-
		4	Traffic-calming	**City B: 1998-2000** 553 traffic-calming features Traffic-calming features audited were: speed humps, road narrowings, and road closures. Average distance between features: 1.4km Traffic-calming density per km road length: 0.69	-
10509	Jones & Farmer (1993)	1	Before intervention	Dual carriageway road. Most pedestrians cross at 1 of 8 partially covered ways. In between these walkways, railings and other features are used to discourage pedestrians from crossing, however, crossing is still possible.	-
		2	Traffic-calming	**Pedestrian ramps** A series of 6 pairs of pedestrian ramps (flat-topped) installed at 6 of the 8 partially covered ways (the remaining 2 were only lightly used) along the dual carriageway road. 'Uneven road' warning signs and signs recommending a speed of 10mph placed at either end of the road, and half way along. Red temporary 'RAMP' sign placed just before each ramp. Spacing between the ramps: ~90m. Pedestrians have no legal priority at the ramps.	-
		3	Traffic-calming	Follow-up data was collected 1 year after installation of the intervention.	-
10518	Layfield et al. (2005)	1	Before intervention	-	Consortium of local authorities looking at transport issues in the area. Study of routes and mode of travel to school in Magor and Undy carried out. Safer routes to school strategy developed.
		2	Traffic-calming	**Home zone**	Monmouthshire County Council have held

RefID	Study	Arm No.	Type of intervention	What delivered	Details of other components of scheme/intervention
				Most home zone proposals implemented; these included: gateway treatments, with 20mph and home zone signing (in English and Welsh) and 20mph roundel road markings, at the entrances; narrowings; one-way systems, and no entry at one end of the zone; road humps; environmental and visual enhancements; bollards installed between the pavement and the road 20mph zone established at boundary of home zone Small playgrounds also proposed but not implemented	on-going consultation with residents, schools, traders and local members.
1011	Lindqvist et al. (2001)	1	Before intervention	-	-
		2	Combination intervention: Traffic-calming + 'Safe way to school' + Education	**Safe Community program** Focus on: free foot spaces and traffic-calming spaces in residential areas, e.g. a 'Safe way to school' program, and a 'Cut your garden hedge' initiative. Also measures directed towards motor transport spaces, e.g. improvement in winter road maintenance.	Community analysis Education aimed at primary and lower secondary school levels. The programme included: a 1 hour traffic lesson scheduled every week for all fourth-graders; a bicycling safety programme; courses offered for school children to 'shape up your bike'; a child safety seat loan programme; a falling prevention programme for the elderly.
		3	Control area	-	-
		4	As above.	-	-
10291	Mackie et al. (1990)	1	Before intervention	-	-
		2	Traffic-calming	**Urban Safety Project** Traffic-calming measures included: pinch points; entry treatments (e.g. Footway crossovers); central refuges and wide islands; roundabouts; staggered parking bays; rumble strips; speed control bumps Other measures, used to redistribute traffic, as well as slow traffic down, included: banned right turns; road closures and selective closures; sheltered parking; right-turn bays; threshold treatments/footway crossovers Some modification were made in order to make the approach more acceptable to the public. On average ~10% of packages of 50-60 measures were substantially modified or removed from initially planned schemes.	Extensive public consultation and approval by local transport committees. The information presented included recent accident history of the area. Some police enforcement of measures, such as no entry for certain types of vehicle, was required where there were problems with non-compliance.
		3	Control area	Area chosen to be of similar size and character, in terms of road network, land use and	-

RefID	Study	Arm No.	Type of intervention	What delivered	Details of other components of scheme/intervention
				numbers and types of accidents.	
		4	As above.	As above.	-
585	Mountain et al. (2005)	1	Before intervention	-	-
		2	Traffic-calming	71 engineering schemes of various types. 31 Vertical deflection interventions (with or without narrowing or horizontal deflections) 39 Narrowing, horizontal deflection or speed-activated signs interventions only. 1 scheme used 30 mph speed warning roundels (excluded from scheme type subgroup analysis)	-
		3	Before intervention	-	-
		4	Speed Cameras	79 **speed enforcement cameras** (17 mobile and 62 fixed)	-
733	Tester et al. (2004)	1	Case	The **Oakland Pedestrian Safety Project** implemented on residential streets: A multidisciplinary alliance addressing child and senior pedestrian injuries in Oakland and advocated for installation of speed humps.	-
		2	Control		-
10516	Tilly et al. (2005)	1	Before intervention	The main road within the zone had been subject to some traffic-calming measures including a single-way working chicane, low thermoplastic humps 'thumps' and speed cushions.	-
		2	Traffic-calming	**Home zone** Measures included: 'green streets' between parallel streets; features such as small gardens and wall mounted pots outside houses; planting trees in the streets; renewing and upgrading street lights; replacing parallel parking with echelon parking on alternate sides of the road; a gateway at the entrance to each home zone street with a specially designed home zone entry sign and a block paving effect; a 'shared' surface along each of the four home zone streets, incorporating features such as designated angled parking bays and large public art 'globes' which form chicanes etc. Although the home zone concept has a shared vehicular/pedestrian surface, many residents expressed concern about it, and as a result different surfaces were applied to vehicle routes and non-vehicular routes, making it appear that the narrow footpath is retained, when in fact it is all one shared surface.	On-going public consultation A newsletter A home zone fun day organised with a home zone mock-up on a street that was closed for the day
1217	von et al. (1998)	1	Traffic-calming	0-5 30kph streets	-

