Bicycle helmets: quality of evidence

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Abstract

Objectives

To analyze the quality of published evidence on the effects of large-scale helmet use

Design

Establishment of quality criteria for the main forms of evidence; analysis of main threats to validity

Data sources

The two Cochrane reviews, the website of the BHRF, and searches of Medline and Google Scholar

Main outcome measures

The validity of studies in relation to their quality

Results

Time-trend studies of good quality find no effect of helmets. Some, not all, lower-quality studies support effectiveness; most of these have well-documented and serious flaws. Case-control studies have severe methodological biases which potentially account for all of their positive results. Engineering evidence does not support the effectiveness of helmets in real crashes.

Conclusions

Bicycle helmets have strangled children and may deter cycling. They have no scientifically-demonstrated useful effect on head injuries. There is fair evidence that the introduction of helmet laws have deterred cycle use, undermining its health and other benefits. There is no good evidence that they reduce the overall number of head injuries, or deaths, suffered by cyclists. A number of reviews have systematically omitted the best evidence and have come to erroneous conclusions as a result.

1. The BHRF

1.1 The Bicycle Helmet Research Foundation (BHRF) was founded to undertake and encourage the scientific study of the use of bicycle helmets and to provide a resource of factual information and analysis to assist the understanding of a complex subject. The BHRF is pro-cycling and pro-health. It is neither for nor against the use of cycle helmets as a matter of principle, but seeks a comprehensive understanding of their effects based on best scientific endeavor.

1.2 Many people associated with BHRF were at one time supportive of helmet use, but examination of the evidence has caused them to reconsider their views.

1.3 This paper summarizes our analysis of the evidence.

2. Initial assumptions

2.1 The history of bicycle helmets is of advocacy preceding evidence. Common sense recommended a device designed by engineers to protect against an obvious risk. Author Richard Ballantine described helmets as *"Vital... for road and track races, and for riding in traffic."*[1] as early as 1977, before scientific evidence had been produced about their effectiveness. The present author sympathizes with this point of view; in the early 1980s he wore a helmet (and for some years saw no other cyclist doing so).

3. Cyclists and helmets

3.1 Since then, a flood of academic and popular literature, and statements from authoritative bodies, have endorsed or (less often) rejected helmet efficacy. In some circles it is difficult to even mention academic doubts about helmets. Helmets had become a ‘ “Mom and apple pie” issue’ in the United States by 1991 and helmet compulsion was seen to be unstoppable. This position was supported by an early and widely-quoted series of case-control studies, from which an ongoing claim that helmets protect against 88% of head injuries is derived.[2] An official campaign in the UK was criticised for using "scare" images of skulls to promote helmets.[3] Helmetless cyclists are effectively voting against widespread pressure.

3.2 The overall rate of helmet wearing on major roads in the UK rose to 30.7% in 2006.[3] Most UK bicycle riders are still not wearing helmets, and many are aware that the level of absolute risk that they face is small. There is about one death per twenty million miles of cycling. A typical British cyclist who rides for 280 hours per year (about 45 minutes per day, 2,300 miles in total) will face an annual risk of road death about double that of a British driver, but the risk is still low, less than one in ten thousand

1Richard Ballantine. The Piccolo Bicycle Book, 1977. Pan Books, London. ISBN 0 330 25017 5

2 Why it is wrong to claim that cycle helmets prevent 85% of head injuries and 88% of brain injuries http://www.cyclehelmets.org/1131.htm

3 Teresa McGarry and Rob Sheldon, Accent. Cycle Helmet Wearing in 2006. Road Safety Research Report No. 84. February 2008. Department for Transport: London. http://www.dft.gov.uk/pgr/roadsafety/research/rsrr/theme1/cyclehelmets.pdf

per year.[4] [5] The risk for children is also low.[6] In many Continental countries, notably France (which does not segregate cyclists) and the Netherlands (which does), the hourly risk is lower for cyclists than for drivers. The main differences are the widespread use of 30kmh speed limits on local streets, the social profile enjoyed by cyclists (which is largely a function of popularity[7]) and their legal protection if injured by bad driving.

Health benefits

3.3 Regular moderate cycling reduces the death rate by about 40% after multivariate adjustment[8] and the effect is unlikely to be entirely due to confounding since people in this study who played vigorous sports also experienced lower death rate if they cycled.[9] Similar benefits were observed in women in Shanghai.[10] The effect is assumed to be mainly due to the healthy exercise involved. Exercise also increases quality of life.[11] A person cycling regularly in mid-adulthood typically has a level of of fitness equivalent to being 10 years younger[12], and a life expectancy 2 years above the average[13]. A 9-year study found that Whitehall civil servants who cycled for at least an hour a week (or 25 miles in a single week) had less than half the death rate of those who didn't during the study period[14]. The health benefits of cycling far outweigh the risks thanks to the life years gained – by a factor of 20:1 according to one estimate[15]. It has also been estimated that, if a group 100,000 people took up regular cycling, statistically one would expect a net reduction of 50 deaths among that group within a year – there would be 7 cycling-related fatalities but 57 deaths averted through the health benefits of cycling.[16] On balance, at least for the great majority, cycling is a fitness-enhancing and life-extending activity. It also

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4 Wardlaw M 2002. Assessing the actual risks faced by cyclists". Traffic Engineering & Control 43: 352–356.

5 Morgan JM. Risk in cycling. Crowthorne: Transport and Road Research Laboratory, 1988. (TRRL Working Paper WP/RS/75.)

6 http://www.cyclehelmets.org/1148.html

7 http://www.cyclehelmets.org/1148.html

8 Andersen LB, Schnohr P, Schroll M, Hein HO. All-cause mortality associated with physical activity during leisure time, work, sports, and cycling to work. Arch Intern Med 2000 Jun 12;160(11):1621-8. http://archinte.ama-assn.org/cgi/content/abstract/160/11/1621

9 Personal communication from Professor Andersen.

10 Matthews CE, Jurj AL, Shu Xo, Li HL, Yang G, Li Q, Cao YT, Zheng W. Influence of exercise, walking, cycling and overall nonexercise physical activity on mortality in Chinese women. American Journal of Epidemiology, 2007 165(12):1343-1350

11 Martin CK, Church TS, Thompson AM, Earnest CP, Blair SN. Exercise Dose and Quality of Life. A Randomized Controlled Trial. *Arch Intern Med.* 2009;169(3):269-278. http://archinte.ama-assn.org/cgi/content/abstract/169/3/269

12 Tuxworth W, Nevill AM, White C and Jenkins C. Health, fitness, physical activity and morbidity of middle aged male factory workers. British Journal of Industrial Medicine 1986, 43 (11: 733-753.

13 Paffenbarger RS Jr, Hyde RT, Wing AL, Hsieh CC. Physical activity, all-cause mortality and longevity of college alumni. New England Journal of Medicine, 1986, 314(10): 605-613.

14 Morris J N, Clayton D G, Everitt M G, Semmence A M, and Burgess E H. Exercise in leisure time: coronary attack and death rates. British Heart Journal, 1990, 63: 325-334.

15 Hillman M, Cycling and the promotion of health. Policy Studies, 1993, 14 : 49-58.

16 Rutter H. Valuing the Mortality Benefits of Regular Cycling. In Lind G. CBA of cycling. Nordic Council of Ministers, Copenhagen 2005 (www.thepep.org/ClearingHouse/docfiles/CBA%20on%20cycling%20nordic%20council%20report%202005.pdf)

offers cheap transportation which poses little threat to others.

