Bicycle helmets: review of effectiveness (No.30)

Contents

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Project brief

Background

As part of its policy to improve the safety of pedal bicyclists DfT promotes the use of bicycle helmets, particularly amongst children. However, there is a wealth of published evidence both for and against promotion and compulsory use of bicycle helmets, and DfT requires an independent objective critique of the most up-to-date evidence on the efficacy of bicycle helmets. It is also important to have up-to-date information on legislative measures internationally and their impact on bicycling activity levels and safety.

Objectives

The objectives are:

- *to provide, in one volume, a critical review of research and literature on the efficacy of bicycle helmets. It is intended that this will provide a valuable reference source in formulating future policy and research decisions;*
- *consider where and how bicycle helmets are worn compulsorily and the impact of this on cycling and safety; and*
- *identify gaps in existing knowledge and research.*

Summary

The overall aim of this report is to examine the efficacy of bicycle helmets. Below, we summarise the key points from seven sections of our review.

Section 1: The epidemiology of bicycle injuries in Great Britain

- On average between 1998/2000 inclusive in Great Britain 28 children and 123 adults were killed as pedal bicyclists each year.
- For each child killed, there were 26 serious and 189 slight injuries and for each adult killed there were 17 serious and 106 slight injuries.
- There is some evidence of under reporting of bicycle injuries, particularly in children.
- Males are four times as likely to be killed or injured as females.
- Most bicycle injuries occur in teenage children or young adults.
- Head and face injuries make up a significant proportion of all bicycle injuries.
- There have been great declines in the distance cycled in Great Britain between 1985/1992.
- Bicycle helmet wearing rates in Great Britain have increased steadily in the last decade but are still low. In 1999 on busy roads the wearing rate was 22 per cent and on minor roads 8 per cent.

Section 2: Bicycle helmets standards

- Bicycle helmets aim to reduce the risk of injury due to impacts on the head.
- Bicycle helmets perform three functions: reduce the deceleration of the skull, spread the area over which the forces of impact apply, and prevent direct impact between the skull and impacting object.
- A range of different helmet standards have been developed in different countries but they are substantially similar. The main differences relate to the impact energy during the drop tests.
- Only the Australian/New Zealand and Canadian standards take serious account of the requirements of children, whose tolerances are lower.
- There is little evidence that helmets of different standards perform better in protecting the wearer.

Section 3: Observational studies

- Bicycle helmets have been found to be effective at reducing the incidence and severity of head, brain and upper facial injury.
- Bicycle helmets have been found to be effective in reducing injury for users of all ages, though particularly for children.

- While most studies indicate that helmets offer protection from head injury, the relative risk of injury in helmeted and unhelmeted bicyclists has varied in different studies.
- There is equivocal evidence relating to the link between helmet use and neck injury.
- There is very little evidence relating to helmet use and cycling style.
- There is considerable heterogeneity in the studies relating to definitions of head and brain injury, choice of controls, target group and context in which cycling takes place.
- Only one of the studies has been conducted in Great Britain.

Section 4: Evaluated intervention studies related to promotion of bicycle helmets

- Most bicycle helmet educational campaigns have been targeted at children.
- Bicycle helmet education campaigns can increase the use of helmets.
- Younger children and girls showed the greatest effects from the campaigns.
- Reducing the costs of helmet through discounts, and give-away programmes facilitates uptake and use.
- Only two of the studies have been conducted in Great Britain.

Section 5: Bicycle helmet legislation: evaluated studies and detailed case studies

- Bicycle helmet legislation has been associated with head injury reductions.
- Bicycle helmet legislation with supporting educational activities is an effective means of increasing observed helmet use.
- Compulsory helmet wearing may discourage some bicyclists leading to decreased bicycle use.
- In Australia, New Zealand and Canada, legislation has not been introduced until high levels of helmet wearing have been attained in the population.

Section 6: Barriers and facilitators of helmet use

- Most of the literature on barriers and facilitators of helmet use has focused on children and teenagers.
- Over time, helmet use has increased, but there remain differences in helmet-wearing rates between and within countries.
- Barriers to helmet use include age (teenagers), social background (lower income), geographical factors, group effects associated with companionship, cost and discomfort.
- Attitudinal barriers to helmet use include low risk perception, peer pressure and parental influence.

Section 7: Opinion pieces

- The pro-bicycle helmet group base their argument overwhelmingly on one major point: that there is scientific evidence that, in the event of a fall, helmets substantially reduce head injury.
- The anti-helmet group base their argument on a wider range of issues including: compulsory helmet wearing leads to a decline in cycling, risk compensation theory negates health gains, scientific studies are defective, the overall road environment needs to be improved.
- The way in which the debate has been conducted is unhelpful to those wishing to make a balanced judgement on the issue.

Section 8: Discussion

In the discussion section, we discuss the heterogeneity within the literature and difficulties of combining studies. We set bicycle helmets within an overall context of bicycle safety, but emphasise that the focus of work has been related to secondary prevention. We consider the implications of our findings for child and adult bicyclists and discuss the importance of context and whether findings from one country can be easily transportable to Great Britain.

In the conclusions, we attempt to summarise what relevance the evidence reviewed has for bicycle helmet promotion in Great Britain.

Introduction

The overall aim of this report is to examine the efficacy of bicycle helmets. We set the scene by considering the specific context of the cycling environment in Great Britain and combine this with international perspectives on four main themes. These are bicycle helmet standards, case control studies of the protection offered by helmets, evaluated intervention studies of bicycle helmet education and/or legislation, and barriers and facilitators of helmet use.

We recognise that the effectiveness of helmets at the point of a crash, secondary prevention, is one part of a wider debate on cycling safety. Diagram 1 on page 11 contains three phases: pre-event, crash event, and post event (the Haddon Matrix). Helmets are only one part of improving bicycle safety. At the broader pre-event stage, bicycle safety is related to a range of government policies and other factors. Helmet promotion/legislation needs to be seen in the context of the climate of cycling. We address these wider questions in the Opinion pieces and Discussion sections of the report.

The review comprises nine sections:

1. The epidemiology of bicycle injuries in Great Britain
2. Bicycle helmet standards
3. Observational studies
4. Evaluated intervention studies related to promotion of bicycle helmets
5. Bicycle helmet legislation: evaluated studies and detailed case studies
6. Barriers and facilitators of helmet use
7. Opinion pieces
8. Discussion
9. Conclusions

In addition to this report, a technical annexe is also available with detailed tables of findings.

Methods employed

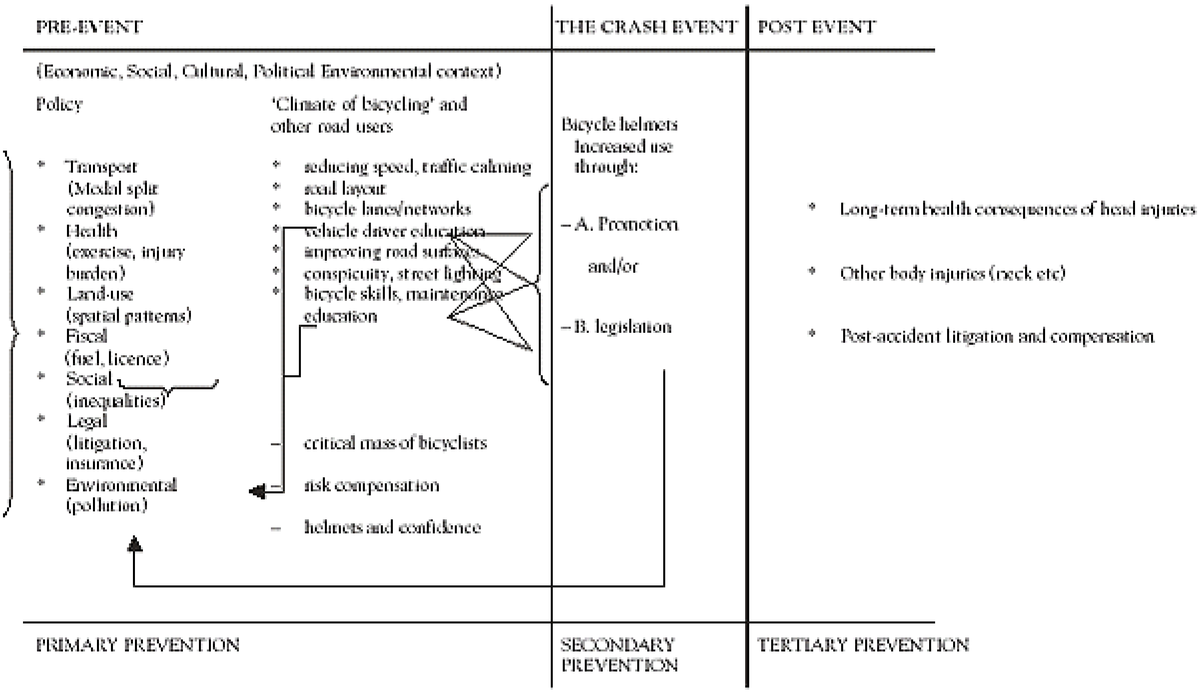
Identification of the literature. Literature has been identified through a search of a range of computerised databases (Web of Science, MEDLINE, CINAHL, Core Medical Collection and Biological Science Databases). In addition a Transport Research Laboratory Library search on International Transport Research was commissioned. These articles and reports have been supplemented by hand searching of relevant journals, such as *Accident Analysis and Prevention, Injury Prevention and Injury Control and Safety Promotion* and the reference lists of recently published articles, books and other systematic reviews. A database of primary sources has already been built up over the years within the Department of Child Health, University of Newcastle and this has also been searched systematically. Consultation with key informants has also taken place.

This review builds on an earlier review published by the Health Development Agency in 2001 (Towner *et al* 2001), particularly for Sections 4 and 5.

In Section 3 (Observational studies), Section 4 (Evaluated intervention studies related to promotion of bicycle helmets) and Section 5 (Bicycle helmet legislation), systematic reviews of the literature published since 1985 have been conducted. In Section 6 (Barriers and facilitators of helmet use) and Section 7 (Opinion pieces), a range of articles have been selected but a systematic coverage has not been done.

Information has been extracted for each of the sections using specially designed extractions forms (see Technical Annexe). The Technical Annexe provides information on bibliographical search terms used, definitions and scope of the studies, inclusion and exclusion criteria, the reviewing process, and how judgements were made on the quality of the evidence.

Diagram 1: Prevention of bicycle injuries a framework diagram



Section 1: The epidemiology of bicycle injuries in Great Britain

The bicycling environment varies considerably in different countries and varies with the road layout, topography, climate, traffic mix and cultural attitudes. In the Netherlands, for example, a large number of the population cycle regularly and this critical mass of bicyclists promotes a different response to bicyclists by other road users. The context of cycling is thus important and here we focus on epidemiology of bicycle injuries in Great Britain. Bicycling behaviour, experience, exposure and injuries are very different in children and adults and we therefore consider the groups separately (McCarthy 1991).

Pedal bicyclist casualties in Britain

The main source of road accident data on bicycling casualties in Great Britain comes from police STATS 19 reports, which are typically collected by the police at the scene of the accident. These statistical returns cover all accidents in which a vehicle is involved that occur on roads and footways and result in death or personal injury, if they become known to the police. The severity of the accident significantly affects the likelihood of recording and many more minor bicycling injuries are not reported to the police (British Medical Association, 1999). Most fatal accidents amongst bicyclists occur as a result of being hit by a car (Department of the Environment, Transport and the Regions [DETR] 1997). Accidents in which no other vehicle is involved are less likely to be reported. Particularly in relation to children's accidents, there is considerable under representation of morbidity from cycle accidents in official statistics (Leonard *et al* 1999). Mills (1989) found that the level of under-reporting of bicycle injuries decreased as the age of the casualty increased. For child casualties aged 012 years, the level of under-reporting was over 80 per cent. This figure decreased to 68 per cent for 1317 year olds and 62 per cent for adult casualties.

Simpson (1996) compared casualties attending hospital and matched these with police casualty records. The matched sample had lower proportions of bicyclists and injuries to children.

Children 014. STATS 19 data for the three-year period 1998/2000 show that 84 children were killed as pedal bicyclists, 2,219 were seriously injured and 15,889 were slightly injured. (For detailed tables, see Technical Annexe.) The average annual number of bicyclist injuries was thus 28 killed, 740 seriously and 5,296 slightly injured. Males were far more likely to be injured compared with females (80:20) and this ratio was similar for each level of severity. There was also a steep age gradient, with older children (aged 1014 years) having the greatest number of casualties and pre-school children (aged 04 years) the fewest. A more pronounced age gradient occurred for deaths (74 per cent of child fatalities were aged 1014 years) than either serious or slight injuries. 80 per cent of casualties in the 07 age group and 68 per cent of the 812 age group were involved in a bike-alone accident (when no other vehicle was involved) (Mills 1989). Children in these age groups probably do most of their bicycling off the road or in quiet roads away from other vehicles. The most frequent cause of bicycle accidents in these age groups were playing or doing tricks and travelling too fast and subsequently losing control.

An estimate of annual bicycle accident rates for children aged 215 years can be obtained from the Health Survey for England (Purdon 1998). For major accidents (about which a hospital was used or doctor consulted) an overall rate of 2 per 100 children was obtained, with the highest rate of 4 per 100 in the 1213 age group. For minor accidents (all other accidents causing pain or discomfort for more than 24 hours) an overall annual rate of 13 per 100 children was estimated, with the highest rate of 30 per 100 in the 1011 age group.

Adults, 15 years and over. STATS 19 data for the three-year period 1998/2000 show that 370 people were killed as pedal bicyclists, 6,421 were seriously injured and 39,275 were slightly injured. (For detailed tables, see Technical Annexe.) The average annual number of bicycle injuries was thus 123 killed, 2,140 seriously injured and 13,092 slightly injured. Like bicycle injuries in childhood, males were far more likely to be killed or injured compared with females (79 per cent male, 21 per cent female). This ratio varied for different levels of severity, with males accounting for 83 per cent of fatalities, 81 per cent of serious injuries and 79 per cent of slight injuries. There is a steep decline of bicycle casualties with age. Nearly a third of adult bicycle casualties were aged <25 years and 60 per cent were aged 1534 years. The male:female ratio was similar at all ages, with a slight increase in the population of females injured in the middle age ranges.

Head injuries

In relation to this review on bicycle helmets, we are particularly interested in the number of pedal bicyclists casualties which involve head injuries. Simpson (1996) analysed national hospital data for the period 1993/1995 and found that 49 per cent of pedal bicyclist casualties sustained an injury to the head or face. Mills (1989) reported that 53 per cent of bicyclist casualties attending A&E departments had sustained head injuries.

Cook and Sheikh reviewed admissions data to NHS hospitals in England (Hospital Episode Statistics) for the period 1991/1995. Of the 12.6 million emergency admissions in the study period 35,056 (0.28 per cent) were for injuries sustained when bicycling. The average length of stay was 3.3 days. Head injuries was the primary diagnosis in 34 per cent (n=11,985) of these admissions, over half of which (n=7,531) were among children aged <16 years. 121 bicyclists (1 per cent) admitted with head injuries died as a result of their injuries (Cook and Sheikh 2000).

Bicycling exposure

Analysis of national travel surveys for different age groups for the period 1985/1992 showed that for children (aged 014 years) the average distance cycled in a year fell from 38 to 28 miles (26 per cent) (Di Guiseppi and Roberts 1997). Girls showed a greater decline than boys but the decline in bicycling mileage did not vary by age. For young people aged 15 to 19 years, the average distance cycled also fell, this time by 31 per cent from 135 miles to 93 miles. The declines were greater in young women than young men (Di Guiseppi *et al* 1998). In both children and young people walking also declined in this period but travel by car increased. A substantial proportion of the decline in pedal bicycle deaths in these age groups could be attributed to changes in travel patterns.

Linking exposure and mortality and morbidity patterns is not straightforward and we need to take into account different bicycling environments, both between and within countries. A report published in the early 1990s compared the safety of bicycling in the UK, Denmark, the Netherlands and Germany (Mynors and Savell 1992). 2 per cent of all trips in the UK took place by bicycle, compared with 10 per cent in Germany, 18 per cent in Denmark and 27 per cent in the Netherlands. The UK had one of the lowest fatality rates for bicyclists measured on a per head of population basis, but in terms of fatalities per kilometre cycled, the UK was the most dangerous of the four countries. The UKs fatal accident rate was five times that of the Netherlands, ten times that of Denmark, and slightly more than that of Germany.

Bicycle helmet wearing in Great Britain

Three nationwide observational surveys of bicyclists have been conducted in the last decade: in 1994 (Taylor and Halliday 1996); 1996 (Bryan-Brown and Taylor 1997); and 1999 (Bryan-Brown and Christie 2001).

In 1994, 27,417 bicyclists were observed at 79 busy sites across Great Britain. 16 per cent of all bicyclists were wearing a helmet. The survey was repeated in 1996 with similar numbers of observations at the same sites and the wearing rate was found to increase to 17.6 per cent, a small but significant increase. When the survey was again conducted in 1999 on built-up roads, the wearing rate had increased to 21.8 per cent. This was due to an increase in adult bicyclists wearing helmets, there was no change in wearing rates amongst children.

In the third survey in 1999, a range of quieter locations was also included in order to boost the sample of children observed and make the sample more representative of the national bicycling population. On built-up minor roads, the bicycle helmet wearing rate was observed to be 8.2 per cent, significantly less than that observed on built-up major roads. On these quieter roads both adults and children were less likely to be wearing helmets.

These nationwide observational surveys demonstrate that bicycle helmet wearing has increased over the years but they also show that rates differ markedly in different localities and the rates are still low.

Key points

- On average between 1998/2000 inclusive in Great Britain 28 children and 123 adults were killed as pedal bicyclists each year.
- For each child killed, there were 26 serious and 189 slight injuries and for each adult killed there were 17 serious and 106 slight injuries.
- There is some evidence of under reporting of bicycle injuries, particularly in children.
- Males are four times as likely to be killed or injured as females.
- Most bicycle injuries occur in teenage children or young adults.
- Head and face injuries make up a significant proportion of all bicycle injuries.
- There have been great declines in the distance cycled in Great Britain between 1985/1992.
- Bicycle helmet wearing rates in Great Britain have increased steadily in the last decade but are still low. In 1999 on busy roads the wearing rate was 22 per cent and on minor roads 8 per cent.

Section 2: Bicycle helmets standards

Almost all bicycle helmets that are the subject of the studies covered in this report conform to specific national and, very occasionally, international standards. However, it is rare for a study to report on the makes and models of helmets found in the study or the standards to which they conform. Given that most of the papers are based on the injuries that the wearer sustained (or did not sustain) rather than the engineering performance of the helmet, this is not surprising.

How bicycle helmets work

To understand the differences between helmets and the standards with which they conform, it is necessary to have a basic understanding of what helmets are intended to do and what they are not expected to.

Put simply, bicycle helmets (and most other sorts of helmets) aim to reduce the risk of serious injury due to impacts to the head. Serious head injuries can take two forms: skull injuries and brain injuries. While simple fractures to the skull can heal, brain injuries, unlike those to other body regions, do not and can lead to long-term consequences.

Bicycle helmets perform three functions:

- reducing the deceleration of the skull and hence brain by managing the impact. This is achieved by crushing the soft material incorporated into the helmet;
- spreading the area over which the forces of the impact reach the skull to prevent forces being concentrated on small areas of the skull; and
- preventing direct contact between the skull and the impacting object.

These three functions can be achieved by combining the properties of the soft, crushable material that is incorporated into helmets usually referred to as the liner, although it may be the only material of which the helmet is actually made and the outer surface of the helmet, usually called the shell. Historically, helmets had hard shells but now the tendency is for there to be no shell at all or a very thin shell. This leads to lighter helmets that are more acceptable to the wearer. To some extent, the shell was an artefact of one of the tests that the helmet had to pass: dropping the helmet on to a sharp or pointed object (or the dropping of such an object on to the helmet). When accident data are examined, such an impact is very rare and so helmet standards now take this into account, resulting in the lighter helmets.

To work at all, the helmet has to stay on the wearers head during the impact phase. Helmets therefore have retention systems usually a system of chin and neck straps that are tested to ensure that they do not break and that they prevent the helmet rolling off the head when a force is applied upwards at the back of the helmet as can occur when a rider is sliding along the road. Helmets have to work in a variety of climatic conditions: sunlight, containing strong ultraviolet light that can damage plastics over time; rain; heat; and cold. Some plastics become brittle when cold or softer when hot. However, helmets are required to provide adequate protection in all conditions, so the tests to which a helmet is subjected are performed following treatment in these conditions.

The amount of the head that a helmet can protect is driven by the needs of the bicyclist. Ideally, the helmet should provide protection against impacts anywhere on the skull, including the face, but the need for the wearer to see upwards and sideways, hear traffic and be able to tilt their head back when riding because of the seating position limits the extent of coverage significantly. In addition, the need for the head to be reasonably cool necessitates the incorporation of ventilation slots into the helmet.

Other factors that have to be taken into account are the tolerance to impact injury of the human head and the size/weight of the helmet that a rider is willing to use. Research has shown that decelerations of about 250300g are the maximum that can be tolerated by the adult head without leading to irreversible injury. (g is the acceleration due to gravity, approximately 9.8 m/s2). However, young children have lower tolerance to impacts and there are strong arguments for helmets for children having different maximum allowable deceleration, as in the Canadian standard. The thicker the energy absorbing material in the helmet, the better it is able to protect. Helmets are designed to provide a certain level of protection that still allows them to be of a socially acceptable size.

Bicycle helmet standards specify criteria that helmets have to meet when tested in reproducible ways in the laboratory, covering most of the points mentioned above impact absorption over a minimum specified area and under defined environmental conditions, and retention system strength and effectiveness. Design restrictions are usually incorporated into standards to cover peripheral vision and hearing obstruction requirements. Product information is specified through marking, labelling, point of sale information and instructional requirements. Finally, there are usually limitations on the types of materials that can be used to ensure that there are no adverse reactions between the helmet and the skin, sharp edges and points are outlawed internally and externally, and in some cases the total mass of the helmet is limited.

Standards have evolved and changed over time reflecting the state of knowledge of real crashes and the ways in which helmets have failed to provide protection. Given that most of the key requirements in standards are specified in terms of performance in tests, they do not restrict the development and use of new materials nor of the skills of the designer.

