PREVENTING UNINTENTIONAL INJURIES IN CHILDREN:

Systematic review to provide an overview of published economic evaluations of relevant legislation, regulations, standards, and/or their enforcement and promotion by mass media

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List of abbreviations

Abbreviation	Meaning
A&E	Accident and emergency department
C$	Canadian dollars
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
NA	Not applicable
NB.	Please note
NR	Not reported
NZ$	New Zealand dollars
PenTAG	Peninsula Technology Assessment Group
PUIC	Prevention of Unintentional Injuries in Children
UK	United Kingdom
USA	United States of America

Glossary

Term	Definition
Base case (analysis)	The main deterministic analysis which uses the best (most plausible/justified) parameters and assumptions.
Cost-consequence analysis	A type of economic evaluation in which the incremental costs are compared with the incremental effects or benefits expressed in two or more ways. Such studies will present together the costs, health outcomes, intermediate outcomes, process outcomes or any other consequences of perceived relevance.
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-savings analysis	A cost savings analysis is a type of economic analysis in which the financial savings due to improved outcomes of the programme (e.g. reduced health care costs associated with reduced number and severity of injuries) are deducted from the additional costs of providing the programme or strategy being evaluated. They are sometimes misleadingly called cost-benefit analyses, but cannot be classed as this because the changed outcomes are not valued other than in terms of the actual savings realised. Cost-savings analyses are also sometimes called cost-offset analyses.
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 study which estimates the overall cost or financial burden to a country of a particular disease or condition. Such studies not consider either the costs or effects of alternative possible treatments or policies.

Continued on following page.

Term	Definition
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	The annual rate used in model-based economic evaluations by which costs or benefits incurred in the future are reduced to reflect positive time preference (that is the common preference of either individuals or society to prefer to receive good things (i.e. benefits) earlier rather than later, but to defer negative things (like expenditure) later rather than earlier)
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	Comparative evaluations which include quantification of both costs and effects or benefits of two or more policy or treatment comparators
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	Varying one model or analysis input variable at a time to explore the impact on the main result of interest
Probabilistic sensitivity analysis	A method of sensitivity analysis in which the uncertainty in most input variables is varied at the same time, by sampling from probability distributions for each uncertain variable value.
Sensitivity analysis	Varying one model or analysis input variable at a time to explore the impact on the main result of interest
Time horizon	The length of time (usually years) from the time of the policy decision over which an analysis estimates costs and outcomes/effectiveness

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1. Summary

1.1. Aims and Rationale

To identify and summarise evidence relating to the cost-effectiveness of:

- Legislation
- Regulations
- Standards
- Enforcement strategies to support the above, and
- Mass media activities to support the above,

where such legislation/regulation or other strategic approaches of interest relate wholly or mainly to the prevention of unintentional injuries in children. (NB. in this report we use the term "legislation/regulation or other strategic approaches of interest" to refer to the aboce five categories of public health strategy or policy).

The review is restricted to legislation/regulation or other strategic approaches of interest where they relate to preventing injuries to children in the road environment, in the home (including the gardens of residential properties), or whilst at play or leisure outdoors.

The review was started primarily to inform the choice of focus and possible methods for a planned economic modelling exercise, to inform CPHE staff and the NICE Collaborating Centre's health economist who would conduct this work. CPHE then asked for a more formal systematic review and summary of relevant past economic evaluations; this report is the outcome of that request.

The review Questions

a. What is the cost-effectiveness of legislation, regulations, standards, intended to prevent unintentional injuries in children, and/or of strategies to enforce them, or to promote them using mass media?

b. What methods have been used in the past to conduct economic evaluations of such strategies for preventing injuries to children?

These two questions will be addressed where they relate to the types of legislation or strategy etc. covered by the review protocols of the effectiveness reviews already conducted as part of the PUIC programme development process.

1.2. Methods

We sought to identify and review full economic evaluations of the legislation/regulation or other strategic approaches of interest published since 1990. Full economic evaluations compare both the costs and the effects/benefits of two or more policy or intervention comparators; they could be cost-benefit analyses, cost-effectiveness analyses, cost-utility analyses, cost-offset analyses, or cost consequence analyses.

Search strategy

The process of identifying studies of potential relevance to this review was based on a combination of searching the 'hits' from the previous literature searches conducted by this team for supporting a suite of NICE intervention and programme guidance on child injury prevention, supplemented by new searches in bibliographic databases of economic studies.

(i) Searches within existing databases of search hits

Using relevant economic study search terms we searched within the RefMan database of search hits of the following seven reviews, which had either been conducted as part of the PUIC Programme reviews, or for the two related public health intervention projects which have already been conducted (preventing unintentional injuries to children on the road, and in the home):

- **PDG 1**: review of international comparative studies; **PDG 2**: review of quantitative correlates; **PDG 3**: review of legislation, regulation etc. and other strategic approaches to preventing unintentional injuries to children on the road; **PDG 4**: review of legislation, regulation etc. and other strategic approaches to preventing unintentional injuries to children in the home; and, **PDG 6**: review of legislation, regulation etc. and other strategic approaches to preventing unintentional injuries to children during play or leisure outdoors

- **Effectiveness and cost-effectiveness of road/street design-based interventions** to preventing unintentional injuries to children on the road*, and; **Effectiveness and cost-effectiveness of programmes involving the give-away or reduced price provision of home safety equipment and/or home risk assessment** interventions to preventing unintentional injuries to children in the home*

*NB. The original searches for the two public health intervention guidance reviews (last two listed above) included searching in EconLit and NHSEED, but the original searches for the other five reviews (for the PUIC PDG) did not.

(ii) New searches within EconLit and NHSEED

We also performed new searches within two databases of economic literature: EconLit and NHSEED (NHS Economic Evaluation Database). We used broader text word and thesaurus terms to cover all aspects of injuries in children. We combined 'accident' terms AND terms related to programme, strategy etc AND child terms. The search was limited to English language studies from 1990 to current.

Study quality

Given the aims of the review, the quality of included studies was not formally assessed.

1.3. Findings

The searches within the previously generated RefMan databases for the two public health intervention reviews (road interventions, and home-based interventions and injuries)

produced a database of 225 titles and abstracts. The searches within the previously generated RefMan databases for the five public health programme reviews (i.e. the search hits for the reviews for PDG meetings 1,2,3,4 and 6) produced a database of 272 titles and abstracts. Finally, the new searches conducted for this review in EconLit and NHSEED produced 405 hits.

Seven studies met our inclusion criteria of being full economic evaluations of the relevant interventions. Three were economic evaluations of legislation to increase use of bicycle helmets in New Zealand (Hansen & Scuffham 1995;Hatziandreu et al. 1995;Taylor & Scuffham 2002), and in the United States (Hansen & Scuffham 1995;Hatziandreu et al. 1995;Taylor & Scuffham 2002). There was one cost-savings analysis from Canada of the introduction of laws to set temperatures on the thermostats of hot water systems (Han et al. 2007), and another from the USA on laws to increase the use of smoke detectors (Jensen et al. 1989). There were also two economic evaluations (one from Canada, one from the UK) of road speed enforcement programmes (Chen 2005;Hooke et al. 1996).

Compulsory wearing of bicycle helmets

The three economic evaluations of legislation about bicycle helmets all compared costs with different measures of effectiveness or societal benefit (e.g. net benefit, cost per life saved, cost per life-year saved, cost per hospitalisation prevented, cost per injury avoided) (Taylor & Scuffham, 2002; Hansen & Scuffham, 1995; Hatziandreu et al, 1995). Partly as a result of this there is inconsistent evidence from New Zealand and the USA that national laws to make the wearing of bicycle helmets compulsory would be cost-effective from a societal perspective. However, from a *public sector* perspective – critically, omitting the cost to individuals or families of purchasing bicycle helmets – the measure is likely to by highly cost-effective. The two New Zealand studies suggested that bicycle helmet laws would be more cost-effective in younger (age 5-12 years) than older children (age 13-18), and one of them estimated that costs would probably exceed benefits in older children and adults (again, from a societal perspective) (Taylor & Scuffham, 2002; Hansen & Scuffham, 1995).