4. Testing the hypothesis that helmets reduce injuries

4.1 It is generally accepted that randomised controlled trials provide the best form of evidence about the effectiveness of health interventions.[17] Despite assertion to the contrary from the Chairman of the British Medical Association at its 2005 Annual Representatives Meeting, no randomised trials of cycling helmets have been conducted (though there has been a randomized trial of walking helmets for schoolchildren).[18] A randomised study taking serious injury as its outcome would require a very large number of cyclists. Even if cycle helmets were 80% effective in preventing serious injuries of any sort, and on the high assumption that there is one serious injury per 8,000 years of average cycling, we would still require 235,500 cyclists to take part in a trial for one year in order to have an 80% chance of showing a statistically significant difference.[19] Also, "blinded" trials would be very difficult; subjects will know whether they are wearing a helmet or not, and arranging for those assessing the outcomes to be ignorant of helmet use would also be difficult. Few studies have been done on such a scale, no such trial seems likely, and in the case of helmets we need to rely on the results of "natural experiments".

.2. This paper makes no attempt to evaluate studies which consider only the effectiveness of interventions to promote helmet-wearing - such studies generally take it as read (implicitly or explicitly) that increases in helmet wearing are beneficial. We are concerned here only with publications of primary data which purport to test the effectiveness of helmets.

4.3 The available evidence broadly falls into two categories: population-level evidence and case-control studies. Most of the studies in the first of these categories analyse changes in helmet-wearing rates over time ("time-trend studies") to determine whether there has been any associated changes in cyclists' safety. Other population-level studies ("population comparison studies") consider whether a group who wore helmets had lower fatality rates than a comparison group who did not. These studies have the advantage that helmet use has generally been measured by third-party observers, but the disadvantage of not recording whether the individuals wearing helmets were those who had relevant accidents. The second category consists of case-control studies, based on much smaller hospital-based populations. All of the case-control studies use individual data on cyclists that had accidents, but they depend on the cyclists to report accurately whether helmets were used or not in the accident.

4.4 The following sections of this paper examine the evidence in the two categories identified above. There are methodological problems with many of the studies in the first group, however the best conducted studies find no evidence of safety benefits from increases in helmet wearing rates. By contrast, the case-control studies tend to indicate substantial benefits from helmet-wearing. However it will be shown that their findings cannot be relied on.

Time-trend studies

Quality criteria

4.5 Numerous studies have analysed changes over time. Some study the proportion of cyclists using helmets, others simply the presence or absence of a helmet law. Outcomes have included deaths among cyclists, and the proportion of head injuries among cyclists. These studies have produced conflicting conclusions. Accepted good practice is to analyse the studies that meet pre-determined quality criteria. The Cochrane Collaboration is a leading international organisation which produces and disseminates systematic reviews of healthcare interventions. These are known internationally as sources of high quality, reliable health information. Those who prepare the reviews are mostly

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17 http://www.cebm.net/index.aspx?o=1047

18 Effectiveness of Wearing Pedestrian Helmets while Walking from Home to School. Tatsuhiro Yamanaka, and Arata Ogihara. Paper presented by Yamanaka at Melbourne Injury Prevention and Control Conference, February 1996

19 http://www.oxfordradcliffe.nhs.uk/research/projects/documents/medical-statistics-online-help.pdf

healthcare professionals who volunteer to work in one of the many Cochrane Review Groups, with editorial teams overseeing the preparation and maintenance of the reviews, as well as application of the rigorous quality standards for which Cochrane Reviews have become known.[20] Ordinarily, the criteria used by a Cochrane Review are definitive of good scientific practice.

4.6 Almost all Cochrane reviews are of randomised controlled trials, but two reviews have been done on observational studies of bicycle helmets. One, by Macpherson and Spinks, reviewed time-trend studies of bicycle helmet legislation,[21] another, by Thompson, Rivara, and Thompson, reviewed case-control studies in which cyclists with head injuries were compared with cyclists who had injuries to other parts of the body.[22] It will be demonstrated that invalid studies have been used and valid ones systematically omitted.

4.7 Macpherson and Spinks would have used randomised trials if any had been available. They included "*the following study designs:*

Types of studies

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)."[23]

4.8 These criteria seemed to produce three papers which contributed to the final review of helmet effectiveness. One describes the Canadian experience, two the Californian experience. All used the percentage of cyclists with head injuries as their main outcome measure, and they analysed the presence or absence of a law, rather than any count of the percentage of helmet-wearing.

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20 http://www.cochrane.org/reviews/impact/index.htm

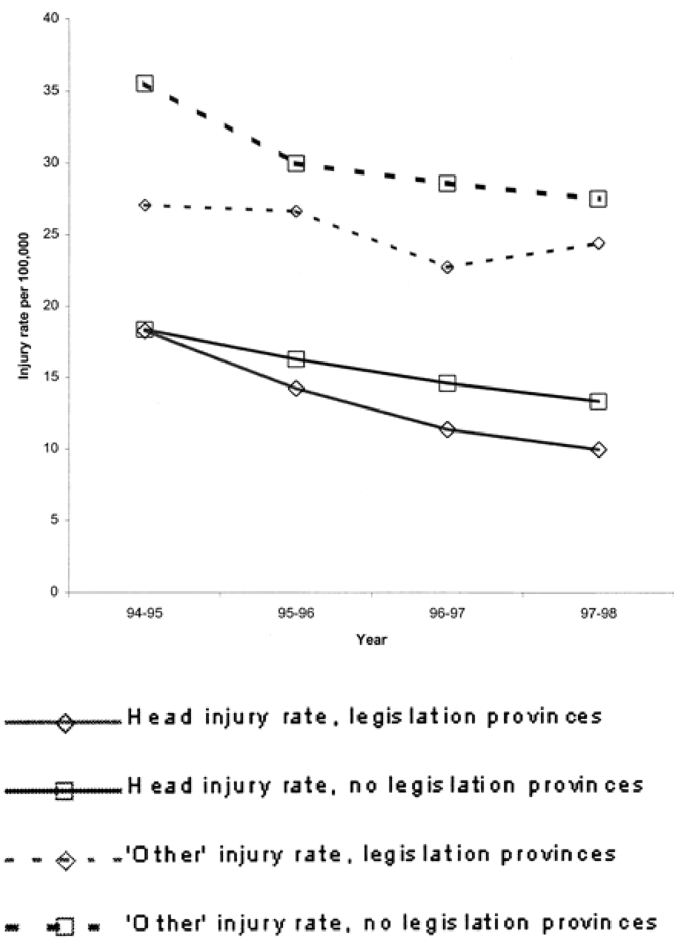
21 Macpherson A, Spinks A. Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries.*Cochrane Database of Systematic Reviews* 2008, Issue 3. Art. No.: CD005401. DOI: 10.1002/14651858.CD005401.pub3

22 Thompson DC, Rivara F, Thompson R. Helmets for preventing head and facial injuries in bicyclists. Cochrane Database of Systematic Reviews 1999, Issue 4. Art. No.: CD001855. DOI: 10.1002/14651858.CD001855

