



## Effectiveness of bicycle helmet legislation to increase helmet use: a systematic review

M Karkhaneh, J-C Kalenga, B E Hagel and B H Rowe

*Inj. Prev.* 2006;12;76-82  
doi:10.1136/ip.2005.010942

---

Updated information and services can be found at:  
<http://injuryprevention.bmj.com/cgi/content/full/12/2/76>

---

*These include:*

**Data supplement**

"Web-only appendix"  
<http://injuryprevention.bmj.com/cgi/content/full/12/2/76/DC1>

**References**

This article cites 31 articles, 21 of which can be accessed free at:  
<http://injuryprevention.bmj.com/cgi/content/full/12/2/76#BIBL>

4 online articles that cite this article can be accessed at:  
<http://injuryprevention.bmj.com/cgi/content/full/12/2/76#otherarticles>

**Rapid responses**

You can respond to this article at:  
<http://injuryprevention.bmj.com/cgi/eletter-submit/12/2/76>

**Email alerting service**

Receive free email alerts when new articles cite this article - sign up in the box at the top right corner of the article

---

**Topic collections**

Articles on similar topics can be found in the following collections

[Injury](#) (850 articles)

---

**Notes**

---

To order reprints of this article go to:  
<http://journals.bmj.com/cgi/reprintform>

To subscribe to *Injury Prevention* go to:  
<http://journals.bmj.com/subscriptions/>

## SYSTEMATIC REVIEW

## Effectiveness of bicycle helmet legislation to increase helmet use: a systematic review

M Karkhaneh, J-C Kalenga, B E Hagel, B H Rowe

*Injury Prevention* 2006;12:76–82. doi: 10.1136/ip.2005.010942

An appendix to this paper is available on our website.

See end of article for authors' affiliations

Correspondence to:  
Dr B H Rowe, Department of Emergency Medicine, University of Alberta, 1G1.43 WMC, 8440-112 Street, Edmonton, Alberta, Canada; [browe@ualberta.ca](mailto:browe@ualberta.ca)

Accepted 7 February 2006

**Background:** Head injuries related to bicycle use are common and can be serious. They can be prevented or reduced in severity with helmet use; however, education has resulted in modest helmet use in most developed countries. Helmet legislation has been proposed as a method to increase helmet wearing; while this social intervention is thought to be effective, no systematic review has been performed.

**Objectives:** This review evaluates the scientific evidence for helmet use following legislation to identify the effectiveness of legislative interventions to increase bicycle helmet use among all age groups.

**Search strategy:** Comprehensive searches of CENTRAL, MEDLINE, EMBASE, CINAHL, Web of Science, British Education Index, LILACS Database, TRIS (Transport Research Information Service), the grey literature, reference lists, and communication with authors was performed to identify eligible studies.

**Selection criteria:** Eligible studies for this review were community based investigations including cohort studies, controlled before-after studies, interrupted time series studies, non-equivalent control group studies

**Data collection and analysis:** Two reviewers extracted the data regarding the percentage of helmet use before and after legislation from each study. Individual and pooled odds ratios were calculated along with 95% confidence intervals.

**Main results:** Out of 86 prescreened articles, 25 were potentially relevant to the topic and 11 were finally included in the review. Of 11 studies, eight were published articles, two were published reports, and one was an unpublished article. One additional survey was incorporated following personal communication with the author. While the baseline rate of helmet use among these studies varied between 4% and 59%, after legislation this range changed to 37% and 91%. Helmet wearing proportions increased less than 10% in one study, 10–30% in four studies, and more than 30% in seven studies. While the effectiveness of bicycle helmet legislation varied ( $n = 11$  studies; OR range: 1.2–22), all studies demonstrated higher proportions of helmet use following legislation, particularly when the law was targeted to a specific age group.

**Conclusions:** Legislation increased helmet use among cyclists, particularly younger age groups and those with low pre-intervention helmet wearing proportions. These results support legislative interventions in populations without helmet legislation.

Bicycling is a popular means of transportation, recreation, and exercise in many countries. However, injuries do occur and they can be severe. Head injuries are among the most severe injuries in cyclists comprising one third of emergency department visits and two thirds of bicycling deaths.<sup>1,2</sup> Use of bicycle helmets can prevent or lessen the severity of brain injury during a bicycle crash. In a recently published Cochrane systematic review, Thompson *et al* provided evidence that bicycle helmets reduce the risk of head injury between 63% and 88%.<sup>3</sup> The review also revealed that bicycle helmets provide equal protection for crashes involving motor vehicles (69%) and crashes from all other causes (68%).

Despite the enormous degree of protection afforded by a bicycle helmet, a 1994 US national telephone survey revealed that only 50% of bicyclists owned a helmet and only 25% reportedly always wear one when cycling.<sup>4</sup> This condition did not improve until 1999, where the percentage of children who reported always using a helmet varied from 13% to 65%, depending on the state.<sup>5</sup> In Sweden, during 14 years of follow up from 1988 to 2002, helmet use increased from 5% to 33% among school children and from 2% to 14% among adults.<sup>6</sup> Helmet use increased from 10.7% to 31.1% among school children from 1988 to 1991 in Ottawa, Canada.<sup>7</sup>

Although educational programs, promotional campaigns, and community incentives have been used to increase bicycle helmet use,<sup>8–12</sup> many jurisdictions decided to make helmet wearing mandatory for children and adolescents in the early

1990s. In the following years, many researchers tried to examine the effectiveness of bicycle helmet legislation in increasing helmet use among children and adults.<sup>13–23</sup> While this intervention has been shown to be effective by studies in selected jurisdictions, no systematic review covering the complete published literature has been performed.

