7.4 Cycle helmet evidence

7.4.1 Injury prevention

A significant body of literature is available on cycle helmet effectiveness. This has been reviewed from time to time[18 19] and these reviews have been subject to criticism.[20 21 22] In December 2009, the Department for Transport issued a further review of cycle helmet effectiveness[23.] Its principal scientific conclusion was that "it was not possible to quantify the amount of benefit offered by modern cycle helmets in the UK from the literature review alone". However, the summary still claimed life-saving benefit from helmets – but close reading reveals this is based merely on the opinion of the authors, not on the basis of the scientific evidence.[24] As a result, the report has drawn heavy criticism.

The published literature falls into two main types of study: case-control studies and population-level time-trends analyses. Case-control studies report high levels of protection from wearing a cycle helmet, up to 88% protection from brain injury. Some population level studies have reported injury reductions from helmets, but in every case the effect was actually due to secular falling trends across all road users. Population-level studies that account for secular trends show no noticeable prevention of serious head injuries, either in traffic collisions or falls in the highway. The case-control studies were conducted while helmet use was still at a low level (3-10%), whereas the population-level studies had to wait until there were high levels of helmet use. The debate thus opened in the mid to late 1980s with apparently strong reasons to promote helmets and make them a legal requirement. The later population level studies have attracted less notice, and have been ignored by official reviews. For instance, the 2002 UK government review,[19] the Cochrane Review[18] and a recent review by NICE[25] all omit mention of population-level studies. The latest (2009) DfT helmet review did consider population level studies, but denied their relevance to judging helmet effectiveness. An explanation is required for the disparity between case-control studies and population-level studies.

In case control studies, people with a particular outcome (such as head injury when cycling, the 'cases') are compared with 'controls' (such as, non-head injuries when cycling). The 'cases' and 'controls' are asked about previous 'exposure' (i.e. whether or not they were wearing a helmet at the time of injury). Case control studies are very useful for generating theories but are less good at confirming cause and effect, both because of difficulties with time sequences and recall bias and also because of confounding: there may be systematic differences between the cases and the controls that affects both the outcome (head injury) and the exposure (wearing a helmet).

The case-control studies were conducted on a 'best endeavours' basis, but nonetheless can aptly be criticised for serious flaws. For instance, it is now known, from directly observed helmet surveys, that social class has a strong influence on helmet use by children.[26] Recent experience has taught the perils of relying on case-control studies when personal choice is involved[27] because of confounding.

The largest case-control study ever conducted[28] gathered data on cyclists' injuries in Seattle during a 2.5 year period from 1992. There were c.3,900 cyclists treated in Emergency Rooms, with adequate data being captured for c.3,400 cases. However, only c.300 (9.4%) required admission. The low number of serious injuries, despite the prolonged data gathering period, underlines that cycling is not in fact a significant cause of serious injury even in a city of (at the time) 2.5 million. The study's conclusions regarding prevention of serious injuries thus rest upon a fairly small dataset. The results show a mysterious pattern, as displayed in Table 7-8 below.

The data show that, apparently, the protective effect of a helmet increases with increasing severity of injury. It is extremely difficult to accept such a result, and indeed, it is the opposite of what is seen in population level studies, which return the more sensible outcome of declining protection with increasing severity of injury. It must be the case that confounding factors systematically caused non-helmeted cyclists to be in more severe crashes. This is in fact explicit in the data presented in the most widely cited of the Cochrane Review papers.[29] Those with head injuries (the cases) had a greater proportion of bicycles damaged beyond repair than the non head-injured (the controls), 9% versus 5% (or <1% in the second control group); a much greater proportion had been in crashes with motor vehicles, 23% versus 13% or (4% in the second control group); as well as the lower rate of helmet use, 7% versus 24% in both other control groups. The cases had a higher proportion of those of limited educational completion (17% versus 12%) and in the lowest household income group (19% versus 16%, or 6% in the second control group). These results are consistent with helmet use being associated with less violent crashes and non-helmet use being associated with low incomes.