Comparisons of standards

This section compares the key requirements of the most common bicycle helmets, namely:

ANSI Z90.4	American National Standards Institute standard Z90.4. One of the first bicycle helmet standards and the basis for many of the others.
ASTM F1447	ASTM International (formerly the American Society for Testing and Materials). Before the CPSC regulation came into force (see below), more than 70 per cent of the bicycle helmets manufactured were certified to this standard. Very similar to the CPSC regulation. Has a certification procedure similar to the Snell system.
Snell B-90S	Specification from the Snell Memorial Foundation, an American nonprofit body. BS-90 is usually recognised as being a specification leading to high quality helmets. Has a rigid certification procedure.
Snell B-95	Also from the Snell memorial Foundation. More demanding than the B-90S specification; some argue that it is too demanding.
CPSC	Regulation enacted by the US Consumer Product Safety Commission in 1998, coming into force in 1999. All helmets sold in the US have to meet its requirements.
BS 6863: 1989	British Standards Institution specification, published in 1989 and later slightly amended. Withdrawn under CEN rules when the CEN standard EN 1078 (see below)

	was published in 1997.
EN 1078	Standard used by all members of CEN, the European standards-making body. Published in 1997.
EN 1080	Standard used by all members of CEN, the European standards-making body. Published in 1997 to address problems associated with strangulation of children playing while wearing helmets. Intended for helmets for young children.
AS/NZS 2063	Joint Australian and New Zealand standard published in 1996. Noted as a highly respected specification.
CSA-D113.2-M	Canadian Standards Association specification. One of the very few standards that contains specific requirements for helmets for young children.

In Table 2.1, the key features of these standards are presented. As can be seen, in terms of these criteria, the different standards are substantially similar, the main differences being the input energy during the drop tests. Only the Australia/New Zealand and Canadian standards take serious account of the requirements of children by specifying different requirements for helmets tested on smaller headforms.

One standard that is significantly different from the others is EN 1080. This was drafted following a number of fatal strangulations of children playing on playground equipment and elsewhere while wearing helmets complying with EN 1078. In these incidents, the helmeted child became trapped in the playground equipment (through which an unhelmeted head would pass) and the childs weight was supported by the chinstrap. To accommodate this scenario, the standard was written that allowed helmets with a relatively weak retention system to be manufactured so that if such a potential strangulation occurred the retention system would open. When this standard was being drafted, the fear was expressed that such a helmet could come off in a crash, when it is essential that the helmet stays in place in order to provide protection to the head. EN 1080 has no test of the effectiveness of the retention system (the so-called roll-off test).

There is little, if any, research evidence that helmets complying with one standard as opposed to another perform better in protecting the wearer in the event of a crash.

It has to be remembered that before the publication of the CPSC regulation in the USA, none of the standards was mandatory. In Europe, there is no requirement to conform to the CEN standard. In practice, a manufacturer only has to meet the so-called essential safety requirements of the Personal Protective Equipment Directive, with compliance with EN 1078 being one means of achieving this. The certification and enforcement processes are important aspects of this issue; a good standard without an independent certification process or a poor enforcement procedure may allow inadequate helmets on to the market.

Until the Snell B90S standard with its associated certification procedure appeared in the USA, conformity was entirely in the hands of the manufacturer. In the UK, helmets carrying the BSI Kitemark were certified as meeting BS 6863 but the third party certification scheme was not mandatory. Currently, it is trading standards officers in the UK who would confirm compliance with the CEN standard, but this would probably only take place in the event of a dispute or significant helmet failure.

Key points

- Bicycle helmets aim to reduce the risk of injury due to impacts on the head.

- Bicycle helmets perform three functions: reduce the deceleration of the skull; spread the area over which the forces of impact apply; and prevent direct impact between the skull and impacting object.
- A range of different helmet standards have been developed in different countries but they are substantially similar. The main differences relate to the impact energy during the drop tests.
- Only the Australian/New Zealand and Canadian standards take serious account of the requirements of children, whose tolerances are lower.
- There is little evidence that helmets of different standards perform better in protecting the wearer.

Table 2.1: Key features of bicycle helmet standards

	ANSI Z90.4	**ASTM F1447**	**Snell B90S**	**Snell B95**	**CPSC**
Country of origin	USA	USA	USA	USA	USA
Status	Published 1984. Withdrawn, 1995	Current	Published 1990	Published 1995	Came into force 1999
Anvils	Flat and 50mm radius hemispherical	Flat, 48 mm hemispherical, and kerbstone	Flat, 48 mm hemispherical, and kerbstone	Flat, 48 mm hemispherical, and kerbstone	Flat, 48 mm hemispherical, and kerbstone
Drop apparatus	Twin wire drop rig	Guided free fall	Guided free fall	Guided free fall	Guided free fall
Impact velocity, energy or drop height flat anvil	4.57 m/s	2.0 m (6.2 m/s)	100 J (2.0 m)	110 J (2.2 m) for certification; 100 J (2.0 m) for follow-up testing	6.2 m/s
Drop height other anvils	4.57 m/s	1.2 m (4.8 m/s)	65 J (1.3 m)	72 J (1.5 m) for certification; 65 J (1.3 m) for follow-up testing	4.8 m/s
Impact energy criteria	< 300g	< 300g	< 300g	< 300g	< 300g
Roll-off test	None	Yes	Yes, in 1994	Yes	Yes

			revision		
Retention system strength	Force applied dynamically. Helmet supported on headform.	Force applied dynamically. Helmet supported on headform.	Force applied dynamically. Helmet supported on headform.	Force applied dynamically. Helmet supported on headform.	Force applied dynamically. Helmet supported on headform.

Table 2.1: Key features of bicycle helmet standards (continued)

	BS 6863	**EN 1078**	**EN 1080**	**AS/NZS 2063**	**CSA-D113.2-M**
Country of origin	UK	Countries in membership of CEN (EU and EEA)	Countries in membership of CEN (EU and EEA)	Australia and New Zealand	Canada
Status	Published 1989. Withdrawn, 1997	Published, 1997	Published, 1997	Published 1996	Published 1996
Anvils	Flat and kerbstone	Flat and kerbstone	Flat and kerbstone	Flat	Flat and cylindrical (50 mm radius)
Drop apparatus	Twin wire drop rig	Guided free fall	Guided free fall	Twin wire drop rig	Twin wire drop rig
Impact velocity, energy or drop height flat anvil	4.57 4.72 m/s	5.42 5.52 m/s	5.42 5.52 m/s	1.451.80 m.	Ranges from 80 J for largest headform to 34 J for smallest
Drop height other anvils	4.57 4.72 m/s	4.57 4.67 m/s	4.57 4.67 m/s		
Impact energy criteria	< 300g	< 250g	< 250g	< 300g, < 200 g for 3 ms, < 150g for 6 ms	Level depends on headform size and drop energy. Ranges from 150g for smallest to 250g for largest
Roll-off test	None	Yes	Yes, in 1994 revision	Yes	Yes
Retention system strength	Force applied dynamically	Force applied dynamically. Helmet	Force applied gradually until helmet	Force applied statically	Force applied dynamically

strength	. Helmet supported on headform.	supported on headform.	releases from headform. Helmet supported on headform.	statically	

Section 3: Observational Studies

In injury research it is often ethically inappropriate to use randomised trials in populations. Obviously it would be unacceptable to cause head impacts in randomly assigned groups of helmet wearers and non-wearers and compare injury outcomes. Instead a comparative observational design is employed. In the studies described in this report observations were made, generally of hospital data, of injury outcomes following a bicycle accident where helmet usage was recorded. From these observations it is possible to obtain a measure of relative risk of injury for helmet wearers compared to non-wearers and in this way obtain a measure of how effective bicycle helmets are in reducing head injury.

A systematic review of the literature on observational studies of the effectiveness of bicycle helmets was conducted. This aimed to build on previous reviews by Attewell *et al* (2000) and Thompson *et al* (2001). Attewell reported protective effects of helmet use in relation to injuries to the head, brain and face as well as fatal injuries. Similarly, Thompson found that helmet use was associated with significant reduction of risk of head, brain, severe brain and upper and mid facial injuries for users of all ages.

Settings and participants

A total of sixteen studies were identified and reviewed. However, five of these studies were derived from two datasets, one dataset was used in both the 1989 and 1990 studies by Thompson *et al*. The second dataset was used in the studies by Thompson *et al* (1996) and Thompson, Nunn *et al* (1996) and Rivara *et al* (1997). Of these sixteen studies, the majority (thirteen in total) were hospital based. Two studies used bicycle enthusiasts as participants (Dorsch *et al* 1987, Wasserman *et al* 1988) conducted a roadside survey of cyclists.

Ten of the studies looked at injuries sustained by bicyclists of all ages, four considered injuries sustained by children only (Thomas *et al* 1994; Finvers *et al* 1996; Linn *et al* 1998; Shafi *et al* 1998) and one considered injuries sustained by adults only (Dorsch *et al* 1987). In one study the age of patients was unclear (Thompson *et al* 1996). Four studies compared protective performance of different helmet types (Dorsch *et al* 1987; McDermott *et al* 1993; Rivara *et al* 1997; Linn *et al* 1998). One study examined off-road bicycling (Jacobson *et al* 1998). A number of studies took into account collisions between bicyclists and motor vehicles, though only one (Spaite *et al* 1991) was restricted to these accidents.

Eight of the studies were from the USA, four were from Australia, two were from Canada and only one was from Britain. The British study (Maimaris *et al* 1994) was carried out in Cambridge, an area of high bicycling rates relative to the rest of Britain. Two of the studies were carried out in countries or states where bicycle helmet legislation had been introduced, nine where no legislation was in place. Four studies failed to make clear the legislative position of the location at the time of the study. One study (Shafi *et al* 1998) included periods before and after the introduction of bicycle helmet legislation, but failed to compare the difference in risk of head injury in the two periods.

Methods and study design

One of the difficulties in comparing the studies reviewed was the heterogeneity that existed within the sixteen studies. Differences in procedure and analysis were apparent throughout the studies, examples of which are given here.

Design

Three classes of design were used.

Design 1 Cases and controls were restricted to those who had sustained a head impact.

Design 2 All who presented to hospital were considered (i.e. had not necessarily sustained a head impact) and adjustment was made for possible confounding variables.

Design 3 All who presented to hospital were considered but no adjustment was made for possible confounding variables.

In studies of the efficacy of bicycle helmets, the main question is whether helmets protect the bicyclist from head injury in the event of a head impact. To answer this question, the rate of head injury among helmet-wearing bicyclists who suffer a head impact should be compared with the rate of head injury among non-helmet wearing bicyclists who suffer a head impact (Jarvis *et al* 1994). This comparison can be made directly using Design 1, but not using the other designs. The odds of head injury among cyclists who had a head impact is thus estimated from:

$$\frac{\textit{(Number of bicyclists who had a head impact and suffered a head injury)}}{\textit{(Number of bicyclists who had a head impact)}}$$

In the estimation of risk of head injury, studies employing Designs 2 and 3 estimate the odds of head injury among bicyclists from:

$$\frac{\textit{(Number of bicyclists who had a head impact and suffered a head injury)}}{\textit{(Number of bicyclists who had a head impact and suffered a non-head injury + number of bicyclists who had an accident but not a head impact and suffered a non-head injury)}}$$

Compared to the formula for Design 1, these studies exclude bicyclists who had a head impact but no injury and include bicyclists who did not have a head impact but who suffered a non-head injury. Hence, these studies can either over-estimate or under-estimate the protective effect of helmets.

Studies using Design 2, which adjust for factors such as age, sex, riding conditions, speed, road surface and collision with motor vehicles may partly compensate for the inadequate design, as allowing for these features may be more likely to compare cases who had a head impact with controls who had a head impact. In this way they are more desirable than studies of Design 3 which make no effort to adjust for these potentially confounding factors.

Setting

The majority of studies recruited cases and controls from those who presented to an emergency department for treatment, though Shafi *et al* (1998) restricted their study only to those who had been admitted to hospital. The thirteen hospital-based studies used Design 2 or 3. Of the remaining three studies, one (Wasserman *et al* 1988) obtained data by interviewing bicyclists in the street and two (Wasserman and Buccini 1990; Dorsch *et al* 1987) obtained data from mail questionnaires. These three studies using Design 1 rely solely on self-report of injuries rather than clinical records. Self-report, by its very nature, can be an inaccurate method of collecting data on injury, particularly after long periods of time have elapsed between injury and recall. Wasserman and Buccini (1990) allowed reported injuries that had occurred within the previous 18 months, Dorsch *et al* (1987) do not state whether a maximum time frame was allowed and Wasserman and Buccini (1990) included self-reports of accidents that had occurred up to five years previously. We would suggest that recollection of injury after five years should be regarded with some caution but it is possible that even more recent injuries may suffer recall bias. Wasserman and Buccini report that a third of helmeted and 40 per cent of unhelmeted bicyclists reported suffered from concussion, yet only 50 per cent of their sample attended a doctor or A&E department and only 25 per cent were admitted to hospital.

It is worth noting that even within the hospital studies, whilst clinical evaluation was largely obtained from medical records, helmet use at the time of the accident was often taken from questionnaires or interviews with the patient or their parents. It is possible that some individuals mis-reported helmet wearing, particularly when helmet legislation was in place.

The legislative position of the region of the study also poses problems in trying to make direct comparisons between the studies. For example, comparing non-helmet wearing bicyclists in the Maimaris study (set in the UK where there is no helmet legislation) with those in the McDermott study (set in Victoria, Australia where all bicyclists are compelled by law to wear helmets) is potentially problematic. We are comparing those who chose not to wear a helmet with those who chose to break the state law by not wearing a helmet. It is possible that these two groups represent very different individuals whose attitudes and behaviours are not directly comparable.

Another difficulty lies in the context of bicycling within the studies. Can bicycle injuries sustained, for example, in the west coast USA city Seattle (for example Thompson *et al* 1989) be directly compared with those in Brisbane in sub-tropical Australia (Thomas *et al* 1994), where the climate of bicycling and patterns of bicycle use may be very different? These points raise questions about the transferability of findings from many of these studies to the UK context.

Definitions of injury

As well as considering the impact of helmet wearing on head injury ten studies considered brain injury, seven considered facial injury, three considered neck injury, three considered fatal injuries and eight considered injury to other parts of the body. Within the classification of injury types there was no uniform approach. The most common approach was to use evidence of skull fracture. Some studies also included soft tissue damage (for example Thompson *et al* 1989; Jacobson *et al* 1998), whilst others (for example Shafi *et al* 1998) specifically excluded soft tissue injuries. Similar differences emerge in relation to brain and facial injuries. The most common assessment of brain injury was concussion (or worse) but some studies (Shafi *et al* 1998; Wasserman *et al* 1988) counted concussion as a head injury, not as a brain injury. In the consideration of facial injury, the face was variously divided into two regions (Thompson *et al* 1990), three regions (Thompson *et al* 1996) or not divided at all (McDermott *et al* 1993). It is important to bear these differences in definition in mind when making comparisons between studies.

Other factors

A number of other factors are worthy of consideration, such as age. There is evidence to suggest that children are more vulnerable to head injury than adults (Thompson *et al* 1989; Jacobson *et al* 1998). This should be borne in mind when comparing studies with different target age groups. Participants in the studies are designated as children at a variety of ages, ranging from under 14 years (Thomas *et al* 1994; Shafi *et al* 1998) to under 19 years (Linn *et al* 1998; Thompson *et al* 1996). This means that at the upper limit, child participants in some studies would be classified as adults in others.

Spaite *et al* (1991) considered only those who had been involved in a collision with a motor vehicle. Some studies (for example McDermott *et al* 1993; Rivara *et al* 1997; Linn *et al* 1998) included those who had died as a result of their injuries while others did not. Therefore some studies may have included more seriously injured bicyclists than many others.

Results

Odds ratios were calculated where possible from the data presented in the studies. In recognition of the considerable heterogeneity described above, it was felt that a formal meta-analysis of the results of the papers was inappropriate. All studies found evidence of a protective effect with regards to head injury of helmet wearing in the event of a bicycle crash. The level of protective effect varied between studies and is shown in the Technical Annexe. Protective effects were also found with regards to brain injury and upper face injury. No protective effects were found for lower face injury, but it should be borne in mind that current helmet standards do not require helmets to provide any facial protection. A reported connection between helmet wearing and an increased likelihood of neck injury (Wasserman and Buccini 1990; McDermott *et al* 1993) is not confirmed by other studies (Rivara *et al* 1997). A number of studies included analysis of injuries sustained by bicyclists to areas other than the head. As bicycle helmets clearly do not provide protection to non-head regions such as limbs, any differences in the number or nature of non-head injuries sustained by helmeted and unhelmeted bicyclists would be indicative of differences in bicycling style between the two groups. Where this analysis has been carried out there is no clear agreement with some studies reporting no differences in non-head injuries between helmeted and unhelmeted bicyclists (Wasserman and Buccini 1990; Finvers *et al* 1996) and others suggesting that unhelmeted bicyclists may have been involved in higher impact collisions than helmeted (Spaite *et al* 1991), a difference in riding style that may lead to an overestimate of helmet protection.

Rating criteria

In the evaluation of the sixteen studies reviewed, a number of factors were considered including quality of design, strengths and weaknesses within the design type, size of sample and appropriateness of statistical analyses used.

A consensus rating was reached between the reviewers regarding the quality of evidence provided by each study. This rating was qualitative in nature and not the result of strict scoring criteria. Studies were rated as good, reasonable or weak. These ratings are included in Table 3.1 in which each study is summarised presenting their setting, design and main findings, along with reviewers comments.

Key points

- Bicycle helmets have been found to be effective at reducing the incidence and severity of head, brain and upper facial injury.
- Bicycle helmets have been found to be effective in reducing head injury for users of all ages, though particularly for children.

- While most studies indicate that helmets offer protection from head injury, the relative risk of injury in helmeted and unhelmeted bicyclists has varied in different studies.
- There is equivocal evidence relating to the link between helmet use and neck injury.
- There is very little evidence relating to helmet use and bicycling style.
- There is considerable heterogeneity in the studies relating to definitions of head and brain injury, choice of controls, target group and context in which cycling takes place.
- Only one of the studies has been conducted in Great Britain.

Table 3.1: Bicycle Helmet Observational Studies (1)

Author, date, area, and legislative position	**Targeted group**	**Aims and objectives**	**Setting, method of data collection and design**	**Injury types**	**Key results and authors conclusions**	**Reviewers comments and score**
Dorsch *et al* (1987) South Australia No legislation	Adults. Bicycling enthusiasts	(a) To determine the effectiveness of bicycle safety helmets in real crashes. (b) To estimate the reduction in mortality risk associated with helmet use.	Questionnaire Self-report Design 1	Head Brain Face Other	(a) Hard shell helmets incorporating a good shock-absorbing liner afford much better protection than hairnet helmets and hard shell helmets with no liner. (b) 90% of deaths due to head injuries could be prevented with good hard shell helmets.	(a) Hard shell helmets do not offer *significantly* greater protection than other helmet types. (b) An unpublished method was used to estimate the number of deaths that could be prevented. As such this claim cannot be evaluated in any way. (c) Bicycle enthusiasts may differ from general bicycling population. **Good** study
Thompson *et al* (1989) Seattle, USA No legislation	All ages	To assess the effectiveness of bicycle helmets in reducing head and brain injury following	Hospital Self-report and clinical record Design 2	Head Brain	(a) Bicycle helmets are highly effective in preventing head and brain injury. (b) Helmets are particularly	(a) Study strengthened by having two control groups. (b) Conditional logistic regression should have been used. (c) Authors may have

					important for children since they suffer the majority of serious head injuries from bicycling accidents.	over-estimated reduction in risk (for all bicyclists) due to wearing helmets. (d) High response rates and accuracy of self-report checked for a random sample. **Good/reasonable** study

Table 3.1: Bicycle helmet observational studies (2)						
Author, date, area, and legislative position	**Targeted group**	**Aims and objectives**	**Setting, method of data collection and design**	**Injury types**	**Key results and authors conclusions**	**Reviewers comments and score**
Thompson *et al* (1990) Seattle, USA No legislation	All ages	(a) To evaluate the potential effectiveness of helmets in preventing facial injuries resulting from bicycle crashes. (b) To describe facial injuries resulting from bicycle crashes.	Hospital Self report and clinical record Design 2	Head Face	(a) Protective effect of helmets on serious injuries to the upper face. (b) No protection appeared to be afforded for lower face injury. (c) Protection for facial injury occurs independently of head injury.	(a) Same data set as that used in Thompson *et al* 1989, but analysed for facial injuries. (b) Cases and controls have different inclusion criterion, invalidating main findings of study. Subsidiary analysis valid but raw data not presented. (c) Protective effect of helmets overestimated. **Reasonable/weak** study
Wasserman *et al* (1988) Vermont, USA	All ages	(a) To determine the prevalence of helmet	Interviews Self-report Design 1	Head Brain	(a) 7.8% helmet wearing. (b) Education	Good design but very small numbers reporting head injury questions the weight that should be attached

USA No legislation		use amongst bicyclists in traffic. (b) To determine what factors are associated with helmet use. (c) To determine whether helmets are effective in injury prevention.			and marital status greatest predictors of helmet wearing.` (c) The findings on helmet use and protection against injury among riders who had hit their heads suggest that helmets may be effective in preventing head injuries.	to this studys findings. **Reasonable/weak** study
Wasserman and Buccini (1990) Florida, USA Legislative position unclear	All ages. Bicycle	(a) To conduct a survey of bicyclists who had struck their heads in a bicycling mishap. (b) To investigate the efficiency of helmets in preventing head injury.	Questionnaire Self report Design 1	Head Brain Face Neck Other	(a) Bicyclists with helmets had fewer injuries overall. These differences reached statistical significance for skull fractures and soft facial tissue. (b) Neck injuries were more common in helmet wearers but this difference was not significant.	(a) Self-reported injury ascertainment may not be accurate. (b) Bicycle enthusiasts may differ from general bicycling population. **Good/reasonable** study

Table 3.1: Bicycle Helmet observational studies (3)