The USA study also estimated the cost-effectiveness of community-wide and school-based strategies for promoting the wearing of bicycle helmets did not directly compare these strategies with the legislative approach (Hatziandreu et al, 1995). However, when

compared with 'no programme' the legislative approach was the most cost-effective of the three strategies (but still with an estimated cost per life-year saved of over US$900,000 – which, from a health care perspective, would not normally be judged as cost-effective).

Water heater thermostat settings

One model-based cost-effectiveness analysis from Ontario, Canada, estimated that legislation to restrict the thermostat temperature on (newly manufactured) hot water systems would be both cost-saving and more effective in terms of tap-water scalds prevented, compared with no legislation (Han et al 2007). In fact, the health care cost savings from injuries avoided were estimated as almost ten times the cost of implementing the legislation (C$480,000 vs C$51,000). However, note than only the educational component of the programme (educational notices about the risks of tap-water scalds sent with utility bills) was included as a 'cost of the legislation'.

Compulsory smoke detectors

The model-based economic analysis of smoke detector legislation in the USA estimated that implementing this legislation to make the fitting of detectors compulsory in all US states would produce net savings (i.e. enforcement plus detector costs, less injury-related savings) of between $150,000 and $250,000 per year, alongside saving over 800 lives per year across the USA (Jensen et al. 1989). If the health care cost savings due to injuries averted are excluded from the analysis, the cost-effectiveness would be approximately $65,000 per life saved.

Camera or radar speed enforcement programmes

There were three cost-benefit analyses which assessed the impact of speed enforcement programmes. The photo radar programme in British Columbia was estimated to produce net benefits to society of about C$114 million (in 2001 C$), and still produced substantial net savings of C$38 million if only considered from the provincial insurance corporation's perspective (Chen, 2002).

Similarly, the 420 automated speed camera sites in the UK in 1995/6 (Hooke et al. 1996) were estimated to have a positive Net Present Value of over £26 million, even after one year, rising to £241 million after ten years. This is because annualised fixed costs of £5.3

million plus annual recurrent costs of £3.6 million, would be offset not just by the £6.7 million in fine income, but also the over £30 million in the estimated annual value to society of accidents avoided. In all ten police force areas there was a positive net present value (i.e. benefits exceeded costs) within a year of the programme starting.

However, these older findings from Hooke et al should be seen as having been superseded by the more recent study for the Department for Transport, which evaluated the national safety camera programme (four-year evaluation report; PA Consulting with University College London, 2005). [NB. This study was added to the review after the original Final report was submitted to NICE]. In this study, it was estimated that there would be 4,230 fewer personal injury collisions (any road collision which results in at least one casualty, whether fatal, serious or slight) annually as a result of the safety cameras across all 38 safety camera partnerships. At an estimated value of £61,120 per collision avoided (using DfT standard estimates for 2004) this means an annual estimated economic benefit of £258 million. This compares with the total annual cost of the programme of £96 million. Comparing only the revenue costs per collision prevented (£61,120) with the corresponding economic benefit per collision due to injuries prevented (£22,653) over the four years gives a cost-benefit ratio of approximately 2.7:1. They also use data from both speed and red light camera sites, although at speed camera sites the falls in personal injury collisions were associated with falls in speeds.

2. Aims

2.1. Objectives and Rationale

To identify and summarise evidence relating to the cost-effectiveness of:

- Legislation
- Regulations
- Standards
- Enforcement strategies to support the above, and
- Mass media activities to support the above,

Where such legislation/regulation or other strategic approaches of interest relate wholly or mainly to prevent unintentional injuries in children.

The review is restricted to such legislation/regulation or other strategic approaches of interest where they relate to preventing injuries to children in the road environment, in the home (including gardens of residential properties), or whilst at play or leisure outdoors. Table 1 below shows the range of legislation/regulation or other strategic approaches of interest for which our previous reviews have found relevant effectiveness studies. (NB. This therefore does not show available evidence for the classes of interventions reviewed as part of the two pieces of intervention guidance development). This may be useful because having evidence of effectiveness and evidence of cost-effectiveness on different strategic approaches would make the combined evidence base less useful, and the opportunity for economic modeling less clear.

Table 1. Overview of previously reviewed evidence on the effectiveness of legislation/regulation or other strategic approaches of interest on preventing injuries in children

	PDG 1 Review **International evidence**	**PDG 3 Review** **Injuries on the Road**	**PDG 4 Review** **Injuries in the Home**	**PDG 6 Review** **Injuries Outdoors at Play and Leisure**
Legislation	Legislative frameworks/degree of safety legislation Off-road leisure vehicles		Smoke detectors Window guards Hot water system temperatures Swimming pool fencing	Wearing of bicycle helmets Restricted sale of fireworks
Regulations				
Standards				Playground design standards
Enforcement		Speed enforcement cameras/devices Other speed enforcement strategies (e.g. media)		
Mass media				Wearing of bicycle helmets
Other/Mixed strategies		National injury reduction targets		Mixed mass-media, community campaign to promote use of life vests to prevent children from drowning

Source: PUIC Programme reviews for PDG 1, PDG 3, PDG 4 and PDG 6.

The review was started primarily to inform the choice of focus and possible methods for a planned economic modeling exercise, to inform CPHE staff and the NICE Collaborating Centre's health economist. CPHE then asked for a more formal systematic review and summary of relevant past economic evaluations; this report is the outcome of that request.

2.2. Review Questions

a. What is the cost-effectiveness of legislation, regulations, standards, intended to prevent unintentional injuries in children, and/or of strategies to enforce them, or to promote them using mass media?

b. What methods have been used to conduct economic evaluations of such strategies for preventing injuries to children?

These two questions will be addressed where they relate to the types of legislation or strategy etc. covered by the review protocols of the effectiveness reviews already conducted as part of the PUIC programme development process.

3. Methods

3.1. Identification of evidence

Relevant policies and strategies

The relevant strategies for which we sought economic evaluations, were the same as those covered by the effectiveness reviews for PDG 3 (Road), PDG 4 (Home) and PDG 6 (Outdoor play and leisure). They are:

- Legislation
- Regulations
- Standards
- Enforcement strategies to support the above, and
- Mass media activities to support the above,

Where the legislation, regulations etc. relate wholly or mainly to prevent unintentional injuries in children. Specific exceptions – which were negotiated between the CPHE and PenTAG collaborating centre – are: legislation relating to the fitting of smoke alarms in homes (covered in PDG 4 review); mass-media campaigns to promote the use of bicycle helmets (even in the absence of legislation regarding compulsory wearing of helmets; PDG 6 review).

Relevant research

We sought to identify and review full economic evaluations of the policies or strategies of interest published since 1990. Full economic evaluations compare both the costs and the effects/benefits of two or more policy or intervention comparators; they could be cost-benefit analyses, cost-effectiveness analyses, cost-utility analyses, cost-offset analyses, or cost consequence analyses.

3.1.1. Search strategy

The process of identifying studies of potential relevance to this review was based on a combination of searching the 'hits' from the previous literature searches conducted by this team for supporting NICE's child injury prevention guidance development, supplemented by new searches in bibliographic databases of economic studies.