Table 7-8. Case-control study of helmet use and injury in Seattle

Outcome	No. with helmet	No. without helmet	Odds Ratio[ii]
Any head injury	222	535	0.32
Brain injury	62	141	0.33
Severe brain injury	15	47	0.24
Fatality	1	13	0.07

The Seattle study dataset forms the core of the Cochrane Review of bicycle helmet effectiveness. Its small dataset of serious injuries and the above noted implausibility of the results are not widely recognised. On the contrary, the results are still widely cited in the literature and media. The other main case-control study[30] cited in the Cochrane Review took place in Cambridge, England and is likewise based on a small dataset of serious head injuries (104 cases). None of the studies considered the full implications of socio-economic differences between helmet and non-helmet users.

In addition to confounding factors, a recent analysis[31] has found evidence of publication bias and time-trend bias in reviews of helmet effectiveness. Publication bias is the tendency of contradictory or inconclusive results not to be published, resulting in a literature formed of apparently consistent findings that exaggerate, or even misconstrue, the actual effect. Time-trend bias is the tendency of findings to change over time. Correction for these factors reduced the original protective effects of helmets, although what remained was still significant. Considering injuries to the head, face and neck together, however, the protection of helmets

[ii] Odds Ratios are the measure that can be obtained from a case control study. In this case it is the ratio of the odds that someone wearing a helmet had that outcome compared with the odds that someone not wearing a helmet had that outcome. An odds ratio below 1.0 means the 'exposure' (helmet wearing) is protective.

was small even in the older studies (a point not necessarily emphasised or even reported in the original papers). In more recent studies, there was no net protective effect after correction for biases. That is, reduced risk of head injury was off-set by increased risk of face and neck injuries.

A fuller discussion of the problems with case-control studies of cycle helmets is available.[32]

In contrast, population studies are much harder to challenge. A number have appeared, two of which stand out as being particularly rich in terms of the time period covered and a control group being presented. Hendrie et al[33] studied the effect of the state helmet law of Western Australia, concerning serious head injuries to cyclists in traffic accidents (collisions or falls in the highway). This was based on study of the proportion of serious casualties with head injuries, when set against a control group. It thus examines the prevention of head injury when crashes happen, not the number of crashes or the risk of being in a crash. They concluded the law prevented 10-20% of head injuries. However, as the authors point out, the result rests upon one step change in the year prior to the law, not upon reductions as the law was enforced, nor upon any reduction with rising voluntary use pre-law.

Scuffham et al[34] studied the same injury class for New Zealand, using a similar technique. They concluded 19% prevention of serious head injuries (mainly scalp lacerations) due to enforced legislation. However, the authors did not model the helmet law as a step change in helmet use. Surveys showed a step increase in helmet use as the law was enforced, but this was not reflected as a step change in head injury trends. The base data show that serious head injuries continued a smooth secular decline through the law enforcement, while serious non-head injuries markedly increased. Other data show that cycle use (in time spent nationally) declined by 33% between 1989/90 and 1997/98[35], the period of helmet promotion and law enforcement. This would imply an increase in risk post-law.

Because there was scope for further analysis as per above, these data, and others from Victoria, Australia *inter alia*, were gathered and published[36] with a conclusion of *"no clear benefit".* The failure of mass helmet use to affect serious head injuries, be it in falls or collisions, has been ignored by the medical world, by civil servants, by the media, and by cyclists themselves. A collective willingness to believe appears to explain why the population-level studies are so little appreciated. It should be noted that the definition of head injury applied in these population level studies was not especially exclusive – for instance, scalp lacerations were included. In both the Hendrie and Scuffham studies, 70% of the head injuries occurred in simple falls, not traffic collisions. Despite this, no reduction of head injuries relative to non-head injuries could be linked to increasing helmet use in the populations concerned.