23 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

The Canadian experience

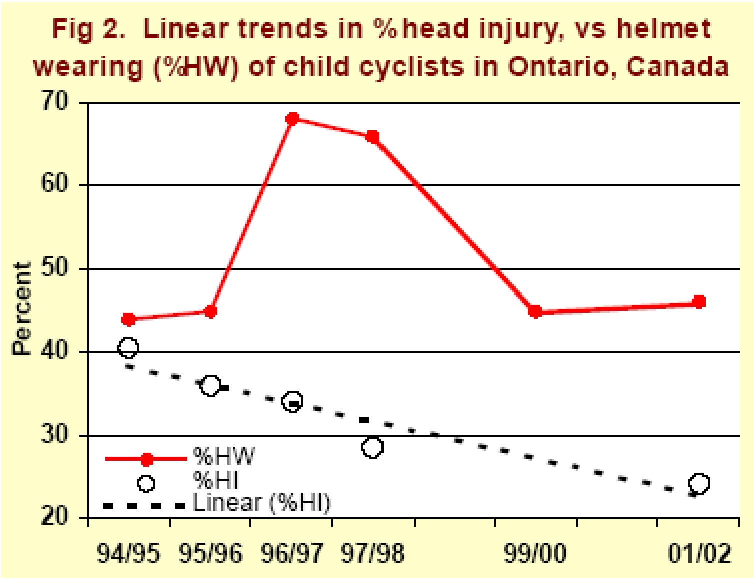
4.9 Macpherson and colleagues suggested that the proportion of head injuries went down more in provinces that had introduced helmet legislation for children.[24]



4.10 However, Macpherson and colleagues omit underlying trends and data on pedestrians, and present no information on actual helmet use. Where available, these give a very different story.

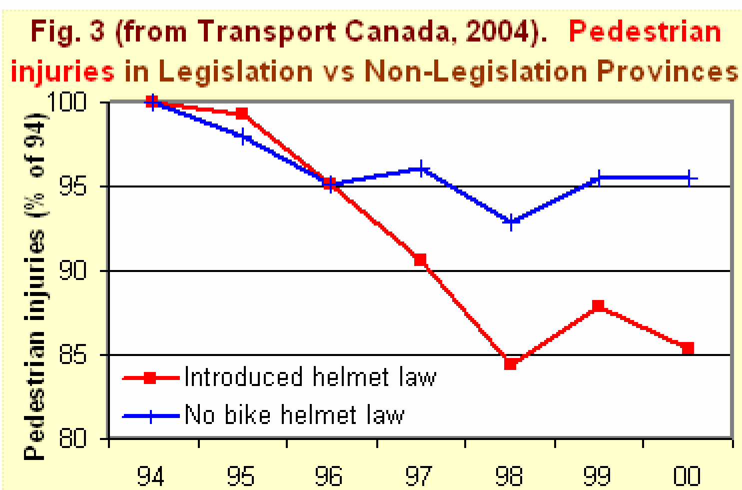
24 Macpherson AK, To TM, Macarthur C, Chipman ML, Wright JG, and Parkin PC. Impact of Mandatory Helmet Legislation on Bicycle-Related Head Injuries in Children: A Population-Based Study Pediatrics 2002; 110: e60

4.11 In Ontario, for example, the rate of helmet wearing increased for two years after the law and then returned to pre-law levels; the downward trend in percentage of head injuries continued without obvious change:



4.12 The results in British Columbia (which with Ontario makes up 89% of the population affected by the laws) were very similar.

4.13 Injury rates among pedestrians followed a very similar downward trend to cyclists:



4.14 The fuller data gives no support to the idea that helmets are responsible for any reduction in injuries. Rather, other road safety interventions approximately coinciding with the laws appear to have had measurable benefits for both pedestrians and cyclists (and presumably for other groups too).[25] The analysis by Macpherson and colleagues is clearly invalid and based on selected data.

25 Robinson DL. Confusing trends with the effect of helmet laws. http://pediatrics.aappublications.org/cgi/eletters/110/5/e60

The Californian experience

4.15 California introduced a statewide helmet law for children and youths under 18 years old from 1st January 1994. There had been a helmet law since 1987 for cycle passengers aged under 5 years.

4.16 One study by Ji et al, included in the Cochrane review, looked at cycling in the single city of San Diego, comparing the injuries suffered by those subjected to the law (under 18) and the adults who were not.[26] No data from cyclists or pedestrians in other areas was adduced, but helmet use by cyclists under 18 in San Diego increased and then fell again:

Table 1.

1992	1993	1994	1995	1996
1%	10%	25%	39%	24%

4.17 This must give rise to the suspicion that helmet wearing rates in the state as a whole are not accurately modeled by the simple introduction of a law in 1994. The authors report that this study "did not confirm that helmet legislation alone significantly reduced head injury rates". Its other failings are analyzed at http://www.cyclehelmets.org/1149.html.

4.18 A second Californian study was included in the Cochrane review. Lee and colleagues used discharge records from all public hospitals in California, from 1991 through 2000, comparing those subjected to the law (under 18) and the adults who were not.[27] They gave no statewide data on helmet use, and in order to follow their analysis it is necessary to assume that the law was effective and that this effectiveness continued for the period covered by the study. This seems unlikely in view of the figures above from San Diego. Their multinomial logit models described a reduction of 18.2% in the proportion of traumatic brain injuries among youth bicyclists after the law. On the other hand, there was no statistically significant change in the proportions of injury outcomes for adult bicyclists. The bicycle safety helmet legislation was associated with a decrease in the likelihood of traumatic brain injury for non-urban residents but not for urbanites, for males but not for females, and for Whites, Asians, and Hispanics, but not Blacks and others. Other data in the paper shows that many other aspects of cycling were changing in this period.[28] A full analysis of data over the entire period of the study reveals no correlation between the law and proportion of head injury.[29] The published data seems to have been unconsciously selected to give a specific result.

4.19 Even if the full dataset showed any relation between a helmet law and head injury, Lee et al present no information on actual helmet use; it is difficult to be certain that any changes were even associated with changes in helmet wearing, still less that they were different from changes in control populations. No data is given on the experience of pedestrians. The conclusions of Lee et al cannot carry credibility.

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26 Ji M, Gilchick RA, Bender BJ. Trends in helmet use and head injuries in San Diego County: The effect of bicycle helmet legislation. Accident Analysis & Prevention, 2006;38(1):128–134

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

28 http://www.cyclehelmets.org/1151.html

29 Personal communication from Paul Hewson to Dorothy Robinson, analysing data supplied by Brian Lee

Criteria of quality for time-trend studies

4.20 It is clear that the criteria used to select studies by Macpherson and Spinks are inadequate; they have produced invalid work. Studies should analyse:

* The actual use of helmets, not the mere presence of legislation, since helmet laws have often not been effectively enforced.[30]

* A large change in the proportion of cyclists using helmets, since the effects of small changes are likely to be small, easily confounded with other causes of changing injury experience.

* All available control groups, including pedestrians in the area affected, and cyclists in unaffected groups, since the unpredictable variations in the accident experience of road users may otherwise conceal real effects or suggest false ones. The correlation between cyclist and pedestrian fatalities in children is almost perfect in the US and the UK for 1979-2004, and pedestrians and cyclists are subject to similar risks on the roads.[31]

* All available data for at least some years before and after, since underlying trends caused by other factors may be mistaken for the effects of a specific intervention.