Author, date, area, and legislative position	**Targeted group**	**Aims and objectives**	**Setting, method of data collection and design**	**Injury types**	**Key results and authors conclusions**	**Reviewers comments and score**
Spaite *et al* (1991) Arizona, USA No legislation	All ages (277 yrs, mean 23 years)	(a) To examine the impact of helmet use on injury severity. (b) To evaluate whether helmet use has an impact on injuries sustained by other body regions.	Hospital Clinical record Design 3	Head Other	(a) Helmet non-use strongly associated with severe injuries. (b) Helmet non-users tend to be in higher impact collisions than helmet users. Some of protective effect of helmets in this and other studies may be due to differences in riding style.	(a) Includes only accidents involving motor vehicles. (b) No multivariate analysis carried out. **Good/reasonable** study
McDermott *et al* (1993) Victoria, Australia Legislation	All ages	Comparison of 366 helmeted and 1,344 unhelmeted casualties treated at Melbourne and Geelong hospitals or dying at crash scene in two periods between 1987 and 1989 (pre-legislation)	Hospital Clinical record Design 2	Head Brain Face Neck Death Other	(a) Those wearing approved helmets were at a reduced risk of head injury, severe head injury and face injury. (b) Helmeted riders were at an increased risk of neck injury (c) Those with non-approved helmets seemed to have similar rates of head injury to those without helmets. (d) Head injury was more likely to have occurred if riders had collided with motor vehicles.	(a) Some comparisons difficult to interpret. (b) Includes comparisons with Seattle studies. **Reasonable** study

Maimaris *et al* (1994) Cambridge, Britain No legislation	All ages separate analysis for children under 16 years)	(a) To study the circumstances of bicycle accidents and the nature of injuries sustained. (b) To determine the effect of safety helmets on the pattern of injuries.	Hospital Self-report and clinical record Design 2	Head Brain	(a) There is an increased risk of head injury if a motor vehicle is involved. (b) Protective effect of helmet wearing for all bicycle accidents. (c) Less helmeted riders sustained head injuries.	(a) Presented results do not substantiate claims of protective effects of helmet use. (b) Not clear how many accidents involved head impact. (c) Rare example of UK study, but conducted in an area where there is high bicycle use. **Reasonable** study

Table 3.1: Bicycle helmet observational studies (4)

Author, date, area, and legislative position	**Targeted group**	**Aims and objectives**	**Setting, method of data collection and design**	**Injury types**	**Key results and authors conclusions**	**Reviewers comments and score**
Thomas *et al* (1994) Brisbane, Australia Legislation	Children 014 yrs	To examine the risk of injury to the head and the effect of wearing helmets in bicycle accidents involving children.	Hospital Self report and clinical record Design 2	Head Brain Face Other	(a) Wearing a helmet reduced the risk of head injury and loss of consciousness in children. (b) Current helmet design maximises protection in the type of accident most commonly occurring in this study.	(a) Legislation introduced during data collection period. (b) Missing data lead to a number of subjects being excluded from each analysis. This could substantially bias the results if missing differentially with respect to outcome or helmet wearing. **Reasonable** study
Finvers *et al* (1996) Alberta, Canada No legislation	Children under 16 years	To identify bicycle-related injuries in children from 19911993 and the effect of helmet use	Hospital Self report and clinical record Design 3	Head Other	The risk of serious injury was three times greater when a helmet was not worn.	(a) Not clear if helmets protect against non-severe injury. (b) The study did not adjust for possible confounding factors, hence there is no direct evidence for claims that reduction in head injury

		on the injury patterns and prevention.				was due to the effect of helmets rather than riding style. **Reasonable** study
Thompson *et al* (1996) Seattle, USA Legislative position unclear	All ages. Children under 6 years, 612 years, 1319 years. Adults 29 yrs or older	To examine the protective effectivenes s of bicycle helmets in four different age groups of bicyclists, in crashes involving motor vehicles, and by helmet type and certification standard.	Hospital Self report and clinical record Design 2	Head Brain	(a) Helmets effective for all ages. Associated with risk reduction for head injury, brain injury and severe brain injury. (b) No evidence that under 6 years need a different type of helmet. (c) Suggestion that hard shell helmets most effective, but would need a bigger study.	(a) Self-reported helmet wearing validated. (b) Study wide-ranging in scope. **Good** study

Table 3.1: Bicycle helmet observational studies (5)						
Author, date, area, and legislative position	**Targeted group**	**Aims and objectives**	**Setting, method of data collection and design**	**Injury types**	**Key results and authors conclusions**	**Reviewers comments and score**
Thompson, Nunn *et al* (1996) Seattle, USA Legislative position unclear	Not clear	To assess the effectivenes s of helmets in preventing facial injury.	Hospital Self-report and clinical record Design 2	Head Face	(a) Bicycle helmets significantly reduced serious facial injuries to the upper and mid regions by approx. 65%. (b) No evidence that helmets offer protection to lower facial regions.	(a) Low on detail. (b) Text and tables contain some discrepancies in the figures reported. **Good/reasonable** study
Rivara *et al* (1997)	All ages	To determine	Hospital Self report	Neck Death	(a) Helmets not associated with	(a) Small number of patients in fatality study.

Seattle, USA Legislative position unclear		the risk factors for serious injuries to bicyclists, aside from helmet use.	and clinical record Design 2		significant reduction in severity. (b) No association with neck injury and helmet use or helmet type. (c) 14.3 times more likely to be involved in fatal crash without a helmet.	(b) Some figures unclear. **Good** study
Jacobson *et al* (1998) Tasmania, Australia Legislation	All ages. Separate analyses for 09 years, 1014 years 15+ years	Examination of all bicyclerelated injuries presenting to an A&E department in Tasmania between 1991/1995	Hospital Self-report and clinical record Design 3	Head Brain Other	(a) Helmet use less likely in those presenting with head injuries. (b) 09 years children without helmets suffered a much higher proportion of head injuries than adults without helmets or children with helmets. (c) Majority of head injuries occurred off road (where helmet use was at its lowest).	(a) Only two years data reported on helmet use. (b) Small numbers of adults. (c) Legislation did not apply off road. **Reasonable** study

Table 3.1: Bicycle helmet observational studies (6)						
Author, date, area, and legislative position	**Targeted group**	**Aims and objectives**	**Setting, method of data collection and design**	**Injury types**	**Key results and authors conclusions**	**Reviewers comments and score**
Linn *et al* (1998)	Children. 04 years.	(a) To describe	Hospital	Head Brain	(a) Head injury occurred more	(a) No breakdown of helmet use by type of

British Columbia, Canada No legislation	59 years, 1014 years, 1519 years.	epidemiology of injuries, helmet use and the occurrence of head injuries prior to legislation. (b) To compare helmet users and non-users admitted to hospital.	Self-report and clinical record Design 3	Face Death Other	often among unhelmeted riders. (b) The risk for head, face, skull and brain injury, concussion as well as admittance for these injuries significantly increased for unhelmeted riders.	injury. (b) Failure to present detailed figures means that many of the studys claims cannot be substantiated. **Reasonable** study
Shafi *et al* (1998) New York State, USA Legislation	Children under 14 years	(a) To evaluate the impact of legislation on helmet use in children admitted to trauma centre. (b) Evaluate the impact of helmet use on the incidence, type and severity of head injuries, mortality, length of stay, and cost of initial hospitalisation.	Hospital Clinical record Design 3	Head	(a) Helmet legislation increases helmet wearing. (b) No difference in head injuries overall in helmeted vs unhelmeted children but helmeted children at reduced risk of skull fracture and intercranial injury.	(a) Only included children admitted to hospital. (b) Numbers small in some calculations. **Reasonable/weak** study

Section 4: Evaluated intervention studies related to the promotion of bicycle helmets

In the past two decades a variety of educational approaches have been used to promote the use of bicycle helmets. These have been used in school, hospital and primary care settings or have employed broader media-based campaigns. Some programmes employ a range of methods through a range of community-wide agencies.

Nineteen studies examined the effectiveness of bicycle helmet programmes. All of these studies focused on children and adolescents. Despite using a number of search strategies, no studies focusing on the promotion of helmets with adult bicyclists were identified. Nine of these studies were based within schools and one of them (Britt *et al* 1998) in a pre-school enrichment programme. Six studies included media-based campaigns, where a school intervention was an important component. Two studies were hospital or primary care based (Cushman *et al* 1991a, 1991b; Kim *et al* 1997) and one study compared a series of local, regional, and nationwide educational and information campaigns in Sweden.

50 per cent of the studies reported were from the USA and another five studies from Canada. The remaining studies were conducted in Australia, New Zealand, Sweden and the UK.

Two USA studies took place in low income areas (Puczynski and Marshall; 1992, Britt *et al* 1998). A third study compared schools in high and low income areas in Canada (Parkin *et al* 1993).

The interventions

The Seattle bicycle helmet campaign included a combination of elements that characterised the most successful interventions (Bergman 1990). The campaign had a single focus, that of increasing rates of helmet wearing and a tight focus in terms of target group. The campaign included a range of organisations and used a variety of settings such as schools and physicians offices, and educational methods ranging from one-to-one counselling to the mass media. The issue of cost was addressed by a variety of subsidies.

Discount schemes for bicycle helmets was a feature of 15/19 studies. Some also used incentives to maintain helmet use over a longer period of time. These included the studies by Moore and Adair (1990) and by Logan *et al* (1998), and local regulations, for example Britt (1998) study in pre-school programmes where children were required to wear helmets on school grounds.

One of the hospital-based studies which took place in Canada (Cushman *et al* 1991a, 1991b, Cushman *et al* 1991) included a short counselling session by a physician and follow up telephone calls 27 weeks later.

The evaluations

Six out of the nineteen studies were randomised controlled trials. In three of the studies the unit of randomisation was the school and in the remaining three, which included school-, hospital-, and primary-care based studies, the unit of randomisation was the child. Nine of the studies were controlled trials without random allocation. There was also one before and after study and three others.

A range of outcome measures were used in the studies and often more than one outcome measure was used. Twelve studies used a measure of observed helmet use and nine included reported helmet use. Five studies included measures of observed sales of helmets and two studies reported sales. Only in three were health data used: Mock *et al* (1995) study in the USA where hospital admissions and severe head injures were used as measures, in Ekman *et al* (1997)study from Sweden where hospital discharge data for bicycling injuries were employed and Lee *et al* (2000) UK study where A&E records were examined for information on head injuries.

Quality of the evidence

The data extraction process involved describing details of the methods used in the evaluations including sample size, attrition rates, and types of outcome measures. Strengths and weaknesses of the various evaluation designs were noted, and the process of assessing the overall quality of the evidence was informed by the NHS Centre for Reviews and Dissemination guidelines on conducting systematic reviews (Arblaster *et al* 1995). Each study was graded on a five-point scale, ranging from weak to good. Grading of the quality of the evidence was a consensus decision reached by the reviewers.

The majority of the studies were rated to be of reasonable quality (thirteen). Two studies were rated as good (Cushman *et al* 1991; Quine *et al* 2001) and one as good/reasonable (Morris and Trimble 1991): all three of these were randomised controlled trials. Three remaining studies were rated as reasonable/weak.

Overall comments

A range of educational and promotional methods has been shown to increase bicycle helmet use in children. An important element is the use of discount purchase schemes to reduce the cost of the helmet.

A number of studies report more success with primary school children compared with secondary school children (Wood and Milne 1988; Puczynski and Marshall 1992; DiGuiseppi *et al* 1989; Logan *et al* 1998) and more success with girls rather than boys (Moore and Adair 1990; Parkin *et al* 1993). Studies comparing the effect of programmes in more deprived and affluent schools reported low use of helmets in more deprived schools. Parkin *et al* (1993) and Farley *et al* (1996) found the campaign less effective in poor municipalities.

Key points

- Most bicycle helmet educational campaigns have been targeted at children.
- Bicycle helmet education campaigns can increase the use of helmets.
- Younger children and girls showed the greatest effects from the campaigns.
- Reducing the costs of helmet through discounts and give-away programme facilitates uptake and use.
- Only two of the studies have been conducted in Great Britain.

Table 4.1: Promotion of bicycle helmets (1)					
Author, date,	**Injury target**	**Aims and**	**Study type and**	**Outcome,**	**Key results**

and country	group and setting	content of intervention	sample size	impact, and process measures	
Wood & Milne (1988) Australia	General population Community wide School-based	Range of mass media campaigns and school-based educational programmes. Discount schemes.	Reviews Several studies reported	(a) Observed helmet use. (b) Helmets sold.	(a) Helmet wearing in young children increased from 5% (1983) to 37% (1985). (b) 20,000 helmets sold through bulk purchase schemes. *Effective for some groups* (More effective for younger rather than older children) **Reasonable** evidence
DiGuiseppi *et al* (1989) Bergman *et al* (1990) USA	Children aged 515 years but particularly targeting elementary school children. School-based.	Mass media campaign. Community education. School-based education programmes. Discount schemes. Narrow focus on increased helmet usage.	Controlled trial without randomisation I = city of Seattle C = city of Portland	(a) Observed helmet use. (b) Sales of helmets pre- and post campaign.	(a) Helmet wearing increased from 5% to 16% in I, compared with 1% to 3% in C. (b) Increase in helmet sales from 1,500 (1986) to 30,000 (1989). *Effective for some age groups* **Reasonable** evidence
Moore & Adair (1990) New Zealand	Children aged 1113 years School-based Inner city school	School based programme including a school assembly, curriculum based education.	Controlled trial without randomisation I = 1 school C = 1 school	Observed behaviour of children bicycling to school. Series of observations.	In I, helmet wearing 3.5% at baseline, 14.4% after interventions and 33.3% at follow up. In C,

		discount vouchers and incentives for wearing helmet.			helmet wearing 6.3% at baseline, 10.1% after interventions and 10.9% at follow ups. *Partially effective* **Reasonable/weak** evidence
Cushman *et al* (1991a) Cushman *et al* (1991b) Canada	Children aged 518 years	Hospital-based counselling to children attending hospital after bicycling injuries. One short counselling session by physician. Follow up telephone calls 27 weeks later.	Randomised controlled trial I = 167 C = 172	Reported purchase/reported use of helmets.	Small reported increase in helmet wearing in I and C (not significant). *Inconclusive* **Good** evidence

Table 4.1: Promotion of bicycle helmets (2)					
Author, date, and country	**Injury target group and setting**	**Aims and content of intervention**	**Study type and sample size**	**Outcome, impact, and process measures**	**Key results**
Morris & Trimble (1991) Canada	Elementary school children School-based	School-based education programme in I1 and I2. Discount scheme in I1.	Randomised controlled trial I^1= Education and discount (550 pupils) I^2 = Education only C = No intervention (schools 450700 children)	(a) Observed helmet use. (b) Helmet sales.	(a) No helmet use in 3 school before. After intervention 6/27 bicyclists in I1 wore helmets, compared with 0/73 in I2 and 0/23 in C (b) 72 helmets purchased in I^1 *Partially effective*

					Good/reasonabl e evidence
Pendergrast *et al* (1992) USA	Elementary school children School based	School-based educational programme. Bicycle club discount scheme.	Controlled trial without randomisation I = 209 children 125 parents C= 470 children 364 parents	(a) Reported behaviour. (b) Knowledge.	(a) No increase in reported helmet wearing in I or C. (b) Increased knowledge in I. *Inconclusive* **Reasonable** evidence
Puczynski and Marshall (1992) USA	Children aged 612 years Community wide School-based Low income area	Regional media campaign of one year. Community awareness of bicycle helmets. Educational campaign of one month and helmet distribution programme in one school.	Controlled trial without randomisation I = 1 school (education and mass media) C = 1 school (mass media only)	Reported behaviour.	After six months 73% of children in I reported wearing helmet compared with 23% in C. Younger children more likely to wear a helmet. *Partially effective* (few details of baseline wearing rates) **Reasonable/wea k** evidence

Table 4.1: Promotion of bicycle helmets (3)					
Author, date, and country	**Injury target group and setting**	**Aims and content of intervention**	**Study type and sample size**	**Outcome, impact, & process measures**	**Key results**
Towner & Marvel (1992) USA	Elementary School children School-based	Range of educational activities run by family doctors and teachers in schools. Literature for parents and	Randomised controlled trial (matched pair allocation at school level) I = 3 schools 395 parent respondents before 273 after	(a) Observed helmet use. (b) Reported helmet use. (c) Purchase of helmets.	(a) No significant increase in observed helmet use in I or C. (b) Parent report of helmet ownership

		children. Discount coupons. Five-day intervention.	before 273 after C = 3 schools 376 parent respondents before 172 after		increased in both I and C. (c) 60 helmets purchased using discount coupons. *Ineffective/inconclusive* **Reasonable** evidence
Parkin *et al* (1993) Canada	Children aged 514 years High and low income groups School based	*Be Bike Smart* School based educational programme Parental involvement Discount schemes	Controlled trial without randomisation I_1= high income 2 schools, 600 students. I_2= low income 2 schools, 500 students. C_1= high income 3 schools C_2= low income 11 schools medium usage	Observed behaviour in high and low income areas and in school yards.	In I_1 (high income area) helmet use increased from 4% to 36% compared with 4% to 15% in C_1. In I_2 (low income area) helmet use increased from 1% to 7% compared with 3% to 13% in C_2. Boys in low income areas lowest use. *Effective for some groups* **Reasonable** evidence
Mock *et al* (1995) USA	All children (particularly 515 years) Community wide	Mass media campaign. Discount schemes. School-based educational activities and bicycle events. Annual campaign from 1986 (see Bergman *et al* 1990, DiGuiseppi *et al* 1989).	Prospective observational study (a) 8,860 observations (b) 466 admissions to hospital with head injury	(a) Observed helmet use at 150 sites 198793. (b) Hospital admissions data.	(a) Children's helmet wearing when riding increased from 5% (1987) to 57% (1993). (b) Severe head injuries (all ages) decreased from 29% of all admissions (1986) to 11% (1993).

					Partially effective **Reasonable** evidence

Table 4.1: Promotion of bicycle helmets (4)					
Author, date, and country	**Injury target group and setting**	**Aims and content of intervention**	**Study type and sample size**	**Outcome, impact, & process measures**	**Key results**
Parkin *et al* (1995) Canada	Children aged 514 years Low income areas School-based	*Be Bike Smart*. Educational & promotional activities. Helmets available at discounted price. (See Parkin *et al* 1993)	Controlled trial without randomisation I = 3 low income schools 1415 children C1 number of schools not clear C2 (educated in previous year) 2 schools number not specified	(a) Observed helmet use in I, C1 and C2. (b) Self-report helmet ownership use in I. (c) Helmets sold.	(a) Observed helmet use in I increased from 4% (1990) to 18% (1992). C1 3% to 19%. C2 1% to 26%. (b) Reported helmet ownership in I increased from 10% to 47%. (c) 910 helmets sold in I schools. *Inconclusive* **Reasonable** evidence
Farley *et al* (1996) Canada	Children aged 512 years School-based	Community-wide promotional activities over four years. Helmet discounts and free helmets distributed.	Controlled trial without randomisation I = 6,087 observations C = 2,025 observations	Observed helmet use in variety of locations. Helmets distributed and discount coupons.	Observed helmet use in I increased from 9.6% (first year) to 32.5% (third year). In C increased from 3.9% to 14.3%. Less effective in poor municipalities. *Partially effective* **Reasonable** evidence

Ekman *et al* (1997) Sweden	Children aged 014 years Community wide	Series of local, regional, nationwide educational and information campaigns. (1) Information within child health centres. (2) Staff and parental education. (3) Bicycle helmet discounts. (4) Community safety programmes I_1 & I_2 counties: (1), (2), (3) and (4) C^1, C^2, C_3 counties and C4 Sweden overall (1) and (2) only.	Time series in different areas I_1 = Skaraborg 55,000 I_2 = Kristianstad 54,530 C_1 = Uppsala 50,350 C_2 = Sörmland 45,540 C_3 = Västmanland 46,200 C_4 = Sweden overall	Hospital discharge data for bicycling injuries.	Over 15-year period. In I_1 48% decrease in bicycle injuries and 59% in head injuries. Sweden (C_4) 32% decrease in bicycle injuries and 43% in head injuries. In I_1 & I_2 decrease before 1985, in Sweden as a whole, after 1987. *Effective* **Reasonable** evidence

Table 4.1: Promotion of bicycle helmets (5)					
Author, date, and country	**Injury target group and setting**	**Aims and content of intervention**	**Study type and sample size**	**Outcome, impact, & process measures**	**Key results**
Kim *et al* (1997) USA	Child bicyclist aged 612 years Primary	Free helmet distribution or helmet discounts along with	Randomised controlled trial I = Education and free helmet at 3	Reported use of helmets.	Reported consistent helmet use high in both groups:

	Health Care	educational intervention at public health clinics.	clinics (n=243 respondents) C = Education and helmet discount at 3 clinics (n=180 respondents)		76% in I and 82% in C (not significant). *Partially effective* **Reasonable** evidence
Britt *et al* (1998) USA	Children aged 34 years attending pre-school enrichment programmes Low income area	Multi-faceted bicycle helmet promotion (1) classroom instructions; (2) parental education; (3) free helmets fitted; (4) bicycle events; (5) requirement to wear helmets on school grounds.	Controlled trial without randomisation I = 14 sites 680 children C = 4 sites 200 children	(a) Observed helmet wearing. (b) Reported behaviour.	(a) Observed helmet use: I increased from 43% to 89% C increased from 42% to 60%. (b) Reported helmet use: I 26% to 58% C 36% to 37%. *Effective* **Reasonable** evidence
Hendrickson & Becker (1998) USA	Children aged 1012 years School-based Low income families High ethnic minority population	Bicycle helmet intervention in schools. 2 sessions of training by school nurses. I_1 school intervention + telephone parental counselling.	Randomised controlled trial I_1 = 142 children in 3 schools I_2 = 163 children in 3 schools C = 102 children in 3 schools	Self-report of bicycle helmet wearing.	Reported helmet use: I increased from 25% to 39% C increased from 17% to 20%. *Partially effective* **Reasonable** evidence

		I2 school only intervention.			