7.4.2 Helmet standards and mechanisms in relation to head injuries

Confirmation of the lack of benefit seen in population-level studies comes from physical evidence. One leading engineer has reported: *"Another source of field experience is our experience with damaged helmets returned to customer service... 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".*[37] The significance of this is that crushing of the liner is evidence of significant energy absorption and therefore impact alleviation. Even earlier, in 1987, the Australian Federal Office of Road Safety found that in real accidents: *"very little crushing of the foam liner was usually evident... What in fact happens in a road crash impact is that the human head deforms elastically on impact. The standard impact attenuation test making use of a solid head form does not consider the effect of human head deformation, with the result that all acceleration attenuation occurs in the compression of the liner. Since the solid head form is more capable of crushing helmet padding, manufacturers have to provide a relatively stiff foam in the helmet so that it would pass the impact attenuation test... cracks* *developing partly or fully through the thickness of the foam renders it useless in crushing and absorbing impact forces".*[38]

Rotational Injury: brain injuries may be caused by linear impact or rotation of the head, or a combination. There is no definitive research on whether cycle helmets increase the risk of rotational injury. Laboratory tests show that rotational accelerations in helmeted head forms can exceed levels likely to cause debilitating injury or death. However, laboratory conditions are not real conditions, as has already been noted above. On the basis of biomechanical test results, one would expect helmets to prevent serious and possibly even fatal head injuries, although probably increase the risk of rotational injury. The absence of noticeable reduction in serious head injuries with mass helmet use is a real world result that cannot sensibly be ignored. An interesting commentary is available that discusses possible reasons for the failure of laboratory results to carry into the real world.[39]

The failings of biomechanical studies do not prevent these results being cited in favour of helmet promotion, in the absence of any positive real world result. Some advocates of cycle helmets dismiss all results from the real world in favour of the assertion that cycle helmets must work because they would be expected to work from laboratory tests. The latest (2009) helmet review[23] by the DfT is an example of this. While concluding that no clear evidence of helmet effectiveness emerges from a review of the literature, it then claims life-saving protection from helmets, but on the basis of the authors' biomechanical assumptions, not scientific fact.

Helmet standards must be mentioned in brief. These have changed since the first ANSI standard for a bicycle helmet in 1966, and vary today around the world. The helmet standard prevailing in Australia and New Zealand at the time the helmet laws came into force (AS/NZS 2063.2) was a tougher specification than the EN1078 standard for helmets in Europe today.[40] Contrary to what one might expect, the robustness of cycle helmets has declined since the 1970s, with the progressive loss of the hard outer shell, increase in venting, and reduction in mass. This has made popular acceptance possible. The most stringent helmet standard in the world today is the Snell B95. Such a helmet is hard to obtain in Europe.

7.4.3 Risk compensation

Risk compensation is the human tendency to alter behaviour when expected consequence changes. For instance, the expected benefits of seatbelt use failed to materialise following legislation.[41] Analysis of car wrecks makes it clear that seatbelts can confer life-saving benefit in a given crash. The only explanation for the failure is a change in behaviour by some drivers forced to wear a seatbelt. Seat belts became law for drivers and front seat passengers in the UK on 1st January 1983, with compliance rising to 90% (from about 30% use) within a few weeks. It has been concluded that one in eight cyclist deaths and one in 12 pedestrian deaths in that year were due to seatbelt legislation.[42] This transfer of danger from those in cars to those hit by them is euphemised as 'migration hypothesis'. Figure 4-1 confirms that 1983 marked no noticeable change in the fatality rate of drivers. The UK government had commissioned research into seatbelt legislation prior to the final Parliamentary debate in 1981. The report by JE Isles of the Department for Transport concluded that seatbelt laws had not detectably reduced road deaths.[43] This was suppressed and only became known when *New Scientist* magazine revealed its existence in February 1985. Thus the 1981 debate that passed legislation was never informed. Claims for success of seatbelt legislation rest upon the long term declining trend that dates back to the 1960s and continues to this day. The lesson of seatbelt laws is: do not ignore risk compensation.