Searches within existing databases of search hits

Using relevant economic study search terms we searched within the RefMan database of search hits of the following seven reviews, which had either been conducted as part of the PUIC Programme reviews, or for the two related public health intervention projects which have already been conducted (preventing unintentional injuries to children on the road, and in the home):

- PDG 1: review of international comparative studies
- PDG 2: review of quantitative correlates
- PDG 3: review of legislation, regulation etc. and other strategic approaches to preventing unintentional injuries to children on the road
- PDG 4: review of legislation, regulation etc. and other strategic approaches to preventing unintentional injuries to children in the home
- PDG 6: review of legislation, regulation etc. and other strategic approaches to preventing unintentional injuries to children during play or leisure outdoors
- Effectiveness and cost-effectiveness of road/street design-based interventions to preventing unintentional injuries to children on the road*
- Effectiveness and cost-effectiveness of programmes involving the give-away or reduced price provision of home safety equipment and/or home

risk assessment interventions to preventing unintentional injuries to children in the home*

*NB. The original searches for the two public health intervention guidance reviews (last two listed above) included searching in EconLit and NHSEED, but the original searches for the other five reviews (for the PUIC Programme guidance) did not. This is because the five reviews for informing the Programme guidance aimed to identify evidence of the effectiveness of the relevant strategies; however, no filter to exclude economic studies was applied.

The search terms sought in the abstracts, titles and key words of these seven RefMan databases are shown in Box 1 below:

Box 1. Search terms for searching existing PUIC review RefMan databases

Round one: "cost" and "economic" in the titles only
Round two: OR, in title and abstract:
Cost-effectiveness or cost effectiveness
Cost-benefit* or cost benefit* or benefit cost*
Net benefit
Cost saving* "estimated savings" "potential savings"
Economic analysis, Economic costs
Cost analysis
Economic evaluation
Decision model*
Decision analysis

AND

(any one or more of …)
The selection of terms already agreed with NICE information specialists for:
Legislation Law(s) Regulation(s) Standard(s) Enforcement "national policy" "strategic policy" "mass media" etc.

The search strategy for EconLit was equivalent, but altered where necessary in order to be run on this database.

Additional searches of economic literature databases

We also performed new searches within two databases of economic literature: EconLit and NHSEED (NHS Economic Evaluation Database). We used broader text word and thesaurus terms to cover all aspects of injuries in children. We combined 'accident' terms AND terms related to programme, strategy etc AND child terms, and limited the search to 1990-current. Box 2 below shows the detailed search that was run in NHSEED (the strategy run in EconLit was very similar, but altered where necessary to run on EconLit).

Box 2. Search run in NHSEED on 22 September 2009

# 1	injury OR injured OR injuries RESTRICT YR 1990 2009	1622
# 2	MeSH Accident Prevention EXPLODE 1	359
# 3	accident* RESTRICT YR 1990 2009	434
# 4	accident*	437
# 5	MeSH Accidents, Home EXPLODE 1	13
# 6	MeSH Accidents, Traffic EXPLODE 1	137
# 7	MeSH Accidental Falls EXPLODE 1	143
# 8	#1 or #2 or #4 or #5 or #6 or #7 RESTRICT YR 1990 2009	2309
# 9	child* OR infant* OR young OR teenager* OR youth OR under OR bab* OR infant*	9609
# 10	MeSH Child EXPLODE 1	3937
# 11	MeSH Infant EXPLODE 1	2537
# 12	MeSH Adolescent EXPLODE 1	4203
# 13	#9 or #10 or #11 or #12 RESTRICT YR 1990 2009	13174
# 14	#8 AND #13	863
# 15	Program* OR Strat* OR Polic* OR Legislat* OR Regulat* OR Complianc* OR Standard* OR enforce* OR law* RESTRICT YR 1990 2009	20098
# 16	#14 AND #15	566

3.1.2. Inclusion of relevant evidence

3.1.2.1. Inclusion criteria

Study design

Full economic evaluations only; that is, comparative evaluations which include quantification of both costs and effects or benefits.

Strategies of interest

Any that have been the focus of previous reviews for the PUIC programme set of systematic reviews to date, but especially those relating to legislation, regulations etc. which impact upon:

- The planning and implementation of road or street design-based road safety improvements
- The enforcement of speed limits on roads (e.g. speed camera programmes)
- The planning and implementation of road or street design-based road safety improvements
- The use of safety devices or equipment in the home and garden environment (e.g. smoke detectors, hot water thermostats, swimming pool fences, window guards)
- The use or provision of play or leisure-related safety equipment in the outdoor environment (e.g. bicycle helmets)
- The sale or availability to children of dangerous leisure-related goods (e.g. fireworks)
- The design, building and maintenance of safe designated play areas

Language

English

3.1.2.2. Exclusion criteria

Study design

Not cost analyses or cost of illness studies (i.e. are not full economic evaluations)

Strategies not of interest

Mass media campaigns where their sole or main purpose is to publicise the existence of or promote compliance with legislation, regulations, standards or other strategic policies

3.1.3. Study selection

3.2. Methods of analysis and synthesis

3.2.1. Data extraction

Details of each included economic evaluation and UK-based cost analysis 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 study (e.g. cost-effectiveness analysis or cost analysis), main data source years (e.g. time period of before-and-after effectiveness study) and base year for the analysis; 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. cost per outcome ratio, or net benefit), and; types of sensitivity analysis conducted.

The **study results table** recorded the following details: the 'from' and 'to' intervention (i.e. the comparison made); the cost of the intervention(s); the benefits associated with each intervention(s) and comparator(s); the incremental cost-effectiveness ratio (where appropriate; or other cost-effectiveness estimate).

3.2.1.1. Study quality appraisal

Due to the time constraints, and because one on the main purposes of this review was to inform a planned economic modelling exercise, no formal (e.g. checklist based) assessment of study quality was made. This was agreed with NICE CPHE staff.

3.2.1.2. Approach to judging the applicability of studies

The applicability of the findings of the included economic evaluations was judged on the basis of:

- The perceived feasibility of providing a similar programme in the UK (e.g. in terms of types of trained staff involved, levels of resources, and delivery organisations)
- The social, economic and geographical context of the programme evaluated compared with equivalent UK settings (including the background prevalence or incidence of the unintentional injury types of interest, and the patterns of causes of injuries where known/described)
- The number of years since the study was conducted
- The extensiveness of sensitivity analyses - potentially allowing some estimation of the programme's cost-effectiveness to settings where particular characteristics of the intervention (e.g. grade and pay of staff delivering it) or its context (e.g. injury incidence rates or severity) are known to vary.

Inevitably, given that the main reviewer is not an expert on the topic of injury or child injury prevention, or on the evaluation of legislation, regulations, mass media campaigns or related strategic approaches these judgements should be viewed as provisional assessments.

3.2.1.3. Synthesising the findings

There was no explicit intention to synthesise or to compare and contrast findings, but more simply just to summarise what cost-effectiveness evidence exists and what methods have been used. This approach was agreed with the CPHE team.

4. Review of cost-effectiveness: Findings

4.1. Study reports identified

The searches within the previously generated RefMan databases for the two public health intervention reviews (road interventions, and home-based interventions and injuries) produced a database of 225 titles and abstracts. The searches within the previously generated RefMan databases for the five public health programme reviews (i.e. the search hits for the reviews for PDG meetings 1,2,3,4 and 6) produced a database of 272 titles and abstracts. Finally, the new searches conducted for this review in EconLit and NHSEED produced 405 hits. These three sets of titles and abstracts were screened by the health economist reviewer to identify potentially includable studies. The new search we conducted for this review, in EconLit and NHSEED, did not produce any new includable studies (at least not any that hadn't already been identified from our 'searches within searches') so we are confident that we have found most if not all of the published literature relevant to our review questions. Potentially relevant systematic reviews of economic studies identified by the previous reviews, such as that by Miller and Levy, also did not yield any additional relevant economic evaluations (Elvik 2003;Miller & Levy 2000).

All seven studies obtained in full-text as likely includes, were included. (However, some other economic evaluation studies found - for example on seat-belt enforcement, motorcycle helmet laws and implementing baby-walker design standards - were also obtained in order to get a broader overview of economic evaluation of legislation and related strategies in the injury prevention field.