RefID	Study	Arm No.	Type of intervention	What delivered	Details of other components of scheme/intervention
		2		6-10 30kph streets	
		3		11-15 30kph streets	
		4		>15 30kph streets	
		5	Traffic-calming	0-1 pelican crossings/street	-
		6		>1-2 pelican crossings/street	
		7		>2-3 pelican crossings/street	
		8		>3 pelican crossings/street	
		9	Other	0 playgrounds	-
		10		1-3 playgrounds	
		11		>3 playgrounds	
10517	Webster et al. (2005)	1	Before intervention	Limited traffic-calming, including 3 road humps, was already present before the home zone was implemented.	-
		2	Traffic-calming	**Home zone** The home zone was implemented in phases: First phase features implemented: an entry gateway: low planters used to make the road narrower; landscaping; and a home zone entry sign designed by local children (later replaced by authorised signs) Second phase changes were made to the priority of the junction at the spur cul-de-sac, including: raising the whole junction to pavement level; extra seating provided adjacent to the area with planting and links to the play area The third phase was built on the idea of a central shared surface area formed by: a new road alignment; 2 of the 3 existing flat-top humps were retained (the other was incorporated into the shared surface area); a chicane constructed between a hump and the spur cul-de-sac	Consultation, including a street party; a visit to Holland for 5 residents (including a child) to experience a Dutch home zone; and a 'planning for real' event. Continual vandalism of certain areas led to installation of a mobile CCTV camera in the planting area
10369	Webster & Layfield (2003)	1	Before intervention	Most zones had 30mph speed limits prior to the intervention.	-
		2	Traffic-calming	78 **20mph Zones** 89% 'area' zones; 11% 'linear' zones	-

RefID	Study	Arm No.	Type of intervention	What delivered	Details of other components of scheme/intervention
				35% purely residential; 4% town/city centres or mainly commercial 61% contained schools Types of traffic-calming measure used: vertical and horizontal deflections Spacing of measures (available for 64% zones): average 'minimum' ~49m, average 'maximum' ~94m. Length of roads (comprising one zone): max. 14.5km, min. 0.15km. Average length of road in each zone: 3.4km. Average size of all the zones: 0.35km2.	
		3	Unclassified roads in London (control)	Comparison used to adjust for general underlying changes in casualty frequency on unclassified roads within London during the time covered by the 'before' and 'after' periods.	-
		4	As above.	As above.	-
10279	Webster & Mackie (1996)	1	Before intervention	Most zones had 30mph speed limits prior to the intervention.	-
		2	Traffic-calming	72 **20mph zones** ~80% zones in predominantly residential areas; remainder in shopping and commercial areas. 15% 'linear' zones. Measures included: round-top humps (52% of measures installed); flat-top humps (30%); raised junctions (10%); sets of speed cushions (4%); pinch points; chicanes; mini-roundabouts; rumble strips Length of roads (comprising one zone): max. 25km, min. 0.19km. Average length of road in each zone: 3.3km. Average size of schemes (excluding linear schemes): 0.28km2.	-
10380	Wheeler & Taylor (2000)	1	Before intervention	All but 7 villages were subject to a 30/40mph speed limit before the schemes were introduced.	-
		2	Traffic-calming	56 **village traffic-calming schemes**. This comprised: 24 schemes aimed at reducing speeds on main roads through villages 9 schemes aimed at reducing speeds on more major roads through villages, particularly trunk roads	Some speed cameras and speed camera signing were introduced.