Table 4.1: Promotion of bicycle helmets (6)					
Author, date, and country	**Injury target group and setting**	**Aims and content of intervention**	**Study type and sample size**	**Outcome, impact, & process measures**	**Key results**
Logan *et al* (1998) USA	513 year-old children Rural town School-based	Multi-faceted school-based campaign. Education, helmet provided and fitted. Bicycle events. Incentive scheme to encourage continued use over 6 months.	Before and after study No controls I = 2 schools 403 children	(a) Observed helmet use (b) Self report surveys for children's and parents attitudes	(a) Observed helmet use. 3% baseline, 25% one day after give-away. 30% at 2 weeks, 38% at 7 months and 5% at 9 months. Older children less likely to wear helmets at all observation points. (b) 96% of students thought helmet use increased safety as did most parents. *Inconclusive* **Reasonable/weak** evidence
Lee *et al* (2000) UK	Children aged 515 years School-based	*Helmet your Head Campaign*. Range of school-based activities to promote the use of bicycle helmets. Included a low-cost helmet	Controlled trial without randomisation I = Reading 3,000 Teenagers C = Basingstoke 3,000 teenagers	(a) Reported behaviour. (b) Bicycle-related head injuries (A&E records).	(a) Reported helmet use in I area increased from 11% to 31% over 5 years and from 9% to 15% in C area. (b) Head injuries as a proportion of all bicycle

		purchase scheme, demonstrations and media events.			related injuries decreased from 22% to 12% in I area over study period. *Effective* **Reasonable** evidence
Quine *et al* (2001) UK	1115-year-old children/ teenagers Regular bicyclists School-based	Educational activities including booklet on helmet use to change attitudes, beliefs and helmet wearing behaviour. Control group received education on bicycle maintenance and proficiency.	Randomised controlled trial I = Helmet education (n = 48) C= General bicycle education (n = 49) Pre and post tests and follow-up for 5 months	(a) Attitudes and beliefs. (b) Reported behaviour.	(a) Intervention promoted positive attitudinal change which was sustained over time. (b) At 5 months follow up 12/48 of the I group and 0/49 of the C group reported wearing helmets. *Effective* **Good** evidence

Section 5: Bicycle helmet legislation: evaluated studies and detailed case studies

Legislation is widely regarded as one of the most powerful tools in injury prevention. It can also be seen as an indicator of the will of the state to intervene within this area (Towner and Towner 2002). From the late 1980s, states and countries have adopted bicycle helmet legislation. Initially this occurred for certain limited age groups: for example the states of California and New York in the USA where legislation for child bicycle passengers under 5 years old was enacted in 1987 and 1989. The state of Victoria in Australia was the first state to introduce legislation for all ages of bicycle riders in July 1990.

The table below summarises the situation in early 2002 with regard to bicycle helmet legislation throughout the world. (British Helmet Safety Institute1 2002 and personal communication.)

Summary of bicycle helmet legislation adopted in countries or states	
Australia	Bicycle helmets mandatory in all states and territories Victoria all ages July 1990 South Australia January 1991 Queensland January 1991 Western Australia January 1992
Canada	Ontario <18 years 1995 Nova Scotia all ages 1996 British Columbia all ages 1996
Czech Republic	Children under 15 January 2001
Iceland	Children under 15 October 1998
New Zealand	All ages on road January 1994 No federal law
Spain	Comprehensive bicycle law mid-1999 With mandatory helmet provision
USA	20 state laws and 84 local laws (States of Alabama, California, Connecticut, Delaware, District of Columbia, Florida, Georgia, Hawaii, Louisiana, Maine, Maryland, Massachusetts, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Tennessee, West Virginia)

The majority of states, provinces and countries have enacted laws which relate to children or young people; laws which *target all ages* are less frequent.

In this section we first examine a range of studies which have evaluated bicycle helmet legislations effect on reported or observed helmet wearing, on head injury outcomes or bicycling exposure (Tables 5. 18). Two case studies from Victoria, Australia and British Columbia, Canada are presented and discussed in more detail.

(1) Evaluated studies

Thirteen studies or groups of studies on the effectiveness of bicycle helmet legislation have been reviewed. One of these relates to national legislation, in the unitary state of New Zealand, and the remainder to legislation in federal states. Four of these are in states in Australia, two in provinces in Canada, three to states in the USA, and the remaining three at county level in the USA.

There is a division between studies which report legislation directed solely at children (seven studies) and those where legislation is directed at all ages (six studies: the four Australian states, New Zealand, and the Canadian province of British Columbia). Where legislation is directed solely at children, the definition of a child is usually <16 years, though in Florida, the legislation relates to <14 years. One USA study (Rodgers 2002) compares states across the country and a variety of age groups of children are included.

Enforcement of the legislation was not specifically mentioned in all the studies. The USA study (Rodgers 2002) of helmet wearing across the country, noted that laws were not rigorously enforced. In Queensland, when legislation was initially introduced, no enforcement of the law took place. Bicycle helmet wearing rates increased post legislation, but then fell back. Eighteen months after the initial legislation, penalty and enforcement were introduced.

Many of the studies described a period of health promotion before legislation was introduced to increase helmet wearing levels and to change attitudes towards the wearing of helmets. In Victoria, for example, ten years of publicity and campaigns in schools and with bicycling organisations took place and wearing levels of 31 per cent were achieved before legislation was introduced. In New Zealand, before legislation was introduced, voluntary wearing levels of 84 per cent were achieved in the 512 age group. In Queensland, 92 per cent of adults supported the idea of legislation for children to wear helmets and 85 per cent supported legislation for adult helmet wearing before legislation was enacted. In the USA, Dannenberg *et al* (1993) compared the effect in three counties in Maryland of legislation combined with education, legislation, alone, and no legislation and found that the combined approach was the most effective of the three. The USA studies paid less attention to a rigorous educational campaign before the introduction of legislation (see Section 8: Discussion).

A variety of different outcome, impact and process measures were employed in the studies. Most of the studies (10/13) used observed helmet wearing measures and 4/12 used reported helmet wearing measures. Four studies reported on health outcomes of injury mortality (2/4) and morbidity (4/4). Four studies reported on whether the legislation had an impact on the levels of bicycling. Studies from Victoria found decreases in teenage bicyclists following legislation; in Western Australia there were decreases in primary school-aged bicyclists and recreational bicyclists. In South Australia there was a significant reduction in the number of children cycling to school. In contrast, the study from Ontario found that bicycling rates did not go down after the introduction of legislation.

Nine of the studies reported on a series of observational studies before and after legislation and did not include a control group. Three studies compared counties with and those without legislation within a USA state. The study from Florida, for example, included 64/67 counties where legislation was introduced and 3/67 counties which opted out of legislation. The opted-in and opted-out counties would probably contain very different populations, so a comparison of helmet wearing in these two groups would be problematic. In the one study conducted across the USA, a telephone survey was used to assess reported helmet wearing in children. The study found that helmet wearing was systematically related to the presence of a state law.

(2) Case studies

Case study 1: Victoria, Australia

On 1 July 1 1990 the Australian state of Victoria introduced a state-wide law requiring bicyclists to wear an approved safety helmet. Victoria became the first jurisdiction in the world to pass such legislation. The introduction of this legislation represented the culmination of a decades work in education, helmet promotion and the development and implementation of national standards for bicycle helmets.

Scope

Bicycle accidents occur to bicyclists of all ages and in all environments (Leicester *et al* 1991)

The aim of the law was to increase helmet wearing across all sections of the bicycling community, both adults and children, for all journeys. As such, legislation demanded that riders of all ages should wear an approved helmet. The law was seen as a complementary extension to previous successfully implemented safety legislation, such as that for compulsory motorcyclist helmet wearing and seat belt wearing. Provisions for dispensation from the bicycle helmet legislation were made, but in practice very few dispensations were given (Vulcan *et al* 1992).

Pre legislation

In the decade prior to the introduction of the bicycle helmet law a raft of initiatives were commissioned. These included school education programmes (Bike-Ed) which encouraged helmet use, a number of mass media campaigns some of which featured prominent sport celebrities, bulk purchase schemes allowing helmets to be purchased through schools at a 33 per cent discount, $10 government rebates for helmet purchases, posters distributed in doctors surgeries and, in 1984, a parliamentary statement of intent to move towards the introduction of a bicycle helmet law. In parallel to these initiatives was the development of suitable Australia-wide standards for safety helmets and of helmets to meet these standards.

Enforcement

The maximum penalty for failing to wear a bicycle helmet was a $100 fine. This maximum penalty was rarely used. However, a lesser fine of $15, or Bicycle Offence Penalty Notice, was frequently awarded. The number of notices served increased to 19,229 during July 1990June1991, a very real level of enforcement. For children, a Bicycle Offence Report was sent to parents. This report carried no monetary fine. 5,028 offence reports were awarded over the same time frame (Vulcan *et al* 1992).

Post legislation

Following the introduction of the state-wide law, a significant pre-post legislation increase in helmet wearing rates was observed.

Helmet wearing rates following legislation in Victoria (Finch et al 1993)			
	Pre-legislation	**1991**	**1992**

Children (5-11 years)	65%	78%	77%
Teenagers (12-17 years)	21%	45%	59%
Adults (18+ years)	36%	74%	84%

As well as increased rates of helmet wearing, post legislation there was a marked decrease in casualty rates. Across the state the number of bicyclists killed or admitted to hospital after sustaining a head injury decreased by 48 per cent in the first year following legislation and by a total of 70 per cent by the second year. In the metropolitan area of the state capital, Melbourne, the number of bicyclists admitted to hospital having sustained a head injury following a motor vehicle collision fell by 66 per cent in the same period. However there was also a smaller reduction in the number of bicyclists admitted to hospital who did not sustain head injuries (Vulcan *et al*, 1992), suggesting a reduction in the amount of bicycle usage. Another factor which may have had an impact on reduced rates of head injury was the introduction of major drink/driving and speeding campaigns in 1989 and 1990 respectively. Following these campaigns there was a reduction of 12 per cent in the number of people killed or admitted to hospital as a result of all types of road accident (Vulcan *et al*, 1992). It is likely that this could account for some of the reduction in bicyclist injury rates following helmet legislation.

Reduced bicycling rates

While the increased rate of helmet wearing and reduced level of bicyclist casualties noted above is impressive, it is worth noting that it is possible that some of these changes were influenced by decreases in exposure. Following the introduction of the bicycle helmet law the estimated adult bicycling exposure increased marginally, however, exposure for children under 12 decreased by 10 per cent. More markedly, the corresponding decrease in exposure for teenagers was 44 per cent representing a major decrease in bicycling activity. It is likely that these decreases had some impact on reported gains in helmet wearing rates and lowered casualty rates. It has been argued that the health gains from bicycling outweigh its risks (Robinson, 1996), so this drop in bicycling exposure is of some concern. The greatest reduction by far is that of teenage bicyclists, and those teenagers who did cycle still had the lowest rates of helmet law compliance. Taking into account teenagers negative attitudes towards bicycle helmets (Finch *et al* 1996) it can be argued that helmet legislation could be responsible for their choosing not to cycle.

Case study 2: British Columbia, Canada

On 3 September 1996 British Columbia became the first Canadian province to enact a mandatory bicycle helmet law.

Scope

As in the Australian case study outlined above, the legislation introduced to British Columbia made it a legal requirement to wear a bicycle helmet for bicyclists of all ages. In doing this British Columbia became the first province or state in North America to introduce a legal requirement for bicyclists of all ages rather than just a requirement for children. Again, bicycle helmet legislation was viewed in the context of, and complementary to, other safety legislation such as that governing seat belt usage.

Pre legislation

Introduction of helmet wearing laws was again accompanied by a range of other measures aimed at increasing the use of bicycle helmets among the population. Included within these measures were educational programmes aimed at safe bicycling behaviour, mass media campaigns and a $10 government rebate for helmet purchases. These programmes were largely started directly prior or concurrently with legislation. A range of local municipality by-laws were launched by Vancouver to promote bicycle use. These included amendments to parking and building by-laws to provide end-of-trip facilities for bicyclists, including changing rooms and shower facilities, and a number of measures such as bicycle route maps and Bike to Work Weeks were launched following the introduction of legislation.

Enforcement

Under the legislation the maximum imposable fine for non-compliance is $100. In addition to this measure parents or guardians of children under the age of 16 can face the charges if they authorize or knowingly allow their child to ride without a helmet. No data is available on the number of fines awarded since legislation.

Post legislation

Observational studies of bicyclists were carried out throughout the province both before the law was enacted in 1995 and then three years following the introduction in 1999 (Foss and Beirness, 1995, 2000). Comparisons of these studies showed a large increase in helmet wearing rates following legislation across all age groups.

Table 5.1: Helmet wearing rates following legislation in British Columbia (Foss and Beirness 2000)

Age	1995 Pre legislation	1999 Post legislation
15 years	60%	78%
615 years	35%	61%
1630 years	47%	69%
3150 years	52%	75%
50 + years	41%	73%

As can be seen in the above table, significant increases in helmet wearing were observed despite relatively high initial levels of helmet wearing. No data is available relating specifically to British Columbia on the impact that this increase in helmet wearing rate has had on the numbers of bicyclists killed or injured. However, a recent countrywide study compared the incidence of childhood bicycle-related injury in the four provinces with helmet legislation (including British Columbia) with the remaining provinces and territories who had not enacted a helmet law. Macpherson *et al* (2002) found that in the 1997/98 period the injury rate per 100,000 was significantly lower in those provinces that had a mandatory helmet law. A longitudinal study of bicycle use in British Columbia is currently under way, and is due to be released soon.

Reduced bicycling rates

In their consideration of the impact of legislation upon helmet use and bicycling Foss and Beirness only look at rates of helmet wearing in terms of percentage of observed population. Surprisingly, they do not give raw numerical totals for the numbers of observed bicyclists in their studies. As a result it is not possible to ascertain whether or not there has been a drop in bicyclist exposure as observed in the Australian case. An interesting finding, however, is that in the 1995 pre-legislation study 50 per cent of observed bicyclists were in the age range 1630. In the 1999 post-legislation observations, this number had dropped to 35 per cent. In the absence of numerical totals it is important not to make too much of this decrease, but it is noteworthy that this group would have contained at least some teenagers of a comparative age with some of the teenager sample in Victoria, the group whose bicycle use was most likely to be reduced following enactment of legislation. There was little impact of legislation on the percentage of observed 615-year-olds.

Key points

- Bicycle helmet legislation has been associated with head injury reductions.
- Bicycle helmet legislation with supporting educational activities is an effective means of increasing observed helmet use.
- Compulsory helmet wearing may discourage some bicyclists leading to decreased bicycle use.
- In Australia, New Zealand and Canada, legislation has not been introduced until high levels of helmet wearing have been attained in the population.

Table 5.2: Bicycle helmet legislation (1)

Author, date, and country	**Injury target group and setting**	**Aims and content of intervention**	**Study type and sample size**	**Outcome, impact, and process measures**	**Key results**
Leicester *et al* (1991)	General population	Legislation requiring bicyclists to wear bicycle helmets introduced in Victoria, Australia in July 1990. Legislation was preceded by 10 years of helmet promotion activities including school-based campaigns,	Series of observational studies focusing on injury rates, observed helmet wearing and exposure. Samples ranged from 1,50011,000 in helmet wearing.	(a) Hospital admissions (insurance data and hospital records). (b) Observed helmet use. (c) Bicycling exposure.	(a) 48% reduction in head injury admissions and deaths between 1989/90 and 1990/91 and 70% between 1989/90 and 1991/92. Reductions in non-head injuries also noted. In 4 years post legislation, changes have continued and were apparent in spite of anomalies in the Hospital Admissions data.
Cameron *et al* (1992)	Specific intervention and analysis for different agegroups				
Vulcan *et al* (1992)					
Finch *et al* (1993)	Children aged 511 years				
Cameron *et al* (1994)	Young people aged 1217 years				
McDermott (1995) Australia	Adults 18+ Statewide				

Carr *et al* (1997)	legislation	bulk helmet purchase schemes and mass media events. Enforcement of legislation.			(b) Helmet wearing increased from 5% (1982/83) to 31% (1989/90) and to 75% (1991) after the introduction of legislation. (c) Adult bicyclist exposure was not reduced but 10% fewer child bicyclists observed following the introduction of legislation Decrease of 46% in teenage bicyclists following legislation compared to 1990. *Effective* **Good/reasonable** evidence

Table 5.2: Bicycle helmet legislation (2)

Author, date, and country	**Injury target group and setting**	**Aims and content of intervention**	**Study type and sample size**	**Outcome, impact, and process measures**	**Key results**
Healy and Maisey (1992) Western Australia	General population Statewide legislation	Legislation introduced on 1 January 1992. Enforcement and fining of noncomplying riders from 1 July 1992. A$25 fines. Media campaigns before and after legislation.	Observational before and after studies	(a) Observed helmet wearing in: (i) primary school children; (ii) high school students; (iii) adult commuter bicyclists; (iv) adult recreational bicyclists. (b) Observed bicycling.	(a) Wearing rates increased in: (i) Metropolitan primary school bicyclists from 51% in 1991 to 87% in 1992. In country areas increase from 62% to 80%; (ii) High school bicyclists from 11% in 1991 to 35% in 1992; (iii) Commuter adult bicyclists

					from 46% in 1991 to 78% in 1992; (iv)Adult recreational bicyclists from (b) Participation in bicycling remained steady for most of survey groups, except primary school children and recreational bicyclists fall of over 21%. *Effective* **Reasonable/weak** evidence
Hendrie *et al* (1999) Western Australia, Australia	General population Statewide legislation	Western Australia invoked in January 1992 made effective in July 1992. Legislation for all ages for on road bicycling. Pre-legislation promotional campaign from approximately 1986. Bike West helmet rebate and helmet subsidy scheme. Pre legislation, overall helmet wearing rate estimated to increase from 33% in 1990 to 37% in 1991.	Logistic regression analysis to model likelihood of bicyclists and pedestrians having head injuries. Aggregate and individual data models used. Trends in head injuries used pedestrians as a control.	(a) Head injuries. (b) Cost effectiveness of legislation.	(a) Overall between 1992 and 1998 head injury estimated to have decreased by 307 due to legislation: an average annual reduction of 44 (using aggregate data model). (b) Alternative model using individual data found that number of headinjured bicyclists decreased by 147. Cost effectiveness ratio valued at A$70,300 per head injury saved. Reduction of between 11 and 21% in number of bicyclists hospitalised with head injury. No measure of whether bicycling activity

					was reduced.

Table 5.2: Bicycle helmet legislation (3)

Author, date, and country	**Injury target group and setting**	**Aims and content of intervention**	**Study type and sample size**	**Outcome, impact, and process measures**	**Key results**
Dannenberg *et al* (1993) Maryland USA Coté *et al* (1992) USA	Children aged under 16 years Middle class, rural and suburban	Bicycle helmet law for children aged under 16 years in Howard County, Maryland 1990. Comparison of 3 counties: I_1 = Legislation and education. I_2 = Education only. C = No campaign.	Controlled trial without randomisation I_1 = Howard County (1,056 before, 929 after) I_2 = Montgomery County (995 before, 888 after) C = Baltimore County (1,164 before, 1,060 after)	(a) Reported behaviour. (b) Knowledge and attitudes. (c) Observed helmet use.	(a) Self reported helmet use in I_1 (legislation and education) increased from 11% to 37%. I_2 (education only) increased from 8% to 13%. C (no campaigns) increased from 7% to 11%. (b) In I1 87% of respondents thought there was a law in their county, compared with 7% in I2 and 6% in C. (c) Children observed wearing a bicycle helmet in: I_1 increased from 4% to 47%; I_2 increased from 8% to 19%; C increased from 19% to 40%. Legislation and education more effective than education alone. *Effective* **Good/reasonable** evidence

Table 5.2: Bicycle helmet legislation (4)					
Author, date, and country	**Injury target group and setting**	**Aims and content of intervention**	**Study type and sample size**	**Outcome, impact, and process measures**	**Key results**
Marshall and White (1994) South Australia	General population Statewide legislation	Legislation requiring all cyclists to wear helmets 1 July 1991.	Observational before and after study	(a) Reported helmet wearing in two Health Omnibus Surveys. (b) Observed helmet wearing: (i) commuter cyclists in city of Adelaide; (ii) children cycling to school, conducted at entrance to 85 metropolitan and county schools; (c) hospital inpatient records from all South Australian hospitals.	(a) Bicycle helmet wearing for bicyclists 15 years and over: over 90% and up to 85.5% in bicyclists under 15 years. In 1990 wearing rates for cyclists 15 years and over was 15%. (b) (i) Commuter cyclists recorded helmet wearing rate of 98%. In 1990 voluntary wearing rate was 49%; (ii) Wearing rates of school children over 90% for all groups except secondary students with a rate of 87%. (c) Hospital admissions decreased by 24.7% comparing the 2 years before and 2 years after legislation. Hospital admissions decreased by 12.1% comparing the years before and one year after legislation. Mean helmet effect of 18.4%. Results are not conclusive about the effect of helmet legislation on exposure. The

					observational study of children cycling to school showed a significant reduction in children bicycling. *Partially effective* **Reasonable** evidence

Table 5.2: Bicycle helmet legislation (5)

Author, date, and country	**Injury target group and setting**	**Aims and content of intervention**	**Study type and sample size**	**Outcome, impact, and process measures**	**Key results**
King and Fraine (1994) Queensland Australia	General population Statewide legislation	Legislation requiring all bicyclists to wear helmets 1 July 1991. No penalty immediately. 1 January 1993 Penalty and enforcement introduced A$30. Widespread publicity, particularly aimed at children.	Observational before and after study. Pre-legislation, postlegislation and postenforcement.	(a) Observed helmet wearing rates in: (i) primary school children; (ii) secondary school students; (iii) commuter bicyclists; (iv) recreational bicyclists. (b) Bicycle crash data from police accident reports. Fatal, hospital treatment and other medical treatment.	Pre-legislation 92% adults supported legislation for children and 85% supported legislation for adults. (a) Wearing rates increased in: (i) Primary school children from 59% in April 1991, 85% in September 1991 and 82% in November 1991; (ii) Secondary school students from 13% in April 1991, 38% in September 1991 and 33% in November 1991; (iii) Commuter bicyclists from 21% in April 1991, 52% in September 1991 and 47% in November 1991; (iv) Recreational bicvclists from

