Cochrane Library

Cochrane Database of Systematic Reviews

Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries (Review)

Macpherson A, Spinks A

Macpherson A, Spinks A.
Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries.
Cochrane Database of Systematic Reviews 2008, Issue 3. Art. No.: CD005401.
DOI: 10.1002/14651858.CD005401.pub3.

www.cochranelibrary.com

WILEY

TABLE OF CONTENTS

[Intervention Review]

Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries

Alison Macpherson[1], Anneliese Spinks[2]

[1]School of Kinesiology & Health Science, York University, Toronto, Canada. [2]School of Medicine, Griffith University, Meadowbrook, Australia

Contact address: Anneliese Spinks, School of Medicine, Griffith University, University Drive, Meadowbrook, Queensland, 4031, Australia. a.spinks@griffith.edu.au.

Editorial group: Cochrane Injuries Group.
Publication status and date: New search for studies and content updated (no change to conclusions), published in Issue 6, 2010.

Citation: Macpherson A, Spinks A. Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries. *Cochrane Database of Systematic Reviews* 2008, Issue 3. Art. No.: CD005401. DOI: 10.1002/14651858.CD005401.pub3.

ABSTRACT

Background

Evidence exists to suggest that bicycle helmets may reduce the risk of head injuries to cyclists, however helmets are not uniformly worn by all bicycle users. Legislation has been enacted in some countries and jurisdictions to mandate helmet use by cyclists, however the issue remains controversial with opponents arguing that helmet laws may inhibit people from bicycle riding and thus from gaining the associated health benefits, or that other countermeasures (e.g. improved road safety) may have been responsible for the observed decline in head injuries.

Objectives

To assess the effects of bicycle helmet legislation on bicycle-related head injuries and helmet use, and the occurrence of unintended adverse consequences.

Search methods

We searched Cochrane Central Register of Controlled Trials (*The Cochrane Library* 2009, Issue 1); The Cochrane Injuries Group specialised register (searched July 2009), MEDLINE (Ovid SP) (1950 to April 2010), EMBASE (Ovid SP) (1980 to April 2010), CINAHL (EBSCO) (1982 to April 2010), TRANSPORT (Ovid SP) (1988 to September 2009) and other specialist electronic databases. In addition we searched government websites, handsearched selected journals and examined the reference lists of selected publications.

Selection criteria

We included studies that reported changes in either the number of head injuries, helmet use or bicycle use post- versus pre-legislation. Only studies that included a concurrent control group and which reported on the effect of legislation implemented at either the country, state or province wide level were included.

Data collection and analysis

Two authors independently extracted data and assessed methodological quality. The data were not appropriate for meta-analysis, thus the results of the included studies have been reviewed narratively.

Main results

Six studies, all with a non-randomised, controlled before and after study design met the inclusion criteria. For each of the studies, bicycle helmet legislation had been enacted for children only. Adults were used as controls in five of the studies, whilst jurisdictions with no helmet legislation were used as controls in the sixth. One study reported on bicycle related mortality while three of the studies reported on

changes in head injury rates and three reported on changes in helmet use. There were no included studies reporting change in bicycle use or other adverse consequences of legislation. In three studies, statistically significant decreases in mortality or head injuries were reported following the implementation of helmet legislation compared with controls, whilst one reported a non-statistically significant decline in head injuries. Bicycle helmet use increased statistically significantly post-legislation in all three of the studies reporting on helmet use.

Authors' conclusions

Bicycle helmet legislation appears to be effective in increasing helmet use and decreasing head injury rates in the populations for which it is implemented. However, there are very few high quality evaluative studies that measure these outcomes, and none that reported data on possible declines in bicycle use.

PLAIN LANGUAGE SUMMARY

Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries

Cycling is a popular past-time among children and adults and is highly beneficial as a means of transport and obtaining exercise. However, cycling related injuries are common and can be severe, particularly injuries to the head.

Bicycle helmets have been advocated as a means of reducing the severity of head injuries, however voluntary use of helmets is low among the general population. Bicycle helmet laws mandating their use have thus been implemented in a number of jurisdictions word-wide in order to increase helmet use. These laws have proved to be controversial with opponents arguing that the laws may dissuade people from cycling or may result in greater injury rates among cyclists due to risk compensation. This review searched for the best evidence to investigate what effect bicycle helmet laws have had. There were no randomised controlled trials found, however five studies with a contemporary control were located that looked at bicycle related head injury or bicycle helmet use. The results of these studies indicated a positive effect of bicycle helmet laws for increasing helmet use and reducing head injuries in the target population compared to controls (either jurisdictions without helmet laws or non-target populations). None of the included studies measured actual bicycle use so it was not possible to evaluate the claim that fewer individuals were cycling due to the implementation of the helmet laws. Although the results of the review support bicycle helmet legislation for reducing head injuries, the evidence is currently insufficient to either support or negate the claims of bicycle helmet opponents that helmet laws may discourage cycling.

BACKGROUND

Bicycling is a very popular pastime and mode of transportation for children. However, bicycle-related injuries are common and frequently lead to hospitalisation. It is a global public health problem but one that particularly affects low-income countries, where road traffic injury rates are highest and where a high proportion of road users are cyclists.

Head injuries are a particularly serious consequence, accounting for 35 to 40% of paediatric hospitalisations and death resulting from bicycle-related trauma (Beaulne 1997; Durkin 1999). Furthermore, bicycle-related trauma has been reported among the most common causes of traumatic brain injury in many countries including Sweden (Peloso 2004), Taiwan (Tsai 2004) and the United States (Durkin 1999).

Bicycle helmets have been shown to be effective in preventing head, brain, and facial injuries to cyclists (Rivara 1998, Thompson 1996). A Cochrane systematic review reports that helmets reduce the risk of head injury by up to 88%, and reduce the risk of facial injury by 65% for cyclists of all ages (Thompson 2001).

However, despite the evidence of the efficacy of helmets in preventing serious injury, they are not universally used. Barriers to use include inhibitive costs, discomfort, lack of belief in the necessity, and an unpopular image of helmets among young cyclists (Finch 1996, Finoff 2001).

In order to overcome resistance to helmet usage, legislation has been implemented in various parts of the world, including Australia, New Zealand, the United States, and Canada. Jurisdictions differ in the population range affected by legislation. In Australia, for example, bicycle riders of all ages must wear a helmet. In Canada, however, most provincial legislation applies to children and adolescents only. Enforcement of legislation also differs across jurisdictions as priorities for policing vary between states and countries.