The seven studies which met our inclusion criteria of being full economic evaluations of the relevant interventions are shown in Table 2. Three of the studies were economic evaluations of legislation to increase use of bicycle helmets in New Zealand (Hansen & Scuffham 1995;Hatziandreu et al. 1995;Taylor & Scuffham 2002), and in the United States (Hansen & Scuffham 1995;Hatziandreu et al. 1995;Taylor & Scuffham 2002). There was one cost-savings analysis from Canada of the introduction of laws to set temperatures on the thermostats of hot water systems (Han et al. 2007), and another from the USA on laws to increase the use of smoke detectors (Jensen et al. 1989). There were also two economic evaluations (one from Canada, one from the UK) of road speed enforcement

programmes (Chen 2005;Hooke et al. 1996). Note that although the Jensen et al study (published in 1989) strictly fell outside our inclusion criterion for publication date (1990 and after), given the paucity of studies, and that this was the only economic evaluation found of smoke detector laws, we decided to include it.

We also identified a report which included a cost-effectiveness analysis of six road safety information campaigns in Sweden (Vaa et al. 2004), but this was excluded because only the report summary was available in English (with only half a page devoted to the cost-effectiveness analyses).

Table 2. Economic evaluations of legislation, regulation standards and associated strategies for enforcing or promoting them

Author & year	Type of strategy	Design	Empirical or model	Country
	Legislation:			
Taylor & Scuffham 2002	Compulsory wearing of bicycle helmets	CBA & CEA	Model	New Zealand
Hansen & Scuffham 1995	Compulsory wearing of bicycle helmets	CEA	Calculation*	New Zealand
Hatziandreu et al 1995	Compulsory wearing of bicycle helmets (vs community-wide and school-based promotion)	CEA	Model	USA
Han et al 2007	Thermostat settings to reduce water scalds	CSA	Model	Canada
Jensen et al 1989	Smoke detector laws	CEA	Model	USA
	Enforcement strategies:			
Chen 2005	Photo radar program	CBA	Model	BC, Canada
Hooke et al 1996	Speed cameras (and traffic light cameras)	CBA	Calculation*	UK

CBA = Cost-Benefit Analysis; CEA = Cost-Effectiveness Analysis; CSA = Cost-Savings Analysis

* Note that the distinction between model-based evaluations and ones based on more straightforward calculations is somewhat arbitrary. However, an analysis was called model-based if there was a clear model structure (e.g. decision tree) reflecting different participant pathways or the conditional probability of different events or states.

4.2. Legislation on wearing bicycle helmets

Table 3 below shows the study characteristics and study designs of the three included economic studies of the introduction of legislation to make the wearing of bicycle helmets by children compulsory, and Table 4 (p.32) shows their results. The programmes evaluated, study designs and results are described and discussed more fully in the sections following the table.

The study from 2002 by Taylor and Scuffham reports a retrospective evaluation of the national bicycle helmet law that was introduced in New Zealand in 1994, and primarily presents a cost-benefit analysis from a societal perspective. The law made the wearing of bicycle helmets compulsory for both children and adults, so the study estimates benefit-cost ratios and net benefits for three different age groups: age 5-12 years, 13-18 years and 19+ years (adults)) over a 3 year period. The only included cost to society of implementing the legislation was the cost to cyclists of purchasing helmets, while the only estimated benefit was the estimated social costs of head injuries. The data on head injuries was for head injuries leading to a hospital admission, and the social value of avoiding a head injury was for two types of head injury: that requiring short-stay hospital treatment (less than seven days) and that requiring long-stay hospital treatment (seven days or more). The marginal costs of enforcement were assumed to be negligible given that it would be a small part of general traffic enforcement activity already happening.

The earlier study in New Zealand, this time by Hansen and Scuffham (1995) again estimated the cost to New Zealand society of the change in national law (for children and adults), but expressed the results as the cost per hospitalisation avoided and cost per death avoided due to introduction of the law. The assumptions about the numbers of regular and irregular cyclists in each age group who would purchase and use a helmet were particularly crude (e.g. the calculations assumed that all regular cyclists, and half of irregular cyclists, who do not already own a helmet would purchase one). It relied upon evidence of the efficacy of cycle helmets from Australia and the USA. In the base case analysis, in addition to the cost of purchasing helmets, an estimate was included of the cost – or value of lost benefits – due to cyclists who stopped cycling in preference to buying or wearing a cycle helmet.

The model-based cost-effectiveness analysis by Hatziandreu et al. (1995) compared three alternative strategies for increasing cycle helmet usage among children (age 5 to 16 years). The strategies compared were: legislation for compulsory use by children (including some educational visits to schools by police officers); a community-wide promotional intervention, and; a school-based campaign to promote helmet use (including the provision of discount vouchers for helmet purchase). Each of these strategies was compared with the absence of the strategy, rather than all four alternatives being compared together. (NB. Although the authors do not justify the approach, this may be appropriate given the disparate programmes around the USA from which data was obtained for comparing each strategy).

In two of the economic evaluations described above the main source of effectiveness data is essentially either measured or estimated before and after data on helmet use, while the analysis by Taylor and Scuffham was able to use actual annual data on the number of admissions to hospital for head injuries in different age-groups.

Table 3. Published economic studies of bicycle helmet legislation: Study designs

Author, year	Analysis type, data	Country, setting	Population, Data sources	Interventions & comparators	Perspective & Model	Time horizon, discounting	Costs & savings included	Benefits included & Statistic estimated	Sensitivity analyses
Taylor & Scuffham 2002	Model-based CEA and CBA Data years: 1989-1992 Base year: 1996	New Zealand, (whole country)	Data sources: Helmet wearing rates NZLTSA Hospital records for admitted head injuries & NZ Health Information Service	Legislation to make wearing bicycle helmets compulsory for child and adult cyclists on the road vs No legislation	Societal Model	3 years 5% per year	Costs (value of lost benefit) of cyclists quitting cycling • Number of cyclists who quit × price of cheapest helmet	Head injuries averted Cost-effectiveness: Cost per head injury averted Benefit:cost ratio Net benefit	One-way

Author, year	Analysis type, data	Country, setting	Population, Data sources	Interventions & comparators	Perspective & Model	Time horizon, discounting	Costs & savings included	Benefits included & Statistic estimated	Sensitivity analyses
Hansen & Scuffham 1995	Model-based CEA Data years: 1989-1992 Base year: 1994	New Zealand, (whole country)	Data sources: Hospital records on deaths and hospitalisations with head injuries & 1993 Cycle Helmet Survey Head injury risk reduction due to helmet from 2 studies (Victoria Australia, and Seattle USA)	Legislation to make wearing bicycle helmets compulsory for children and adults vs No legislation	Societal Model of 3 age-groups and 2 types of cyclist (regular and irregular)	3 years Benefits discounted at 5% per year, (costs all in year 1)	Cost of obtaining a helmet for those previously without one Costs (value of lost benefit) of cyclists quitting cycling • Number of cyclists who quit × price of cheapest helmet	Deaths avoided Hospitalisations avoided Cost-effectiveness: Cost per death avoided Cost per hosp-italisation avoided	One-way and two-way sensitivity analysis only: % of cyclists who quit Valuation of lost benefit to quitters Years use per helmet purchased

Author, year	Analysis type, data	Country, setting	Population, Data sources	Interventions & comparators	Perspective & Model	Time horizon, discounting	Costs & savings included	Benefits included & Statistic estimated	Sensitivity analyses
Hatziandreu et al. 1995	Model-based CEA Data years: Various e.g. 1985 hospital costs 1987-91 for changes in helmet wearing rates Base year: 1992	USA, (evidence from approaches implemented in 3 settings: Maryland, Seattle, and Michigan)	Data sources: Contact/interviews with programme personnel. National injury rate and attributable risk model	1. Legislation to make wearing bicycle helmets compulsory for children (aged 5 to 16 years), with some school-based education (*Howard County, Maryland*) 2. Community-wide intervention to increase use of helmets by children (age 5-16 years) (*Seattle, Washington State*) 3. School-based promotion of helmet use (with discount vouchers) to children aged 5-16 years (*Oakland County, MI*) **NB. All compared separately with no legislation**	Societal, but mainly focusing on impact on 5- to 16-year-olds	4 years, except life-years due to deaths prevented estimated over 66 years NR	Cost of programme: • Cost of bicycle helmets • Other start-up and ongoing programme costs (personnel paid and voluntary, & materials) Cost of injuries avoided: • Health care costs for hospitalised head injuries • Health care costs of deaths	Head injuries prevented Deaths avoided Years of life saved Cost-effectiveness: Cost per head injury prevented Cost per death avoided Cost per year of life saved	One-way only