With respect to cycle helmets, risk compensation has not been much studied. One study showed that helmet use altered <u>driver</u> behaviour[44]: some drivers passed faster and closer to a helmeted cyclist. Hedlund has proposed a general model[45] of behaviour, in which cycle helmets score highly in likelihood of causing risk compensatory behaviour in riders. A study of children running around an obstacle course with and without helmets (and other protective equipment) showed strong risk compensation, with children going faster and being more reckless when using the protective equipment.[46] Surveys of US cyclists in the late 1980s found that helmet users were more than seven times more likely to say they had struck their head in the last 18 months than non-users.[47] At this time the rate of helmet use was c.10%. But is this self-reporting bias? Or bias due to self-selection by higher risk cyclists to wear helmets? If risk compensation was a serious problem, one would expect to see an increase in road traffic casualties as helmets become popular. This can happen, but not in a consistent way. One may easily note from Figure 4-1 that cyclist deaths sharply increased after 1994, in the years when helmets first became popular in Britain, although the effect has faded. A US study[48] found a statistically significant association between helmet use and risk of death to US cyclists in the period 1973 to 1985. On the other hand, analysis of Edinburgh road casualties[49] found no evidence that adult cyclist injuries in traffic crashes had worsened since 1990, relative to the control group (pedestrians). Research into cyclists' attitudes has found that the more a person believes a helmet to be effective against serious or fatal injury, the more likely they are to wear one.[50] In summary, on the balance of probability, risk compensation by helmet wearing cyclists is likely, but the evidence is not conclusive. The evidence that drivers may impose more risk on helmet wearing cyclists is disturbing and warrants further research.

7.4.4 Effect of helmets on cycling levels

The British Medical Association has had a policy since 2005 of supporting helmet legislation. This was greatly influenced by one study concluding that the Ontario child cyclist helmet law of 1996 had not deterred children from cycling and that therefore previous experience with enforced legislation was no longer relevant.[51] However, the paper's authors never mentioned that the Ontario law was not enforced; helmet use returned to pre-law levels after about three years.[52] Close inspection of the data shows that cycling levels did in fact increase when helmet use returned to pre-law levels. This paper has been widely misinterpreted as applying to enforced legislation. Another paper[53] claimed that the Ontario law had cut child cyclist deaths by half in the following ten years, and quoted data selectively to suggest that helmet use was maintained at a high level in this period when in fact it was not. The decline in deaths was seen in pedestrians too and was clearly an environmental effect.[54] Still another paper[55] concluded that provincial helmet laws in Canada had not reduced cycling levels, yet data presented in the research show the contrary; notably a 50% decline in the number of trips cycled by youths in Alberta.

It is not widely appreciated that there is now a significant literature of studies casting doubt on the wisdom of helmet programmes.[56] These studies typically do not receive media attention and remain little known. With the sole exception of Ontario, where the law was not enforced and rates of helmet wearing were already high, jurisdictions that have introduced mandatory helmet use have suffered a pronounced reduction in the number of cyclists and cycle trips made. For instance, cycle use in New Zealand has dropped 55% since 1989/90.[35] Analysis of census data shows permanent reductions of utility cycling in Australia too.[57] Helmet promotion also hinders cycling programmes.[58] Reducing active travel has a significant, negative impact on the public's health by reducing physical activity levels.[59]

The disconnect between received wisdom and the facts is stark.

The facts are:

1. It is rational for an individual to choose to wear a cycle helmet - but no more so than to choose to wear a helmet when walking, driving, playing football or playing rugby.

2. There is however a disturbing discrepancy between engineering or clinical evidence of the effectiveness of helmet wearing (which suggest them to be effective) and population studies (which suggest that they are not).