Without conclusive and scientifically sound evidence, the issue of helmet legislation remains controversial. Opponents of helmet legislation claim that people will use bicycles less if they are required to wear a helmet, and thus miss out on the health benefits and enjoyment that may be derived from cycling. One study published subsequent to the enactment of legislation in Australia supports this hypothesis (Robinson 1996). Another argument against bicycle helmet legislation is that other potential safety initiatives (for example, separate bicycle paths and lower speed limits) may be passed over in favour of helmet legislation. Others adhere to the risk compensation theory, claiming that helmeted cyclists ride more dangerously than those without helmets, and hence put themselves at greater risk of injury (Hillman 1993; McCarthy 1993).

Why it is important to do this review

A systematic review of the highest level evidence is the first step to providing a clearer picture of the effectiveness of bicycle helmet legislation. If helmet legislation leads to a reduction in bicycle-related head injuries, the public health benefits could be substantial. The current review examined studies that have evaluated the effectiveness of bicycle helmet legislation for reducing head injuries in the whole population. The review also aimed to examine studies that evaluate changes in helmet use and additionally those assessing cycling participation to gauge possible deterrent effects of legislation, including reduced cycling.

OBJECTIVES

To assess the effects of bicycle helmet legislation on bicycle-related head injuries and helmet use, and the occurrence of unintended adverse consequences.

METHODS

Criteria for considering studies for this review

Types of studies

We included the following study designs:

- cluster randomised controlled trials;
- interrupted time series analysis with a concurrent comparison group;
- controlled before-after study.

Types of participants

The whole population.

Types of interventions

Enactment of bicycle helmet legislation for either the whole population or for children only at a provincial, state, or country-wide level.

Types of outcome measures

- Head injuries (brain injuries, fractures, concussion, scalp lacerations and facial injuries) based on diagnosis given by a health professional and/or included in the medical chart.
- Helmet use (both self-reported and observed measures).
- Adverse effects of legislation (for example, reduced cycling participation).

Search methods for identification of studies

The searches were not restricted by language or publication status.

Electronic searches

We searched the following electronic databases:

- Cochrane Injuries Group's specialised register (to July 2009),
- CENTRAL (*The Cochrane Library*, Issue 1, 2009),
- MEDLINE (to April 2010)
- EMBASE (to April 2010)
- TRANSPORT (to September 2009)
- CINAHL (EBSCO) (1982 to April 2010)
- National Research Register (issue 1, 2007)
- Trials websites: Clinical Trials (www.clinicaltrials.gov searched April 2010); and Controlled Trials *meta*Register (www.controlled-trials.com searched April 2010)
- Zetoc: British Library's table of contents of journal articles and conference proceedings (http://zetoc.mimas.ac.uk/) (to February 2006)
- SPECTR (database of the Campbell collaboration) (to February 2006)

- HealthPromis (to February 2006)
- Bibliomap (EPPI-Centre database) (to February 2006)

Search strategies are reported in full in Appendix 1.

Searching other resources

We handsearched the journals *Injury Prevention, Accident Analysis and Prevention* and the *American Journal of Public Health* (to April 2010) in addition to the reference lists of all relevant studies found.

In an attempt to identify further unpublished studies we contacted colleagues from the International Society for Child and Adolescent Injury Prevention, World Injury Network, and CDC-funded Injury Control and Research Centers.

We also searches government web pages (in countries known to have helmet legislation including Australia, Canada, Finland, Iceland, New Zealand, Spain, Sweden, United States) to locate official reports.

Data collection and analysis

Selection of studies

Following the identification of possible studies for inclusion using the search strategy listed above, the two authors independently assessed the studies against the inclusion criteria. There were no disagreements between authors on study inclusion.

Data extraction and management

Data were extracted independently by two authors using a standardised data extraction form.

Assessment of risk of bias in included studies

We independently assessed methodological quality using the Downs and Black's instrument for non-randomised studies (Downs 1998). This instrument consists of a 27 item checklist which rates studies on the following key areas;

- reporting,
- external validity,
- internal validity,
- bias and confounding, and
- power.

We reported how each study performed in each area.

Data synthesis

Data were available as measures of association linking either bicycle helmet legislation and changes in cycling related head injury rates, the proportion of head injuries amongst bicycle related injuries or helmet use.

A narrative approach was adopted to describe and synthesise the results due to the heterogeneity of the data and uniqueness of methodological design for each included study. The specific reason for this narrative approach included different population size and demographics between studies, different study durations and different levels of enforcement between study jurisdictions. These elements rendered the combination of data inappropriate.

RESULTS

Description of studies

We retrieved the full text of 29 potentially relevant studies, six of which met the inclusion criteria. Each of the included studies had a controlled before and after study design. We did not identify any randomised controlled trials.

Most of the excluded studies were not eligible as they failed to use a concurrent control group in the analysis (Borglund 1999, Cameron 1994, Finch 1996, Foss 2000, Leblanc 2002, Liller 2003, Macpherson 2001, Moyes 2007, Ni 1997, Pardi 2007, Parkin 2003, Povey 1999, Robinson 1996, Scuffham 2000, Shafi 1998, Taylor 2002, Vulcan 1992). Other reasons for exclusion were lack of baseline (pre-legislation) data (Kanny 2001, Puder 1999, Macknin 1994, Rodgers 2002), and the lack of legislation implemented at a state or provincial level (Cote 1992, Ichikawa 2007, Nolen 2004).

The six included studies reported changes in mortality, head injury rates and/or helmet use in Canada (Hagel 2006; Macpherson 2002; Wesson 2008), and the USA (Gilchrist 2000; Ji 2006; Lee 2005).

One of the included studies reported on bicycle related mortality (Wesson 2008), two studies assessed the impact of helmet legislation on head injury (Lee 2005; Macpherson 2002), two studies reported on changes in helmet use (Gilchrist 2000; Hagel 2006) and one study reported on both head injuries and helmet use (Ji 2006). There were no included studies that assessed change in bicycle use or any other potential adverse effects of legislation.