					22% in April 1991, 46% in September 1991 and 38% in November 1991; (b) Bicycle crash data more serious injuries reduced from 81.2 (before legislation), to 70.5 (legislation but no enforcement) to 57.3 (legislation and enforcement period). Less severe injuries reduced from 141 to 111.7 to 95. Some suggestion of reduced bicycle numbers but not clear. *Effective* **Reasonable** evidence
Macknin and Medendorp (1994) Cleveland, Ohio USA	Children aged under 16 years Elementary school grades 17 targeted Legislation/ school-based	Combination of approaches to promote bicycle helmet use. Two communities passed bicycle helmet legislation: Beechwood on 4 December 1990 and Orange on 20 January 1991. Communities of Moreland Hills and Pepper Pike no legislation.	Controlled trial without randomisation I_1 = 615 children I_2- = 277 children C_1 = 229 children C_2 = 362 children	(a) Reported helmet use. (b) Observed helmet use (I_1).	(a) In I_1 68% reported always wearing a helmet, in I_2 37%, C1 18% and C2 22%. (b) Observed helmet wearing in I_1 85%. *Effective* **Reasonable/weak** evidence

		Penalty of $25 fine. I1 = Legislation and education with events, reward schemes and discounted helmets I2 = Legislation C1 = No intervention C2 = No intervention			

Table 5.2: Bicycle helmet legislation (6)

Author, date, and country	**Injury target group and setting**	**Aims and content of intervention**	**Study type and sample size**	**Outcome, impact, and process measures**	**Key results**
Abularrage *et al* (1997) New York State USA	Children aged 114 years Multi-racial Community-wide Statewide legislation	(1) Legislation Mandated helmet use for children 114 years in New York State on 1 June 1994. Parent fines for non compliance (in I and C) (2) Bicycle helmet campaign in month before legislation. Community, school and media activities and	Controlled trial without randomisation I = 14 school-based observation sites C = 12 school-based observation sites	Observed helmet wearing	Observed helmet useI increased from 4.7% to 13.9%: C decreased from 5.6% to 4.2%; Increased use in girls, 59 age group; Education and legislation effective; Legislation alone no effect on C. *Effective for some groups* **Good/reasonable** evidence

		discount coupons (in I alone).			
Ni *et al* (1997) Oregon USA	Children under 16 years Community-wide Statewide legislation	Statewide legislation in Oregon (1 July 1994) all children under 16 years to wear bicycle helmets when riding on public property $25 fine for non-compliance Statewide promotional campaigns.	Four separate before and after studies in 1993 and 1994: (i) Statewide observation Before: 1610 After: 1703; (ii) Observations in 33 schools Before: 558 After: 437; (iii) School survey Before: 66 schools and 7088 observations After: 64 schools and 7417 observations; (iv) Telephone survey Before: 961 After: 476.	(a) Observed helmet use in (i) and (ii) (b) Reported helmet use and knowledge in (iii) and (iv)	(a) Statewide: (i) Observed helmet use increased from 25% to 49%. Schools: (ii) Observed helmet use increased from 20% to 56%. (b) Schools: (iii) Reported behaviour: Helmet use increased from 15% to 39% Helmet ownership increased from 51% to 76%. Telephone survey: (iv) Reported helmet use increased from 37% to 66%; 95% of parents knew about the legislation. *Effective* **Good/reasonable** evidence

Table 5.2: Bicycle helmet legislation (7)					
Author, date, and country	**Injury target group and setting**	**Aims and content of intervention**	**Study type and sample size**	**Outcome, impact, and process measures**	**Key results**
Povey *et al* (1999) New Zealand	General population National legislation	New Zealand legislation enacted 1 January 1994 required all bicyclists to wear a	Variety of models tested.	Head injuries	Bicyclist head injuries decreased with increased helmet wearing across all age groups most strongly amongst children of

		standard approved helmet for all on-road bicycling. Since 1994 wearing rate remained static at 95%.			1ß school age. Bicycle helmets may make bicyclists more visible to motorists. Increased wearing rates due to law reduced overall head injuries by nearly 30%.
Scuffham *et al* (2000) New Zealand	General population. Specific analysis for different age groups 512 years 1318 years 19 + years. National legislation	New Zealand legislation enacted 1st January 1994 required all bicyclists to wear a standard approved helmet for all on-road bicycling. Pre-legislation, voluntary helmet wearing widely promoted. 1986 wearing levels zero. By 1992 helmet wearing 84% in 512 years, 62% in 1318 years and 39% in adults.	Series of observational studies of bicycle helmet wearing from 1986 onwards. For each of 3 age groups, helmet wearing rates compared with head injures sustained.	Deaths. Hospital admissions. Head injuries.	There was a positive effect of helmet wearing on head injury and this effect was consistent across age groups and head injury types. Estimated that law had averted 139 head injuries over 3-year period (19% overall reduction). Effect most pronounced in age groups with lowest pre-law helmet wearing rates (24% in adults, 16% in 1318 year olds, 6% in 5112 year olds). *Effective* **Good** evidence

Table 5.2: Bicycle helmet legislation (8)

Author, date, and country	Injury target group and setting	Aims and content of intervention	Study type and sample size	Outcome, impact, and process measures	Key results
Foss and Beirness (2000) British Columbia, Canada	General population. Province wide.	In September 1996 British Columbia became the first state/province in North America to enact a law mandating	Observational studies of helmet wearing rates pre legislation and three years following legislation. Same observation	Observed helmet wearing	Rate of helmet use increased across all ages, bicycle types and regions. Helmet misuse decreased. *Effective* **Reasonable**

		helmet use by all bicyclists of all ages when riding on a public roadway. Before legislation helmet wearing ranged from 60% in commuter sites and 39% in community sites.	sites in 12 communities. No comparison group not exposed to legislation		evidence
Kanny *et al* (2001) Florida USA	Children aged Statewide legislation. 64/67 counties opted in and 3/67 opted out	In January 1997 a state law took effect in Florida. Mandatory helmet use by all bicyclists <16 years when riding. In first year of law verbal warnings and education brochures to violators. In second year fines of $15. 3/67 counties in State opted out.	Cross sectional study. Observations in opted-in counties and opted-out counties. I = 21,313 in 50 opted-in counties. C = 450 in 1 of opted-out counties.	Observed helmet wearing on school property.	In I, 79% riders wore a helmet compared with 33% of riders in C. Children living in counties with a law were 2.4 times more likely to wear a helmet than in those without a law. *Effective* **Reasonable/weak** evidence
Macpherson & Parkin (2001) Ontario, Canada	Children aged 514 years. Province wide legislation for under 16 year olds.	Ontario introduced legislation in October 1995 requiring all children younger than 16 years old to wear helmets.	Series at observational studies of child bicyclists from 19931999 spanning the introduction of legislation. Bicyclists observed at 111 sites.	Observed bicycling levels. A general linear model compared the mean number of bicyclists per hour for each year, and for each type of site.	Variation in bicycling rates in different years. Bicycling rates did not go down after the introduction of mandatory helmet legislation. *No effect on bicycling rates* **Reasonable/weak** evidence

Table 5.2: Bicycle helmet legislation (9)

Author, date, and country	Injury target group and setting	Aims and content of intervention	Study type and sample size	Outcome, impact, and process measures	Key results
Rodgers (2002) USA	Children and adolescents State helmet laws across USA	By November 2001, 19 states and DC had evoked legislation. 12 state laws apply to children <16 years, 1 to children <18 years 6 state laws to younger children. None of state laws require use of helmets by adults. Laws are not rigorously enforced.	Cross sectional survey of bicycle helmet use by children in the USA telephone survey of 1,000 across USA. Multiple regression analysis used to quantify independent effect of state law on helmet use.	Reported helmet state laws. Presence of state laws.	Helmet use was systematically related to presence of state helmet laws. Odds ratios 2.65 (CI 1.29 5.44). The increase in average probability of helmet use attributable to state helmet laws was 18.4% (95% CI 17.8 19%). *Effective* **Reasonable** evidence

Section 6: Barriers and facilitators of helmet use

In this section we examine qualitative and quantitative studies to identify the broad range of factors associated with helmet ownership and use. These include economic, social and cultural factors along with features of the road environment (such as residential street or main road) and area associated with helmet wearing. We also examine studies focusing on attitudes and beliefs amongst different groups of bicyclists. The methods and findings of 26 studies published between 1986 and 2002 are set out in Section 6: Tables 18; here we provide a brief summary. In addition, we re-examined intervention studies included in Section 4 to provide information on barriers and facilitators of helmet use and uptake of interventions in different groups (see Section 6: Table 9).

Settings and participants

Of the twenty-six studies reviewed, seven were carried out in the UK, ten in the USA, three in Canada and the rest in other higher income countries. Of the UK studies, all but two were carried out in the South of England. In one study which included teenage respondents from northern and southern areas, there were marked differences in bicycling practices and behaviour in the two areas (Lee 1993).

Most of the studies (nineteen) focused on children and teenagers. Studies including older and younger children frequently compared behaviour and attitudes in different age groups. Five studies included both children and adults, whilst only two focused specifically on adult bicyclists.

The selection of study participants varied. For example, in the UK studies, Skarratts (Skarratts 1992) included adolescents aged 1014 attending bicycling proficiency schemes. Halliday *et al* (Halliday 1996) included children and adults selected by quota sampling methods. Cryer *et al* (Cryer 1998) compared behaviour and views amongst children aged 1012 years with teenagers aged 1416 years.

As the focus of many studies was on children, most of the studies were carried out via schools. The sample sizes included in the various studies varied considerably and depended on the type of data being collected. As expected, those studies collecting detailed, qualitative data tended to include fewer participants.

Study type and data collection methods

The studies utilised three broad types of data collection methods. First, the majority of studies (seventeen) involved the use of questionnaires and frequently collected data on bicycling practices, helmet use, and attitudes towards helmet wearing. Studies were carried out in schools, via mailed surveys, or telephone interviews. Many included large numbers of respondents. These studies provide information about reported behaviour, health beliefs and behavioural intentions and thus may be valuable in identifying the attitudinal barriers/facilitators which constrain or encourage helmet use. This information is useful to underpin helmet promotion campaigns. Several of these studies also included questions relating to legislation and provide information on prevailing views regarding compulsory helmet wearing. One disadvantage of surveys is that data may be unreliable. Reported behaviour may not reflect actual behaviour, and this may be particularly true when parents were surveyed and asked to second-guess their childs attitude towards helmets and to report on their childs helmet use. This occurred in four surveys. There was also considerable variation in the way that helmet use was defined and operationalised (for example in some studies it was reported use on last journey, in others, reported always using). This means that making comparison between studies is not easy.

Second, four studies collected observational data on helmet use by bicyclists riding in different types of location. Typically, the age, gender and companions of bicyclists were noted and information on road/area type and other bicyclist safety behaviours was collected. These data were used to identify factors associated with helmet use. Again, this information is useful in planning and targeting helmet promotion campaigns. Observational studies may also provide information on baseline helmet use and highlight factors (for example bicyclist age) which may prove a barrier to behavioural change.

Third, five studies collected data via focus or discussion groups. Here, participants were asked in detail about their practices, attitudes and beliefs. In one UK study (Halliday *et al* 1996) twelve separate groups were convened. Groups were single gender and there were separate groups for different age groups. The sampling strategy was devised to ensure that individuals from a range of social backgrounds and with varying levels of bicycling experience and exposure were included. This study provided detailed information on attitudes to bicycling safety (including helmet legislation) in different age groups.

Results

Many of these studies provide baseline information on bicycle helmet wearing at different times and in different social, geographical and legislative contexts. Attitudes and behaviour have changed over time, with a general increase in helmet use. However, change has not been consistent and the very varied helmet wearing rates reported in these studies suggest that there are likely to remain profound differences in attitudes and practices within different contexts and amongst different groups within the same context.

The earliest studies indicate that in the mid/late 1980s helmet ownership and wearing rates were generally low. For example, Otis *et al* (Otis 1992) in a USA study report that whilst most children included in the study were regular bicyclists, helmet ownership stood at less than 5 per cent. In a UK study in the early 1990s, Skarratts (1992) noted that of 25 children attending a bicycling proficiency scheme only 3 reported wearing helmets. Higher rates of ownership and use were recorded in some geographical contexts, for example, in Australia and in some USA counties, where there had been active promotion of helmets. Whilst baseline rates of helmet wearing increased during the 1990s, there remained considerable variation between and within countries and amongst different groups. For example, in one UK study focusing on adolescents aged between 11 and 16 years, Lee (1993) described different rates of helmet ownership and use in different geographical areas. Here, 14 per cent of females and 28 per cent of males in West Berkshire reported always wearing helmets compared with 3 per cent of females and 5 per cent of males in a northern area Thameside. The reason for these differences between the two areas were not clear.

In addition to information on baseline helmet wearing rates the demographic data collected as part of questionnaire surveys provide evidence of factors related to helmet use. Factors associated with helmet ownership identified in at least one study include: age, gender, social group, bicycling location and geographical areas, and companionship. Each of these factors will be considered in turn.

Age**:** Findings from both observational studies and surveys were unequivocal with respect to teenage bicyclists. Invariably, teenagers were less likely than both younger and older bicyclists to report owning/wearing helmets or to be observed wearing helmets. Amongst teenagers, older teenagers were less likely to wear helmets than younger ones. In the UK context, Sissons Joshie *et al* (Sissons Joshi 1994) examined helmet use amongst teenagers and results indicated that 52 per cent of 15-year-olds compared to 38 per cent of those aged 17 and over reported owning helmets. Similarly, Cryer *et al* (1998) found that at age 11, 69 per cent of children owned, and 30 per cent reported wearing helmets, whereas for those aged 15, 38 per cent owned, and 12 per cent reported wearing helmets. Berg and Westerling (2001) describe a discontinuation of helmet wearing amongst teenagers. In this study, 27 per cent of 12 year olds and only 1 per cent of 15-year-olds reported wearing helmets. In a study of adult bicyclists, young adults (those aged between 1824) were significantly less likely to wear helmets than bicyclists in older age groups. In studies including a range of age groups, helmet ownership/use appears greatest in young children, least amongst teenagers, and somewhere in between for adult bicyclists.

Gender: Findings relating to helmets and gender are more equivocal. It is not clear whether males and females of different ages and in different contexts are more or less likely to own or wear helmets.

Social background: Where participants provided information on income and/or education, or where observations have taken place in both affluent and poorer areas, findings have all tended in the same direction, that is helmet ownership and use are positively associated with income and educational level, and helmet wearing is greater in more, rather than less affluent areas. In some studies, these trends were marked. One study (Dannenburg *et al* 1993) recorded bicyclists ethnicity and here, helmet use appeared greater amongst whites. The reasons for these differences are not understood.

Bicycling location/type of area: There is some evidence from observational studies that helmet use is greater in urban, as compared to rural areas. For example, Harlos *et al* (Harlos 1999) reported urban helmet use at 23 per cent compared to 9 per cent in rural areas. There is also evidence that helmet use is greater on main roads as opposed to residential streets.

Geography: Where helmet use has been recorded in different geographical areas within the same country, there have been marked differences in rates of use. For example, amongst adult bicyclists Dannenberg *et al* (Dannenburg 1993) reported helmet wearing rates of between 49 per cent and 74 per cent in 3 USA counties. Bolen *et al* (1998) also reported different regional rates. Different levels of helmet promotion may possibly explain some of the differences.

Companionship: In studies where helmet use by accompanied bicyclists have been noted or where both parents and children have been asked about ownership/use, findings have again tended in the same direction. If a bicyclist is travelling with helmeted companions (be they parents, children, or peers) they too tend to wear helmets. There is evidence that parent use is strongly associated with use by children.

Attitudes: barriers and facilitators: Questionnaire surveys and focus groups have identified a range of attitudinal barriers to increased helmet use and some attitudes/beliefs that encourage use. Again, we will examine different factors in turn.

Perception of risk

Studies of children and teenagers reveal evidence that bicycling is perceived as a low risk activity and that serious injury and death are extremely unlikely consequences of bicycling accidents (Howland *et al* 1989, Loubeau 2000). There is also some evidence that some types of journey are perceived as less risky, for example short journeys and journeys on residential streets are perceived as less dangerous than longer journeys or journeys on busier roads. For example Finch (1996) found that of 1017-year-olds, 84 per cent thought that helmets should be worn on main roads compared to 37 per cent for quieter streets. Previous crash history, or knowing someone who has had an accident, does not seem to influence helmet use in any clear way. There is some evidence that helmet wearers tend to be more safety conscious altogether. For example, McGuire and Smith (2000) found that helmet wearers were more likely to have working front and rear lights and to be wearing high visibility clothing compared to non-wearers. Lajunen and Räsänen (2001) in a study of teenagers found that helmet use was associated with other positive health behaviours (for example non smoking). In most studies, there was general agreement amongst helmet users and non-users that helmets were protective against head injury.

Apperance/Peer Pressure

Studies including teenagers and older children revealed that peer pressure may constrain or encourage helmet use. In general, helmets have been regarded as ugly and stupid by young people. The opinion of friends and whether or not their friends wore helmets seemed to influence children's and teenagers attitudes towards helmets. For example Gielen *et al* (1994) found that children who reported that their friends wore helmets were nine times more likely to wear helmets themselves than those where friends did not wear helmets. Sissons Joshie *et al* (1994) in a study of teenagers reported that 45 per cent of non-helmet-wearers said that friends using helmets would encourage their own use.

Parent influence

Both observational studies and questionnaire studies reveal that parent ownership/use encourages child ownership/use. The results of qualitative studies support these findings. However, Loubeau (2000) suggests that parent influence may be less important with teenagers. DiGuiseppi *et al* (1990) revealed that many parents were unaware of the need for bicycle helmets.

Discomfort

Discomfort associated with helmet use (for example too hot, ill-fitting) was mentioned as a barrier to use in a number of studies involving all age groups.

Cost

The high cost of helmets was mentioned as a reason for non-ownership in a number of studies examining barriers to use.

Legislation

Positive attitudes towards mandatory helmet use were revealed in several studies including studies in the UK. For example Lee (Lee 1993) reported that 58 per cent of teenagers thought that helmet use should be made law. In the study by Sissons Joshie *et al* (1994) 55 per cent agreed. The qualitative study by Halliday *et al* (Halliday 1996) revealed that most, but not all, participants favoured legislation and there were several arguments put forward against bicycle helmet laws.

The Intervention studies

The intervention studies confirm many of the findings of the qualitative and quantitative studies on barriers and facilitators (Table 6.9). Helmet use has been lower in teenagers, and is positively associated with income and educational level. At the same time, campaigns to promote helmet use show that uptake may be lower amongst boys, teenagers and in children bicycling or living in less affluent areas.

Key points

- Most of the literature on barriers and facilitators of helmet use has focused on children and teenagers.
- Over time, helmet use has increased, but there remain differences in helmet-wearing rates between and within countries.
- Barriers to helmet use include age (teenagers), social background (lower income), geographical factors, and group effects associated with companionship, cost and discomfort.
- Attitudinal barriers to helmet use include low risk perception, peer pressure and parental influence.

Table 6.1: Barriers to /facilitators of helmet use

Author, date, and place of study	**Participants and setting**	**Study type and data collection**	**Key findings**
Weiss (1986) Tucson, USA	Children and young adults attending 10 schools and university. Ages not specified. 68 bicyclists observed.	Observational study of helmet wearing at school and university campus entrances. Elementary, junior and senior high schools observed (10 schools) and 1 university campus.	Very low helmet use observed. 4/318 school pupils and 15/150 university bicyclists wearing helmets. *Facilitators*: *Age*: young adults more likely to be observed wearing helmets than children.
Howland *et al* (1989) Boston, USA	Children aged 1014 years attending 3 schools. 42 child bicyclists selected by teachers for participation. 2 schools in affluent areas. 1 in inner city area.	Focus groups to explore children's attitudes to risk and helmet wearing. Younger and older children in separate groups (6 groups in total). Similar numbers of boys and girls.	Only 4/42 children (12%) owned helmets. *Barriers*: *Perception of low risk*: helmets perceived as unnecessary for normal bicycling use (perceived as needed for sports bicycling). Risk of serious injury/death perceived as low. *Appearance*: helmets perceived as ugly and stupid. *Facilitators*: Positive attitude to law
DiGuiseppi *et al* (1990)	Parents of children (mean age 9.1) attending Seattle schools in 1987. 1,057	Postal survey of parents whose children attended selected schools. Study	88% of children owned bicycles of which 24% reported helmet ownership. Of these, 56% of

Seattle, USA	responses. Respondents more likely to be from affluent areas.	of parent attitudes, child helmet ownership and use. Final section of questionnaire on helmet use completed by child.	children wore them on last journey. *Barriers*: *Social group*: 40% with college education versus 10% of those with high school education reported ownership. *Knowledge*: 51% of parents reporting non-ownership were not aware of need for helmets. *Child attitudes*: 20% of non-owners reported child would not wear helmet. *Cost*: 29% of non owners mentioned high cost. Children's reason for not wearing helmet: *Peer pressure*: friends dont wear: 28%; *Uncomfortable*: 42%; *Forgot/didnt think*: 51%; *Not necessary*: 13%.