3. Plausible explanations of this discrepancy include cyclists taking greater risks because they think their helmet makes them safe or drivers taking less care of helmeted cyclists because they see them as less vulnerable. A single study has examined this but its findings supports the latter of these.

4. There are also other possible explanations based on postulated unknown hazards of cycle helmets. We consider these explanations to be much less likely than the behavioural explanations given above.

5. It is now well established that legislation mandating cycle helmet use causes a reduction in the levels of cycling and thereby does more harm than good.

6 It is unclear whether this is because many people find cycle helmets troublesome, because many people find them unfashionable and odd or because people consider the mandation of helmet use as evidence that cycling is dangerous.

7. If the last of these explanations is true then not only legislation but also any vigorous promotion of voluntary helmet use are likely to be harmful.

8. The one study in which cycle helmet legislation did not reduce cycle use (Ontario) is highly unusual both because of the high levels of voluntary helmet use before the legislation and the fact that the law was not enforced. This makes it difficult to draw clear conclusions from it. It certainly cannot be regarding as annulling the considerable volume of evidence that cycle helmet legislation is harmful.

As Hedlund warned:

> *"Don't over-predict benefits. Many injury prevention measures promise more benefits than they deliver, due to bad science, political pressures, or failure to consider risk compensation or system effects. While calm and realistic benefit estimates are difficult to produce, unduly optimistic predictions will hamper injury prevention efforts in the long run".* [45]

7.5 Reference

[1] Department for Transport. *Pedal cyclist casualties in road accidents: 2008.* London: DfT, 2010. www.dft.gov.uk/pgr/statistics/datatablespublications/accidents/casualtiesgbar/suppletablesfactsheets/pedalcyclist2008.pdf

[2] Department for Transport. *Road Casualties Great Britain 2007.* London: DfT, 2007.

[3] Wardlaw M. Assessing the actual risks faced by cyclists. *Traffic Engineering & Control* 2003;43:420-24.

[4] Krag T. *Cycling, Safety and Health*. in European Transport Safety Council Yearbook 2005. www.etsc.eu/documents/Yearbook_2005.pdf

[5] Department for Transport. *The National Travel Survey* 2007 and previous years. London: HMSO, 2008. www.dft.gov.uk/pgr/statistics/datatablespublications/personal/mainresults/nts2007/

[6] Shafer A. *Regularities in Travel Demand; an International Perspective.* Research and Innovative Technology Administration (RITA), US Department of Transportation, undated (approx. 2000). www.bts.gov/publications/journal_of_transportation_and_statistics/volume_03_number_03/paper_01/index.html

[7] World Health Organisation. *Helmet Initiative.* www.whohelmets.org/

[8] De Hartog JJ, Boogaard H, Nijland H, Hoek G. Do the health benefits of cycling outweigh the risks? *Environmental Health Perspectives.* 2010;**118**:1109-16.

[9] Dekoster J, Schollaert U. *Cycling: The way ahead for towns and cities.* European Commission, 1999. http://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

[10] Morgan JM. *Risk in Cycling*. Transport and Road Research Laboratory Working Paper WP/RS/75 Crowthorne TRL, 1988.

[11] Rijksoverheid. "Kerncijfers Verkeersveiligheid 2009". www.rijksoverheid.nl/documenten-en-publicaties/brochures/2009/04/01/kerncijfers-verkeersveiligheid-2009.html (accessed 17/02/2011)

[12] Dutch Ministry of Transport, Public Works and Water Management. *Dutch Bicycle Master Plan*. The Hague. Directorate-General for Passenger Transport, 1999.

[13] Wardlaw MJ. Three lessons for a better cycling future. *BMJ* 2000;**321**:1582-5.

[14] Jacobsen 2003 Safety in numbers: more walkers and bicyclists, safer walking and bicycling. *Injury Prevention* 2003;**9**:205-9.

[15] Broughton J, Allsop R, Lynam D, McMahon C. *The numerical context for setting national casualty reduction targets.* Transport Research Laboratory Report 382. Crowthorne: TRL, 2000.