Studies from the USA

Gilchrist 2000

This study examined the effects of a local police enforcement program on bicycle helmet use in children in a rural community in the state of Georgia. Bicycle helmet legislation was passed for the state of Georgia in July 1993, mandating helmet use for all cyclists under 16 years of age. An enforcement program coupled with a helmet giveaway and education program, was implemented in one rural community (population = 2400) during the summer of 1997. The enforcement program required police to impound bicycles of non-helmet wearers after one prior written warning had been issued. Approximately 580 children from kindergarten to grade seven received free helmets along with fitting instructions and safety education. Helmet use observations were made before distribution, several times during the five month program, and once two years later. Riders were classified as children if their age was estimated to be under 13 years, teens if 13 to 15 years and adults if older than 16. The adult population was used as a comparative control group.

Ji 2006

This study assessed the effects of the state-wide Californian helmet law in San Diego County. The law was enacted on January 1st, 1994 and required all cyclists aged 17 years and under to be helmeted. Violation of the law was punishable by a fine of up to $US25. The study authors accessed data from the San Diego County Trauma Registry from 1992 until 1996. Injured youths aged 17 years comprised the intervention group and injured adults (18 years and over) acted as controls. The outcome measures were serious injury, defined by anatomic region and abbreviated injury score (AIS) greater than three; and helmet use as reported by the

injured cyclists. The head injury data reported in this study overlaps with those reported in Lee 2005.

Lee 2005
This study assessed the effects of the Californian helmet law throughout the entire state. The study authors obtained 10 years of patient discharge records from all public Californian hospitals from 1991 to 2000. This included three years of baseline data (1991 to 1993) and seven years of post-intervention data (1994 to 2000). Adults, who were not required by law to wear helmets whilst cycling, were used as a control group for comparison. Three types of injury were used as outcomes: traumatic brain injury, other head or facial injury and other (below neck) injury. All fatal cases were excluded. No data were available on actual helmet use at the time of injury, or on enforcement or compliance with the law.

Studies from Canada

Hagel 2006
This study measured the prevalence of bicycle helmets two years after the introduction of legislation mandating their use in cyclists under 18 years of age, in the province of Alberta. The legislation was introduced in 2002. The study authors compared bicycle helmet use observations conducted from July to August 2004 (two years post-legislation), to similar observations performed in 2000 (prior to legislation). Observations were made for both child and adult cyclists, with the age of the cyclist estimated into broad age groups (< six years, six to 12 years, 13 to 17 years, 18 to 54 years, > 54 years) The adult group (aged 18 years and over) was not subject to the legislation requirements and was therefore used as a comparative control group. In 2000, the observations were conducted in the two main cities of Edmonton and Calgary, and additional communities located within 50 km of these two centres. In 2004, the observations were made in Edmonton only.

Macpherson 2002
This study examined Canada-wide hospital discharge data over a four year period, to examine the protective effect of legislation in provinces that had implemented bicycle helmet laws. Four provinces had enacted legislation on the following dates: Ontario, October 1995; New Brunswick, December 1995; British Columbia, September 1996; and Nova Scotia, July 1997. Data were collected for the fiscal years 1994 to 1998 from Canadian Institute of Health Information. All children aged between five and 19 years, hospitalised with injuries related to pedal cycle incidents were included. Children for whom discharge diagnosis data were missing or who died before being admitted to hospital were excluded. The study authors defined a head injury as any injury to the head, face or brain. Children residing in the provinces with bicycle helmet legislation comprised the intervention group, whilst children from the rest of Canada were controls. Hospitalisation rates from the provinces were combined irrespective of when the helmet legislation was passed. The study authors maintain that this approach was adopted for methodological reasons and would confer a conservative estimate of the protective effect of helmet legislation.

Wesson 2008

This study reported bicycle-related mortality in Ontario, Canada for 12 years from 1991-2002. The Ontario bicycle helmet law requiring children under the age of 18 years to wear a helmet while cycling was introduced in 1995, hence the available data included 5 years of pre-legislation data and 7 years of post-legislation data. Using a time series analysis, the study compared bicycle related mortality for two age groups: children aged 1-15 years and adolescents and adults aged 16 years and over. The older age group served as a control group for the younger (intervention) group. The authors explained that the decision to include adolescents aged 16 and 17 years in the control group despite being subject to the helmet law was due to difference in sanctions for non-helmet use for this age group. The law holds parents responsible for helmet use for children aged up to 15 years while adolescents aged 16 and 17 are held personally responsible for non-compliance. All deaths data were obtained from the coroner's office and population estimates were obtained from census data provided by Statistics Canada.

Risk of bias in included studies

The five key areas of methodological quality assessed by the Downs and Black Instrument are: reporting, external validity, bias (internal validity), confounding (internal validity), and power. The performance of the included studies in each of these areas is discussed below and presented in Table 1. Other methodological issues relevant to the topic are explored further in the discussion of the review.

Reporting

Reporting was adequate for all of the included studies. This included reporting of the study hypothesis, the main outcomes and interventions, estimates of random variability and the distributions of principal confounders. However, none of the studies attempted to report adverse impacts of bicycle helmet legislation.

External validity

External validity was good for each of the included studies, with each study population representative of the general population.

Internal validity

According to the rating instrument, internal validity bias may have occurred because of an inability to apply blinding to either the study population or the study investigators. This was due to the nature of the intervention itself and it can be argued that these two methodological techniques are infeasible to implement in community-based research where the unit of intervention is the community itself. A further threat to the internal validity for four of the included studies (Ji 2006; Lee 2005; Macpherson 2002; Wesson 2008), however, was compliance with the legislation requirements. For these studies either no attempt was made to measure helmet use and hence compliance (Lee 2005; Macpherson 2002; Wesson 2008), or the proportion of participants for whom helmet use was unknown was high (Ji 2006). Other issues related to internal validity bias (appropriate statistical tests, valid outcome measures) were not problematic for any of the studies.

Bias and confounding

Confounding bias to internal validity was limited for each of the included studies despite none of the studies employing randomisation of intervention or allocation concealment. As with blinding, these methodological techniques are infeasible to apply for evaluation studies implemented at the community level. Nonetheless, internal validity was maintained by each of the studies by including cases and controls from the same populations and over the same period of time.

Statistical power

Power was adequate for each of the included studies.

Effects of interventions

Mortality

Wesson 2008

There were 362 bicycle related deaths recorded in the province of Ontario over the twelve year study period, including 107 deaths among children aged under 16 years and 255 deaths among individuals aged 16 years and older. After the introduction of the helmet law, deaths decreased for the younger (intervention) group by 52% (mortality rate per 100 000 person years decreased by 55%) with time series analysis indicating a significant reduction following the introduction of the legislation. By comparison, there were no significant changes in bicycle related deaths for the older (control) age group. The analysis did not take into account the actual cause of death, so it was not possible to determine how many of the deaths were due to head injuries. During the study period, nine children were reported to have been wearing a bicycle helmet at the time of death including three in the pre-legislation and six in the post-legislation period.