Table 6.2: Barriers to /facilitators of helmet use

Author, date, and place of study	**Participants and setting**	**Study type and data collection**	**Key findings**
Otis *et al* (1992) Montreal, Canada	Children aged 812 years old attending French language schools in Montreal. 797 (84%) respondents. 27% attending schools in rural and 73% urban areas.	Questionnaire survey completed by children in school. Study of perceptions of risk and attitudes to bicycle helmets.	93% rode bicycles at least 3 times each week. Low helmet ownership: 4.1%. *Barriers*: *Attitudes*: neutral attitudes towards helmets.
Skarratts (1992) Southampton, UK	Children aged 1014 years enrolled on bicycling proficiency scheme and their parents. 25 children and 16 parents responded.	Questionnaire survey of children and parents exploring attitudes and bicycling practices.	Low helmet use. 3 children (12%) reported wearing helmets. *Barriers*: *Perception of risk*: bicycling on quiet roads and off-road regarded as low risk. *Cost*: helmets regarded as high cost.
Stevenson and Lennie (1992) Southern Queensland, Australia	Children/teenagers aged approximately 718 years. School-based and community-wide activities.	Action research programme in 1988: 1 Observations of helmet use by children attending 3 schools (n=397 observed);	40% of primary and 10% of high school child bicyclists observed wearing helmets. *Barriers*: *Age*: younger children more likely to wear helmets. *Gender*: boys more likely to

		2 Focus groups involving students 714 years in 3 schools; 3 Baseline survey of helmet use/attitudes (n=565 respondents aged 1018 yeas in 8 schools); 4 Workshops and helmet trials. *Aim*: to develop strategies to increase helmet use	wear helmets. *Appearance*: discomfort, poor fit, cost identified as barriers. *Facilitators*: 92% thought helmets were protective. 57% thought helmet use should be compulsory.
Dannenburg *et al* (1993) Montgomery/ Baltimore and Howard counties, USA	Adults observed bicycling in 120 sites in 3 USA counties. *Ages*: approximately 20 years. Diversity of sites. Observations before and after child bicycle helmet law introduced into 1 county in 1990. 2,068 observations of adult bicyclists analysed.	Observations of helmet use in a variety of locations. Data collection included ethnicity and riding circumstances (eg location and whether bicycling with companions).	Helmet use ranged from 49% to 74% in the 3 counties. *Barriers/facilitators (associated with helmet use)*: *Ethnicity*: whites more likely to be observed wearing helmets *Location*: helmet use greater on main county roads (68%) versus residential streets (45%). *Social group/area*: helmet use greater in upper middle class (60%) versus middle class areas (52%). *Comparisons/group effect*: helmet use greater where companions also wearing helmets.

Table 6.3: Barriers to /facilitators of helmet use			
Author, date, and place of study	**Participants and setting**	**Study type and data collection**	**Key findings**
Lee (1993) West Berkshire and Thameside, UK	Children and teenagers attending schools and youth clubs in two areas in the UK. 858 bicyclist responders (96%) aged 1116 years.	Questionnaire survey in schools and youth clubs examining teenagers attitudes to helmets and to identify factors associated with use.	*Gender*: and *Location*: 14% of females and 28% of males in West Berkshire reported always wearing helmets compared with 3% females and 5% of males in Thameside. *Barriers*: *Appearance*: 40% mentioned. *Cost*: and *Peer Pressure*: also important. *Facilitators*: 40% in West Berkshire and 36% in Thameside thought legislation

			would increase use. 58% thought helmet wearing should be mandatory.
Gielen *et al* (1994) Howard, Montgomery and Baltimore Counties, USA	Community-wide survey in three US counties (1 with bicycle helmet law for children	Questionnaire survey of children exploring helmet use, attitudes and perceptions of risk.	92% had bicycles, 33% owned helmets and 19% reported wearing helmets on last journey. Helmet use greatest (37%) in county where helmet use mandatory (13% and 11% in other counties).
Sissons Joshi *et al* (1994) Oxford, UK	Teenagers/young adults aged 1418 years in 4 Oxford schools. Mean age 15 years Respondents = 655 teenagers.	Questionnaire survey via 4 UK schools.	18% reported always using helmets, 53% never. Males and females equally likely to wear helmets. Helmet users and non-users perceived helmets as protective. *Barriers*: *Age*: 52% reported wearing helmets at age 15, 38% at age 17+. *Appearance*: 71% thought helmets looked stupid. *Discomfort*: 81% thought helmets hot and uncomfortable. *Peer pressure*: 45% of non-wearers said use by friends would encourage use. *Cost* and *Inconvenience*: also mentioned. *Facilitators*: *Legislation*: 55% thought helmet wearing should be mandatory.

Table 6.4: Barriers to /facilitators of helmet use

Author, date, and place of study	**Participants and setting**	**Study type and data collection**	**Key findings**
Seijts *et al* (1995) Netherlands	Children aged 713 years attending 3 schools. Voluntary participation in intervention study. 233 respondents.	Questionnaire survey in 1991. Intervention: children were given helmets to wear for six weeks and asked to wear them on the school journey. After the intervention period they were asked to complete questionnaires.	*Barriers*: *Location/journey type*: 48% reported always wearing helmets on school journey versus 21% while playing. Reasons for not wearing helmets included *Appearance, Peer pressure*, *Discomfort*: Only 8/259 children still reported wearing helmets 3 months after the intervention.
Finch	Teenagers aged 1317 years	Questionnaire survey in	69% who had ridden bicycle in

(1996) Melbourne, Australia	attending 12 state and 1 private school with helmet promotion activities. Schools typically served lower/middle income areas 1,240 eligible respondents.	1993 via Melbourne schools. Information on attitudes, knowledge, behaviour and demographics collected.	past year reported owning helmets. Of these 24% reported always wearing helmet Barriers: Location/risk perception: 84% thought helmets should be worn on main roads, 37% on quiet streets and 45% on paths/tracks. Reasons for not wearing helmets included Discomfort (34%) Not fashionable/dislike (23% and 11%), perception of Low Risk (7%). Facilitators: Perceptions of Risk: 54%. Parent pressure: 32%. The Law: 8%.
Halliday *et al* (1996) London and Banbury, UK	Children and adults included. Groups included 84 bicyclists (36 helmet wearers and 48 nonwearers). Groups: Adults: 2540 years Young adults: 1824 years Teenagers: 1517 years Young teenagers: 1315 years Younger children:	Qualitative data collected. Focus groups/discussion groups to explore attitudes to bicycling, helmet use and reasons for use/non-use. 12 focus groups. Single gender groups.	Helmet use generally perceived as unpopular. General agreement that helmets protective. Less agreement about the degree of protection. *Barriers*: reasons for not wearing helmets included: *Appearance, Discomfort, Cost, Inconvenience, Perceptions about risk*, helmets perceived as being used by minority. *Facilitators*: *Compulsion*: many, but not all favoured introduction of helmet law. *Previous injury*: reminder of personal vulnerability. *Pressure*: from teachers, parents or friends mentioned less frequently.

Table 6.5: Barriers to /facilitators of helmet use			
Author, date, and place of study	**Participants and setting**	**Study type and data collection**	**Key findings**
Sacks *et al* (1996) USA	Children aged under 15 years who had ridden bicycle in previous month. USA wide survey. Results weighted to reflect USA population statistics 1,645 child bicyclists.	Random dialling telephone survey of parents with children under 15 years. Survey explored bicycling practices, helmet ownership and use.	50.2% bicyclists owned helmets. 25% reported always using helmets. Slightly higher ownership and use by boys. Greater ownership by higher income and more educated groups. *Barriers*: Reasons for non-ownership included perceptions of *Low risk, Lack of awareness*,

			perceptions of negative child attitudes. Social group: 34% of highest and 20% of lowest income group reported use. *Facilitators*: *Age*: younger children more likely to wear helmets (32% of 59s versus 18% of 1014s wore helmets.
Britto and Dowd (1997) USA	Teenagers 1115 years. Focus on African-American teenagers. 37 participants attending selected schools.	Four focus groups exploring attitudes to bicycling safety and barriers to helmet use.	19% owned helmets *Barriers*: Bicycling safety seen as irrelevant compared to other health issues. Reasons for non-use of helmets included *Appearance, Peer pressure, Discomfort*, Low *risk* perceptions.
Bolen *et al* (1998) Statewide survey, USA	Stratified random sample with results weighted to be representative of USA population.	Random-digit dialled telephone survey. Questions included details of bicycling practices and helmet use and aimed to identify those factors associated with consistent helmet wearing.	*Barriers/Facilitators* *Gender*: 21.7% of females versus 16.0% male bicyclists reported always wearing helmets. *Age*: bicyclists 1824 significantly less likely to report helmet wearing than older age groups. *Social/Economic group*: education and income positively associated with helmet use. *Region/Geography*: helmet use varied in different geographical areas. *Location*: helmet use in urban areas 20.7% versus 5.2% in rural areas.

Table 6.6: Barriers to /facilitators of helmet use (6)

Author, date, and place of study	**Participants and setting**	**Study type and data collection**	**Key findings**
Cryer *et al* (1998) South East England, UK	Children aged 1012 years and 1416 years included. 3,082 bicyclists completed questionnaires.	Questionnaire survey in 1994 via 23 secondary schools. Surveys completed during class time and explored factors associated with helmet wearing.	*Barriers/Facilitators*: *Age*: at age 11 69% owned helmets versus 38% at age 15. 30% of 11-year-olds always wore helmet compared to 12% at 15. *Gender*: boys were more likely to report always wearing helmets. Reasons for non-use

			included *Discomfort* and negative attitude. Factors encouraging use included *Parental encouragement*, friends wearing helmets and bicycling circumstances/location.
Wardle and Iqbal (1998) Staffordshire, UK	Children aged 1015 years attending primary and secondary schools in Staffordshire. 1 Focus groups children attending 6 primary schools and 4 secondary schools. 2 Questionnaires completed by 2,284 children.	Questionnaire survey via schools focusing on 10- and 11-year-old and 14- and 15-year-old children. Survey examined wearing rates and attitudes. Focus groups examined attitudes in more detail.	43% of bicyclists owned helmets. *Barriers*: *Age*: older pupils less likely to own/use helmets. *Gender*: girls less likely to own helmets but as likely to wear them. Reasons for non-use included *Appearance, Peer pressure, Discomfort, Length of Journey* (short journey). *Forgetting/lack of awareness*. *Facilitators*: Focus group revealed most children were positive about legislation.
Harlos *et al* (1999) Winnipeg, Canada	Adult and child bicyclists observed in 190 urban and 30 rural sites. Observations recorded for 1,286 children and 1,343 adults.	Observation of helmet use at a variety of locations. Age, gender, location, companion and correct helmet use noted.	Helmet use overall = 21.3%. *Barriers*: *Gender*: 26% of females versus 19% males helmeted. *Age*: helmet use in teenagers approximately 8%, 24% in adults, 40% in children under 8. *Location*: helmet use 23% in urban v 9% in rural areas. *Social group/area*: high income areas helmet use 31%, low income 8%. *Companionship*: for teenagers, riding with an adult was associated with increased use.

Table 6.7: Barriers to/facilitators of helmet use (7)			
Author, date, and place of study	**Participants and setting**	**Study type and data collection**	**Key findings**
Mulle *et al* (1999) South West England, UK	Cohort of parents/children attending a hospital paediatric outpatients department. 178 questionnaires completed by parents. Age not clear - 40% of children < 5 years.	1996 questionnaire survey. Completed by parents at child hospital appointments. Questionnaires focused on bicycling practices and helmet use.	79% of child bicyclists reported to own helmets. Similar ownership for boys and girls. *Barriers/facilitators*: *Parent pressure/companionship*: 35% of bicycling parents owned helmets all children in these

	40% of children < 5 years.	and helmet use.	families owned helmets. *Social group*: helmet use reported as lower in low income families.
Loubeau (2000) New York area, USA	Children aged 1213 years attending two schools. All had worn helmet on at least 1 occasion. 31 students participated (17 male and 14 female).	1998 study. 4 focus groups investigating barriers to bicycle helmet use. Attitudes, risk perception and behaviour examined. Content analysis.	9/31 always or usually wore helmets. 13/31 never wore helmets. *Barriers*: *Discomfort*: helmets perceived as hot and ill-fitting. *Peer pressure*: helmets perceived as looking dumb. *Low risk perception*: few perceived bicycling as a high risk activity. *Parent pressure*: rules not enforced with this age group.
McGuire and Smith (2000) Oxford, UK	Busy two-way road observed. 392 bicyclists observed: 104 helmeted; 288 no helmet; all ages included.	Roadside observation of helmet use during evening rush hour. Observation of range of bicycling safety behaviours.	*Facilitators*: Helmeted bicyclists were more likely to adopt other safety measures, eg both rear and front lights working and wearing high-visibility clothing.
Berg and Wersterling (2001) Sweden	Children/adolescents aged 1215 years attending 14 schools in two towns. Responses: 1,485	Questionnaire survey in schools examining helmet use and attitudes.	*Barriers*: *Age*: 27% of 12-year-olds and 1% of 15-year-olds reported helmet use. Reasons for discontinuing use included *Appearance* and *Discomfort*. *Facilitators*: Helmets perceived as protective. 84% of those who wore helmets said their parents had encouraged helmet use.
Finnoff *et al* (2001) Minnesota, USA	Children and adults included. Separate analysis for children 710 years, teenagers 1119 years and adults> 19. Survey in 3 schools and 3 bicycle tracks. 2,039 surveys completed by school pupils and 463 on bicycle tracks.	Questionnaire survey to explore why children and adults do or do not wear bicycle helmets.	*Barriers*: *Age*: older bicyclists (> 50 most likely to wear helmets (use> 62%). Lowest use by adults 3039 (30%) and teenagers (31%). Reasons for non-use included *Discomfort, Low risk perception*. *Facilitators*: Children more likely to wear helmets if accompanied by adults wearing helmets.

Table 6.8: Barriers to/facilitators of helmet use

Author, date, and place of study	Participants and setting	Study type and data collection	Key findings
Lajunen and Räsänen (2001) Finland	Teenagers aged 1219 years attending two secondary schools. 965 students included.	Questionnaire survey completed during class time investigating helmet use, crash history and attitudes. Analysis by logistic regression.	52% owned helmets. *Facilitators*: Helmet ownership positively related to parent attitudes. *Barriers*: *Age, Peer pressure, Attitude to risk* reduced likelihood of wearing helmets. Older students, those using alcohol and low use by friends associated with non-use.
Morrongiello and Major (2002) Canada	54 mothers with children aged between 79 years randomly selected from hospital-attending population	Telephone survey of parents looking at attitudes to risk and possible risk compensation relating to a range of safety equipment	Parents perceived helmets as protective. These parents suggested a greater tolerance of risk taking (eg faster bicycling) if a child was wearing a helmet.

Table 6.9: Barriers to/facilitators of helmet use in Intervention Studies	
1 Wood and Milne (1988)	Describes 1983 market research by Road Traffic Authority and observational data on helmet use 198385. Helmet use is 39% among primary school children, 14% among secondary schoolchildren and 42% among adults.
2 DiGuiseppi *et al* (1989)	Observation of helmet use in Seattle and Portland revealed higher helmet use amongst white, accompanied bicyclists. Concluded *the strongest association of helmet use was use by companions, both child and adult*.
3 Cushman *et al* (1991)	This paper describing an intervention study reported some data from a parent survey on helmet use. This study revealed that a previous bicycling injury increased the likelihood of helmet use and concluded a bike accident is a strong motivator to purchase a helmet (p45).
4 Pendergrast *et al* (1992)	This study included pre- and post-intervention surveys of parents and children. Most children thought helmets were protective. The strongest predictor of helmet ownership/use was helmet ownership by sibling. Parent non-use of helmet was strongly associated with child non-use.
5 Puczynski and Marshall (1992)	This study included a survey of helmet use and attitudes. Helmet ownership was positively associated with family income and parent education. Younger children were more likely to wear helmets than older children. Reasons for not wearing helmets included: travelling a short distance, forgetting, and friends not wearing helmets.
6 Towner and Marvel (1992)	In this study parent attitudes were surveyed before and after an intervention. Helmet ownership and use was more frequent among families with two or fewer children, higher income families and higher educated parents. The most frequent reason given

	for non-ownership was parent lack of awareness.
7 Parkin *et al* (1995)	At baseline helmet use was greater in high income families. This study also showed that children were more likely to wear helmets if they were accompanied by an adult wearing a helmet.
8 Farley *et al* (1996)	This study revealed that location was associated with helmet use. Girls and younger children were more likely to wear helmets. In this study, the intervention was more effective in the more affluent than in the poorer areas.
9 Farley *et al* (1997)	In this study pre- and post-intervention surveys were completed. Following the intervention, helmet use was greater amongst girls and amongst younger children.
10 Kim *et al* (1997)	This study included a parent survey and revealed that helmet use was greater amongst younger children, girls, more educated, and higher income groups
11 Logan *et al* (1998)	This study included pre- and post-intervention observation of helmet use along with a survey of children's attitudes. Results suggested that the intervention did not improve attitudes to helmet wearing.
12 Quine *et al* (2001)	This study included bicyclists who did not wear helmets and the intervention specifically aimed to change attitudes and beliefs. Both I and C groups believed helmets were protective, however, for other beliefs the school-based activities did achieve a significant impact on beliefs and behaviour, which was sustained over time.

Section 7: Opinion Pieces

The purpose of this section is to summarise the range of arguments that have been deployed in the bicycle helmet debate and to consider some of the ways in which this debate has been conducted. A selection of papers from the late 1980s/2002 were chosen for analysis; largely editorials and opinion pieces with associated correspondence from the main journals in the field together with reports from various interest groups and associations (see reference list for Section 7).

The sample was not scientifically selected but aimed to capture the flavour of the debate as it has emerged in the 1990s onwards. In the interests of balance, approximately half the sample were for and half against bicycle helmet wearing.

The main arguments used in the debate

The following table presents the main arguments that were found in the sample of papers together with an indication of the frequency with which those arguments were employed overall. Although this information should be seen as presenting only very broad indicators, it does reflect certain characteristics of the debate.

For

Thirty-one papers out of 67 were in favour of bicycle helmet wearing and 20 of these advocated legislation. This pro-helmet group is largely drawn from the medical profession and they base their arguments overwhelmingly on one main theme: namely, that in the event of a fall, bicycle helmets substantially reduce the incidence and severity of head injury and this has been proven by scientifically valid research methods.

Three other arguments are employed by this group to a lesser degree. First, they point out that introducing helmet legislation does not exclude other safety measures being pursued at the same time. Second, they occasionally refer to the particular nature of child bicycling epidemiology including stages of child development and where their bicycling takes place. Third, and largely in response to arguments put forward by the anti-helmet group, they refute the notion of risk compensation and the effect that helmet wearing would have on bicycling behaviour. Other arguments: the longer-term consequences of head injury, health costs and the issue of individual liberty, are rarely employed in this sample.

Against

Thirty two papers were against bicycle helmet wearing and legislation. This anti-helmet group is more diverse in its composition than the pro-group. A range of health professionals and academics are joined by representatives of bicycling organisations.

Table Section 7 summary of the main arguments employed

(Scores represent an assessment of the number of times a particular argument is employed across the total number of papers analysed)

N=67

Arguments for bicycle helmets

1. A proven case for head injury reduction from scientific studies	= 35
2. Helmet legislation does not exclude other safety measures being pursued	= 10
3. Child bicycling epidemiology has to be considered	= 9
4. There is little or no evidence for the risk compensation theory	= 7
5. The longer-term consequences of head injuries should be considered	= 1
6. Health cost implications	= 1
7. Compulsory helmet wearing represents no real loss of liberty	= 1

Arguments against bicycle helmets	
1. Compulsory helmet wearing leads to a decline in bicycling	= 23
2. The risk compensation theory is clearly demonstrated	= 18
3. The scientific methods of many studies are defective	= 15
4. There is a need to improve the overall road environment	= 15
5. Helmets do not prevent injury to other parts of the body	= 8
6. Logically, other road users should wear helmets	= 8
7. Compulsory helmet use represents a loss of individual freedom	= 7
8. Basic epidemiological data is poor	= 6
9. The Netherlands and Denmark have few bicyclists with helmets	= 6
10. Victim blaming	= 3
11. Enforcement problems	= 3
12. Cost of helmets	= 2
13. Overall bicycle injury numbers are small	= 2
14. Helmets give the impression that bicycling is a dangerous activity	= 2
15. The focus should be on primary prevention	= 2
16. Helmet appearance is poor	= 1
17. Scientific studies should show a proximate cause between injury and helmet use	= 1

18. Helmets may increase brain injury	= 1

Overall, 31 papers were in favour of helmet wearing of which 20 advocate legislation. 32 papers were against helmet wearing/legislation. The remaining papers took no position.

Perhaps this is one reason why the range of arguments on the anti-side is far wider and no theme dominates their case to the same extent as for the pro-helmet groups.

The most frequently cited argument in the sample was the claim that compulsory wearing of helmets leads to a decline in bicycling and that this then leads to a more sedentary lifestyle with consequent health risks. Much of this material is based on work in Australia. Another major argument asserts the robustness of the risk compensation theory and that this will negate any health gains from helmets. Furthermore, the quality of the scientific research cited by the pro-helmet group is often questioned. The other principal argument is to point to the need to improve the overall road environment for bicyclists as well as other road users and that bicycle helmets are a distraction from this central issue.

The anti-helmet group also use a range of other arguments. These include the view that helmets do not reduce injuries to other parts of the body and that, logically, other road users at risk should also wear helmets if bicyclists are made to. The issue of loss of individual freedom is also sometimes raised. Linked to the criticism of the quality of scientific studies, the anti-group also point to the sparcity of the basic epidemiological data on bicycling and injuries which should form a basis for any decision on helmets. The high bicycling but low helmet wearing culture of the Netherlands and Denmark is also referred to. Lesser used arguments cover issues such as victim blaming of bicyclists, problems of law enforcement, cost of helmets, the low number of bicycle-related injuries and the impression that helmets would give that bicycling is a dangerous activity. Only very rarely is there an argument that helmets might actually increase head injury.

In summary, the pro-bicycle helmet group base their argument fundamentally on one main theme whilst the anti-bicycle helmet group use a far wider range of arguments to endorse their case.

The nature of the debate

In terms of tone, the bicycle helmet debate can best be described as sour and tetchy. Neither side seems willing to concede that there can be alternative points of view. Both sides can descend into language that reflects little credit for either, for instance, expressions such as irresponsible zealots who oppose legislation find their counterpart in helmet advocates dismissed as do gooders and mandarins of health promotion. This can be disappointing for those seeking enlightenment from the debate. A notable exception to this seems to be the contribution by Unwin (1996) who steps back from the details to discuss the overall criteria upon which the debate should be founded. (This is pursued further in the discussion section.)

In the area of tactics, both sides have obviously used the device of questioning the validity of each others data, scientific methods and conclusions and this is reflected in the table. Although this section does not provide a critique of these methods, it is worth noting how narrow the range of supporting references called upon by both pro and anti-groups can be. Thus, the anti-groups assertion of the validity of risk compensation is frequently based on the work of both Hillman and Adams, (eg Hillman 1993) whilst the pro-group make much use of Thompson (1989).