The objective of this review was to identify the effectiveness of bicycle helmet legislation to increase bicycle helmet use among all age groups.

## METHODS

### Inclusion criteria

Included studies were required to be community based and one of these design types: cohort studies, controlled before-after studies, interrupted time series studies, or non-equivalent control group studies. Studies involving children, adolescents, and/or adults of both genders observed while cycling for any purpose in any location within a defined community were considered. We included those studies with introduction of bicycle helmet wearing legislation at the regional, state/province-wide, or municipal level, compared with a pre-, non-legislative period in the same community or a matched control community without legislation.

### Search strategies

The following electronic databases were searched using standardized terms: Cochrane Injuries Group Trials

**Table 1** The 12 included studies: study methods and population sizes

Study ID	Location	Method	Sample size	
			Before/case	After/control
Cote, 1992	Maryland, US	Non-equivalent control group	51	379
Cameron, 1994	Melbourne, Australia	Before/after*	3709	2477
Ni, 1997	Oregon, US	Before/after	2168	2140
Foss, 2000	British Columbia, Canada	Before/after	3950	4246
Kanny, 2001	Florida, US	Non-equivalent control group	21313	450
LeBlanc, 2002	Novo Scotia, Canada	Before/after	1494	672
Thomas, 2002	North Carolina, US	Before/after	2448	1949
Delamater, 2003	Florida, US	Before/after	1658	1029
Liller, 2003	Florida, US	Before/after	–	–
Parkin, 2003	Toronto, Canada	Before/after	1227	916
Hagel, 2005	Alberta, Canada	Before/after	699	271
Povey, 2005	New Zealand	Before/after	10646	5725

\*Before/after road side observation or interrupted times series method.

Register, Cochrane Central Register of Controlled Trials, DARE (Database of Abstracts of Reviews of Effectiveness), MEDLINE, EMBASE, CINAHL, Web of Science, British Education Index, LILACS Database, and the TRIS (Transport Research Information Service) database. Search terms and outputs are available from the authors upon request. In addition, the grey literature was searched (Google Scholar, University Microfilms (UMI) for dissertations) as were conference proceedings. Finally, reference lists of included studies and communication with authors were also performed to identify unpublished studies.

### Study selection

A two-step selection process for study inclusion was used. First, the initial search results were screened by two reviewers and relevant articles were retrieved. Two reviewers then read the full reports to ensure that each met the predetermined inclusion criteria. Disagreements were resolved through consensus or, if necessary, a third person adjudication.

### Inclusion criteria

In order to be included in this review, studies needed to be one of the following types:

#### Cohort studies

These studies were required to involve measurement of helmet use in two groups of individuals in two separate, yet similar communities. These communities were required to be comparable on the basis of environmental conditions, population size, cultural issues, socioeconomic status, and bicyclist population. One community was also required to be exposed to legislation while the control community was not and minimum follow up of six months after legislation implementation was required.

#### Controlled before-after study

These studies involved direct observations of cyclists. With this approach, exposure to helmet legislation would be introduced at the group level (that is, geographic area); however, the outcome of helmet use would be measured at the individual level. Two or more communities without legislation would be observed. One or more of these communities would subsequently implement legislation.

#### Interrupted time series studies

These studies involved measurement of helmet use at multiple times before and after the implementation of helmet legislation.

#### Non-equivalent control group study

These studies were required to involve measurement of helmet use in a community exposed to helmet legislation compared with one or more non-intervention communities in order to determine bicycle helmet wearing prevalence.

#### Exclusion criteria

Excluded were hospital based studies, telephone or mailing surveys, and self-reported questionnaire based studies.

#### Quality assessment

There is no specifically designed quality assessment tool in use to evaluate the methodological quality of such observational studies. Some researchers have used the Downs and Black checklist for evaluating cohort studies;<sup>24</sup> however, this checklist was designed to assess the methodological quality of both randomized and non-randomized studies of health-care interventions. A modified version of this form, including 15 applicable questions for these study designs, was independently used by two reviewers (MK, JC) to rate each article.

#### Statistical analyses

We examined changes in the helmet use proportions among cyclists before and after legislation. We also reported the odds ratios (OR) comparing helmet use before and after the implementation of legislation. For calculating individual and pooled ORs with 95% confidence intervals (CI), we used available population data from intervention and control groups or pre and post-legislation studies.

When available, we used data on helmet prevalence from one year pre-legislation and the last year of the study post-legislation. This approach attempted to negate the temporary effects of legislation immediately after implementation. To explore any variability of the legislation effectiveness on helmet use, age groups, gender, and pre-intervention helmet wearing prevalence were examined in our analyses.

#### Promotion and enforcement

We reviewed the original manuscripts seeking further information on enforcement/promotion surrounding the implementation of legislation. When no manuscript information was available, efforts to communicate with the lead author of each article were repeatedly made. A three-question electronic mail correspondence was sent on two occasions and the tabulated results were sent for confirmation to each lead author. Authors were requested to provide the promotional activities and enforcement approaches employed during the implementation of legislation.