4.21 Lack of one of these characteristics does not in every case imply that the work must be rejected at once, but their conclusions can only be tentative and should be abandoned if better work contradicts them, or if a more thorough analysis makes clear that they were incorrect.[32]

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30 Abularrage JJ, DeLuca AJ, Abularrage CJ. 1997. Effect of education and legislation on bicycle helmet use in a multiracial population. Arch. Pediatr. Adolesc. Med.151(1):41–44

31 Riley Geary. Determining true effectiveness of safety measures. BMJ 2006;332:852 (8 April), doi:10.1136/bmj.332.7545.852. http://www.bmj.com/cgi/content/full/332/7545/852

32 Bicycle helmet legislation: Can we reach a consensus? Robinson DL. Accident Analysis & Prevention, 2007;39(1):86-93.

Time-trend studies of head injuries, analyzed by quality, by publication date:

Table 2.

Reference	Outcome is % of injuries to the head not only absolute numbers of injuries	Objective observation of helmet use, not self-reporting	Over 40% change in helmet-wearing	Comprehensive use of control groups including pedestrians	Author's conclusions about helmet effectiveness	Comments
Robinson 2006 March[33]	Yes	Yes	Yes	Yes	Not supported	This is the soundest paper and its conclusions are more robust than any other. An extraordinary omission from Macpherson and Spinks' review.
Ji et al 2006 January[34]	Yes	Yes	No	No	Not supported	No definite conclusions, no data that might lead to better answers
Hewson P 2005 June (TIP)[35]	Yes	Yes	No	Yes	Not supported	In 1995-2002 the rates of injury declined in close parallel among pedestrians and cyclists.

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33 Robinson DL. No clear evidence from countries that have enforced the wearing of helmets. *BMJ* 2006;332: 722-5. http://www.bmj.com/cgi/content/full/332/7543/722-a

34 Ji M, Gilchick RA, Bender BJ. Trends in helmet use and head injuries in San Diego County: The effect of bicycle helmet legislation. Accident Analysis & Prevention, 2006;38(1):128–134

35 Hewson PJ. Cycle helmets and road casualties in the UK. Traffic Injury Prevention 2005, 6(2): 127-134

Hewson P 2005 May (AAP)[36]	Yes	Yes	No	Yes	Not supported	Helmet wearing is different between male and female children but there are no matching trends in head injury.
Lee et al 2005[37]	Yes	No measurement of helmet use	Unlikely	Selected data only	Supported	A fuller analysis, above, makes clear that this analysis is poor and probably mistaken
Cook and Sheikh 2003 [38]	Yes	Yes	Changes were small, a few percent	Failure of detailed analysis; data set overlaps Hewson's but is smaller.	Supported	Children were reducing their use of helmets in the period analyzed, but had similar reductions in %HI to adults. [25, 26]
Macpherson et al 2002[39]	Yes	Yes	No	No	Supported	The analysis using control groups (above and in refs) does not support helmet use

36 Hewson PJ. Investigating population level trends in head injuries amongst child cyclists in the UK. Accident Analysis & Prevention 2005, 27(5): 807-815

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

38 Cook A, Sheikh A. Trends in serious head injuries among English cyclists and pedestrians. Inj Prev 2003; 9: 266-26 http://injuryprevention.bmj.com/cgi/content/full/9/3/266

39 Macpherson AK, To TM, Macarthur C, Chipman ML, Wright JG, and Parkin PC. Impact of Mandatory Helmet Legislation on Bicycle-Related Head Injuries in Children: A Population-Based Study Pediatrics 2002; 110: e60

Scuffham et al 2000[40]	Yes	Yes	Yes	Pedestrians omitted	Supported	A fuller analysis indicates that the effects of helmets have been confused with a continuing trend which also affected pedestrians, and that random fluctuations have been misinterpreted as an effect of helmets.[96]
Povey et al 1999[41]	No	Yes	Yes	No control groups used	Supported	Use of available data on time trends and control groups shows no effect of helmets.[42]
Ekman et al 1997[43]	Yes	Yes	No	Failure of detailed analysis	Supported	Reduction in non-head injuries greater for intervention area than non-head injuries, other factors likely to have been at work.[44]

40 Scuffham P, Alsop J, Cryer C, Langley JD. Head injuries to bicyclists and the New Zealand bicycle helmet law. Accident Analysis & Prevention, 2000;32,p565-573

41 Povey LJ, Frith WJ, Graham PG. Cycle helmet effectiveness in New Zealand. Accident Analysis and Prevention 1999 Nov;31(6):763-70

42 Robinson DL. Use of available control groups shows no effect of helmets. Changes in head injury with the New Zealand bicycle helmet law. Accident Analysis & Prevention, 2001 Sep;33(5):687-91

43 Ekman R, Schelp L, Welander G, Svanstrom L. Can a combination of local, regional and national information substantially increase bicycle-helmet wearing and reduce injuries? Experiences from Sweden. Accident Analysis and Prevention, 1997 May;29(3):321-8

44 http://www.cyclehelmets.org/papers/c2010.pdf

Robinson 1996[45]	Yes	Yes	Yes	Yes	Not supported	Another important paper bizarrely omitted by Macpherson and Spinks, on the counterfactual grounds that no control group was used.
Carr et al 1995[46]	Numbers only, not percentages of head injury	Yes	Yes	Not used	Supported	Percentage of head injuries fell by more among pedestrians than among cyclists.[47]
Rivara et al 1994 [48]	No	Yes	No	No control groups used	Supported	No control groups, reduction in head injuries higher than increase in helmets, other factors likely to have been responsible.
Pitt et al 1994[49]	Yes in cyclists only	Yes	No	Yes - all head injuries	Supported	Proportion of head injury not reported for any control group.

45 Robinson DL. Head injuries and bicycle helmet laws. Accident Analysis & Prevention. Volume 28, Issue 4, July 1996, Pages 463-475

46 Carr D, Dyte D, Cameron M. Evaluation of the Bicycle Helmet Wearing Law in Victoria during its First Four Years. Monash University Accident Research Centre Report 76, 1995

47 http://www.cyclehelmets.org/1093.html

48 Rivara FP, Thompson DC, Thompson RS, Rogers LW, Alexander B, et al. The Seattle children’s bicycle helmet campaign: changes in helmet use and head injury admissions. Pediatrics 1994 93(4):567–69

49 Pitt WR, Thomas, Nixon J, Clark R, Battistutta D, and Acton C. Trends in head injuries among child bicyclists. BMJ Jan 1994; 308: 177. http://www.bmj.com/cgi/content/full/308/6922/177

Vulcan et al 1992 [50]	No	Yes	No	No	Supported	The helmet law coincided with other road safety improvements which are more likely to have caused the reduction in head injuries.

4.21 4.21 The soundest study to date is that of Robinson (2006), supported by Robinson (1996).[51] Robinson reviewed the experience of cyclists and control groups in jurisdictions where helmet use increased by 40% or more following compulsion. She concluded that "enforced helmet laws discourage cycling but produce no obvious response in percentage of head injuries". This remains the most defensible scientific position. Publications by other authors omit critical aspects of appropriate methodology, and many have come to indefensible conclusions as a result.

4.22 4.22 Robinson's findings are further supported by the two papers by Hewson. Although the changes in helmet-wearing rates considered by Hewson are smaller than those considered by Robinson's papers, and his first paper is based on data for overall cyclist injuries rather than head injuries specifically, both papers have the benefit of comparing cyclist and pedestrian injury trends, and his second paper (which looks specifically at child cyclists) also compares trends for boys and girls. His papers find no association between changes in helmet wearing rates and cyclists' safety for the populations considered. Whilst this does not rule out the possibility that helmets may provide some benefits for some subgroups within the cycling population, Hewson concludes that there is no evidence to support the claims for helmets which typically arise from small-population case-control studies.