Other tactics are also employed in the debate. In one pro-helmet paper commonsense and personal observation were produced as evidence (Sibert 1996). Elsewhere, an anti-helmet paper claimed that millions will die early because they did not cycle (Wardlaw 2000 p1584). Selective interpretation of material is also widespread. For instance, the BMA report on bicycle helmets clearly stated that, whilst it was opposed to the compulsory wearing of helmets at present, it strongly recommends that all bicyclists, especially children, wear proper fitting helmets (British Medical Association [BMA] 1999, p31). This measured judgement has been seized upon by some of the anti-helmet group to signify the BMAs opposition to helmet wearing. An Australian website (www.bicyclehelmets. com/) concludes that one of the most respected medical bodies in the world was against helmet laws but it fails to refer to the BMAs strong recommendation that helmets be worn.

At times, the same data is interpreted differently. Thus, Lane and McDermott (1994, p965) refer to 19 deaths that could have been saved by helmets as a pro- argument, but Kennedy (1994, p1437) felt that this number confirmed the impression that the potential for life saving was quite small. Elsewhere, Wardlaw (2000, p1584) quotes a figure of a 19 per cent reduction in head injuries to bicyclists following the introduction of the New Zealand bicycle helmet law as a modest reduction, whereas the original authors (Scuffham *et al* 2000) feel that this figure reflects an effective road safety intervention.

One reason why the debate so often seems circular as well as bad natured, could be that the two sides are often arguing about rather different issues. Only occasionally does an author explicitly note that the problem involves both primary and secondary intervention (Kennedy 1994, p1437). Generally, this distinction is not made at all or, at best, only implicitly. The recent Cochrane Review (Thompson *et al* 2001) shows this clearly. On page 7, Thompson, Rivara and Thompson state: The fundamental issue is whether or not when bicycle riders crash [our emphasis] and hit their heads they are benefited by wearing a helmet. To which Hillman (1993, p24) counters that they are making an obvious judgement, confirmed in hospital-based studies that, if bicyclists fall off their bicycles helmeted heads are very likely to be less seriously damaged. No one is denying that (Thompson *et al* 2001). Hillmans concern is with the processes that occur before the incident takes place. Thus both sides can sometimes seem to be talking at cross-purposes with no clear overall framework for their arguments.

There are times, however, when new perspectives are introduced into the bicycle helmet debate. We have already referred to Unwins (1996) wider reflection on the issue but Braithwaite (1999) comments on a specific legal dimension. This is the issue of whether or not wearing a bicycle helmet can be considered contributory negligence in the event of a road accident. In the case Braithwaite raises the lack of a legal requirement to wear a helmet in Britain was part of a successful case for an injured bicyclist. When linked to the issue of whether bicyclists should have insurance cover for road use, legal issues evidently need to be incorporated into the discussion.

The bicycle helmet debate has been waged for many years now. We have attempted in this section to summarise the main arguments used by both sides and to give some sense of the way in which this debate has been conducted. Few on either side seem happy to concede that both have legitimate points to make.

Key points

- The pro-bicycle helmet group base their argument overwhelmingly on one major point: that there is scientific evidence that, in the event of a fall, helmets substantially reduce head injury.
- The anti-helmet group base their argument on a wider range of issues including: compulsory helmet wearing leads to a decline in bicycling, risk compensation theory negates health gains, scientific studies are defective, the overall road environment needs to be improved.
- The way in which the debate has been conducted is unhelpful to those wishing to make a balanced judgement on the issue.

Section 8: Discussion

The overall aim of this report has been to examine the efficacy of bicycle helmets. In order to do this, we have considered a variety of sources of information: bicycle helmet standards (Section 2), observational studies (Section 3), evaluated intervention studies related to the promotion of and legislation for bicycle helmets (Sections 4 and 5), barriers and facilitators of helmet use (Section 6), and opinion pieces examining the arguments employed in the bicycle helmet debate (Section 7).

Within each of the sections there is considerable *heterogeneity*, for example in the case controls studies there are variations in the study design, in the definitions employed in head and brain injury, the age groups of the population and whether data are collected from clinical records or from self-report. In the evaluated legislation studies, the legislation can relate to a general population, or just to a child population, varying degrees of enforcement occur and outcomes can include helmet wearing, mortality and morbidity data, and/or levels of bicycling. Combining such heterogeneous studies is not straightforward and we have not attempted to conduct meta-analyses of the systematic reviews contained in Sections 3, 4 and 5. However, we have attempted to draw out the key points and summarise these at the end of each section. Here we consider how strands from the different sections can be woven together and what major themes emerge.

First we return to the introduction, where we stressed that bicycle helmets are only one part of improving bicycle safety. Diagram 1 (page 11) summarises three phases which we need to consider in bicycle safety the Pre-Event, the Crash Event and the Post-Event. Bicycle helmet promotion and legislation is focused on the phase of the crash event and is essentially an aspect of secondary prevention. The crash event has occurred and the role of the helmet is to protect the head and to reduce the severity and, in some cases, the incidence of the injury. Within the pre-event phase, a variety of policy level interventions could have an impact both on bicycling and on bicycle injuries. Specific road safety intervention can reduce speed, change road layouts or separate bicycles from other traffic, and these also have the potential to reduce bicycle injuries (Towner *et al* 2001). What Diagram 1 also attempts to convey is the dynamic nature of the system: inputs in both the Crash Event and Post-Event phases could have an impact on the climate of bicycling in the Pre-Event phase. For example, mandatory wearing of helmets may influence the number of bicyclists on the roads. Similarly, the decision of insurance companies may also have an impact on bicycling behaviour. Furthermore, if risk compensation operates, helmets may influence the manner in which people cycle and their exposure to risk. This report has not reviewed the evidence in relation to risk compensation. Hedlund (2000) provides a useful overview in this area: he believes that,

> *behavioural adaptation and risk compensation clearly occur in some situations*
> but also that,
> *the evidence is overwhelming that every safety law or regulation is not counterbalanced by compensating behaviour*

Debates have also recently taken place in the journal Injury Prevention and a Cochrane Review about this area, and there has been a call for the risk compensation theory to be subjected to a systematic review (Adams and Hillman 2001, Thompson and *et al* 2001a, Thompson *et al* 2001b).

It is important to emphasise that the focus of work in this brief has been on literature related to secondary prevention.

One theme to emerge in this report is the difference between child and adult bicyclists, and how the results may have different implications for different age groups. In Section 2, for example, on bicycle standards, only the Australia/New Zealand and Canadian standards take serious account of the requirements of children whose tolerances to head injury are low. In Section 1, we noted that children in the UK are more likely to be involved in bicycle accidents where no other vehicles are involved. Children probably do most of their bicycling off the road or in quiet roads away from other vehicles. Most of the literature in the sections on evaluated health promotion studies (Section 4) and barriers and facilitators of helmet use (Section 6) relate to children. In Section 5, much of the legislation from the USA relates solely to children, and where the legislation applies across the general population (for example New Zealand, Australian States) different results are apparent for different age groups. Interventions which have been successful with young children may not be appropriate or achieve similar success with teenagers or adults. Similarly the factors which discourage helmet use in children or teenagers may not be relevant for adult bicyclists (for example peer pressure) and factors that encourage or discourage helmet use in adult commuters may not be relevant to adult recreational bicyclists.

We noted in Section 1 that the bicycling environment varies considerably in different countries. Most of the evidence reviewed in this report comes from outside Britain: only 1 of the 16 observational studies was conducted in Britain and only 2 out of the 19 intervention studies on the promotion of bicycle helmets was conducted in Britain. Can the findings of one country such as the USA or Australia be easily transportable to Britain?

One example to demonstrate how important context is in injury prevention relates to legislation: the contrasting manner in which bicycle helmet legislation has been introduced in Australia and New Zealand and in the USA. In the state of Victoria in Australia, and in New Zealand, vigorous promotional campaigns were conducted for many years (for example 10 years in Victoria) before legislation was introduced and only when wearing rates were high was legislation enacted. In contrast, in some parts of the USA, legislation can be used as a lever to disseminate the idea of bicycle helmets to a wider audience. Graitcer *et al* (1995) comment:

The relative difficulty in implementing educational programs to promote helmet use, their potentially great costs, and their limited success in greatly increasing helmet use, have led to the introduction of mandatory helmet wearing laws as a principle strategy of many governmental jurisdictions.

In the USA, legislation can be introduced at a County or State or Federal level, and with a State law, individual counties can choose to opt out of certain elements. Clearly even such a seemingly robust tool as legislation, does not mean the same in different countries. The tables in Section 5 summarise the effect of legislation in helmet use in different states and counties: in Oregon, USA for example, observed helmet use increased from 25 per cent before and 49 per cent after the law was introduced. Certain groups in society can remain unaffected by such a strategy. McLoughlin *et al* (1985), when talking about both smoke detector and seat belt legislation, argue that:

> *unless compliance is virtually universal, the higher rates of deaths and injuries among high-risk populations are likely to mask the effectiveness of the devices for the majority of people.*

The section on Barriers and Facilitators (Section 6) also highlights the difficulties inherent in transferring findings from one context to another. It is clear from these studies that the barriers to helmet use vary with age, social, economic and possibly cultural groups and that bicycling circumstances influence behaviour. Even within the same group and the same country, behaviour may be different across geographical areas.

Section 9: Conclusions

What relevance does the evidence reviewed have for bicycle helmet promotion in Britain?

Unwin (1996), when considering the context of the British legislative system, has put forward four criteria which must be met before bicycle helmet wearing is enforced. These criteria are:

(1) There must be a high level of scientific evidence that bicycle helmets are effective in reducing the rate of head injury to bicyclists.

(2) The benefits to society and others of mandatory bicycle helmets must be convincingly demonstrated, mandatory bicycle helmets cannot be justified simply to protect individual adult bicyclists.

(3) There must be widespread agreement, ideally by a large majority, that the potential benefits of compulsory bicycle helmets outweigh the infringement of personal liberty and other disbenefits.

(4) There must be good evidence to suggest that compulsory helmet wearing would not make the public health benefits of increased levels of bicycling significantly harder to obtain.

Unwin has also suggested that mandatory bicycle helmets for children may be justified for their own protection.

The first of these criteria has been met. There is now a considerable amount of scientific evidence that bicycle helmets have been found to be effective at reducing head, brain and upper facial injury in bicyclists. Such health gains are apparent for all ages, though particularly for child populations (Section 3). Criterion 2 is less easy to demonstrate and must relate to a broader debate about the whole bicycling environment: bicycle helmet promotion and legislation needs to be seen as one part of a broader package of measures which enhances bicycling safety. The experience of countries such as Australia and New Zealand suggests that this process takes time. Barriers to helmet use can be overcome (Criterion 3). An infrastructure which promotes bicycling and provision for bicycle helmet is needed (for example employers, schools providing facilities for bicycle helmet storage).

In relation to Criterion 4 there is some evidence that legislation may have resulted in decreased levels of bicycling (for example in Victoria, Australia) but there are confounding factors and no clear long-term trends. Attention needs to be paid to enhancing the bicycling environment generally rather than concentrating solely on the individual approach of wearing helmets.

Finally, is there a case for mandatory helmets for children rather than all age groups? The UN convention on the rights of a child asserts that the child has a right to a safe environment. In the barriers and facilitators to helmet wearing section, we noted when children and adults bicycle in groups, children are more likely to wear a helmet if adults also do so. The role model effect of adults is an important factor in enhancing helmet wearing in children. It is also more difficult to enforce a law for one age group. Countries such as New Zealand or States or Provinces which have enacted universal legislation have attained high wearing levels. There may also be problems of enforcement if legislation relates to one environment, for example on-road rather than off-road because different sectors of a bicycle journey may encompass both on-road and off-road environments.

Bicycle helmet review

References for Introduction and Section 1

British Medical Association (BMA) (1999) *Cycle Helmets*. BMA, London.

Bryan-Brown, K. and Christie, N. (2001) *Cycle Helmet Wearing in 1999*. TRL Report 487.

Bryan-Brown, K. and Taylor, S. (1997) *Cycle Helmet Wearing 1996*. TRL Report 286.

Cook, A. and Sheikh, A. (2000) *Trends in Serious Head Injuries among Bicyclists in England: Analysis of Routinely Collected Data. BMJ*, **321:10SS**.

Department of the Environment, Transport and the Regions (DETR). (1997) *Road Accidents Great Britain 1996. The Casualty Report* HMSO, London.

Di Guiseppi, C. and Roberts, I. (1997) Influence on Changing Travel Patterns on Child Death Rate. Injury Trend Analysis. *BMJ*, **314**, 7103.

DiGuiseppi, C., Li, L. and Roberts, I. (1998) Influence of Travel Patterns on Mortality from Injury among Teenagers in England and Wales, 198595. *BMJ*, **316**, 9045.

Leonard, P., Beattie, T. and Gorman, D. (1999) Under Representation of Morbidity from Paediatric Bicycle Accidents by Official Statistics a Need for Data Collection in the Accident and Emergency Department. *Injury Prevention*, **5**, 30304.

McCarthy, M. (1991) Pedal Cyclists, Crash Helmets and Risk. *Pub Health*, **105**, 32734.

Mills, P. (1989) *Pedal Cycle Accidents a Hospital Based Study*. Research Report 220. Transport & Road Research Laboratory (TRRL).

Mynors, P. and Savell, A. (1992) *Bicycling on the Continent*. Local Authority Cycle Planning Group, London.

Purdon, S. (1998) Non Fatal Accidents. *The Health Survey for England 1995, Vol 1: Findings*. Prescott-Clarke and P. Primatesta (Eds). The Stationery Office. London.

Simpson, H. (1996) *Comparison of Hospital and Police Casualty Data: A National Study*. TRL Report 173/SA.TRL 173/SA. Transport Research Laboratory. Crowthorne, Berks.

Taylor, S. and Halliday, M. (1996) *Cycle Helmet Wearing in Great Britain*. TRL Report 156.

Towner, E., Dowswell, T., Mackereth, C. and Jarvis, S. (2001) *What Works in Preventing Unintentional Injuries in Children and Young Adolescents? An Updated Systematic Review*. Health Development Agency, London.

References for Section 3

Attewell, R., Glase, K. and McFadden, M. (2000) *Bicycle Helmets and Injury Prevention: A Formal Review*. Report CR15. Australian Transport Safety Bureau. Australia.

Dorsch, M., Woodward, A. and Somers, R. (1987) Do Bicycle Safety Helmets Reduce the Severity of Head Injuries in Real Crashes? *Acc Anal Prev*, **19**, (3), 18390.

Finvers, K., Strother, R. and Mohtadi, N. (1996) The Effects of Bicycling Helmets in Preventing Significant Bicycle-Related Injuries in Children. *Clin J Sport Med*, **6**, 19297.

Jacobson, G., Blizzard, L. and Dwyer, T. (1998) Bicycle Injuries: Road Trauma Is Not the Only Concern. *Aust J Pub Health*, 45155.

Jarvis, S., Towner, E. and Dowswell, T. (1994) Reducing childhood accidents. The effectiveness of health promotion interventions: A review of research methodologies. Northern and Yorkshire Regional Health Authority, Newcastle.

Linn, S., Smith, D. and Sheps, S. (1998) Epidemiology of Bicycle Injury, Head Injury, and Helmet Use from British Columbia: A 5 Year Descriptive Study. *Inj Prev*, **4**, 12225.

Maimaris, C., Summers, C., Browning, C. and Palmer, C. (1994) Injury Patterns in Cyclists Attending an Accident and Emergency Department: A Comparison of Helmet Wearers and Non-Wearers. *BMJ*, **308**, (11 June), 153740.

McDermott, F., Love, J., Brazenor, G. and Debney, E. (1993) The Effectiveness of Bicyclist Helmets: A Study of 1710 *Casualties. J Trauma*, **34**, 83444.

Rivara, F., Thompson, D. and Thompson, R. (1997) Epidemiology of Bicycle Injuries and Risk Factors for Serious Injury. *Inj Prev*, **3**, 11014.

Shafi, S., Gilbert, J., Loghnamee, F., Allen, J. *et al* (1998) Impact of Bicycle Helmet Safety Legislation on Children Admitted to a Regional Pediatric Trauma Center. *J Paediatr Surg*, **33**, 31721.

Spaite, D., Murphy, M., Criss, E., Valenzuela, T. and Meislin, H. (1991) A Prospective Analysis of Injury Severity among Helmeted and Nonhelmeted Bicyclists Involved in Collisions with Motor Vehicles. *J Trauma*, **31**, (4), 151016.

Thomas, S., Acton, C., Nixon, J., Battistutta, D., Pitt, W. and Clark, R. (1994) Effectiveness of Bicycle Helmets in Preventing Head Injury in Children: Case Control Study. *BMJ*, **308**, (15 January), 17376.

Thompson, D., Nunn, M., Thompson, R. and Rivara, F. (1996) Effectiveness of Bicycle Safety Helmets in Preventing Serious Facial Injury. *JAMA*, **276**, (24), 19745.

Thompson, D., Rivara, F. and Thompson, R. (1996) Effectiveness of bicycle safety in preventing head injuries. *JAMA*, **276**, 196871.

Thompson, D., Rivara, F. and Thompson, R. (2001) *Helmets for Preventing Head and Facial Injuries in Bicyclists*. Cochrane Review. Oxford Update Software.

Thompson, D., Thompson, R., Rivara, F. and Wolf, M. (1990) A Case Control Study of the Effectiveness of Bicycle Safety Helmets in Preventing Facial Injury. *Am J Public Health*, **80**, 147174.

Thompson, R., Rivara, F. and Thompson, D. (1989) A Case-Control Study of the Effectiveness of Bicycle Safety Helmets. *N Engl J Med*, **320**, (21), 136167.

Wasserman, R. and Buccini, R. (1990) Helmet Protection from Head Injuries among Recreational Bicyclists. *Am J Sports Med*, **18**, (1), 9697.

Wasserman, R., Waller, J., Monty, M., Emery, A. and Robinson, D. (1988) Bicyclists, Helmets and Head Injuries: A Rider Based Study of Helmet Use and Effectiveness. *Am J Public Health*, **78**, (9), 1220-21.

References for Section 4

Arblaster, L., Entwistle, V., Lambert, M., Forster, M., Sheldon, T. and Watt, I. (1995) *Review of the Research on the Effectiveness of Health Service Interventions to Reduce Variations*. CRD Report 3. NHS Centre for Reviews & Dissemination, University of York.

Bergman, A., Rivara. F., Richards, D., and Rogers, L. (1990) The Seattle children's bicycle helmet campaign. *American Journal of Diseases of Children* 1990;144:72731.

Britt, J., Silver, I., Rivara, and F,. Bicycle helmet promotion among low income preschool children. *Inj Prev* 1998;4:2803.

Cushman, R., Down, J., MacMillan, N. and Waclawik, H. (1991a) Helmet Promotion in the Emergency Room Following a Bicycle Injury: A Randomized Trial. *Pediatrics*, **88**, (1), 43-47.

Cushman, R., James, W., and Waclawik, H. (1991b) Physicians promoting bicycle helmets for children: A randomized trial. *Am J Public Health* 1991;81(8):10446.

DiGuiseppi, C., Rivara, F., Koepsell, and T., Polissar, L. Bicycle helmet use by children. Evaluation of a community-wide helmet campaign. *JAMA* 1989;262(16):225661.

Ekman, R., Schelp, L., Welander, G., and Svanstöm, L. (1997) Can a combination of local, regional and national information substantially increase bicycle-helmet wearing and reduce injuries? Experiences from Sweden. *Acc Anal Prev* 1997;29:3218

Farley, C., Haddad, S., and Brown, B., (1996) The effects of a 4-year program promoting bicycle helmet use among children in Quebec. *Am J Public Health* 1996;86:4651.

Hendrickson, S., and Becker, H. (1998) Impact of a theory based intervention to increase bicycle helmet use in low income children. *Inj Prev* 1998;4:126-31.

Kim, A., Rivara, F., Koepsell, T .(1997) Does sharing the cost of a bicycle helmet help promote helmet use? *Inj Prev* 1997;3:3842.

Lee, A., Mann, N., Takriti, R. A hospital led promotion campaign aimed to increase bicycle helmet wearing among children aged 1115 living in West Berkshire 1992-98. *Inj Prev* 2000;6:1513.

Logan, P., Leadbetter, S., Gibson, R., Schieber, R., *et al* 1998. Evaluation of a bicycle helmet giveaway program Texas, 1995. *Pediatrics* 1998;101:57882.

Mock, C., Maier, R., Boyle, E., *et al* (1995) Injury prevention strategies to promote helmet use to decrease severe head injuries at a Level 1 Trauma Centre. *J Trauma* 1995;39:2933.

Moore, D. and Adair, V. (1990) Effects of a school-based education programme on safety helmet usage by 11- to 13-year-old cyclists. *Educ Psychol*, **10**, (1), 738.

Morris, B., Trimble, N. (1991) Promotion of bicycle helmet use among schoolchildren: A randomized clinical trial. *Can J Public Health* 1991;82(March/April):924.

Parkin, P., Spence, L., Hu, X., Kranz, K., Shortt, L., and Wesson, D. (1993) Evaluation of a promotional strategy to increase bicycle helmet use by children. *Pediatrics* 1993;91(4):7727.

Parkin, P., Hu, X., Spence, L., Kranz, K. *et al*. (1995) Evaluation of a subsidy program to increase bicycle helmet use by children of low-income families. *Pediatrics* 1995;96(2) 2837.

Pendergrast, R., Ashworth, C., DuRant, R., and Litaker, M. (1992) Correlates of children's bicycle helmet use and short-term failure of school-level interventions. *Pediatrics* 1992;90(3):3548.

Puczynski, M., Marshall, D. (1992) Helmets! All the pros wear them. *American Journal of Diseases of Children* 1992;146:14657.

Quine, L., Rutter, D. and Arnold, L. (2001) Persuading School-Age Cyclists to Use Safety Helmets: Effectiveness of an Intervention Based on the Theory of Planned Behaviour. *Br J Health Psychol*, **6**, 32745.

Towner, P., and Marvel, M. (1992) A school-based intervention to increase the use of bicycle helmets. *Family Med* 1992;24:1568.

Wood, T., Milne, P. (1988) Head injuries to pedal cyclists and the promotion of helmet use in Victoria, Australia. *Accident Analysis and Prevention* 1988;20(3):17785.

References for Section 5

Abularrage, J., De Luca, A., and Abularrage, C. (1997) Effect of education and legislation on bicycle helmet use in a multiracial population. Arch Pediatr Adol Med 1997;151:41-4.