**Table 2** General descriptions of the 12 included studies

Study ID	Cyclist population	Intervention (legislation)	Control	Outcome	Methods
Cote, 1992	All rider ages	Helmet law for children <16 years	Communities without legislation	Helmet use	Recording: concurrent roadside observations; Factors: age, gender, race, place; Follow up timing: <1 year after legislation.
Cameron, 1994	All rider ages	Statewide helmet law for all cyclists	Pre-legislation period	Helmet use	Recording: Pre-post roadside observations; Factors: age, gender, time, place; Follow up timing: <2 years after legislation.
Ni, 1997	All rider ages	Statewide helmet law for children <16	Pre-legislation period	Helmet use	Recording: Pre-post roadside observations; Factors: age, gender, place; Follow up timing: 3 years after legislation
Foss, 2000	All rider ages	Helmet law for all cyclists	Pre-legislation period	Proper and improper helmet use	Recording: Pre-post roadside observations; Factors: age, gender, bicycle type, protective devices, backpack, time, place; Follow up timing: 3 years after legislation
Kanny, 2001	Elementary school	Statewide helmet law for children <16	Other community without legislation	Helmet use	Recording: concurrent roadside observations; Factors: gender, race; Follow up timing: 1 years after legislation
LeBlanc, 2002	All rider ages	Provincial helmet law for all cyclists	Pre-legislation period	Helmet use	Recording: Pre-post roadside observations; Factors: age, gender, accompaniment, type of road; Follow up timing: 2 years after legislation
Thomas, 2002	All riders ages	Statewide helmet law for children <15	Pre-legislation period	Proper and improper helmet use	Recording: Pre-post roadside observations; Factors: age, gender, bicycle type, backpack, gloves, time, place; Follow up timing: <1 years after legislation
Delamater, 2003	Elementary, middle school	Statewide helmet law for children <16	Pre-legislation period	Helmet use	Recording: Pre-post roadside observations; Factors: age, time, place; Follow up timing: 4 years after legislation
Liller, 2003	Children <16	Helmet law for children <16	Pre-legislation period	1. Helmet use 2. Bicycle injuries	Recording: Pre-post roadside observations; Factors: age, gender, race/ethnicity, helmet use of companions; Follow up timing: <2 years after legislation
Parkin, 2003	Children 5–14 years	Provincial helmet law for children <16	Pre-legislation period	Helmet use	Recording: Pre-post roadside observations; Factors: age, gender, time, place; Follow up timing: 1 year after legislation
Hagel, 2005	All rider ages	Provincial helmet law for children <18	Pre-legislation period	Helmet use	Recording: Pre-post roadside observations; Factors: age, gender, time, place; Follow up timing: 2 years after legislation
Povey 2005	All rider ages	Nationwide helmet law for all cyclists	Pre-legislation period	Helmet use (the survey)	Recording: Pre-post roadside observation; Factors: age; Follow up timing: up to 11 years after legislation

## RESULTS

### Description of search

From 86 citations, 25 were assessed as potentially relevant. Overall, 14 studies were excluded based on a priori criteria resulting in 11 studies selected for review. Eight reports were journal publications<sup>15 16 21 25–29</sup> and two were formal reports.<sup>30 31</sup> One relevant survey was unpublished<sup>32</sup> and another incorporated following personal communication with the author.<sup>33</sup> Detailed information on each study is

provided in the following summaries (see <http://www.injuryprevention.com/supplemental>).

### Description of studies

All of the studies included in this review were published after 1992 (table 1). Studies were based in the United States, Canada, Australia, and New Zealand. Two studies used non-equivalent control groups,<sup>15 27</sup> and 10 were interrupted time series or pre-post observational studies.<sup>16 21 25 26 28–33</sup> While four included studies involved children of school age exclusively,<sup>26–29</sup> eight included all riding ages.<sup>15 16 21 25 30–33</sup>

Among the 12 studies, various cyclist factors were recorded including: age (11), gender (10), location (8), time of day (7), racial characteristics (3), bicycle type (2), backpack use (2), accompaniment (2), and type of road (1) (table 2). Length of follow up after helmet legislation varied between six months<sup>30</sup> and 11 years.<sup>33</sup> Three studies had <1 year follow up,<sup>15 16 30</sup> six studies had 2–3 years follow up,<sup>21 25 27 29 28 32</sup> and three studies had four or more years of follow up.<sup>26 31 33</sup>

Two surveys<sup>26 27</sup> obtained information only from observational sites in elementary and middle schools, but others collected data from sites everywhere in the communities.<sup>15 16 21 25 28–33</sup> Almost all studies used trained observers to collect data in pre-defined sites except one<sup>27</sup> which used questionnaires completed by school personnel.