Head injury

Ji 2006
In San Diego County, there were 1,116 bicycle-related trauma patients admitted to hospital during the study period: 510 children and 606 adults. Of the admitted cases, 310 involved serious head injuries. Although downward trends were apparent in the post legislation period, logistic regression analysing time trends of serious head injury found no statistically significant decrease in the proportion of head injuries post legislation compared with the pre-legislation period for either children (P = 0.19) or adults (P = 0.40).

Lee 2005
Between 1991 and 2000, there were 44,069 cases of non-fatal bicycle related injury events that required hospitalisation in the State of California. Aggregate data analysis revealed changes in the distribution of proportion of injury types for youth aged 17 years and younger (P < 0.001) but not for the adult comparison group (P = 0.505). The authors computed odds ratios (OR) to examine these changes further: proportions of traumatic brain injury among youth were found to have decreased after legislation (OR 0.82; 99% CI 0.76 to 0.89), while other head and facial injuries did not change (OR 1.08; 99% CI 0.90 to 1.23), and other (below neck) injuries increased (OR 1.09; 99% CI 1.05 to 1.13). The corresponding ORs for pre- versus post-legislation for the adult comparison group were: TBI (OR 1.01; 99% CI 0.93 to 1.10), other head injury (OR 1.05; 99% CI 0.91 to 1.22) and other (non-head) injury (OR 0.99; 99% CI 0.97 to 1.02). The authors therefore concluded that an 18.2% (99% CI 11.5 to 24.3) reduction occurred in the proportion of traumatic brain injury in youth cyclists during the post compared with the pre-legislation period.
Additional statistical analysis was conducted to assess the effects of legislation on injuries in different age groups within the youth category. The greatest changes were in the younger age groups (zero to four and five to nine years) compared with youth aged 10 years and older. Teenagers aged 14 to 17 experienced a small decrease in the proportion of TBI and slight increase in proportion of other head injuries.

Macpherson 2002
Over the study period, there were 9,769 paediatric admissions due to bicycle related injury throughout Canada. Discharge information was missing for 119 children so only 9,650 were included in the analysis. Thirty-five percent (n = 3,246) of cases sustained head injuries. Before legislation was implemented, the rates of head injuries in provinces were similar (18.27 and 18.35 per 100,000 respectively in provinces with and without legislation). Following the enactment of legislation, a 45% reduction in head injuries occurred in the intervention provinces (to 9.96 per 100,000) whilst a concurrent decline of 27% occurred in the control provinces (to 13.33 per 100,000). A Chi square test showed that the decline in the intervention provinces was significantly greater (P < 0.001) than that in the control provinces. At the same time, there were no significant differences in the change in other (non-head) injuries between provinces with and without legislation (P = 0.11).

Secondary analysis showed that the ratio of head injuries to other bicycle related injuries decreased significantly in both legislation and non-legislation provinces. The decrease in legislation provinces was 38% (ratio difference = 0.26; 95% CI 0.25 to 0.27) compared with 8% in the non-legislation provinces (ratio difference = 0.04; 95% CI 0.03 to 0.05).

Helmet use

Gilchrist 2000
Prior to the enforcement program, no cyclists wore helmets during 97 observations. Sixty-one of the cyclists initially observed were children. During the five months of the enforcement program police impounded 167 bicycles and 654 observations of cyclists were made. Forty-five percent of children (range 30 to 71%) wore helmets during 358 child observations. There were, however, no significant changes in adult usage among adult controls (from zero to 3%). Two years later post intervention, 54% of child cyclists (21/39) observed wore a helmet compared with 15% (2/13) teens and no (0/23) adults.

Hagel 2006
Pre-legislation, there were 699 observations of cyclists made. Twenty-eight percent (46/164) of child cyclists and 49% (234/474) of adult cyclists were helmeted during these observations. There were 271 observations made in the post-legislation period. During this time, 83% (34/41) of child and 48% (110/230) of adult cyclists were helmeted. The prevalence of helmet use amongst children increased significantly (Prevalence Ratio 2.96; 95% CI 2.22 to 3.94) and remained unchanged in the adult population. After adjusting for gender, age and average annual income, the increase in prevalence of helmet use amongst children was 3.69 (95% CI 2.65 to 5.14) compared with the pre-law period.

Ji 2006
Helmet use as reported by injured cyclists post injury increased significantly amongst children post-legislation (OR 1.84; 95% CI 1.48 to 2.28). There was a concurrent smaller trend amongst adult controls for increased helmet wearing (OR 1.17; 95% CI 1.00 to 1.38).

DISCUSSION

Principal findings

This review found positive evidence that bicycle helmet legislation both increases bicycle helmet use and reduces both bicycle related mortality and head injuries. No evidence was found to either

support or counter the possibility that legislation may lead to negative societal and health impacts such as reductions in cycling participation.

We identified and included six controlled evaluative studies that examined the effect of bicycle helmet legislation on mortality, bicycle related head injuries and helmet use. A large number of potential studies were excluded from the review, the majority for failing to include a concurrent control group.
All of the included studies were controlled time series analyses that were conducted in North America. The main findings of the review are discussed below.

Helmet laws and mortality

One study was identified which reported the effect of bicycle helmet legislation on bicycle related mortality. Although a significant decrease in mortality occurred for the age group affected by the laws compared to no change in mortality for the control group, the results of this study are limited in that it was not possible to determine what proportion of deaths were due to head injuries.

Helmet laws and head injuries

There is a paucity of high quality evaluative studies assessing the effect of helmet legislation on bicycle related head injuries: only three were identified for this review. Two of the studies reported a significant protective effect of helmet legislation on bicycle related head injuries, whilst the third reported a non-significant decline in the proportion of head injuries compared with other bicycle related trauma.

Helmet use

The three studies included in this review found that helmet use increased significantly from between 45% and 84% with the introduction of helmet laws or, in the case of Gilchrist 2000, helmet law enforcement. This finding supports the results of a recently published systematic review on the same topic which used different criteria for including studies (Karkhaneh 2006).

Adverse effect of legislation (reduced cycling participation)

None of the included studies measured pre- and post-legislation cycling participation rates, hence no evidence was available to assess the adverse potential of helmet legislation.