Bicycle Helmet Safety Institute (BHSI) (2002) *Helmet Laws for Bicycle Riders*. www.bhsi.org/mandator.htm.

Cameron, M., Heiman, and L., Neiger, D. (1992) Evaluation of the Bicycle Helmet Wearing Law in Victoria during its first 12 months. Victoria, Australia: Accident Research Centre Monash University, 1992; Report No: 32.

Cameron, M., Vulcan, A., Finch, C, and Newstead, S. (1994) Mandatory bicycle helmet use following a decade of helmet promotion in Victoria, Australia An evaluation. *Acc Anal Prev* 1994;26(3):32537.

Carr, D., Skalava, M. and Cameron, M. (1997) *Evaluation of the Bicycle Helmet Wearing Law in Victoria During the First Four Years*. Report 76. Monash University Accident Research Centre.

Coté, T., Sacks, J., Lambert-Huber, D., Dannenberg, A., *et al*. (1992) Bicycle helmet use among Maryland children: Effect of legislation and education. *Pediatrics* 1992;89(6):121620.

Dannenberg, A., Gielen, A., Beilenson, P., Wilson, M., Joffe, A. (1993) Bicycle helmet laws and educational campaigns: An evaluation of strategies to increase children's helmet use. *Am J Public Health* 1993;83(5):66774.

Finch, C., Newstead. S., Cameron, M., Vulcan, A. (1993) Head injury reductions in Victoria two years after introduction of mandatory bicycle helmet use. Victoria, Australia: Monash Accident Research Centre, Monash University, 1993. Report No: 51.

Finch, C., (1996) Teenagers attitudes towards bicycle helmets. Three years after the introduction of mandatory wearing. Inj Prev, 2(2), 12630.

Foss, R. and Beirness, D. (1995) *An observational survey of bicycle helmet wearing rates in British Columbia Traffic* Injury Research Foundation of Canada, Ottawa.

Foss, R. and Beirness, D. (2000) *Bicycle Helmet Use in British Columbia. Effects of the Helmet Use Law*. University of North Carolina Safety Research Center and Traffic Injury Research, Ottawa.

Healy, M. and Maisey, G. (1992) *The impact of helmet wearing legislation and promotion in Western Australia. Report TB92-6. Traffic Board Western Australia*. Perth, Australia.

Hendrie, D., Legge, M., Rosman, D. and Kirov, C. (1999) *An Economic Evaluation of the Mandatory Bicycle Helmet Legislation in Western Australia. November. Department of Public Health, University of Western Australia*. Western Australia.

Kanny, D., Schieber, R., Pryor, V. and Kresnov, M. (2001) Effectiveness of a State Law Mandatory Use of Bicycle Helmets among Children: An Observed Examination. *American Journal of Epidemiology*, **154**, (11), 107276.

King, M. and Fraine, G. (1994) *Bicycle helmet legislation and enforcement in Queensland 19911993: Effects on helmet wearing and crashes*. Road User Behaviour Section, Road Transport and Safety Division, Queensland Transport.

Leicester, P., Nassau, F., Wise, A. (1991) The introduction of compulsory bicycle helmet wearing in Victoria. Victoria, Australia, 1991: Vic Roads Report, (GR 914)

Macknin, M., and Medendorp, S. (1994) Association between bicycle helmet legislation, bicycle safety education, and use of bicycle helmets in children. *Arch Pediatr Adol Med* 1994;148:255-9.

Macpherson, A., Parker, P. and To, T. (2001) Mandatory Helmet Legislation and Children's Exposure to Cycling. *Injury Prevention*, **7**, (228230).

Macpherson, A., To, T., Wright, J., Chipman, M., Macarthur, C. and Parkin, P. (2002) Mandatory bicycle helmet legislation and childhood head injuries: A population based study (Abstract). 6th World Conference on Injury Prevention and Control, Montreal. Les Presses de lUniversité de Montréal.

Marshall, J. and White, M. (1994) *Evaluation of the compulsory helmet wearing legislation for bicyclists in South Australia* Report 8/94. *South Australian Department of Transport*. Walkerville, South Australia.

McDermott F. (1995) Bicyclist head injury prevention by helmets and mandatory wearing legislation in Victoria, Australia. *Ann R Coll Surg Engl* 1995;77:3844.

Ni, H., Sacks, J., Curtis, L., Cieslak, P., and Hedberg, K. (1997) Evaluation of a statewide bicycle helmet law via multiple measures of helmet use. *Arch Pediatr Adol Med* 1997;151:5965.

Personal communication Dr M. Grivna, Czech Republic.

Povey, L., Frith, W. and Graham, P. (1999) Cycle Helmet Effectiveness in New Zealand *Accident Analysis & Prevention*, **31**, 76370.

Robinson, D. (1996) Head Injuries and Bicycle Helmet Laws. *Accidents, Analysis & Prevention*, **28**, (4), 46375.

Rodgers, G. (2002) Effect of State Helmet Laws on Bicycle Helmet Use by Children and Adolescents. *Injury Prevention*, **8**, 4246.

Scuffham, P., Alsop, *et al* (2000) Head Injuries to Bicyclists and the New Zealand Bicycle Helmet Law. *Accident Analysis & Prevention*, **32**, 56573.

Towner, E. and Towner, J. (2002) UNICEFs Child Injury League Table. An Analysis of Legislation: More Mixed Messages. *Inj Prev*, (8), 2.

Vulcan, A., Cameron, M. and Heiman, L. (1992) Mandatory bicycle helmet use Victoria, Australia. *MMWR*, **42**, (18), 35963.

References for Section 6

Berg, P. and Westerling, R. (2001) Bicycle Helmet Use among Schoolchildren the Influence of Parental Involvement and Children's Attitudes. *Inj Prev*, **7**, 21822.

Bolen, J., Kresnow, M. and Sacks, J. (1998) Reported Bicycle Helmet Use among Adults in the United States. *Arch Fam Med*, **7**, (1), 7277.

Britto, M. and Dowd, M. (1997) Young Adolescents Attitudes toward Bicycle Helmet Use. *J Adol Health*, **20**, (2), 148.

Cryer, P., Cole, J., Davidson, L., Rahman, M., Ching, V. and Goodall, J. (1998) Rates of, and the Factors Affecting, Cycle Helmet Use among Secondary School Children in East Sussex and Kent. *Inj Prev*, **4**, (2), 10610.

Cushman, R., Down, J., MacMillan, N. and Waclawik, H. (1991a) Helmet Promotion in the Emergency Room Following a Bicycle Injury: A Randomized Trial. *Pediatrics*, **88**, (1), 4347.

Dannenburg, A., Cote, T., Kresnow, M., Sacks, J., Lipsitz, C. and Schmidt, E. (1993) Bicycle Helmet Use by Adults: The Impact of Companionship. *Pub Health Rep*, **108**, (2), 21217.

DiGuiseppi, C., Rivara, F., Koepsell, T. and Polissar, L. (1989) Bicycle Helmet Use by Children. Evaluation of a Community-Wide Helmet Campaign. *JAMA*, **262**, (16), 225661.

DiGuiseppi, C., Rivara, F. and Koepsell, T. (1990) Attitudes Towards Bicycle Helmet Ownership and Use by School-Age Children. *Am J Dis Ch*, **144**, 8386.

Finch, C. (1996) Teenagers Attitudes Towards Bicycle Helmets Three Years after the Introduction of Mandatory Wearing. *Inj Prev*, **2**, (2), 12630.

Finnoff, J., Laskowski, E., Altman, K. and Diehl, N. (2001) Barriers to Bicycle Helmet Use. *Pediatrics*, **108**, (1), e4.

Farley, C., Haddad, S. and Brown, B. (1996) The Effects of a 4-Year Program Promoting Bicycle Helmet Use among Children in Quebec. *Am J Public Health*, **86**, 4651.

Farley, C., Otis, J. and Benoit, M. (1997) Evaluation of a four year bicycle helmet promotion campaign in Quebec aimed at children aged 8 to 12: Impact on attitudes, knowledge and behaviour. *Can J Public Health*, **88**, (1), 6266.

Gielen, A., Joffe, A., Dannenberg, A., Wilson, M., Beilenson, P. and De Boer, M. (1994) Psychosocial Factors Associated with the Use of Bicycle Helmets among Children in Counties with and without Helmet Use Laws. *J Pediatr*, **124**, (2), 20410.

Halliday, M., White, C., Finch, H. and Ward, K. (1996) *Attitudes to Cycle Helmets a Qualitative Study*. TRL Report 154. Transport Research Laboratory. Crowthorne, Berkshire.

Harlos, S., Warda, L., Buchan, N., Klassen, T., Koop, V. and Moffatt, M. (1999) Urban and Rural Patterns of Bicycle Helmet Use: Factors Predicting Usage. *Inj Prev*, **5**, (3), 18388.

Howland, J., Sargent, J. and Mwitzman, M. (1989) Barriers to Bicycle Helmet Use among Children. *Am J Dis Ch*, **143**, 74144.

Kim, A., Rivara, F. and Koepsell, T. (1997) Does Sharing the Cost of a Bicycle Helmet Help Promote Helmet Use? *Inj Prev*, **3**, 3842.

Lajunen, T. and Räsänen, M. (2001) Why Teenagers Owning a Bicycle Helmet Do Not Use Their Helmets. *J Safety Res*, **32**, (3), 32332.

Lee, A. (1993) Peer Pressure in Cycle Helmet Use. *Paediatr Nursing*, **5**, (4), 1215.

Logan, P., Leadbetter, S., Gibson, R. and Schieber, R. (1998) Evaluation of a Bicycle Helmet Giveaway Program Texas, 1995. *Pediatrics*, **101**, 57882.

Loubeau, P. (2000) Exploration of the Barriers to Bicycle Helmet Use among 12 and 13 Year Old Children. *Accident, Analysis and Prevention*, **32**, 11115.

McGuire, L. and Smith, N. (2000) Cycling Safety: Injury Prevention in Oxford Cyclists. *Inj Prev*, **6**, (4), 28587.

Morrongiello, B. and Major, K. (2002) Influence of Safety Gear on Parental Perceptions of Injury Risk and Tolerance for Children's Risk Taking. *Inj Prev*, **8**, (1), 2731.

Mulle, M., Turnbull, J. and Glasper, E. (1999) Prevalence of Cycle Helmet Use in Children. *Paediatr Nursing*, **11**, (1), 2730.

Otis, J., Lesage, D., Godin, G., Brown, B., Farley, C. and Lambert, J. (1992) Predicting and Reinforcing Children's Intentions to Wear Protective Helmets While Bicycling. *Pub Health Rep*, **107**, (3), 28389.

Parkin, P., Hu, X., Spence, L. and Kranz, K. (1995) Evaluation of a Subsidy Program to Increase Bicycle Helmet Use by Children of Low-Income Families. *Pediatrics*, **96**, (2), 28387.

Pendergrast, R., Ashworth, C., DuRant, R. and Litaker, M. (1992) Correlates of Children's Bicycle Helmet Use and Short-Term Failure of School-Level Interventions. *Pediatrics*, **90**, (3), 35458.

Puczynski, M. and Marshall, D. (1992) Helmets! All the Pros Wear Them. *Am J Dis Ch*, **146**, 146567.

Quine, L., Rutter, D. and Arnold, L. (2001) Persuading School-Age Cyclists to Use Safety Helmets: Effectiveness of an Intervention Based on the Theory of Planned Behaviour. *Br J Health Psychol*, **6**, 32745.

Sacks, J., Kresnow, M.-J., Houston, B. and Russell, J. (1996) Bicycle Helmet Use among American Children, 1994. *Inj Prev*, **2**, (4), 25862.

Seijts, G., Kok, G., Bouter, L. and Klip, H. (1995) Barriers to Wearing Bicycle Safety Helmets in the Netherlands. *Arch Pediatr Adolesc Med*, **149**, 17480.

Sissons Joshi, M., Beckett, K. and Macfarlane, A. (1994) Cycle Helmet Wearing in Teenagers Do Health Beliefs Influence Behaviour? *Arch Dis Ch*, **71**, (6), 53639.

Skarratts, D. (1992) Parental Attitudes to Cycle Helmets for Children. *Paediatr Nursing*, (July), 1216.

Stevenson, T. and Lennie, J. (1992) Empowering School Students in Developing Strategies to Increase Bicycle Helmet Wearing. *Hlth Educ Res*, **7**, (4), 55566.

Towner, P. and Marvel, M. (1992) A School-Based Intervention to Increase the Use of Bicycle Helmets. *Family Med*, **24**, 1568.

Wardle, S. and Iqbal, Z. (1998) Cycle Helmet Ownership and Wearing; Results of a Survey in South Staffordshire. *J Pub Health Med*, **20**, (1), 7077.

Weiss, B. (1986) Prevention of Bicycle-Related Head Injuries. *Am J Prev Med*, **2**, (6), 33033.

Wood, T. and Milne, P. (1988) Head Injuries to Pedal Cyclists and the Promotion of Helmet Use in Victoria, Australia. *Accident Analysis and Prevention*, **20**, (3), 17785.

References for Section 7

Acton, C. (1998) Helmet Laws and Health. *Injury Prevention*, **4**, 171172.

Adams, J. and Hillman, M. (2001) The Risk Compensation Theory and Bicycle Helmets. *Injury Prevention*, **7**, 8991.

Adams, J. and Hillman, M. (2001) Risk Taking Is Influenced by Peoples Perception of Safety and Danger. *Br Med J*, **321**, 10351036.

British Medical Association [BMA] (1999) *Cycle Helmets* BMA, London.

Braithwaite, W. (1999) Cycling Helmets and Contributory Negligence. *Solicitors Journal*, **3 Dec**, 1144.

Bryan-Brown, K. and Christie, N. (2001) *Cycle Helmet Wearing in 1999*. TRL Report 487.

Committee on Accident and Poison Prevention (1990) Bicycle Helmets. *Pediatrics*, **85**, (2), 229230.

Committee on Accident and Poison Prevention (1995) Bicycle Helmets. *Pediatrics*, **95**, (4), 609.

Cook, A. and Sheikh, A. (2001) Cycle Injury Trends: Helmets Are Most Likely Explanation. *Br Med J*, **322**, 14271428.

Curnow, B. (1998) Compulsory Self-Protection on Roads: Gain or Harm to Society? *Current Affairs Bulletin*, **74**, 6.

Dannenberg, A. and Vernick, J. (1993) A Proposal for the Mandatory Inclusion of Helmets with New Children's Bicycles. *American Journal of Public Health*, **83**, (5), 644646.

Davis, A. (1997) Increasing the Number of Cyclists Is More Important. *Br Med J*, **314**, 69.

Davis, R. and Pless, B. (1996) Evidence Shows That Cyclists Should Wear Helmets. *Br Med J*, **313**, 629.

Della-Guistrina, D. (1998) The Effectiveness of Bicycle Helmets. *American Society of Safety Engineers*, **July**, 35-36.

Editorial (1988) When Are Cyclists Going to Wear Helmets? *Lancet*, **23**, 159160.

Editorial (2000) Head Start for Cyclists. *New Scientist*, **167**, (2248), 3.

European Cyclists Federation (1998) *Improving Bicycle Safety without Making Helmet Use Compulsory*. ECF, Brussels.

Evans, L. (1994) Cycle Helmets and the Law. *Br Med J*, **308**, (11 June), 15211522.

Franklin, J. *The Effectiveness of Cycle Helmets*. CTC, Surrey.

Franklin, J. (2001) *Cycle Helmet Performance in the Real World*. Velo City Conference, Edinburgh, September 2001.

Godefrooij, T. (2001) Debate Is Counterproductive. *Br Med J*, **322**, 1064.

Hall, G. (1997) Do Gooders Intolerance Is Counterproductive to Their Aims. *Br Med J*, **314**, 70.

Hillman, M. (1993) *Cycle Helmets: The Case for and Against*. Policy Studies Institute, London.

Hillman, M. (1997) Health Benefits of Cycling Greatly Outweigh Loss of Life Years from Deaths. *Br Med J*, **314**, 70.

Hoskins, J. (1990) Hard Facts. *Cycle Trader*, **Jan/Feb**, 3233.

www.cycle-helmets.com/(2002) *Mandatory Bicycle Helmet Laws in Western Australia*.

Illingworth, C. (1992) The Argument for Helmets. *Br Med J*, **305**, 882883.

Jacobsen, P. (2001) Using Helmets Alone Will Not Prevent Serious Bicycle Injuries. *Br Med J*, **322**, 1064.

Jeys, L., Cribb, G., Toms, A. and Hay, S. (2001) Mountain Biking Is Particularly Dangerous. *Br Med J*, **322**, 1065.

Juden, C. (1991) CTC and Helmets. *Cycle training and Campaigning*, **Feb/Mar**, 1617.

Keatinge, R. (1997) Better to Control the Demand for Fast Cars. *Br Med J*, **314**, 70.

Kennedy, A. (1994) Cyclists Helmets (Letter). *Lancet*, **344**, (Nov 19), 1437.

Lane, J. and McDermott, F. (1993) Do Helmet Wearing Laws Prevent Bicycle Injuries? *Medical Journal of Australia*, **159**, 719721.

Lane, J. and McDermott, F. (1994) Effectiveness of Cycle Helmets (Letter). *Lancet*, **344**, (October 1), 965.

League of American Wheelmen ? (Date) *Helmet Issue Gets Hot Time to Take Action*. Baltimore, USA.

Mann, N. and Lee, A. (1999) Bicycle Helmets. Their Role in Injury Prevention. Current *Paediatrics*, **9**, 173176.

McCarthy, M. (1991) Pedal Cyclists, Crash Helmets and Risk. *Public Health*, **105**, 327334.

McCarthy, M. (1992) Do Cycle Helmets Prevent Serious Head Injury? *Br Med J,* **305**, 881882.

McCarthy, M. (1996) Controversy. Children and Cycle Helmets the Case Against. *Child: Care, Health and Development*, **22**, (2), 105111.

McDermott, F. (1991) Helmets for Bicyclists Another First for Victoria. *Medical Journal of Australia*, **154**, (4 February), 156157.

Minerva (1996) *Br Med J*, **312**, 1310.

Mullins, J. (2000) Hard-Headed Choice. *New Scientist*, **167**, (2248), 16.

Pedder, J. (1996) Bicycle Helmets Are They up to Standard? *Inj Prev*, **2**, (4), 250251.

Pless, B. (2000) Still More on Helmets: Setting an Example. *Inj Prev*, **6**, 7677.

Pless, B., Wardlaw, A., Langley, J., Vulcan, P. and Thomas, R. (2002) *E-Mail Correspondence*. E. Towner. Newcastle.

Rivara, F. P., Thompson, D. C. and Thompson, R. S. (2000) Bicycle Helmets: Its Time to Use Them. *Br Med J*, **321**, 1035-1036.

Robinson, D. (1997) Australian Laws Making Helmets Compulsory Deterred People from Cycling. *Br Med J*, **314**, 69-70.

Robinson, D. (1998) Helmet Laws and Health. *Inj Prev*, **4**, 170171.

Scuffham, P., Alsop, *et al* (2000) Head Injuries to Bicyclists and the New Zealand Bicycle Helmet Law. *Accident Analysis & Prevention*, **32**, 56573.

Sibert, J. (1996) Controversy. Children and Cycle Helmets: The Case For. *Child: Care, Health and Development*, **22**, (2), 99103.

Thompson, D., Rivara, F. and Thompson, R. (2001a) *Helmets for Preventing Head and Facial Injuries in Bicyclists. Cochrane Review*. Oxford Update Software.

Thompson, D., Thompson, R. and Rivara, F. (2001b) Risk Compensation Theory Should Be Subject to Systematic Reviews of the Scientific Evidence. *Inj Prev*, **7**, 8688.

Thurber, S. (1993) Dont Use Your Head, Use Your Helmet. *Family Safety and Health*, **Summer**, 2627.

Trippe, H. (1992) Helmets for Pedal Cyclists. *Br Med J*, **305**, 843844.

Unwin, N. (1996) Cycle Helmets: When Is Legislation Justified? *Journal of Medical Ethics*, **22**, 4145.

Vulcan, P. and Lane, J. (1996) Bicycle Helmets Reduce Head Injuries and Should Be Worn by All. *Inj Prev*, **2**, (4), 251252.

Wardlaw, A. and Thomas, R. (2002) *E-Mail Correspondence*. E. Towner. Newcastle.

Wardlaw, M. (2000) Three Lessons for a Better Cycling Future. *Br Med J*, **321**, 15821585.

Wardlaw, M. (2001) Subsequences and Consequences Need To Be Distinguished. *Br Med J*, **322**, 10640165.

Waterston, T. (1997) Motorists Are the Cause of the Problem. *Br Med J*, **314**, 69.

Whitelegg, J. and Davis, R. (1992) Cycle Helmets (Letter). *Br Med J*, **305**, 504.

*Some of the references above (eg Thompson *et al* 2001) have multiple contributions from different authors. Total number of studies = 67.

References for Sections 8 and 9

Adams, J. and Hillman, M. (2001) The risk compensation theory and bicycle helmets. *Inj Prev*, **7**, 89-91.

Graitcer, P., Kellerman, A. and Christoffel, T. (1995) A review of educational and legislative strategies to promote bicycle helmets. *Inj Prev* 1995;1:1229.

Hedlund, J. (2000) Risky business: safety regulations, risk compensation and individual behaviour. *Inj Prev*, **6**, (2), 8289.

McLoughlin, E., Marchone, M., Hanger, L., German, P. and Baker, S. (1985) Smoke Detector Legislation: Its Effect on Owner-Occupied Homes. *Am J Public Health*, **75**, (8), 85862.

Thompson, D., Rivara, F. and Thompson, R. (2001a) *Helmets for preventing head and facial injuries in bicyclists*. Cochrane Review. Oxford Update Software.

Thompson, D., Thompson, R. and Rivara, F. (2001b) Risk compensation theory should be subject to systematic reviews of the scientific evidence. *Inj Prev*, **7**, 8688.

Towner, E., Dowswell, T., Mackereth, C. and Jarvis, S. (2001) *What Works in Preventing Unintentional Injuries in Children and Young Adolescents?* An Updated Systematic Review. Health Development Agency, London.

Unwin N. Cycle helmets: when is legislation justified? *J Med Ethics* 1996;22:415.