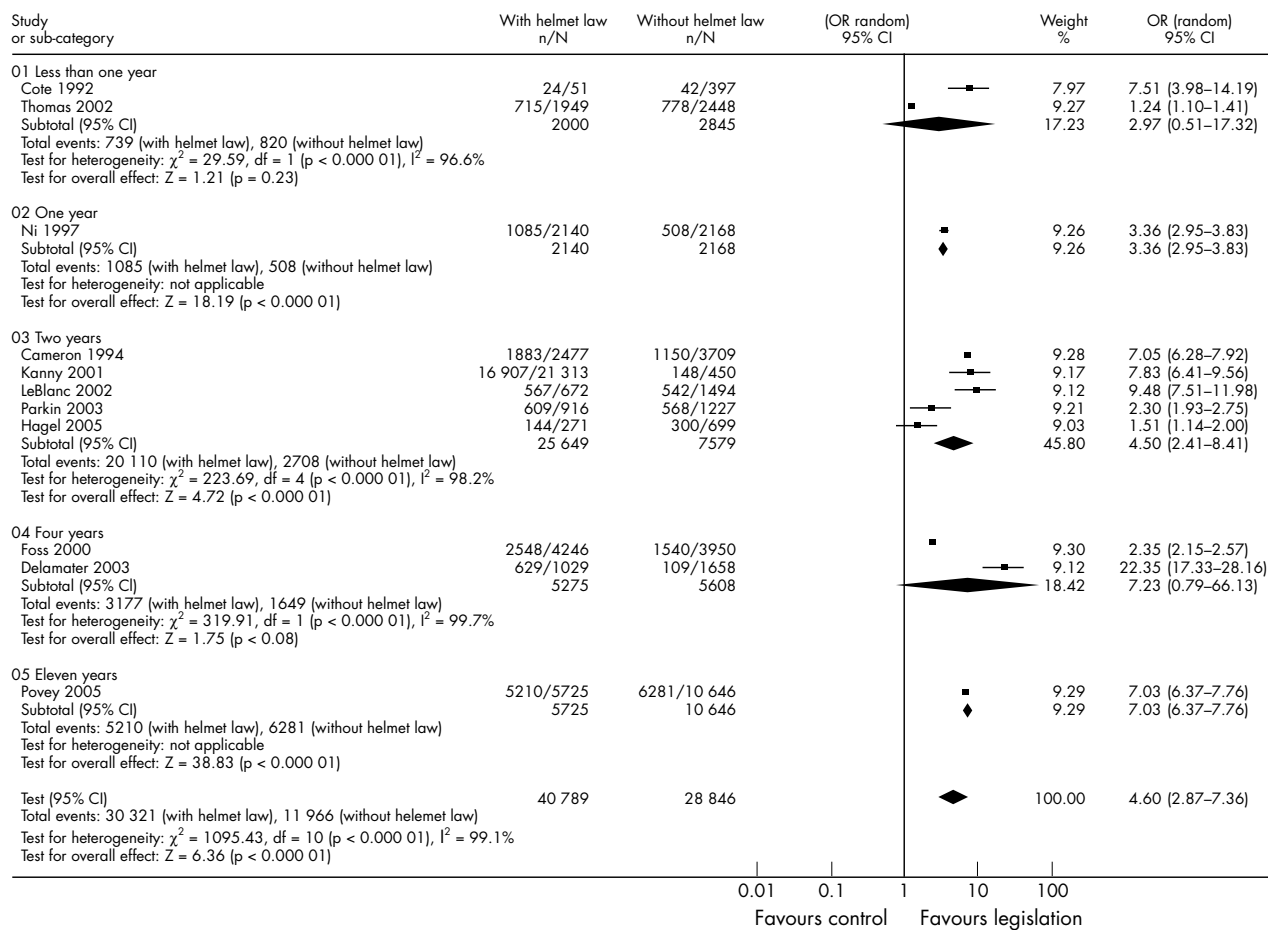
### Changes in helmet use proportions

The primary result in most of the studies was the proportion of cyclists using helmets before and after helmet legislation. The baseline rate of helmet use varied between 4% and 59%

**Table 3** Change from baseline helmet use in studies evaluating the effectiveness of legislation on helmet use in cyclists

Study ID	Pre-intervention proportion	Post-intervention proportion	Δ
1. Cote, 1992	4	47	+43
2. Cameron, 1994	31	75	+44
3. Ni, 1997	24	51	+27
4. Foss, 2000	39	60	+21
5. Kanny, 2001	33	79	+46
6. Leblanc, 2002	38	84	+46
7. Thomas, 2002	32	37	+5
8. Delamater, 2003	7	61	+54
9. Liller, 2003	7	57	+50
10. Parkin, 2003	44	66	+22
11. Hagel, 2005	43	53	+10
12. Povey, 2005	59	91	+32

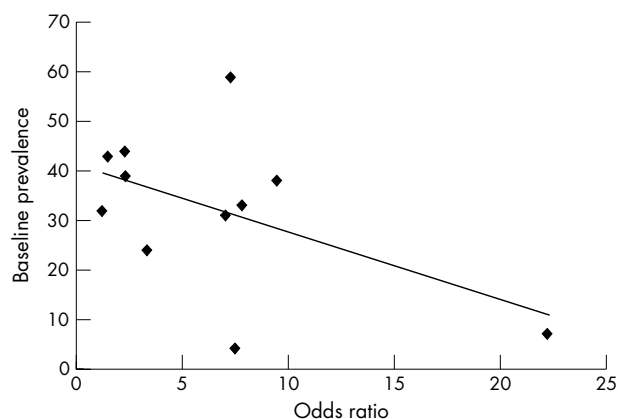
Review: Effectiveness of bicycle helmet legislation to increase helmet use  
 Comparison: Effectiveness in subgroups  
 Outcome: Long-term effect of helmet law



**Figure 1** Relationship between the effect of helmet legislation and long term effect of legislation.

and this range after legislation changed to be between 37% and 91%. One study demonstrated an increase of helmet wearing proportions after introduction of the law of less than 10%; four studies reported a 10%–30% increase, while seven studies reported an increase of more than 30% (table 3).