4.23 None of this comment should suggest that earlier authors were wrong to write, or editors to publish, studies that could be described as "quick and dirty". There is a role for such studies to give quick, albeit imperfect, evidence on new projects. However, now that so many of them are known to have serious flaws, repeated biased studies can best be described as pseudo-science. Macpherson and Spinks have excused their omission of Robinson (2006) on the extraordinary grounds that Robinson's work was "*a commentary not a study*"[52] and of Robinson (1996) on the counterfactual basis that no control group was used. There is no excuse for supposedly "systematic" reviews which selectively omit evidence - the best available - that disagrees with their conclusion.

50 Vulcan AP, Cameron MH, Watson WL. Mandatory bicycle helmet use: Experience in Victoria, Australia. World Journal of Surgery 1992, 16: 389-397

51 Robinson DL. No clear evidence from countries that have enforced the wearing of helmets. *BMJ* 2006;332: 722-5. http://www.bmj.com/cgi/content/full/332/7543/722-a

52 Response to author's comment on their Cochrane review

Deaths: time trend studies

4.24 The largest of all the time-trend studies, analysing US cyclist fatalities up to the late 1980s, found a positive correlation of deaths with helmet use.[53] In the UK, cyclist deaths sharply increased in the years when helmets first became popular, despite steady declining trends for pedestrians.[54] Death rates in Canada for pedestrians and cyclists have declined in close parallel for the last thirty years, showing no obvious effect of helmet use.[55] On the other hand, Wesson et al. concluded that child deaths in Ontario were lower after a bicycle helmet law was passed.[56]

4.25 Macpherson et al report data on child cycle use in the suburb of East York, Toronto, Ontario, Canada before and after the introduction of a cycle helmet law for children.[57] The law came into force in October 1995. The authors stated that in the following years, there was no enduring fall in child cycle use, as had been seen in other countries that introduced such a law. The authors thus concluded that attitudes to cycle helmets must have changed, and that legislation could be introduced without compromising public health by discouraging people from cycling. Their conclusion is misleading and further, the authors should have been well aware that they were presenting their results in a misleading way. Between 1990 and 2000, they monitored child cyclist numbers and helmet wearing according to socio-economic area. They accumulated a valuable dataset, showing that helmet use by children is strongly influenced by socio-economic status. Children of wealthy parents were about twice as likely to wear helmets as compared with those from modest backgrounds.

4.26 Although helmet use did increase due to promotion during the period of study, the 1995 law itself was never enforced. The Toronto Metropolitan Police confirmed to the authors that no child cyclist was ever fined for riding without a helmet. There was thus a temporary increase in helmet wearing as the law came into force, especially amongst children from lower socio-economic groups. This rise faded after about three years, by which time helmet use returned to pre-law levels. The authors should have known from their own data that the effect of legislation was strictly temporary, a fact which is obvious even to casual local observers.[58] Despite this, they did not mention anywhere in their published research that the law was not enforced and helmet use soon returned to pre-law levels. Their analysis assumes that it had a lasting effect. Wesson et al cited Macpherson's work, described above, which presented data showing that helmet use returned to pre-law levels. Thus they should have known that the drop in child cyclist deaths was not in fact associated with helmet use. The authors quote Macpherson's results selectively. Consider this statement, from the paper:
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4.27 *"In the same urban community, helmet use increased from 3.4% in 1990 to 45% in 1995 before legislation, exceeded 65% in the 2 years after the introduction of legislation, and reached 85% in high-income areas 6 years after the introduction of legislation."* The statement is seriously misleading and is fundamental to the analysis. Children of high-income parents are a minority in the population. Their habits are not significant relative to the majority of children drawn from middle and low income families. For the whole population of children, as mentioned above helmet use fell back to pre-law levels - therefore the authors' central reported conclusion that the helmet law led to a reduction in deaths is invalid. The BMA, for example, seem to have assumed that the authors had reported upon enforced legislation. The authors did nothing to correct this misinterpretation even after it was pointed

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53 Rodgers GB. Reducing Bicycle Accidents: A Reevaluation of the Impacts of the CPSC Bicycle Standard and Helmet Use. Journal of Products Liability, 1988,11:307-317

54 Wardlaw MJ. Three lessons for a better cycling future.

55 The Vehicular Cyclist. Cyclist Fatality Trends in Canada. http://www.vehicularcyclist.com/fatals.html

56 Wesson DE, Stephens D, Lam K, Parsons D, Spence L, and Parkin PC. Trends in Pediatric and Adult Bicycling Deaths Before and After Passage of a Bicycle Helmet Law. Pediatrics 2008 122 605-610. doi:10.1542/peds.2007-1776

57 Macpherson A., Parkin P., To T., Mandatory helmet legislation and Children's exposure to cycling. *Injury Prevention* 2001;7:228-30. http://injuryprevention.bmj.com/cgi/reprint/7/3/228

58 Enforce law on kids wearing bike helmets. Sudbury Star Article ID# 1144968 from the Chatham Daily News http://www.thesudburystar.com/ArticleDisplay.aspx?e=1144968&&#postbox

out them in a written response to Injury Prevention.[59] The actual reason for the reported fall in child cyclist deaths was probably reduced exposure and better street management, which benefited child pedestrians just as much.[60]

4.28 None of these studies meet the relevant quality criteria above. Fortunately, the number of cyclist deaths is small; large random fluctuations are therefore inevitable. These studies do not give a definite indication in one direction. For detailed analysis and full references, the BHRF has analyzed most of the available literature on this subject.[61]

Deaths: other population comparisons

4.29 A final group of two population-level studies has used comparisons between the proportion of cyclists observed to wear helmets on the roads, and the (lower) proportion of cyclist fatalities recorded as wearing helmets in routine police records.[62] [63] The figures for dead cyclists are based on the U.S. Department of Transportation's Fatality Analysis Reporting System (FARS). The forms used by FARS do not in general have a convenient box for recording helmet use, which if done at all is done in free text. Thus data entry does not record helmet use accurately after fatalities, and many deaths where helmets were in fact worn will be recorded as "helmet not used".[64] [65] As a result these studies cannot provide any useful evidence. They are nevertheless widely quoted; they appear, for example, to be the main support for New York State's assertion that "Bike helmets save lives!"[66]

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59 http://injuryprevention.bmj.com/cgi/eletters/12/4/231#1600

60 Wardlaw MJ Cycle helmets: an Ineffective and Unnecessary Intervention. http://pediatrics.aappublications.org/cgi/eletters/122/3/605#39245

61 What evidence is there that cycle helmets save lives? http://www.cyclehelmets.org/1012.html

62 Bicyclist Fatalities and Serious Injuries in New York City 1996-2005. A Joint Report from the New York City Departments of Health and Mental Hygiene, Parks and Recreation, Transportation, and the New York City Police Department, undated. http://www.nyc.gov/html/doh/downloads/pdf/episrv/episrv-bike-report.pdf

63 Insurance Institute for Highway Safety. Fatality Facts 2007 Bicycles http://www.iihs.org/research/fatality_facts_2007/bicycles.html

64 Geary R, Faulty FARS bicycle helmet use data & implications for effectiveness. http://injuryprevention.bmj.com/cgi/eletters/12/3/148

65 http://www.cyclehelmets.org/1174.html

66 New York State department of health. Bike Helmets Save Lives! & it's the Law! Undated, http://www.health.state.ny.us/publications/3128/

Case-control studies

4.30 Most studies in this category are over ten years old, some nearly twenty years old. They are still widely quoted; this paper gives only a brief outline, concentrating on recent comment. A convenient list is given by the Cochrane review by Thompson, Rivara, and Thompson. Helmets for preventing head and facial injuries in bicyclists.[67] Similar comments apply to later case-control studies.