Strengths and weaknesses of this systematic review

Strengths of this review are the high level of methodological rigour required for studies to be included. Comparison of the intervention group against a control is important for study validity mainly because it allows for the control of changes over time. Without a concurrent comparison group, it is impossible to determine the relative effect of the law compared with other environmental and legislative changes including changes in cycling rates, improved bicycle paths and lower vehicle speeding limits (Robinson 2001).

Limitations of the review are related to the small number of high quality studies that were identified for inclusion, meaning that there was either restricted or no evidence to provide sound scientific support for either side of the bicycle helmet legislation debate. Only four studies were available that reported on bicycle related mortality or head injuries, and none that reported on potential adverse effects of helmet legislation. There were, in addition, no studies that assessed bicycle helmet legislation for adult populations. Therefore, the results of this review can only be applied to paediatric populations, and are limited in their conclusive strength.

Strengths and weaknesses of the included studies

The findings of the review must also be interpreted within the context of the methodological limitations of the included studies. The inability to measure actual helmet use, or missing information on helmet use were the biggest limitations for the studies which evaluated changes in bicycle related head injury. The lack of helmet use data makes it difficult to clearly illustrate that lower head injury rates are the direct consequence of increased helmet use.

Other possible explanations for the decreases in the reported head injury rates or proportion of serious head injuries include changes in hospital admission procedures, reduced cycling exposure (for reduced head injury rates) or an increase in other bicycle related injuries (for reduced proportion of head injuries).

The inclusion of comparison control groups attempts to discount these other possible explanations, however the adequacy of the chosen controls may also be called into question. In particular, comparing adults with children may be problematic because admission procedures or cycling exposure may have changed for one age group but not the other, whilst comparisons between states or provinces may not take other local changes (e.g. changes to speeding laws, improved road conditions) into account.

Arguments against helmet legislation

Opponents of bicycle helmet legislation have argued that decreasing trends in head injuries in jurisdictions with bicycle helmet legislation can be explained by lower numbers of people cycling. They argue that enforced helmets act as a deterrent to cycling, and the net overall effect on health is negative because of the reduction in the benefits of exercise and enjoyment. We attempted to address this concern in our review, however we found no studies meeting predetermined quality standards that directly measured cycling rates before and after the introduction of helmet legislation.

However, comparisons between the pre- and post-legislation proportion of head injuries of total bicycle related injuries (as performed by both Lee and Macpherson) does allow for cycling exposure to be controlled.
Both of these studies reported significant declines in the proportion of head injuries compared with other bicycle related injuries.

Other arguments against helmet legislation are that other effective safety initiatives (for example, lower vehicle speeding limits and separate cycling paths) may be overlooked, or that cyclists may be less careful if wearing a helmet. This review was not able to explore these possibilities.

Enforcement

Many jurisdictions with helmet legislation impose monetary fines for non-compliance. Unfortunately, there was insufficient evidence available to determine the level at which legislation was enforced in four of the included studies. The study conducted in rural

Georgia, however, clearly demonstrates the importance of police enforcement (Gilchrist 2000). Prior to the enforcement program, the existing helmet legislation had a negligible effect on actual helmet use with no children observed using a bicycle helmet despite the pre-existing law. The positive effect of the enforcement program in which police were instructed to impound the bicycle of non-helmeted child cyclists was still discernible two years later, although it was not possible to distinguish the effects of the enforcement program with the concurrent helmet give-away program on helmet use.

Future Research

We believe that the results of this review highlight the necessity for further high quality evaluations of the impact of bicycle helmet legislation. Evaluations are required in order to strengthen the evidence base suggesting a protective effect of helmet legislation against head injuries and extend the evidence to the adult population. High quality evaluations are also needed to either support or dispute the argument that legislation may discourage cycling and hence negatively impact upon health by reducing physical activity participation increasing reliance on motor-vehicle use as an alternative transport mode.

High quality evaluations to provide the necessary evidence would include objective assessment of head injury rates both prior to and after the introduction of helmet legislation in both an intervention and control group. The ideal control group would be the same age cyclists in a neighbouring state or province where all other influential factors such as driving laws and other environmental initiatives would be kept as similar as possible. Accurate measurements of both cycling participation rates and actual helmet use would also be measured in both intervention and control groups so that the mechanism of effect could be clearly illustrated. Ideally, a time frame of several years would be used for both pre and post legislation periods so that the long term effect of helmet legislation could be evaluated, and to capture the effect of pre-legislation trends in head injury rates, cycling participation and helmet use.

AUTHORS' CONCLUSIONS

Implications for practice

The best available evidence, although limited in quantity and quality, suggests a protective effect of bicycle helmet legislation against head injury among cyclists.

It can be surmised with reasonable certainty that legislation increases bicycle helmet use, however enforcement is necessary to ensure compliance. The relationship between police enforcement of laws, helmet use and cycling rates is yet to be determined, although there is some evidence that legislation without enforcement may have a limited effect on helmet use.

No strong evidence yet exists to either suggest or discount an adverse effect of bicycle helmet legislation (for example, fewer cyclists).

In summary, helmet legislation is just one of many interventions that may decrease head injuries to cyclists. It is most likely that a similar approach must be taken as that adopted for motor vehicle safety, that is a variety of countermeasures are necessary to increase overall safety.

Implications for research

More high quality studies are needed to assess the impact on bicycle related head injuries, particularly in adult populations, and the potential for legislation to discourage cycling participation.

Funding should be made available by governments introducing helmet laws to ensure that methodologically sound evaluations of the protective effect and potential reductions in cycling are conducted.

ACKNOWLEDGEMENTS

We would like to acknowledge the input and suggestions from anonymous peer referees who commented on the draft of this review.

REFERENCES

References to studies included in this review

Gilchrist 2000 *{published data only}*

Gilchrist J, Schieber RA, Leadbetter S, Davidson SC. Police enforcement as part of a comprehensive bicycle helmet program. *Pediatrics* 2000;**106**:6-9.

Hagel 2006 *{published data only}*

Hagel BE, Rizkallah JW, Lamy A, Belton KL, Jhangri JS, Cherry N, et al. Bicycle helmet prevalence two years after the introduction of mandatory use legislation for under 18 year olds in Alberta, Canada. *Injury Prevention* 2006;**12**(4):262-5.

Ji 2006 *{published data only}*

Ji M, Gilchick RA, Bender SJ. Trends in helmet use and head injuries in San Diego County: the effect of bicycle helmet legislation. *Accident Analysis and Prevention* 2006;**38**:128-34.