CEA = Cost-Effectiveness Analysis; NZLTA = New Zealand Land Transport Safety Authority

Table 4. Economic studies of bicycle helmet legislation: Results

Author, Year, Country	Legislation change	Cost of the introducing the legislation	Costs related to impact of legislation			Effectiveness the intervention		Cost-effectiveness or cost-benefit base case results	
Taylor & Scuffham 2002 New Zealand (NZ$)	Legislation to make wearing bicycle helmets compulsory for children and adults vs No legislation		Expenditure on new helmets (h)	Total health care costs averted	Total societal costs averted (c)	Head injuries averted	Cost per head injury averted	Benefit-cost ratio [=(c)/(h)]	Net benefit [=(c)-(h)]
		Age 5-12	$180,792	$28,387	$471,920	18.1	$9,990	2.61	$291,128
		Age 13-18	$1,507,312	$75,110	$1,279,050	46.8	$32,241	0.85	-$228,262
		Age 19+	$5,819,397	$173,158	$4,289,602	128.2	$45,396	0.74	-$1,529,796
Hansen & Scuffham 1995 New Zealand (NZ$)	Legislation to make wearing bicycle helmets compulsory for children and adults vs No legislation	Cost of introducing legislation not included	Expenditure on new helmets (irregular + regular cyclists)	Lost benefit to irregular cyclists quitting	Total extra cost to all NZ cyclists	Annual deaths prevented	Annual hospitalisations prevented	Cost per life saved (over 3 years)	Cost per hospitalisation prevented (over 3 years)
		Age 5-12	$38,567 + $317,803	$19,218	$375,588	1.2[s] 1.6[v]	32.4[s] 41.7[v]	$88,379[s] $113,744[v]	$3,304[s] $4,252[v]
		Age 13-18	$368,960 + $3,040,280	$110,339	$3,519,578	1.6[s] 1.9[v]	63.7[s] 75.1[v]	$694,013[s] $817,874[v]	$17,207[s] $20,278[v]

Author, Year, Country	Legislation change	Cost of the introducing the legislation	Costs related to impact of legislation	Effectiveness the intervention			Cost-effectiveness or cost-benefit base case results	
		Age 19+ $1,605,364+ $13,228,478	$480,092 $15,313,934	5.5[s] 6.3[v]		100.4[s] 114.4[v]	$890,041[s] $1,014,850[v]	$49,143[s] $56,035[v]
Hatziandreu et al. 1995 USA		‘Start-up’ costs + Maintenance + Helmet purchase	Health care costs of injuries avoided or Costs of deaths avoided	Increase in helmet wearing	Injuries avoided[a]	Life-years saved[a]	Cost per injury avoided	Cost per life-year saved
	Legislation + school visits by Police	$12,744 + $28,850 + $933,100	$68,726 or $805	from 4% to 47%	24.72	1.04	$36,643	$934,904
	Community-wide programme	$79,821 + $285,804 + $4,327,400	$322,012 or $3,769	from 5% to 33%	115.84	4.87	$37,732	$961,958
	School-based pilot programme (adjusted to total County population)	$125,042 + $1,772,185 + $686,000	$48,411 or $584	from 2% to 7.5%	17.54	0.76	$144,498	$3,417,551

a All discounted, over 4 years, at 5% per year.

s Using head injury risk reduction estimates from a 1990-1991 study in Victoria, Australia

v Using head injury risk reduction estimates from a 1989 study in Seattle, USA

Cycle helmet laws in New Zealand: cost-effectiveness

It is difficult to compare the results of the two economic evaluations of the New Zealand law because they compare estimated costs (mostly the cost to individuals of buying helmets) with completely different outcomes. The later study generates cost benefit estimates, while the 1995 study estimates the cost per life saved and the cost per hospitalisation prevented. However, both studies show that the law is much more likely to be cost-effective in children than adults, and especially so in younger children (age 5 to 12 years; see Table 4). In the 1995 study, for children aged 5-12 years, the incremental cost per life saved was from NZ$88,000 and NZ$114,000, and the incremental cost per hospitalisation prevented was from NZ$3,300 to NZ$4,300 – depending on whether helmet efficacy at reducing injuries was taken from Seattle, USA, or from Victoria Australia. Although such ratios are typically very hard to interpret, given that each life of a child saved would entail many life-years saved, the incremental cost per life-year would be many times lower. Therefore, at least in the 5 to 12 age group, it seems reasonable to conclude that the legislation would be judged as cost-effective on the basis of the value of health outcomes generated.

This conclusion is supported by the later cost benefit analysis, which shows that benefits exceed costs in this younger age-group, but not in the 13- to 18-year-olds or in adults (Taylor & Scuffham, 2002). Some caution is needed since both these studies rely upon a number of basic assumptions, and also do not include any costs of drafting, developing and consulting on the legislation. Nevertheless, it seems probable that in New Zealand in 1994, the implementation of this legislation was a highly cost-effective means of reducing injuries in children, from either a societal or a health perspective.

Cycle helmet laws in USA: cost-effectiveness

The cost-effectiveness analysis by Hatziandreu et al. (1995) generated estimates of the incremental cost per injury avoided and per life-year saved for legislation, a community-wide promotion programme, and a school-based

promotional programme for encouraging children to wear bicycle helmets (Table 4). The incremental cost per injury avoided, *for each strategy compared to no strategy*, ranged from $36,600 to $144,500, but such figures are almost meaningless without a notional value of the maximum societal willingness to pay for an avoided injury. The cost per life-year saved is more interpretable, and it can probably be concluded that all three strategies would not be considered a cost-effective approach, compared with other potential investments in health care or disease prevention (with a cost per life-year saved of over $900,000, for the legislative and the community-wide programme, and a cost per life-year saved of over $3.4 million for the school-based programme).

The difference between these results and the New Zealand helmet legislation evaluations may be partly explained by differences between the countries in the exact nature of the programmes or legislation implemented, but also differences in the evaluation methods used. For example, the Hatziandreu study in the USA included an apparently more comprehensive estimation of the cost of initiating the legislation and maintaining the programme, and also only included the health care cost savings due to injuries or deaths avoided. Furthermore, the earlier of the two New Zealand studies might be expected to generate more favourable results because they assumed much greater compliance with the law (100% for regular cyclists and 50% for irregular cyclists, in Hansen & Scuffham 1995; and achieving 98.6% and 97.1% compliance in the two child age-groups in Taylor and Scuffham, 2002). They also start from completely different bases of prior levels of helmet wearing by children: 4%, 5% or 2% (in the three USA studies on which the Hatziandreu evaluation was based), and 87% (age 5-12 years) and 56% (age 13-18 years) in the later of the two New Zealand studies, which suggests a very different implementation context for this law in the two countries.

4.3. Other injury prevention legislation (Canada & USA)

Apart from the three studies about bicycle helmet laws described above, we found only two other studies which evaluated the cost-effectiveness of legislation which aimed to prevent unintentional injuries in children. One study evaluated the cost-effectiveness of introducing legislation to reduce tap water scalds in children by restricting the factory temperature settings (thermostats) of hot water systems in Ontario, Canada (Han et al. 1997). The other study evaluated the cost-effectiveness of implementing legislation to make the installation of smoke detectors in private homes compulsory in the USA (Jensen et al 1989).