4.31 Case-control studies asked cyclists who had attended hospital after an accident whether they had been wearing a helmet. All find that cyclists with non-head injury are more likely to report wearing a helmet than are cyclists with a head injury. They have been reported (as a result of conceptual error) as showing that helmets prevent 88% of head injuries.[68] This figure is still widely used.

4.32 Before considering potential flaws in the case-control study methodology, it is worth looking at some data from the most widely quoted case-control study and some parallel evidence from the same area gathered at the same time, in Seattle in the late 1980s.

Table 2.

Helmet wearing objectively recorded on street survey[69]	Helmet use reported by head-injured cyclists[70]	Helmet use reported by cyclists with non-head injuries[71]
6% Rates counted by third parties should be accurate	7% A cyclist with an injured head is unlikely to claim they were wearing a helmet if in fact they were not	23% Cyclists with an injury to other parts of the body are free to claim they were wearing a helmet even if they were not

4.33 The case-control study notes that there was a much higher rate of helmet-wearing among cyclists who suffered non-head injuries than head injuries. Like other case-control studies it assumes that the helmet-wearing and non-wearing cyclists were alike in all other respects, and that the helmet was the one difference that might explain the difference in the likelihood of head injury between the two groups. It is also worth noting at this stage that the objectively observed helmet-wearing rate is close to that reported by the cyclists who suffered head injuries, but much lower than that reported by those who suffered non-head injuries. This in turn suggests several possible sources of bias, all of which are inherent in the use of the case-control methodology to assess the effectiveness of helmets:

- Firstly, asking people to self-report whether they were wearing a helmet may be unreliable, with those who have not suffered a head injury having less motivation to reply accurately and a greater motivation instead to give the answer which they think will please the researcher. This

67 Thompson DC, Rivara F, Thompson R. Helmets for preventing head and facial injuries in bicyclists. Cochrane Database of Systematic Reviews 1999, Issue 4. Art. No.: CD001855. DOI: 10.1002/14651858.CD001855

68 http://www.cyclehelmets.org/papers/c2010.pdf

69 DiGuiseppi CG, Rivara FP, Koepsell TD. Bicycle helmet use by children. Evaluation of a community-wide helmet campaign. JAMA 1989;262:2256-61

70 A case-control study of the effectiveness of bicycle safety helmets. Thompson, Rivara & Thompson. New England Journal of Medicine 1989, Vol 320 No 21 p1361-7

71 A case-control study of the effectiveness of bicycle safety helmets. Thompson, Rivara & Thompson. New England Journal of Medicine 1989, Vol 320 No 21 p1361-7

mechanism could result in helmets appearing effective when in fact they are not.

- Secondly, the people who choose to wear helmets may be different from those who do not. In particular the former may be more prone to suffer simple falls (which are typically relatively minor injuries to body-parts other than the head), and/or to seek health care in the event of a fall. This again would result in case-control studies showing that helmets are effective when they are not.

- Thirdly, there are a number of ways in which the wearing of a helmet may increase the risk of having an accident in the first place, thus undermining any benefits a helmet might provide in the event. This could result in case-control studies that accurately found protection from helmets among those who crash, but incorrectly predicted benefit from mass use of helmets.

The following sections consider each of these possible sources of bias.

Ascertainment bias due to self-reporting: trying to please

4.34 All the case-control studies listed in the Cochrane review depended on cyclists reporting their own helmet use. In the case of the Seattle study cited in the table above, the study organisers observed helmet use on the streets but neither they nor other case-control researchers seem to have checked systematically and objectively whether a helmet was present at the site of the crash, or was worn at the time of the accident.[72] In this interpretation, helmets would have no significant effect, as the epidemiological evidence suggests. The directly observed figures would be reasonably accurate, as would those for cyclists with a head injury. These will find it difficult to persuade themselves, or anyone else, that they were wearing a helmet if in fact they were not. But those with other injuries would be free to improve on the truth to placate their interviewers, and some of them may well have done so. This would be a good example of ascertainment bias, a well-known problem in this type of study.[73]

4.35 There is other evidence which suggests that cyclists are prone to claim that they wear helmets when this is not the case. In one study that compared observations of helmet use to a statewide telephone survey, the survey overestimated helmet use by 15 to 20 percentage points.[74] In another paper, children were asked on two separate occasions whether they had been wearing protective equipment at the time of their accident; the percentage reporting use was 13% different between the two questionnaires, consistent with the possibility that individuals may "improve" their answers still more in face-to-face interviews.[75] (*"Initial information obtained from the CHIRPP form revealed that 325 children used (protective equipment). However, at the* [telephone] *interview, only 234 claimed to have done so..."* Clearly, where there is pressure to wear bicycle helmets, a significant minority of people may say they wear a helmet when in fact they do not.

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72 Thompson D, Thompson RS. Re: Objective observation of helmet use is essential. BMJ Rapid Responses 8th July 2006. http://www.bmj.com/cgi/eletters/332/7543/722-a#137351

73 K Sutton-Tyrrell. Assessing bias in case-control studies. Proper selection of cases and controls. Stroke 1991;22;938-942. http://stroke.ahajournals.org/cgi/reprint/22/7/938.pdf

74 Rivara FP, Thompson DC, Patterson MQ, Thompson RS, Prevention of bicycle-related injuries: Helmets, Education, and Legislation, Annu Rev Public Health, 1998. 19:293-318

75 Pless BI, Magdalinos H, Hagel B. Risk-Compensation Behavior in Children Myth or Reality? Arch Pediatr Adolesc Med. 2006;160:610-614. http://archpedi.ama-assn.org/cgi/content/full/160/6/610

Social and behavioural differences between wearers and non-wearers of helmets

4.36 Helmet wearing has been associated with markers of higher socio-economic status in several studies.[76] These are likely to be markers in turn for different attitudes to risk and to seeking health care. Such confounding is very difficult to correct for; it is likely to have caused, for example, the finding from one case-control study that helmets provide a large measure of protection from arm and leg injuries.[77]

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76 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 Vol. 112 No. 3 September 2003, pp. e192-e196

77 Spaite DW, Murphy M, Criss EA, Valenzuela TD, Meislin HW. A prospective analysis of injury severity among helmeted and non helmeted bicyclists involved in collisions with motor vehicles. Journal of Trauma, 1991 Nov;31(11):1510-6

Ways in which helmet-wearing may increase the risk of head injury

4.37 All the criticisms that have been leveled at the original case-control comparison apply also to the comparison with street cyclists. But it seems that crashed cyclists without head injuries report a high rate of helmet-wearing. The observed rate among cyclists on the roads is lower, as is the rate reported by cyclists with a head injury. There are several possible interpretations of this pattern. One is that the reported rates are accurate, and helmets are effective in averting head injuries. By the same logic, helmets also seem to cause crashes in the first place. This is not entirely implausible; apart from the obvious risks of a weight high up, they might cause the rider, or other road users, to change their behavior very slightly.[78] On this interpretation, wearing a helmet would increase the risk of an accident, but would give partial protection against the results.