Lee 2005 *{published data only}*

Lee BH, Schofer JL, Koppelman FS. Bicycle safety helmet legislation and bicycle-related non-fatal injuries in California. *Accident Analysis and Prevention* 2005;**37**:93-102.

Macpherson 2002 *{published data only}*

Macpherson AK, To TM, Macarthur C, Chipman ML, Wright JG, Parkin PC. Impact of mandatory helmet legislation on bicycle-related head injuries in children: a population-based study. *Pediatrics* 2002;**110**:e60.

Wesson 2008 *{published data only}*

Wesson DE, Stephens D, Lam K, Parsons D, Spence L, Parkin PC. Trends in pediatric and adult bicycling deaths before and after passage of a bicycle helmet law. *Pediatrics* 2008;**122**:605-10.

References to studies excluded from this review

Borglund 1999 *{published data only}*

Borglund ST, Hayes JS, Eckes JM. Florida's bicycle helmet law and a bicycle safety educational program: did they help?. *Journal of Emergency Nursing* 1999;**25**:496-500.

Cameron 1994 *{published data only}*

Cameron MH, Vulcan AP, Finch CF, Newstead SV. Mandatory bicycle helmet use following a decade of helmet promotion in Victoria, Australia - an evaluation. *Accident Analysis and Prevention* 1994;**26**:325-7.

Cote 1992 *{published data only}*

Cote TR, Sacks JJ, Lambert-Huber DA, Dannenberg AL, Kresnow M, Lipsitz CM, et al. Bicycle helmet use among Maryland children: effect of legislation and education. *Pediatrics* 1992;**89**:1216-20.

Finch 1996 *{published data only}*

Finch CF. Teenagers' attitudes towards bicycle helmets three years after the introduction of mandatory wearing. *Injury Prevention* 1996;**2**:126-30.

Foss 2000 *{published data only}*

Foss RD, Beirness DJ. Bicycle helmet use in British Columbia: effects of the helmet use law. University of North Carolina Highway Safety Research Centre April, 2000.

Ichikawa 2007 *{published data only}*

Ichikawa M, Nakahara S. School regulations governing bicycle helmet use and head injuries among Japanese junior high school students. *Accident Analysis and Prevention* 2007;**39**:469-74.

Kanny 2001 *{published data only}*

Kanny D, Schieber RA, Pryor V, Kresnow MJ. Effectiveness of a state law mandating use of bicycle helmets among children: an observational evaluation. *American Journal of Epidemiology* 2001;**154**:1072-6.

Leblanc 2002 *{published data only}*

Leblanc JC, Beattie TL, Culligan C. Effect of legislation on the use of bicycle helmets. *Canadian Medical Association Journal* 2002;**166**:592-5.

Liller 2003 *{published data only}*

Liller KD, Nearns J, Cabrera M, Joly B, Noland V, McDermott R. Children's bicycle helmet use and injuries in Hillsborough County, Florida before and after helmet legislation. *Injury Prevention* 2003;**9**:177-9.

Macknin 1994 *{published data only}*

Macknin M, Mendenthorp SV. Association between bicycle helmet legislation, bicycle safety education, and use of bicycle helmets in children. *Archives of Pediatric and Adolescent Medicine* 1994;**148**:255-9.

Macpherson 2001 *{published data only}*

Macpherson AK, Parkin PC, To TM. Mandatory helmet legislation and children's exposures to cycling. *Injury Prevention* 2001;**7**:228-30.

Moyes 2007 *{published data only}*

Moyes SA. Changing pattern of child bicycle injury in the Bay of Plenty, New Zealand. *Journal of Paediatrics and Child Health* 2007;**43**:486-8.

Ni 1997 *{published data only}*

Ni H, Sacks JJ, Curtis L, Cieslak PR, Hedberg K. Evaluation of a statewide bicycle helmet law via multiple measures of helmet use. *Archives of Pediatric and Adolescent Medicine* 1997;**151**:59-65.

Nolen 2004 *{published data only}*

Nolen S, Lindqvist K. A local bicycle helmet 'law' in a Swedish municipality - the effects on helmet use. *Injury Control and Safety Promotion* 2004;**11**:39-46.

Pardi 2007 *{published data only}*

Pardi La, King BP, Salemi G, Salvator AE. The effect of bicycle helmet legislation on pediatric injury. *Journal of Trauma Nursing* 2007;**14**:84-7.

Parkin 2003 *{published data only}*

Parkin PC, Khambalia A, Kmet L, Macarthur C. Influence of socioeconomic status on the effectiveness of bicycle helmet legislation for children: a prospective observational study. *Pediatrics* 2003;**112**:e192-6.

Povey 1999 *{published data only}*

Povey LJ, Frith WJ, Graham PG. Cycle helmet effectiveness in New Zealand. *Accident Analysis and Prevention* 1999;**31**:763-70.

Puder 1999 *{published data only}*

Puder DR, Visintainer P, Spitzer D, Casal D. A comparison of the effect of different bicycle helmet laws in 3 New York City suburbs. *American Journal of Public Health* 1999;**89**:1736-8.

Robinson 1996 *{published data only}*

Robinson DL. Head injuries and bicycle helmet laws. *Accident Analysis and Prevention* 1996;**28**:463-75.

Rodgers 2002 *{published data only}*

Rodgers GB. Effects of state helmet laws on bicycle helmet use by children and adolescents. *Injury Prevention* 2002;**8**:42-6.

Scuffham 2000 *{published data only}*

Scuffham P, Alsop J, Cryer C, Langley JD. Head injuries to bicyclists and the New Zealand bicycle helmet law. *Accident Analysis and Prevention* 2000;**32**:565-73.

Shafi 1998 *{published data only}*

Shafi S, Gilbert JC, Loghmanee F, Allen JE, Caty MG, Glick PL, et al. Impact of bicycle helmet safety legislation on children admitted to a regional pediatric trauma center. *Journal of Pediatric Surgery* 1998;**33**:317-21.

Taylor 2002 *{published data only}*

Taylor M, Scuffham P. New Zealand bicycle helmet law - do the costs outweigh the benefits?. *Injury Prevention* 2002;**8**:317-20.

Vulcan 1992 *{published data only}*

Vulcan P, Cameron MH, Watson WL. Mandatory bicycle helmet use experience in Victoria, Australia. *World Journal of Surgery* 1992;**16**:389-97.