RefID	Study	Arm No.	Type of intervention	What delivered	Details of other components of scheme/intervention
				23 schemes (not previously studied). At 10 villages speeds were reduced as part of the scheme. At two villages the speed limit remained at 60mph. Traffic-calming measures included: vertical deflections; horizontal deflections; narrowing; pelican and zebra crossings; pedestrian refuges and islands; enhanced/new signing, including some use of flashing lights; white field gates/white vertical planking carrying signing on verges at gateway; speed limit roundels; school markings; SLOW marking; reflective marker posts; surface colour changes; buff bar markings; double white lines; block paved surfacing; rumble strips/areas before start of speed limit; weight restrictions; illumination; sheltered parking; environmental enhancements.	
10660	WSP Development and Transportation (2008a)	1	Before intervention	Some environmental enhancements had been carried out as part of the urban regeneration project. Measures to improve safety and pedestrian provision had also been carried out previously	-
		2	Traffic-calming	**Mixed Priority Route scheme** Length of scheme: ~1km long Road widths: min. 7.5m; max. 11m; majority 9m Key aspects of the design include: three areas of 'shared space' where the carriageway is raised to footway level and width of carriageway is reduced; buff anti skid surfacing; a 20mph speed limit in the core of the shopping area, including 4 compact vehicle activated signs; minimum use of carriageway markings – except for cycle symbols; kerb build outs at junctions to prevent parking and loading, and to create 'sheltered' parking / loading bays; formal parking and loading provision in marked bays; additional cycle parking and seating in extended footway areas; zebra crossings; raised crossings at side road junctions; repaving of footway and tree planting; relocation of some bus stops.	Agreement to include cycle awareness in bus driver training and include speed monitoring on buses to assess driver behaviour. Consultation, including a public exhibition which attracted reports on local radio, television and in local newspapers. Further media interest due to death of a young student involved in an accident.
10662	WSP Development and Transportation (2008b)	1	Before intervention	Speed limit along the route: 30mph. Speed limit on most adjacent residential side roads: 20mph (with associated traffic-calming).	-
		2	Traffic-calming	**Mixed Priority Route scheme** Key aspects of the design include: existing pelican crossings replaced by combination of zebras and informal marked crossings on raised tables; a 'median strip' in the centre of the carriageway alongside parking/loading bays on busy central areas; raised bus boarding areas; gateway feature at one end; echelon parking; loading bays to be located on side roads instead of main street; speed cushions in between raised areas at one end of the scheme; establishment of a 20mph zone; creation of an 'urban square' with seating, cycle shelters and increased/enhanced pedestrian space; environmental enhancement; bollards to prevent vehicle encroachment onto areas of widened footway.	Consultation, including a 'Launch Event' and regular design workshops with residents and local traders Press involved in wider promotion of the scheme.

RefID	Study	Arm No.	Type of intervention	What delivered	Details of other components of scheme/intervention
10661	WSP Development and Transportation (2008c)	1	Before intervention	-	-
		2	Traffic-calming	**Mixed Priority Route scheme** The scheme area runs 800m. Key aspects of the design include: widening of footways to balance creation of more direct pedestrian crossings; speed cushions; formal parking and loading provision in marked bays; interchange re-design with new alignments and restricted turning movements; a 'median strip' along the full length of one of the streets, flush with the carriageway and without any breaks at junctions; bus infrastructure improvements; an Access Control System on one street to control access during very busy weekend-evening hours; provision of open spaces with environmental enhancements; combined street lighting and traffic signal facilities to reduce street clutter. The scheme, although unique in nature as a demonstration project, was one of a number of major redevelopment works in and around the city centre at the time.	Consultation, including a public exhibition and presentations. Progress updates broadcast daily on local radio.

Appendix 8 Quality assessment of included economic evaluations

Table 33. Quality assessment of economic evaluations (using the CHEC criteria list)