Risk compensation

4.38 "Risk compensation" describes the tendency of people to act less cautiously if they feel better-protected, or conversely to act more cautiously if they perceive greater threat. is a mechanism which could allow accurate case-control studies to give inaccurate predictions of protection for whole populations. In this case, it would include a tendency to take more risks when wearing gear such as a helmet than without. This is well-described in children.[79] and the phenomenon has also been self-reported by cyclists, particularly teenagers.[80] [81] There is no information available about the extent of this behavioural response, nor the degree to which it may influence the safety of helmet-wearing cyclists, but there is reasonable evidence that it occurs, and it is a bias that would cause case-control studies to give false predictions about the benefits of mass helmet use. (A paper denying the phenomenon of risk compensation has severe errors.[82] An account of these is available from the BHRF.[57])

4.39 However it is not only cyclists who may engage in risk compensation – drivers might also do so. One small study found that drivers gave less road space when overtaking a helmeted cyclist than an unhelmeted one.[83]

Rotational injury

4.40 Helmets are tested against direct impact without a significant rotational component. In almost any real accident to the head, a significant rotational component will be present.[84] [85] '*"In mechanical terms,*

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78 Walker I. Drivers overtaking bicyclists: objective data on the effects of riding position, helmet use and apparent gender. Accident Analysis and Prevention. Volume 39, issue 2, March 2007, 417-425. Summary at http://www.drianwalker.com/overtaking/overtakingprobrief.pdf

79 Morrongiello BA, Walpole B, Lasenby J. Accident Analysis & Prevention, 2007 May;39(3):618-23. Understanding children's injury-risk behavior: Wearing safety gear can lead to increased risk taking

80 Taylor S, Halliday M. Cycle helmet wearing in Britain. Report 156, TRL, 1996

81 Halliday M et al. Attitudes to cycle helmets – a qualitative study. TRL 1996 Report 154

82 Pless BI, Magdalinos H, Hagel B. Risk-Compensation Behavior in Children Myth or Reality? Arch Pediatr Adolesc Med. 2006;160:610-614. http://archpedi.ama-assn.org/cgi/content/full/160/6/610

83 Walker I. Drivers overtaking bicyclists: objective data on the effects of riding position, helmet use and apparent gender. Accident Analysis and Prevention. Volume 39, issue 2, March 2007, 417-425. Summary at http://www.drianwalker.com/overtaking/overtakingprobrief.pdf

84 Curnow WJ. The efficacy of bicycle helmets against brain injury. Accident Analysis & Prevention, 2003,35:287-292

85 Albert I. King, King H. Yang, Liying Zhang, Warren Hardy, David C. Viano. Is head injury caused by linear or angular acceleration? IRCOBI Conference – Lisbon (Portugal), September 2003. http://www.smf.org/articles/hic/King_IRCOBI_2003.pdf

the head is an elliptical spheroid with a single universal joint, the neck. It is therefore almost impossible to hit it without causing it to rotate. The head tries to dampen these forces using a combination of built-in defenses: the scalp, the hard skull and the cerebrospinal fluid beneath it. During an impact, the scalp acts as rotational shock absorber by both compressing and sliding over the skull. This absorbs energy from the impact.''[86] Most helmets provide no protection against rotational injury and may make it worse.[87] If helmets reduce scalp injuries, they may do so only by transferring rotational damage to the contents of the skull. Such injuries may be less spectacular at the time, but the long-term effects may be worse.[88]

4.41 In the context of case-control studies, if helmets give protection to the scalp but not the brain, unhelmeted cyclists with head injuries would be systematically overcounted and some of the positive results explained. This mechanism remains an interesting possibility.[89]

Conclusions from case-control studies

4.42 Serious confounding is well documented in case-control studies of bicycle helmets. They are also based on invalid and potentially-biased ascertainment of the facts on which they depend. Either of these factors alone could account for all of their positive results. Other reasons why they may be mistaken have been described. They do not agree with the good-quality time-trend studies, which are based on objective observation of helmet use. These weaknesses are severe enough to disqualify them from use as robust evidence; reviews based on them also cannot carry weight.

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86 Duncan Graham-Rowe. Soft hat. New Scientist. 13 February 2001. http://www.newscientist.com/article/dn418-soft-hat.html

87 Corner JP, Whitney CW, O'Rourke N, Morgan DE. CR 55: Motorcycle and bicycle protective helmets requirements resulting from a post crash study and experimental research. DEPARTMENT OF TRANSPORT, FEDERAL OFFICE OF ROAD SAFETY. Report No. CR 55. Date May, 1987. ISBN 0 642 510 431 ISSN CR = 0810-770. http://www.atsb.gov.au/publications/1987/Mcycle_Helm_1.aspx

88 Curnow WJ. The Cochrane Collaboration and bicycle helmets. Accid Analy Prev May 2005; 37(3):569-573

89 http://www.cyclehelmets.org/1039.html.

5. Engineering evidence

In laboratory tests

5.1 Standards call for helmets to reduce peak acceleration of instrumented metal headforms in carefully-controlled situations.[90] [91] [92] There is no good data on how these standards relate to heads made of flesh and blood in real accidents.

In real or simulated accidents

5.2 It has been known for decades that helmet liners may be too stiff to be effective. Most standards require the use of headforms heavier and more rigid than the human head; these are more capable of crushing foam than is the human head.[93] The Australian office of road safety made an extensive study of helmets from real accidents in which *'"very little crushing of the liner foam was usually evident... What in fact happens in a real crash impact is that the human head deforms elastically on impact. The standard impact attenuation test making use of a solid headform does not consider the effect of human head deformation with the result that all acceleration attenuation occurs in compression of the liner. Since the solid headform is more capable of crushing helmet padding, manufacturers have had to provide relatively stiff foam in the helmet so that it would pass the impact attenuation test.'"*[94] The senior engineer of Bell Helmets has made similar observations: *''I collected damaged infant/toddler helmets for several months in 1995. Not only did I not see bottomed out helmets, I didn't see any helmet showing signs of crushing on the inside."*[95]

6. Anecdotal evidence

6.1 This is worth mentioning only because of its large volume. It is produced by doctors who treat injured cyclists, and overwhelmingly by cyclists who may or may not have had an accident, and may or may not have hit their heads or destroyed their helmets. One non-sequitur may serve as an example of them all. Daniel Cline was cycling without a helmet when he was hit by a car door and fell off, severely injuring his shoulder. His head was fine. He has learned his lesson and now wears a helmet whenever he rides.[96] It is inappropriate that professional organisations such as the British Medical Association are

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90 Mills NJ, Gilchrist A. Finite-element analysis of bicycle helmet oblique impacts. Int Journal of Impact Engineering, 2008;35(9):1087-1101

91 Mills NJ, Gilchrist A. Oblique impact testing of bicycle helmets. Int Journal of Impact Engineering, 2008;35(9):1075-1086

92 BS EN 1078:1997. Helmets for pedal cyclists and for users of skateboards and roller skates. 15 June 1997

93 Jim G Sundahl, Senior Engineer, Bell Sports. 19th January 1998. Letter to the U. S. Consumer Product Safety Commission, c/o Scott Heh, Project Manager, Directorate for Engineering Sciences, Washington, D. C, 20207. http://www.cpsc.gov/LIBRARY/FOIA/FOIA98/PUBCOM/34C7A89B.PDF, accessed 18th February 2008