Additional references

Beaulne 1997

Beaulne G, editor. For the safety of Canadian children and youth: From injury data to preventive measures. 1. Ottawa: Health Canada, 1997. [ISBN 0-660-17066-3]

Downs 1998

Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *Journal of Epidemiology and Community Health* 1998;**52**(6):377-84.

Durkin 1999

Durkin MS, Laraque D, Lubman I, Barlow B. Epidemiology and prevention of traffic injuries to urban children and adolescents. *Pediatrics* 1999;**103**:e74.

Finoff 2001

Finnoff JT, Laskowski ER, Altman KL, Diehl NN. Barriers to bicycle helmet use. *Pediatrics* 2001;**108**:E4.

Hillman 1993

Hillman M. Cycle helmets: the case for and against. Policy Studies Institute. London: Policy Studies Institute, 1993. [ISBN 0 855374 602 8]

Karkhaneh 2006

Karkhaneh M, Kalenga JC, Hagel BE, Rowe BH. Effectiveness of bicycle helmet legislation to increase helmet use: a systematic review. *Injury Prevention* 2006;**12**:76-82.

McCarthy 1993

McCarthy M. Do cycle helmets prevent serious injury? Cycling without helmets. *BMJ* 1992;**305**:881-2.

Peloso 2004

Peloso PM, von Holst H, Borg J. Mild traumatic brain injuries presenting to Swedish hospitals in 1987-2000. *Journal of Rehabilitation Medicine* 2004;**Feb**(43 Suppl):22-7.

Review Manager [Computer program]

The Nordic Cochrane Centre. Review Manager (RevMan). Copenhagen: The Cochrane Collaboration, 2008.

Rivara 1998

Rivara F, Thompson DC, Patterson MQ, Thompson RS. Prevention of bicycle-related injuries: helmets, education, and legislation. *Annual Review of Public Health* 1998;**19**:293-318.

Robinson 2001

Robinson DL. Changes in head injury with the New Zealand bicycle helmet law. *Accident Analysis and Prevention* 2001;**33**:687-91.

Thompson 1996

Thompson DC, Rivara FP, Thompson RS. Effectiveness of bicycle safety helmets in preventing head injuries: a case-control study. *JAMA* 1996;**276**:1968-73.

Thompson 2001

Thompson DC, Rivara FP, Thompson R. Helmets for preventing head and facial injuries in bicyclists. *Cochrane Database of Systematic Reviews* 2001, Issue 3. [DOI: 10.1002/14651858.CD001855]

Tsai 2004

Tsai WC, Chiu WT, Chiou HY, Choy CS, Hung CC, Tsai SH. Pediatric traumatic brain injuries in Taiwan: an 8-year study. *Journal of Clinical Neuroscience* 2004;**11**:126-9.

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Gilchrist 2000

Methods	Controlled before-and-after study.
Participants	Intervention: Child cyclists in one community in rural Georgia. Control: Adult cyclists living in the same community.
Interventions	Legislation requiring mandatory bicycle helmets for children, in combination with helmet give-away program, fitting instructions and safety education. Police enforced helmet use by impounding bicycles of non-helmet wearers after one written warning.
Outcomes	Observed bicycle helmet use.
Notes	

Hagel 2006

Methods	Controlled before-and-after study.
Participants	Intervention: Child cyclists in Alberta, Canada. Control: Adult cyclists in Alberta, Canada.
Interventions	Legislation requiring mandatory bicycle helmets for all youth aged 17 years and under. Enacted 2004.
Outcomes	Observed bicycle helmet use.
Notes	

Ji 2006

Methods	Case-controlled before-and-after study.
Participants	Intervention: Injured youth (aged 17 years and under) hospitalised for bicycle related trauma in San Diego County, California. Control: Injured adults hospitalised for bicycle related trauma.
Interventions	Legislation requiring mandatory bicycle helmets for all youth aged 17 years and under. Enacted 1st January 1994.
Outcomes	Proportion of head injury. Reported bicycle helmet use.
Notes	

Lee 2005

Methods	Case-controlled before-and-after study.

Lee 2005 *(Continued)*

Participants	Intervention: Californian youth (aged 17 years and under) hospitalised for bicycle related trauma. Control: Californian adults hospitalised for bicycle related trauma.
Interventions	Legislation requiring mandatory bicycle helmets for all youth aged 17 years and under. Enacted January 1st 1994.
Outcomes	Three types of injury; - traumatic brain injury, - other head or facial injury, - other injury (below neck).
Notes	

Macpherson 2002

Methods	Controlled before-and-after study.
Participants	Intervention: Children in four Canadian provinces (Ontario, New Brunswick, Nova Scotia, British Columbia). Control: Children in the remainder of the country (six provinces, three territories).
Interventions	Legislation requiring mandatory bicycle helmets for cyclists of various ages.
Outcomes	Rates of head injury requiring hospitalisation, obtained from the Canadian Institute of Health. Information for fiscal years 1994 to 1998.
Notes	

Wesson 2008

Methods	Controlled before-and-after study.
Participants	Intervention: Children aged 1-15 years in Ontario, Canada. Control: Older adolescents and adults aged 16 years and older in Ontario, Canada
Interventions	Legislation requiring mandatory bicycle helmets for children aged under 18 years.
Outcomes	Rates of cyclist mortality, obtained from the Coroner's office for years 1991-2002.
Notes	

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Borglund 1999	No control community used as comparison.
Cameron 1994	No control community used as comparison.

Study	Reason for exclusion
Cote 1992	Legislation was not implemented at state or provincial level.
Finch 1996	No control community used as comparison.
Foss 2000	No control community used as comparison.
Ichikawa 2007	Legislation was not implemented at state or provincial level.
Kanny 2001	No (pre-legislation) baseline data was available.
Leblanc 2002	No control community used as comparison.
Liller 2003	No control community used as comparison.
Macknin 1994	No (pre-legislation) baseline data were available.
Macpherson 2001	No control community used as comparison.
Moyes 2007	No control community used as comparison.
Ni 1997	No control community used as comparison.
Nolen 2004	Legislation was not implemented at state or provincial level.
Pardi 2007	No control community used as comparison.
Parkin 2003	No control community used as comparison.
Povey 1999	No control community used as comparison.
Puder 1999	No (pre-legislation) baseline data were available.
Robinson 1996	No control community used as comparison.
Rodgers 2002	No (pre-legislation) baseline data were available.
Scuffham 2000	No control community used as comparison.
Shafi 1998	No control community used as comparison.
Taylor 2002	No control community used as comparison.
Vulcan 1992	No control community used as comparison.