Long term effect of legislation (two, four, and 11 years) were compared with the short term effects (less than or about one year follow up). The long term effect of helmet legislation



**Figure 2** Relationship between baseline helmet prevalence and odds ratios.

was examined by some authors,<sup>21 25–29 31 32 33</sup> five demonstrated an increase of 40% or more,<sup>21 25–28</sup> three demonstrated an increase of 21–32%,<sup>29 31 33</sup> and one reported an increase of 10%.<sup>32</sup> In the longest study identified, helmet wearing remained unchanged 10 years after the introduction of the original legislation.<sup>33</sup>

### Effect measures

The results (OR = 4.60; 95% CI 2.87 to 7.36) indicate that helmet use was more than four times higher following helmet legislation. This result is heterogeneous ( $I^2 = 99\%$ ) and four a priori subgroups (type of control group, <16 years old *v* all-age cyclists, length of follow up, males *v* females) were examined in an effort to understand this heterogeneity (fig 1). Some of the heterogeneity was explained on the basis of control methodology. The before-after method resulted in a smaller effect size (OR = 4.13; 95% CI 2.45 to 6.97) than the non-equivalent control groups design (OR = 7.8; 95% CI 6.45 to 9.44).

The results suggest no clear differences between communities with legislation focusing on children <16 (OR = 4.22; 95% CI 2.03 to 8.76) compared with communities with legislation for all cyclists (OR = 5.35; 95% CI 2.74 to 10.47). In one study, helmet legislation was only in effect for children <18 years old; however, age subgroup information was reported. The subgroup analysis for children generated a larger effect estimate (OR = 12.46; 95% CI 5.16 to 30.10) than the overall effect estimate (OR = 1.51).<sup>32</sup>

**Table 4** Promotional activities and enforcement employed in addition to helmet legislation for locations of included studies

	Cote, 1992	Cameron, 1994	Ni, 1997	Foss, 2000	Kanny, 2001	LeBlanc, 2002	Thomas, 2002	Delamater, 2003	Liller, 2003	Parkin, 2003	Hagel, 2005	Povey, 2005
<i>Promotional activity before legislation</i>												
Helmet price discount	-	+	✓	+	+	-	✓	✓	✓	✓	✓	✓
Print media campaign	✓	+	✓	+	?	✓	✓	-	✓	✓	✓	✓
Radio media campaign	✓	+	✓	+	?	✓	✓	-	-	✓	✓	✓
TV media	✓	+	✓	+	?	✓	✓	-	✓	✓	-	✓
Spot checks/fake ticketing	✓	?	✓	?	?	-	-	-	-	-	-	✓
Bicycle clinics	-	+	-	?	?	-	-	✓	✓	✓	✓	✓
Other	-	-	-	-	-	-	-	-	✓	✓	✓	✓
<i>Enforcement of the helmet law</i>												
Verbal warnings	-	?	✓	?	+	✓	-	-	✓	-	✓	✓
Ticket issued, no payment required	✓	+	✓	?	+	-	-	-	-	-	-	-
Ticket issued, reduced payment required	-	+	✓	?	?	-	-	-	-	-	-	-
Ticket issued, full payment required	-	?	✓	?	+	✓	-	-	-	-	-	✓
Other	-	-	-	-	-	-	-	-	✓	-	-	-
<i>Overall assessment</i>												
No law enforcement	-	?	-	?	-	-	-	✓	-	-	-	-
Very limited enforcement	-	?	-	?	?	-	-	-	✓	-	✓	-
Somewhat limited enforcement	-	?	-	?	?	-	-	-	-	-	-	-
Enforcement neither limited nor aggressive	✓	+	✓	?	?	✓	-	-	-	-	-	✓
Enforcement was somewhat aggressive	-	?	-	?	?	-	-	-	-	-	-	-
Enforcement was somewhat aggressive	-	?	-	?	?	-	-	-	-	-	-	-
Strict law enforcement	-	?	-	?	?	-	-	-	-	-	-	-

✓, Response received (affirmative); -, response received ("not used"); +, used data available in the paper; ?, response unavailable and unclear in the manuscript.

For evaluating the long term effect of legislation on bicycle helmet use, a subgroup analysis using the time period after legislation (<1 year, 1 year, 2 years, 4 years, and 11 years) in each community was performed. The point estimates appear quite dissimilar among these studies based on long term effect (fig 1).

Four studies which provided gender subgroup data failed to identify an influence of gender on the relationship between helmet use and legislation (OR = 5.27; 95% CI 4.20 to 6.62 for men v OR = 5.61; 95% CI 4.90 to 6.42 for women). The possible relationship between the OR of individual studies and the corresponding baseline proportion of helmet use was explored (fig 2); a negative, although not statistically significant, relationship between baseline rate of helmet use and the effect of helmet use after legislation ( $r = -0.51$ ;  $p = 0.11$ ) was identified. This subgroup analysis implies that higher baseline proportions of helmet use may be associated with smaller subsequent intervention effectiveness.