The evaluation of provincial (Ontario) legislation for the setting of hot water system thermostats was a well-described decision tree-based cost-effectiveness study, which used an assumed reduction in tap water scalds due to the legislation of 56% from a previously published before and after study (Erdmann et al. 1991). It also defined and costed four levels of hospital care required to treat tap water scalds in children: emergency department care only; emergency department care with outpatient follow-up; hospital admission without surgery, and; hospital admission with skin graft surgery. No cost of developing and implementing the legislation was included (e.g. cost of altered factory processes), so the only included cost was of producing and distributing educational notices to utility customers. The analysis was implicitly conducted from a societal perspective (given the costs considered, if not actually estimated), and calculated the cost per scald case prevented.

The evaluation of the cost-effectiveness of introducing a law in the USA to make smoke detectors compulsory in private homes also used a simple decision tree, this time to estimate the incremental cost per life saved (Jensen et al 1989). It used a number of plausible simplifying assumptions (e.g. smoke detectors do not prevent fires, that enforcement carries costs) and various national data sources to estimate the likely level of take-up and compliance should states which currently have no law choose to introduce one.

A sophisticated aspect of their modelling, and one explored in their sensitivity analysis, was to assume a different probability of (a) experiencing a domestic fire (b) properly installing and maintaining the detector, amongst (i) those who own a smoke detector voluntarily (ii) those coerced by the law into obtaining a detector, and (iii) those who refuse to obtain a detector even when required by law. While the decision tree model is highly plausible and, in the above respect, quite sophisticated, the sources of the probability data are quite varied and and the sources of the cost data not well described at all. In fact, given that the per household cost of enforcement used was $0.50 and the cost per detector was $1 (sources not stated), there is considerable doubt over the validity of the costs of implementing the legislation. (NB. for the assumption that, where a residential fire occurs, people are twice at risk of dying in a home without than one with a smoke detector, they cite a 1982 report by the USA's Federal Emergency Management Agency)

Table 5. Published economic studies of other injury prevention legislation: Study designs

Author, year	Analysis type, data	Country, setting	Population, Data sources	Interventions & comparators	Perspective & Model	Time horizon, discounting	Costs & savings included	Benefits included & Statistic estimated	Sensitivity analyses
Han et al. 2007	Decision tree model-based CEA Data years: Various: 1991, 1995-2000, 2002-2003 Base year: 2002	Ontario, Canada (Whole province)	Children aged from 0 to 9 years Data sources: Hospital for Sick Children Erdmann et al. 1991 (impact of legislation on hospital admissions) National Ambulatory Care Reporting System + others	Legislation to set thermostat settings on new domestic water heaters to a maximum of 49˚C, plus annual educational notices vs No legislation	Implicit societal (but see only two types of cost) Decision tree	10 years 3% per year discounting	Cost of policy/programme • Costs of legislation: NONE • Cost of educational notices Cost due to impact • Health care costs avoided	Scald cases prevented Cost per Scald cases prevented	One-way and threshold analysis

Author, year	Analysis type, data	Country, setting	Population, Data sources	Interventions & comparators	Perspective & Model	Time horizon, discounting	Costs & savings included	Benefits included & Statistic estimated	Sensitivity analyses
Jensen et al. 1989	Decision tree model-based CEA Data years: 1982 or 1983 Base year: 1983	USA, Setting or decision context not stated	Children and adults (presumed) Data sources: Federal Emergency Management Agency US National Fire Incident Reporting System	Legislation to make the installation of smoke detectors in private homes compulsory (NB. enforcement or publicity strategies not specified) vs No legislation	Not stated (but partial societal – see included costs) Decision tree	NR NR	Cost of legislation: • Detector purchase costs • Enforcement activity Cost of fire property damage avoided	Lives saved Cost per life saved	One- and two-way

CEA = Cost-Effectiveness Analysis

Table 6. Economic studies of other injury prevention legislation: Results

Author, Year, Country	Legislation change	Cost of the introducing the legislation	Costs related to impact of legislation	Effectiveness the intervention	Cost-effectiveness or cost-benefit base case results
Han et al. 2007 Canada	Legislation to set thermostat settings on new domestic water heaters to a maximum of 49˚C	C$51,000	Health care cost savings of C$480,000 (=C$1.65m - C$1.17m)	895 avoided cases of tap-water scalds (=1599-704)	Legislation both cheaper and more effective than no legislation
Jensen et al. 1989 USA	Legislation to make the installation of smoke detectors in private homes compulsory	$1.50 per year (= $0.50 enforcement & $1.00 detector costs)	Not stated But total net costs (legislation less savings) were from -$150,000 to -$250,000 (i.e. savings)	825 lives saved across USA per year	Legislation both cheaper and more effective than no legislation $65,000 per life saved (if only costs of legislation are included)

a

Legislation regarding hot water thermostat settings: cost-effectiveness

The analysis of this policy in Canada estimated that the legislation would be both cost-saving and more effective in terms of tap-water scalds prevented than no legislation. In fact, the health care cost savings from injuries avoided were estimated as almost ten times the cost of implementing the legislation (C$480,000 vs C$51,000). One-way sensitivity analysis of six key model assumptions suggests that the intervention would remain cost-saving under all plausible variations of these parameters (prior incidence of tap water scalds, hospital admission rate for scalds, skin graft rate, direct medical care unit costs, cost of intervention, and effectiveness of intervention – varied from a reduction of 38% to 73% in number of tap water scalds)

Legislation on compulsory fitting of smoke detectors: cost-effectiveness

The economic analysis of smoke detector legislation in the USA estimated that this legislation would produce net savings (i.e. enforcement plus detector costs, less injury-related savings) of between $150,000 and $250,000, alongside saving over 800 lives per year across the USA. If the health care cost savings due to injuries averted are excluded from the analysis, the cost-effectiveness would be approximately $65,000 per life saved.

Note that the cost-effectiveness estimates from this study relate to both children and adults.

4.4. Speed enforcement strategies (Canada & UK)

We found two cost-benefit analyses which assessed the impact of speed enforcement programmes (see Table 7 and Table 8). In addition a later study from the UK was brought to the review group's attention after the submission of the original final report in October 2009. This study, by PA consulting with UCL (2005) is summarised below, but is not critically appraised or described in the tables mainly because the level of

detail in the report on their cost-benefit analysis would not justify it. The study by Chen (2002) was of a mobile, police-delivered, photo radar programme in British Columbia, Canada. The study by Hooke et al 1996 evaluated the cost-benefit of automated speed cameras across 420 sites in ten police force areas in the UK.

The photo radar based speed enforcement programme in British Columbia involved mobile units being widely deployed, but with initial operations focusing on areas of community complaints about speeding and also where there was a high frequency of collisions (Chen, 2002). In terms of what sanctions followed speeding violations, they were mainly speeding fines (from C$115 to C$460 per incident in 1997); the highest fines were in school and construction zones.

The cost-benefit analysis methods were very comprehensive in terms of identifying and estimating the cost of planning, developing and operating the programme, and the cost or financial value of collisions avoided (see Table 7). This reflected the author's intention to adopt a conservative approach to estimating the benefits; so, for example, although the analysis included the substantial societal value of reducing fatal and non-fatal collisions, it also estimated and included the value of time lost due to longer road journeys and time lost due to disputing tickets.

The evaluation report by Hooke et al. (1996) of speed cameras (and traffic light cameras) in the UK provides a comprehensive assessment of their effectiveness, cost and cost-benefits and the whole process of installation and operation, and the enforcement of offences. Despite this, the description of the methods used to make their cost-benefit assessment is very scant (NB. it would not have been possible to formally assess the study against conventional criteria). However, it can be deduced that they evaluated outcomes over different time periods (one, five and ten years) and the analysis is probably from a societal perspective (assuming that their attributed value for an accident avoided was derived from a willingness to pay exercise – which is not clear). They compared the whole programme of 420 camera sites in ten police forces, based on 1995-96 data, with the absence of the programme.

After submission of the original Final Report to NICE (20th October 2009 version) the following economic study was also brought to the review group's attention:

A report in December 2005 by PA Consulting with UCL updates an earlier (2004) analysis published by the Department of Transport, and analyses collision and casualty data from 38 road safety camera areas that were operating within the national programme over the four year period from April 2000 to March 2004. It should probably be regarded as superseding the results of the older Hooke et al (1996) study.