ADDITIONAL TABLES

Table 1. Methodological quality of included studies

	Gilchrist 2000	Hagel 2006	Ji 2006	Lee 2005	Macpherson 2002	Wesson 2007
REPORTING	Yes	Yes	Yes	Yes	Yes	Yes

Table 1. Methodological quality of included studies *(Continued)*

Is the hypothesis/aim/objective of the study clearly described?						
REPORTING Are the main outcomes to be measured clearly described in the Introduction or Methods section?	Yes	Yes	Yes	Yes	Yes	Yes
REPORTING Are the characteristics of the patients included in the study clearly described?	Yes	Yes	Yes	Yes	Yes	Yes
REPORTING Are the interventions of interest clearly described?	Yes	Yes	Yes	Yes	Yes	Yes
REPORTING Are the distributions of principal confounders in each group of subjects to be compared clearly described?	Yes	Yes	Yes	Yes	Yes	Yes
REPORTING Are the main findings of the study clearly described?	Yes	Yes	Yes	Yes	Yes	Yes
REPORTING Does the study provide estimates of the random variability in the data for the main outcomes?	Yes	Yes	Yes	Yes	Yes	Yes
REPORTING Have all important adverse events that may be a consequence of the intervention been reported?	No	No	No	No	No	No
REPORTING Have the characteristics of patients lost to follow-up been described?	Yes	Yes	Yes	Yes	Yes	Yes
REPORTING Have actual probability values been reported for the main outcomes except where the probability value is less than 0.001?	Yes	Yes	Yes	Yes	Yes	Yes
EXTERNAL VALIDITY Were the subjects asked to participate in the study representative of the entire populations from which they were recruited?	Yes	Yes	Yes	Yes	Yes	Yes
EXTERNAL VALIDITY Were those subjects who were prepared to participate representative of the entire population from which they recruited?	Yes	Unclear	Yes	Unclear	Yes	Yes
EXTERNAL VALIDITY Were the staff, places, and facilities where the patients were treated, representative	Yes	Yes	Yes	Yes	Yes	Yes

Table 1. Methodological quality of included studies *(Continued)*

of the treatment the majority of patients receive?						
INTERNAL VALIDITY Was an attempt made to blind study subjects to the intervention they have received?	No	No	No	No	No	No
INTERNAL VALIDITY Was an attempt made to blind those measuring the main outcomes of the intervention?	No	Yes	No	No	No	No
INTERNAL VALIDITY If any of the results of the study were based on 'data dredging', was this made clear?	Yes	No	Unclear	Yes	Yes	Yes
INTERNAL VALIDITY In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case-control studies, is the time period between the intervention and outcome the same for cases and controls?	Yes	Yes	Yes	Yes	Yes	Yes
INTERNAL VALIDITY Were the statistical tests used to assess the main outcomes appropriate?	Yes	Yes	Yes	Yes	Yes	Yes
INTERNAL VALIDITY Was the compliance with the intervention/s reliable?	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear
INTERNAL VALIDITY Were the main outcome measures used accurate (valid and reliable)?	Yes	Yes	Yes	Yes	Yes	Yes
INTERNAL VALIDITY Were the patients in different interventions groups (trials and cohorts studies) or were the cases and control (case-control studies) recruited from the same population?	Yes	Yes	Yes	Yes	Yes	Yes
INTERNAL VALIDITY Were the patients in different interventions groups (trials and cohorts studies) or were the cases and control (case-control studies) recruited over the same period of time?	Yes	Yes	Yes	Yes	Yes	Yes
INTERNAL VALIDITY Were the study subjects randomised to intervention groups?	No	No	No	No	No	No
INTERNAL VALIDITY Was the randomised intervention assignment concealed from both patients and	No	No	No	No	No	No

Table 1. Methodological quality of included studies *(Continued)*

health care staff until recruitment was complete and irrevocable?						
INTERNAL VALIDITY Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?	Yes	Yes	Yes	Yes	Yes	Yes
INTERNAL VALIDITY Were losses of patients to follow-up taken into account?	Yes	Yes	Yes	Yes	Yes	Yes

APPENDICES

Appendix 1. Search strategies

Medline, Embase, CINAHL. Last searched April 2010

1. Bicycle* or bike* or cycl*
2. Helmet*
3. Law* or legislat*
4. 1 and 2 and 3

Controlled Trials *meta*Register and Clinical Trials websites. Last searched April 2010

1. bicycle* or helmet*

Transport Database (Ovid SP) 1988 to June 2009. Last searched: 7 Sept 2009

1. bicyclists.cs.
2. (Bicycl* or bike* or cycl*).mp.
3. (bicycle or bicycle accidents or bicyclist or bicycling or bicyclette).de.
4. 1 or 2 or 3
5. (helmet* or (head adj5 protect*)).mp. [mp=abstract, title, heading word, accession number]
6. safety.cs.
7. bicycling safety.de.
8. 5 or 6 or 7
9. 4 and 8
10. law.cs.
11. (Law* or legislat*).mp.
12. 10 or 11
13. 9 and 12

WHAT'S NEW

Date	Event	Description
19 April 2010	New search has been performed	4 new studies considered for inclusion: -1 subsequently included (Wesson 2007) -3 excluded

HISTORY

Protocol first published: Issue 3, 2005

Review first published: Issue 2, 2007

Date	Event	Description
10 April 2008	Amended	Converted to new review format.

CONTRIBUTIONS OF AUTHORS

The original concept and design of this review was initiated by Alison Macpherson. Both authors (Alison Macpherson and Anneliese Spinks) were responsible for searching for and locating potential studies, independently screening studies against inclusion criteria, extracting results, assessing methodological quality of the included studies and writing and editing the text of the review. Anneliese Spinks prepared the review for the Cochrane Database of Systematic Reviews using the Review Manager software.

DECLARATIONS OF INTEREST

Alison Macpherson is an author of one of the included studies.

INDEX TERMS

Medical Subject Headings (MeSH)

Bicycling [*injuries] [*legislation & jurisprudence]; Canada [epidemiology]; Craniocerebral Trauma [epidemiology] [*prevention & control]; Head Protective Devices [adverse effects] [*statistics & numerical data]; United States [epidemiology]

MeSH check words

Adolescent; Adult; Child; Humans