Criteria	Burns et al. 2001	Grundy et al. 2008	Gorell & Tootill, 2001	Manchester City Council, 2008	Cheshire County Council, 2008	Norfolk County Council, 2008	Mackie et al 1990	Wheeler & Taylor, 2000	Sælensminde, 2004	Erke & Elvik 2007	Elvik 2003	Meuleners et al. 2008
Type of economic evaluation (*reminder - not a CHEC question*)	CBA	CBA	CBA & CEA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
Is the study population (sites/areas) clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Are competing alternatives clearly described?	Yes	No but#	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No but#	Yes	Yes but#
Is a well-defined research question posed in answerable form?	No but*	No but*	No but*	No but*	No but*	No but*	No but*	No but*	No but*	No but*	No but*	No but*
Is the economic study design appropriate to the stated objective?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is the chosen time horizon appropriate to include relevant costs and consequences? (time horizon in years shown)	No (1y)	Yes (5y & 10y)	Prob not (3y)	No (1y)	No (1y)	No (1y)	Yes (5y)	None	Yes (25y)	No	No	Yes (10y)
Is the actual perspective chosen appropriate?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Are all important and relevant costs for each alternative identified?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Are all resources measured appropriately in physical units?	No	No	No	No	No	No	No	No	No	No	No	No
Are resources valued appropriately?	na	na	na	na	na	na	na	na	na	na	na	na
Are all important and relevant outcomes for each alternative identified?	Yes@	Yes@	NR	Yes@	Yes@	Yes@	Yes	Yes@	Yes	Yes	Yes	Yes@
Are all outcomes measured appropriately in physical units?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Are outcomes valued appropriately?	Yes@	Yes@	Yes@	Yes@	Yes@	Yes@	Yes@	Yes@	Yes@	Yes@	Yes@	Yes@
Is an incremental analysis of costs and outcomes performed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Are all future costs and outcomes discounted appropriately?	No**	Yes (costs)	No**	No**	No**	No**	No**	No**	Yes (costs)	No**	No**	Yes (costs)
Are all important variables, whose values are uncertain, appropriately subjected to sensitivity analysis?	No but$	No	No	No	No	No	No	No	No	No	No	Some
Do the conclusions follow from the data reported?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Does the study discuss the generalisability of the results to other settings and patient/client groups (other places/roads)?	No	No	No	No	No	No	No	No	No	No	No	No

Criteria	Burns et al. 2001	Grundy et al. 2008	Gorell & Tootill, 2001	Manchester City Council, 2008	Cheshire County Council, 2008	Norfolk County Council, 2008	Mackie et al 1990	Wheeler & Taylor, 2000	Sælensminde, 2004	Erke & Elvik 2007	Elvik 2003	Meuleners et al. 2008
Does the article indicate that there is no potential conflict of interest of study researcher(s) and funder(s)?	No	No	No	No	No	No	No	No	No	No	No	No
Are ethical and distributional issues discussed appropriately?	No	No	No	No	No	No	No	No	No	No	No	No
OVERALL STUDY QUALITY RATING	+	+	+	+	+	+	+	+	++	+	+	+

NB. The ‘CHEC’ list for assessing quality of health economic evaluations (Evers et al. 2005) incorporates all but one of the widely used critical appraisal questions recommended by Drummond et al (2005).

*Can be reasonably inferred from the data and the analysis method used.

@On the basis of having used standard costs for different types of injury or accident, as specified by the relevant national authority’s methods guidance.

#No space in a journal article to fully describe the scale and detailed content of the large number of different schemes/treatments in these studies.

**This seems defensible given the short time horizon of the analysis.

$Probably as important to explore the variation of results by type of intervention/scheme and year of scheme etc. (i.e. variability in intervention and context as important as uncertainty)

Appendix 9 Studies excluded at full text stage (Review 2: Cost-effectiveness)

Reference	Exclusion reason
Bishai, D. M. & Hyder, A. 2006, "Modeling the cost effectiveness of injury interventions in lower and middle income countries: opportunities and challenges", Cost Effectiveness and Resource Allocation, vol. 4, no. 2.	Setting not included (non-OECD)
Ewing R. Traffic-calming: State of the Practice. 1999.	Study design not included (cost study from USA)
Hakim, S., Shefer, D., Hakkert, A. S., & Hocherman, I. 1991, "A critical review of macro models for road accidents. [Review] [95 refs]", Accident Analysis & Prevention, vol. 23, no. 5, pp. 379-400.	Study design not included
Lalani, N. 1991, "Comprehensive safety program produces dramatic results", ITE Journal, vol. 61, no. 10, pp. 31-34.	Intervention not included
Ogden, K. W. 1997, "The effects of paved shoulders on accidents on rural highways", Accident Analysis & Prevention, vol. 29, no. 3, pp. 353-362.	Intervention not included
Roberts, I., Ashton, T., Dunn, R., & Lee-Joe, T. 1994, "Preventing child pedestrian injury: pedestrian education or traffic-calming?", Australian Journal of Public Health, vol. 18, no. 2, pp. 209-212.	Study design not included (cost study from New Zealand)
Zaloshnja, E., Miller, T. R., Galbraith, M. S., Lawrence, B. A., DeBruyn, L. M., Bill, N., Hicks, K. R., Keiffer, M., & Perkins, R. 2003, "Reducing injuries among Native Americans: five cost-outcome analyses", Accident Analysis & Prevention, vol. 35, no. 5, pp. 631-639.	Intervention not included