Table 7. Published economic studies of speed enforcement strategies: Study designs

Author, year	Analysis type, data	Country, setting	Population, Data sources	Interventions & comparators	Perspective & Model	Time horizon, discounting	Costs & savings included	Benefits included & Statistic estimated	Sensitivity analyses
Chen 2002	Model-based CBA Data years: 1996-1998 Base year: 2001	Canada, Whole of British Columbia (BC)	All road users in BC Data sources: Previously published evaluations (Chen et al. 2000 and Chen et al. 2002); BC government; Insurance Corporation of British Columbia	British Columbia photo radar programme, comprising: wide deployment of photo radar units, plus extra police to operate them. Higher fines in school and construction zones vs No photo radar enforcement programme	Societal & Provincial Insurance agency Simple model	NA: Annualised costs & benefits (although 10-year life of equipment assumed) 6% per year	Costs of providing the programme • Start-up (planning, equipment, software, signing, programme education/publicity • Police costs • Photo & ticket processing • Equipment maintenance costs • Court costs Effect of injury reductions; societal value of: • Fatal collisions • Non-fatal Injury collisions • Time loss due to speed reductions • Time loss ins disputing tickets	*Net benefit	One-way only

Author, year	Analysis type, data	Country, setting	Population, Data sources	Interventions & comparators	Perspective & Model	Time horizon, discounting	Costs & savings included	Benefits included & Statistic estimated	Sensitivity analyses
Hooke et al. 1996	Calculation-based CBA Data years: 1995-1996 Base year: 1995/6	UK 10 Police force areas in the UK	Data sources: Participating police forces, local authorities, Highways Agency, magistrates' courts, and Crown Prosecution Service.	Speed cameras implemented at 420 sites across 10 police forces vs not having the speed cameras	Societal	1, 5 and 10 year periods Discounting at 6% per year	Costs of providing the programme • Annualised fixed costs • Recurrent running costs Effect of speed cameras;: • Fine income • Value of accident reductions	*Net present value (at 1, 5 and 10 years)	One-way sensitivity analysis of time horizon and 5 key variables

CBA = Cost-Benefit Analysis; *Net Benefits, Net Savings and Net Present Value are the same (i.e. they are calculated in the same way)

Table 8. Economic studies of speed enforcement strategies: Results

Author, Year, Country	Legislation change	Cost of the introducing the legislation	Costs related to impact of legislation		Effectiveness the intervention	Cost-effectiveness or cost-benefit base case results		
Chen, 2002 Canada	Photo radar program	Start-up (capital costs) of: C$4.745m Ongoing programme costs: C$22.545m	Safety improvement (WTP value of deaths and injuries avoided): C$513.930m + Time lost – due to travel slowing: -C$371.643m + Time lost – disputing tickets: -C$1.041m = C$141.245m		Annual reduction in injury collisions: 1,542 Annual reduction in fatal collisions: 70	From a societal perspective: Net Benefits* of C$113.955 From the perspective of the Insurance Corporation of British Columbia (only cost saving = claims avoided due to reduced speeding): Net Savings* of C$38.264m		
Hooke et al. 1996 UK	Automated speed cameras at 420 sites, in 10 police force areas	Annual fixed costs + Annual recurrent costs (£'000s)	Annual fine income (£'000s)	Annual value of accident reduction (£'000s)		Net Present Value* (£000s) after 1 year	Net Present Value (£000s) after 5 years	Net Present Value (£000s) after 10 years
		5,264 + 3,595	6,730	30,239		+26,391	+136,074	+241,690

WTP = Willingness to Pay, and common valuation approach in economics for non-marketed goods.

*Net Benefits, Net Savings and Net Present Value are the same (i.e. they are calculated in the same way)

Speed enforcement strategies: results

The photo radar programme in British Columbia was estimated to produce net benefits to society of about C$114 million (in 2001 C$), and still produced substantial net savings of C$38 million if only considered from the provincial insurance corporation's perspective (Chen, 2002).

Similarly, the 420 automated speed camera sites in the UK in 1995/6 (Hooke et al. 1996) were estimated to have a positive Net Present Value of over £26 million, even after one year, rising to £241 million after ten years. This is because annualised fixed costs of £5.3 million plus annual recurrent costs of £3.6 million, would be offset not just by the £6.7 million in fine income, but also the over £30 million in the estimated annual value to society of accidents avoided. In all ten police force areas there was a positive net present value (i.e. benefits exceeded costs) within a year of the programme starting. Two police forces, accounting for over 70% (299) of the 420 speed camera sites evaluated, generated over half of the total net benefits of the programme across the ten police forces.

However, these older findings from Hooke et al should be seen as having been superseded by the more recent study for the Department for Transport, which evaluated the national safety camera programme (four-year evaluation report; PA Consulting with University College London, 2005). In this study, it was estimated that there would be 4,230 fewer personal injury collisions (any road collision which results in at least one casualty, whether fatal, serious or slight) annually as a result of the safety cameras across all 38 safety camera partnerships. At an estimated value of £61,120 per collision avoided (using DfT standard estimates for 2004) this means an annual estimated economic benefit of £258 million. This compares with the total annual cost of the programme of £96 million. Comparing only the revenue costs per collision prevented (£61,120) with the corresponding economic benefit per collision due to injuries prevented (£22,653) over the four years gives a cost-benefit ratio of approximately 2.7:1. They also use data from both speed and red light camera sites, although at speed camera sites the falls in personal injury collisions were associated with falls in speeds.

Sensitivity analyses explored the impact on these estimates of a gradual reduction in collision reduction benefits over time, the possibility that some accidents would be 'displaced' to other roads, fine income declining (or not treated as an off-settable benefit), or no financial value attached to accident reductions. For all these varied assumptions net present values of the programme remained positive, except that without the value of accidents avoided the programmes benefits would only exceed the costs after two years.

5. Discussion

5.1. Main findings

Compulsory wearing of bicycle helmets

The three economic evaluations of legislation about bicycle helmets all compared costs with different measures of effectiveness or societal benefit (e.g. net benefit, cost per life saved, cost per life-year saved, cost per hospitalisation prevented, cost per injury avoided) (Taylor & Scuffham, 2002; Hansen & Scuffham, 1995; Hatziandreu et al, 1995). Partly as a result of this there is inconsistent evidence from New Zealand and the USA that national laws to make the wearing of bicycle helmets compulsory would be cost-effective from a societal perspective. However, from a *public sector* perspective – critically, omitting the cost to individuals or families of purchasing bicycle helmets – the measure is likely to by highly cost-effective. The two New Zealand studies suggested that bicycle helmet laws would be more cost-effective in younger (age 5-12 years) than older children (age 13-18), and one of them estimated that costs would probably exceed benefits in older children and adults (again, from a societal perspective) (Taylor & Scuffham, 2002; Hansen & Scuffham, 1995).

The USA study also estimated the cost-effectiveness of community-wide and school-based strategies for promoting the wearing of bicycle helmets did not directly compare these strategies with the legislative approach (Hatziandreu et al, 1995). However, when compared with 'no programme' the legislative approach was the most cost-effective of the three strategies (but still with an estimated cost per life-year saved of over US$900,000 – which, from a health care perspective, would not normally be judged as cost-effective).

Water heater thermostat settings

One model-based cost-effectiveness analysis from Ontario, Canada, estimated that legislation to restrict the thermostat temperature on (newly manufactured) hot water systems would be both cost-saving and more effective in terms of tap-water scalds prevented, compared with no legislation (Han et al 2007). In fact, the health care cost savings from injuries avoided were estimated as almost ten times the cost of

implementing the legislation (C$480,000 vs C$51,000). However, note than only the educational component of the programme (educational notices about the risks of tap-water scalds sent with utility bills) was included as a 'cost of the legislation'.