### Promotion and enforcement

Overall, email responses were obtained from nine of 12 authors (responses rate: 75%). The results suggest that a variety of promotional activities were associated with implementation of the helmet legislation; however, enforcement was uniformly weak in these regions. These data are presented in table 4.

### DISCUSSION

From 10 observational before/after studies involving 47 417 observations and two non-equivalent control group studies involving 22 193 observations, the results of this review provide insight regarding the effectiveness of bicycle helmet legislation. First, based on the available data it appears that any legislation will increase the use of helmets. Second, this effect reported is not equal in different jurisdictions, and multiple factors are likely responsible.

The effect of helmet legislation on helmet use ranges from modest (OR = 1.24),<sup>30</sup> to massive (OR = 22.25).<sup>26</sup> The largest effect sizes are observed in studies with lower baseline helmet use,<sup>15 26 28</sup> and in those where helmet laws apply to all ages in the community.<sup>21 25 31 33</sup> In this review, we were unable to identify any negative relationship between legislation and bicycle helmet use; however, one must wonder if this is a true effect or a consequence of publication bias. Given the paucity of research and our comprehensive attempts to secure published and unpublished data, we feel that this is a valid reflection of the effect of legislation rather than an example of publication bias. Moreover, while the influence of helmet laws appears positive, the magnitude of that change from baseline is difficult to estimate due to the interactions of many factors (for example, time, socioeconomics, incentives, and enforcement) and the estimate of these influences with available information was difficult. Conversely, the requirements of legislation in each jurisdiction might differ and could influence which mechanism of injury prevention would be selected by the policy makers to cope with a public issue.

Results of long term effects suggest that the legislation takes time to produce the desired effect following implementation. Although only two non-equivalent control group studies were available in this subanalysis, the larger effect estimate was generated with a smaller sample size. Overall, this finding is promising; however, further longitudinal studies are needed to determine the role of time in legislative periods.

The effect of socioeconomic status of the community on any increase of helmet use due to legislation is an important consideration. Communities with higher socioeconomic status tend to have a higher proportion of helmet use than mid and low income populations.<sup>34-36</sup> When helmet laws come into effect, high income communities demonstrate lower effect estimates.<sup>34</sup> Regarding community incentives,

the literature indicates a positive effect on helmet wearing.<sup>9 25 26</sup> Despite this previous research, however, we were not able to determine the effects of socioeconomic status and incentives, as the included studies failed to provide the level of detail required for analysis.

Confounding effects of some promotional activities such as extensive media campaigns, community incentives, education/instruction in schools, and enforcement following legislation has been widely acknowledged by the researchers. In the New Zealand survey, the rate of helmet use following promotional and educational activities, increased from 11% to 59% (↑45%) over five years.<sup>33</sup> In addition, Seattle saw helmet use climb from 3% to 16% (↑13%) in a three year period.<sup>9</sup> However, a 10 year study in Australia<sup>25</sup> demonstrated that helmet promotion programs accounted for a 30% (6% to 36%) increase in helmet use during an eight year period before legislation (~4% increase/year); when legislation was subsequently introduced in the ninth year, helmet use increased from 36% to 73% (37%) in one year.

Opponents of mandatory helmet legislation have suggested that legislation has a negative effect on cycling activity.<sup>37</sup> Once again, the included studies in this review failed to provide a level of detail on a consistent basis to examine the effect of legislation on cycling participation. This issue was, however, examined by Macpherson *et al*, in East York, Ontario, Canada, from 1993 to 1999. They studied trends in bicycling among elementary and middle school children during eight years, and found no significant change in the number of cyclists observed per hour from pre- to post-legislation.<sup>20</sup> Other researchers from Australia, however, noted decreased adolescent but not child or adult participation two years after introduction of bicycle helmet legislation.<sup>25 38</sup>

There are several limitations of the review. For calculating initial and pooled odds ratios, we used population data of 11 included studies. The population of one study was not available so it was excluded from analysis.<sup>28</sup> Influence of some factors such as media campaigns, educational programs, financial incentives, and police enforcement may have been mixed with the effect of helmet legislation. We did attempt to contact the authors regarding this issue; however, many lacked the knowledge to catalogue all of the associated programs and enforcement activities associated with the legislation. Therefore, we were uncomfortable about formally analyzing the extent of enforcement and educational interventions as they related to helmet prevalence beyond what is presented in table 4. However, the results in table 4 indicate that enforcement activities were not aggressive in any jurisdictions that implemented legislation. Clearly, more work is needed on this issue.

Alternatively, the published evidence does provide some insight into the level of enforcement and helmet legislation effectiveness. Data from Coté *et al*<sup>15</sup> and Ni *et al*<sup>16</sup> support the contention that even with minimal enforcement, there is a significant increase in helmet wearing rates accompanying legislation. Finch found that fear of police and the possibility of receiving a fine for not wearing a helmet was a relatively unimportant reason (~15%) for wearing even in the face of enforcement.<sup>39</sup> Safety was the major reason cited for helmet wearing (54%).<sup>39</sup> Cameron *et al*, reported a 6% to 36% increase in helmet use over an eight year period of promotion; however, a 37% increase in the year following legislation.<sup>25</sup> Finally, a major review concluded that "Minimal enforcement of helmet laws does not seem to undermine the positive effects of legislation".<sup>40</sup> The published evidence and our results suggest that perhaps the main effect of the legislation is to educate the community/parents that bike helmets are protective, subsequently changing social norms about helmet

## Key points

- Overall, helmet legislation increased bicycle helmet use.
- Legislation was consistently associated with an increase in helmet prevalence; however, variability is present.
- The effect of legislation appears smaller in areas with a higher baseline proportion of helmet use and areas with high socioeconomic status.
- Limited evidence exists on the role of helmet legislation for children on adult helmet wearing proportions; one study suggested no effect.

use and increasing prevalence. This appears to occur even in the absence of rigorous enforcement.