94 Corner JP, Whitney CW, O'Rourke N, Morgan DE. CR 55: Motorcycle and bicycle protective helmets requirements resulting from a post crash study and experimental research. DEPARTMENT OF TRANSPORT, FEDERAL OFFICE OF ROAD SAFETY. Report No. CR 55. Date May, 1987. ISBN 0 642 510 431 ISSN CR = 0810-770 http://www.atsb.gov.au/publications/1987/Mcycle_Helm_1.aspx

95 Jim G Sundahl, Senior Engineer, Bell Sports. 19th January 1998. Letter to the U. S. Consumer Product Safety Commission, c/o Scott Heh, Project Manager, Directorate for Engineering Sciences, Washington, D. C, 20207. http://www.cpsc.gov/LIBRARY/FOIA/FOIA98/PUBCOM/34C7A89B.PDF, accessed 18th February 2008

96 Daniel Cline. Commuting in Denmark. The Mailbag - Brain buckets, confessions and bike fit. Jan. 9, 2009. http://www.velonews.com/article/86451/the-mailbag---brain-buckets-confessions-and-bike-fit. I would recommend that he keeps clear of the door zone in future.

using stories of this sort.[97] The issue is examined further in "A helmet saved my life!".[98]

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97 http://www.bma.org.uk/wa/health_promotion_ethics/transport/promotingsafecycling.jsp?page=7

98 http://www.cyclehelmets.org/1019.html

7. Testing the hypothesis that helmets and their promotion cause harm

Discouraging cycling

7.1 By analogy with the criteria for time-trend studies above, we should look for good-quality studies that describe the amount of cycling in relation to measurements of helmet use, in relation to figures from neighboring areas with different experiences of the use of helmets, and for significant periods before and after major changes in helmet use. There is a large amount of methodologically-modest data (most of which supports the idea that helmets reduce cycling)[99] [100] The best work is again by Robinson, based on Australian census data on cycling to work.[101] It suggests that helmets do indeed have a serious effect in discouraging cycling.

Reducing safety for those cyclists who remain

7.2 The discouragement of cycling may also have a secondary effect on the safety of cyclists who remain. There is substantial evidence that cycling gets safer the more cyclists there are – the "safety in numbers" effect.[102] [103] [104] Conversely, reducing cycle use erodes those "safety in numbers" benefits. This is another factor, in addition to those identified in section 4, which may explain the discrepancy between the best available population level evidence and the majority of case-control studies.

Hanged children

7.3 There are a few documented cases of young children, playing on bunk-beds, trees, jungle gyms, and so on, suffering death or severe brain damage as a result of strangulation by the straps of their bicycle helmets.[105] [106] [107] [108] [109] One Swedish researcher commented of the Swedish Helmet Initiative: *"We knew we'd killed, but didn't know we had saved anybody".*[110] The numbers are fortunately small

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99 http://www.cyclehelmets.org/1020.htm

100 http://www.cycle-helmets.com

101 Robinson DL. No clear evidence from countries that have enforced the wearing of helmets. *BMJ* 2006;332: 722-5. http://www.bmj.com/cgi/content/full/332/7543/722-a

102 Leden L, Gårdner P, Pulkkinen U. An expert judgment mode applied to estimating the safety effect of a bicycle facility. Acc Anal Prev 2000;32:589–99

103 Wardlaw M. Assessing the actual risks faced by cyclists. Traffic Engineering and Control 43;9 (2002) 352-256

104 Jacobsen P. Safety in numbers: more walkers and bicyclists, safer walking and bicycling. Injury Prevention 9 (2003) 205-209

105 U. S. Consumer Product Safety Commission. http://www.cpsc.gov/cpscpub/pubs/5121.html Wear Bike Helmets On Bicycles - Not On Playgrounds. CPSC Document #5121

106 Valerie Zehl. After son's accident, family learns to find joy. Press and Sun-Bulletin, Greater Binghamton, New York. January 28, 2008. http://nl.newsbank.com and search for "eddie holewa".

107 Child deaths from helmet use. http://www.vehicularcyclist.com/kids.html

108 ABC News (Australia). Ambulance staff cleared over toddler's death. 2004-05-07. http://www.abc.net.au/news/stories/2004/05/07/1103511.htm accessed 2008-05-01

109 http://www.news.com.au/adelaidenow/story/0,22606,21510562-5006301,00.htm Helmet strangles boy, 3. Sam Riches, Police Reporter. The Advertiser, Adelaide, South Australia. April 05, 2007

110 Nigel Perry, 1996. Notes on the 3rd International Conference on Injury Prevention and Control. http://members.tip.net.au/~psvansch/crag/3icipc.htm

but there can be little doubt about causality. There are likely to be more cases than those we have identified; no medical coding system makes it easy to identify cases of "strangulation by cycle helmet". Most of these reports are from local media, and collected by Google searches for English-language phrases. Helmet promotion may encourage parents to put young children at risk of death by hanging.[111]

111 http://www.hallieandtravis.com/?p=2477

8. Conclusion; ineffectiveness and confirmation bias

8.1 In our considered opinion, effectiveness of bicycle helmets has not been demonstrated. The best-quality evidence shows no effectiveness of helmets. The remainder, a large quantity, has serious flaws, not minor imperfections but multiple errors, each one of which could invalidate an entire corpus of work. Most reviews have concentrated on the case-control studies, which we find to have fatal flaws.[112] [113] [114] The main review that purported to analyze the remaining literature omitted on bizarre and counter-factual grounds the evidence which contradicted its thesis.[115] This is very poor science at best. At its worst it is pseudoscience, in which inconvenient facts are ignored and support seized from invalid reports. The credibility of the Cochrane Collaboration is reduced by the state of its reviews on the subject of bicycle helmets.

8.2 The continued promotion of helmets by people who should know better can be attributed to confirmation bias, in which the obvious first guess is never subjected to testing. As the National Children's Bureau has said, *"The 2004 BMA statement announcing its decision to support compulsory cycle helmets shows how the uncritical use of accident statistics can lead to poor conclusions."*[116] The BMA's website still promotes cycle helmets.[117]

8.3 Good quality evidence does not show that helmets offer any advantage. They have many disadvantages, most notably helping to mislead the public to believe that a safe (by everyday standards) and extremely healthy form of travel is dangerous. Arguing about them is a distraction from the task of improving cycling. They should form no part of public policy.

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112 Towner, Dowswell, Burkes, Dickinson & Hayes. Road Safety Research Report No 30. Bicycle Helmets - A review of their effectiveness: A critical review of the literature. Department for Transport, London, November 2002

113 Attewell RG, Glase K, McFadden M. Bicycle helmet efficacy: a meta-analysis. Acc Anal Prev 2001 v33 n3 p345-52. http://www.infrastructure.gov.au/roads/safety/publications/2000/Bic_Crash_5.aspx

114 Thompson DC, Rivara F, Thompson R. Helmets for preventing head and facial injuries in bicyclists. Cochrane Database of Systematic Reviews 1999, Issue 4. Art. No.: CD001855. DOI: 10.1002/14651858.CD001855

115 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

116 Cycling and Children and Young People. A review. Tim Gill. Published by the National Children’s Bureau. Registered Charity Number 258825. 8 Wakley Street, London EC1V 7QE. Tel: 020 7843 6000 © National Children’s Bureau, December 2005. ISBN 1-904787-62-2 http://www.cycle-helmets.com/cyclingreport_timgill.pdf

117 http://www.bma.org.uk/wa/health_promotion_ethics/transport/promotingsafecycling.jsp?page=7