Compulsory smoke detectors

The model-based economic analysis of smoke detector legislation in the USA estimated that implementing this legislation to make the fitting of detectors compulsory in all US states would produce net savings (i.e. enforcement plus detector costs, less injury-related savings) of between $150,000 and $250,000 per year, alongside saving over 800 lives per year across the USA (Jensen et al. 1989). If the health care cost savings due to injuries averted are excluded from the analysis, the cost-effectiveness would be approximately $65,000 per life saved.

Camera or radar speed enforcement programmes

There were two cost-benefit analyses which assessed the impact of speed enforcement programmes. The photo radar programme in British Columbia was estimated to produce net benefits to society of about C$114 million (in 2001 C$), and still produced substantial net savings of C$38 million if only considered from the provincial insurance corporation's perspective (Chen, 2002).

Similarly, the 420 automated speed camera sites in the UK in 1995/6 (Hooke et al. 1996) were estimated to have a positive Net Present Value of over £26 million, even after one year, rising to £241 million after ten years. This is because annualised fixed costs of £5.3 million plus annual recurrent costs of £3.6 million, would be offset not just by the £6.7 million in fine income, but also the over £30 million in the estimated annual value to society of accidents avoided. In all ten police force areas there was a positive net present value (i.e. benefits exceeded costs) within a year of the programme starting.

These older findings from Hooke et al should be seen as having been superseded by the more recent study for the Department for Transport, which evaluated the national safety camera programme (four-year evaluation report; PA Consulting with University College London, 2005). [NB. This study was added to the review after the original Final report was submitted to NICE]. In this study, it was estimated that there would

be 4,230 fewer personal injury collisions (any road collision which results in at least one casualty, whether fatal, serious or slight) annually as a result of the safety cameras across all 38 safety camera partnerships. At an estimated value of £61,120 per collision avoided (using DfT standard estimates for 2004) this means an annual estimated economic benefit of £258 million. This compares with the total annual cost of the programme of £96 million. Comparing only the revenue costs per collision prevented (£61,120) with the corresponding economic benefit per collision due to injuries prevented (£22,653) over the four years gives a cost-benefit ratio of approximately 2.7:1. They also use data from both speed and red light camera sites, although at speed camera sites the falls in personal injury collisions were associated with falls in speeds.

5.2. Strengths of the review

This systematic review has been based on explicit review questions, and used search strategies developed by an information specialist, which were specifically designed to identify potentially relevant studies. Our search strategy combined searching the hits of previous comprehensive searches in the same topic area, together with some new bibliographic searches in databases of economic literature.

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.

5.3. Limitations of the review

5.3.1. 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 very little time available for checking study inclusion/exclusion choices or for checking data extraction.

e

By searching within our previous search results (for the seven other systematic reviews on the broader topic) - rather than implementing a full new search strategy – people may question the validity of this approach to searching. However, given that the new search we conducted for this review, in EconLit and NHSEED, did not produce any new includable studies (at least not any that hadn't already been identified from our 'searches within searches') we are confident that we have found most if not all of the published literature relevant to our review question.

5.3.2. Main limitations of the included studies

Relatively few studies relevant to our review question were found. However, they fortunately cover legislation or enforcement strategies for which there was some evidence regarding effectiveness from the previous reviews in this series (see Table 9).

Table 9. Previously reviewed evidence on the effectiveness of legislation etc. on preventing injuries in children, with coverage of cost-effectiveness evidence shown

	PDG 1 Review International evidence	PDG 3 Review Injuries on the Road	PDG 4 Review Injuries in the Home	PDG 6 Review Injuries Outdoors at Play and Leisure
Legislation	Legislative frameworks/degree of safey legislation Off-road leisure vehicles		**Smoke detectors** Window guards **Hot water system temperatures** Swimming pool fencing	**Wearing of bicycle helmets** Restricted sale of fireworks
Regulations				
Standards				Playground design standards
Enforcement		**Speed enforcement cameras/devices** Other speed enforcement strategies (e.g. media)		
Mass media				Wearing of bicycle helmets
Other/Mixed strategies		National injury reduction targets		Mixed mass-media, community campaign to promote use of life vests to prevent children from drowning

Source: PUIC Programme reviews for PDG 1, PDG 3, PDG 4 and PDG 6.
Bold text indicates legislation or strategic policies where this review has found at least one study

As before with economic evaluations of more 'upstream' or strategic interventions, their methods are often described in minimal detail. This is especially true for UK-based transport and road safety evaluations (e.g. Hooke et al. 1996). However. the study by Hooke et al was the only one from the UK, all the others being from the USA, Canada or New Zealand.

Only the study by Hatziandreu et al (1995) compared legislative approaches with other strategic approaches, in this instance, for encouraging children to wear bicycle helmets. All of the other evaluations only compared legislation or enforcement programmes with the absence of those programmes. This is clearly a limitation, in that there will almost always be non-legislative more publicity-based strategies as an alternative to bringing in a law to make certain behaviours mandatory. In general, it is disappointing that the economic evaluations mainly focused on legislation and the enforcement of legislation, with only one study focusing on standards (thermostat settings), and none focusing on regulations, mass media and other strategies approaches.

While some studies briefly considered the possible costs of developing and implementing legislation, regulation or standards (e.g. Han et al. 2007), few actually estimated such costs and included them as part of their cost-effectiveness calculations or modelling. This is despite examples from other studies which have estimated the cost of developing and implementing standards (Rodgers & Leland 2008). Also, if public health policy making adopts a public sector perspective – as opposed to a societal perspective for analysis – then those costs of implementation that fall on individuals (e.g. the purchase of bicycle helmets) would not be included as a cost of the legislation or other strategic approach.

The ratios produced by those cost-effectiveness studies where the legislation or strategic policy was both more costly and more effective are hard to interpret. While there are notional thresholds for deciding what might be judged as cost-effective in terms of cost per life-year, or cost per quality-adjusted life-year, it is difficult to know whether a particular 'cost per hospitalisation prevented' or 'cost per injury avoided' represent good value for money or not.

Sensitivity analyses were often quite limited, typically exploring the impact of less than ten alternative assumptions. However, in most of the studies that we found this is of minor concern, as the extent to which benefits exceeded costs (in cost-benefit analyses), or the margin by which legislation dominated 'no legislation' (i.e. was both more effective and substantially cost-saving) was typically very large. In other words,

more extensive and sophisticated sensitivity analysis, while often useful, would be highly unlikely to alter the conclusions in most of the included studies.

5.3.3. Insights for possible economic modelling

One of the two aims of this review was to help inform the possible focus for a planned economic modelling exercise. This has been achieved in two ways. Firstly, the health economist who has conducted this review has read and reflected upon the included studies as well as other relevant studies found by the searches. Second, for informing NICE public health guidance, the included studies provide the following insights:

- The paucity of studies which assess the cost of process of drafting, consulting on and/or passing any legislation or standards.
- The likely restriction of accurate costs of injuries to those types of legislation and/or enforcement which relate to preventing specific injury types (e.g. bicycle helmets and head injuries), or to countries where health services must keep more detailed records of injuries involving certain objects or substances (e.g. consumer products, or poisons).
- Evaluations of enforcement strategies are more likely (and therefore cost-effectiveness analysis more feasible) where the enforcement is achieved via specific measuring devices (e.g. speed cameras) which can be deployed to particular localities.
- The economic evaluation of potential changes in relevant legislation, regulation, standards and other strategic approaches in the UK context is dependent on the availability of valid and generalisable research evidence on the effectiveness of such strategies elsewhere.

5.3.4. Further research

In general, there simply needs to be more high quality economic evaluations of strategic programmes and policies to prevent unintentional injuries to children (or to

children and adults), including better attempts to evaluate more formally the cost-effectiveness or cost-benefits of legislation and regulatory approaches to preventing injuries.

Future economic evaluations of legislative or regulatory strategies for injury prevention should make greater efforts to estimate the resources involved in proposing, drafting and passing laws or regulations (i.e. as well as the costs of implementing or enforcing them).

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