Lack of control group for the surveys was a common problem. This issue is more important for non-equivalent control group studies, but may still be an issue for pre-post intervention studies due to the effect of time bias. Many researchers have been reluctant to attribute causal associations to ecological studies due to the threat of the *ecological fallacy*. However, consistency in the literature of the positive effect of helmet legislation indicates that we cannot ignore the relationship between helmet legislation and subsequent helmet use.

The pooling of study results in the face of variability of results is controversial. In some cases, reviewers elect to simply present the individual results without a summary statistic. In this case, despite the variability of results, we elected to pool results in an effort to provide an average estimate of the effect of legislation. We recognize this variability, and caution readers regarding the interpretation of the effect estimate.

## IMPLICATIONS

### Communities

While universal use of helmets is desirable, legislation appears to substantially increase helmet wearing. Subgroup analysis suggests the effect of the intervention may be less impressive where baseline rates are high; however, this does not imply that the intervention should be abandoned in such settings.

### Research

Although helmet legislation is effective in increasing helmet use by cyclists, the effect of helmet laws on outcomes (for example, injuries) is also important. These results do not provide detailed evidence of the effectiveness of the components of the legislation, and additional research comparing similar communities with and without helmet legislation is required. Further efforts to explore the transition effect of helmet law expansion from younger to all ages is also required.

## ACKNOWLEDGEMENTS

The authors wish to thank Ms Lynley Povey (Senior Scientist, Research and Statistics, Ministry of Transport; Wellington, New Zealand) for her assistance with this project. Lisa Tjosvold and Carol Friesen are acknowledged for their assistance with constructing the literature searches. In addition, the authors would like to thank an anonymous reviewer for his/her recommendations. Dr Rowe is supported by the Canadian Institute of Health Research (CIHR; Ottawa, ON) as a Canada Research Chair. Dr Hagel is supported through a Professorship in Child Health and Wellness, funded by an Anonymous Donor to the Alberta Children's Hospital Foundation, Calgary, Alberta, Canada. Part of this work was completed while Dr Hagel was with the Alberta Centre for Injury Control & Research, Dept of Public Health Sciences, Faculty of Medicine and Dentistry, University of Alberta.

**Authors' affiliations**

**M Karkhaneh, J-C Kalenga**, Department of Public Health Sciences, University of Alberta, Edmonton

**B H Rowe**, Department of Emergency Medicine, University of Alberta, Edmonton, Alberta, Canada

**B E Hagel**, Departments of Paediatrics and Community Health Sciences, University of Calgary, Calgary, Alberta, Canada

**REFERENCES**

- Rowe BH, Rowe AM, Bota GW. Bicyclist and environmental factors associated with fatal bicycle-related trauma in Ontario. *Cmaj* 1995;**152**:45–53.
- Sacks JJ, Holmgren P, Smith SM, et al. Bicycle-associated head injuries and deaths in the United States from 1984 through 1988. How many are preventable? *JAMA* 1991;**266**:3016–18.
- Thompson D, Rivara F, Thompson R. *Helmets for preventing head and facial injuries in bicyclists*, 2005. Cochrane Database of Systematic Reviews.
- Sacks JJ, Kresnow M, Houston B, et al. Bicycle helmet use among American children, 1994. *Inj Prev* 1996;**2**:258–62.
- BRFSS. *Behavioral Risk Factor Surveillance System (BRFSS)*, National Center for Chronic Diseases Prevention and Health Promotion, 2001.
- Nolen S, Ekman R, Lindqvist K. *Bicycle helmet use in Sweden during the 1990s and in the future*, Health Promot Int, 2005.
- Cushman R, Piess R, Hope D, et al. Trends in bicycle helmet use in Ottawa from 1988 to 1991. *Cmaj* 1992;**146**:1581–5.
- Wood T, Milne P. Head injuries to pedal cyclists and the promotion of helmet use in Victoria, Australia. *Accid Anal Prev* 1988;**20**:177–85.
- DiGiuseppi CG, Rivara FP, Koepsell TD, et al. Bicycle helmet use by children. Evaluation of a community-wide helmet campaign. *JAMA* 1989;**262**:2256–61.
- Bergman AB, Rivara FP, Richards DD, et al. The Seattle children's bicycle helmet campaign. *Am J Dis Child* 1990;**144**:727–31.
- Kimmel SR, Nagel RW. Bicycle safety knowledge and behavior in school age children. *J Fam Pract* 1990;**30**:677–80.
- Morris BA, Trimble NE. Promotion of bicycle helmet use among schoolchildren: a randomized clinical trial. *Can J Public Health* 1991;**82**:92–4.
- Schieber RA, Kresnow MJ, Sacks JJ, et al. Effect of a state law on reported bicycle helmet ownership and use. *Arch Pediatr Adolesc Med* 1996;**150**:707–12.
- Vulcan AP, Cameron MH, Watson WL. Mandatory bicycle helmet use: experience in Victoria, Australia. *World J Surg* 1992;**16**:389–97.
- Cote TR, Sacks JJ, Lambert-Huber DA, et al. Bicycle helmet use among Maryland children: effect of legislation and education. *Pediatrics* 1992;**89**:1216–20.
- Ni H, Sacks JJ, Curtis L, et al. Evaluation of a statewide bicycle helmet law via multiple measures of helmet use. *Arch Pediatr Adolesc Med* 1997;**151**:59–65.
- Shafi S, Gilbert JC, Lohmanee F, et al. Impact of bicycle helmet safety legislation on children admitted to a regional pediatric trauma center. *J Pediatr Surg* 1998;**33**:317–21.
- Borglund ST, Hayes JS, Eckes JM. Florida's bicycle helmet law and a bicycle safety educational program: did they help? *J Emerg Nurs* 1999;**25**:496–500.
- Puder DR, Visintainer P, Spitzer D, et al. A comparison of the effect of different bicycle helmet laws in 3 New York City suburbs. *Am J Public Health* 1999;**89**:1736–8.
- Macpherson AK, Parkin PC, To TM. Mandatory helmet legislation and children's exposure to cycling. *Inj Prev* 2001;**7**:228–30.
- Leblanc JC, Beattie TL, Culligan C. Effect of legislation on the use of bicycle helmets. *Cmaj* 2002;**166**:592–5.
- Nolen S, Lindqvist K. A local bicycle helmet 'law' in a Swedish municipality—the structure and process of initiation and implementation. *Inj Control Saf Promot* 2002;**9**:89–98.
- Taylor M, Scuffham P. New Zealand bicycle helmet law—do the costs outweigh the benefits? *Inj Prev* 2002;**8**:317–20.
- Downs JBN. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health* 1998;**52**:377–84.
- Cameron MH, Vulcan AP, Finch CF, et al. Mandatory bicycle helmet use following a decade of helmet promotion in Victoria, Australia—an evaluation. *Accid Anal Prev* 1994;**26**:325–37.
- Delamater AM, Patino AM. Bicycle helmet wearing in children: a seven-year, observational study in Broward County, Florida. *Children's Health Care* 2003;**32**:287–95.
- Kanny D, Schieber RA, Pryor V, et al. Effectiveness of a state law mandating use of bicycle helmets among children: an observational evaluation. *Am J Epidemiol* 2001;**154**:1072–6.
- Liller KD, Nearn J, Cabrera M, et al. Children's bicycle helmet use and injuries in Hillsborough County, Florida before and after helmet legislation. *Inj Prev* 2003;**9**:177–9.
- Parkin PC, Khambalia A, Kmet L, et al. Influence of socioeconomic status on the effectiveness of bicycle helmet legislation for children: a prospective observational study. *Pediatrics* 2003;**112**:e192–6.
- Thomas LHW, Feaganes JR, Foss RD. *Helmet use in North Carolina following a state-wide bicycle helmet law in Final project report for the North Carolina Governor's Highway Safety Program*, UoNCHSR Center, Editor. 2002. University of North Carolina, Highway Safety Research Center.
- Foss RD, Beirness DJ. *Traffic Injury Research Foundation. Bicycle helmet use in British Columbia: effect of helmet use law*, HNC Highway Safety Research Centre, 2000:1–21.
- Hagel BE, Rizkallah JW, Lamy A, et al. *Trends in bicycle helmet use associated with helmet legislation in a Canadian province*, University of Alberta, 2005.
- Povey L, Novis K. *Cycle helmet wearing rate: result of observational surveys conducted during morning/afternoon peak, weekdays 1989–2005*; Research and Statistics section, Ministry of Transport, Po Box 3175, Wellington, New Zealand. Available at <http://www.transport.govt.nz/business/land/research/helmets.php> (accessed December 2005).
- Harlos S, Warda L, Buchan N, et al. Urban and rural patterns of bicycle helmet use: factors predicting usage. *Inj Prev* 1999;**5**:183–8.
- Parkin PC, Spence LJ, Hu X, et al. Evaluation of a promotional strategy to increase bicycle helmet use by children. *Pediatrics* 1993;**91**:772–7.
- Mower G, Bemis C. *Bicycle helmet use in Utah; 10-year observational survey*, RbUDoH. Violence and Injury Prevention Program, Editor. 2004, Bureau of Health Promotion, Division of Community and Family Health Services, Utah Department of Health.
- Carnall D. Cycle helmets should not be compulsory. *BMJ* 1999;**318**:1505.
- Finch CF, Heman L, Neiger D. Bicycle use and helmet wearing rates in Melbourne, 1987 to 1992; the influence of helmet wearing law, in Reports no 45. Monash University Accident Research Center, 1993.
- Finch CF. Teenagers' attitudes towards bicycle helmets three years after the introduction of mandatory wearing. *Inj Prev* 1996;**2**:126–30.
- Rivara FP, Thompson DC, Patterson MQ, et al. Prevention of bicycle-related injuries: helmets, education, and legislation. *Annu Rev Public Health* 1998;**19**:293–318.