[16] Pucher J, Dill J, Handy S. Infrastructure, programmes, and policies to increase bicycling: An international review. *Preventive Medicine* 2010;50:S106-S125.

[17] Transport for London. Focus on Cycling. Chapter 7 in *Travel in London* Report #1. London: TfL, 2009. http://www.tfl.gov.uk/assets/downloads/corporate/Travel-in-London-report-1.pdf

[18] Thompson D, Rivara F, Thompson R. *Helmets for preventing head and face injuries in cyclists (Cochrane Review).* The Cochrane Library (ISSN 1464-780X) 1999 (last assessed in 2006)

[19] Towner E et al. *Bicycle Helmets – a review of their effectiveness. A critical review of the literature.* Department for Transport Research Report 30. London: DfT, 2002.

[20] Bicycle Helmet Research Foundation. *Cochrane Review – Helmets for preventing head and facial injuries in bicyclists. Commentary.* www.cyclehelmets.org/1069.html (accessed 19/9/09)

[21] Franklin J. *Bicycle helmet effectiveness – a broader perspective.* Commentary: Bicycle Helmet Research Foundation, 2003. www.cyclehelmets.org/papers/c2002.pdf (accessed 19/9/09)

[22] Curnow W. The Cochrane collaboration and bicycle helmets. *Accident Analysis and Prevention* 2005;37:569-74.

[23] Transport Research Laboratory. *The Potential for Cycle Helmets to Prevent Injury – a review of the evidence.* Report PPR446 Crowthorne, Berks: TRL, 2009. www.trl.co.uk/online_store/reports_publications/trl_reports/cat_road_user_safety/report_the_potential_for_cycle_helmets_to_prevent_injury___a_review_of_the_evidence.htm

[24] *Government report identifies flaws in pro-helmet evidence but reaches equally flawed conclusions*. Press release by Cyclists' Touring Club 15/12/09 www.ctc.org.uk/DesktopModules/Articles/ArticlesView.aspx?TabID=0&ItemID=341&mid=13641

[25] Killoran A et al. *Transport interventions promoting safe walking and cycling.* London: National Institute for Clinical Excellence, 2006.

[26] Macpherson A et al. Economic disparity in bicycle helmet use by children six years after the introduction of legislation. *Injury Prevention* 2006;**12**:231-5.

[27] Smith GD. Classics in epidemiology; should they get it right? *International Journal of Epidemiology* 2004;**33**:441-2.

[28] Thompson D, Rivara P, Thompson R. Effectiveness of bicycle helmets in preventing road injuries. *Journal of the American Medical Association.* 1996;**276**:1968-73.

[29] Thompson R, Rivara P, Thompson D. A case-control study of the effectiveness of bicycle safety helmets. *The New England Journal of Medicine* 1989;320(21):1361-1367

[30] Maimaris C, Summers CL, Browning C, Palmer CR. Injury patterns in cyclists attending an accident and emergency department: an comparison of helmet wearers and non-wearers. *BMJ.* 1994;**308**:1537-40

[31] Elvik R. Publication bias and time-trend bias in meta-analysis of bicycle helmet efficacy; a re-analysis of Attwell, Glase and McFadden 2001. *Accident Analysis & Prevention*. 2011. doi:10.1016/j.aap.2011.01.007

[32] Bicycle Helmet Research Foundation. *Contradictory evidence about the effectiveness of cycle helmets.* www.cyclehelmets.org/1052.html (accessed 19/9/09).

[33] Hendrie D et al. *An economic evaluation of the mandatory bicycle helmet legislation in Western Australia.* Road Accident Prevention Research Unit. University of Western Australia 1999.

[34] Scuffham P et al. Head injuries to bicyclists and the New Zealand bicycle helmet law. *Accident Analysis and Prevention* 2000;**32**:565-73

[35] *Cycling for Transport: ongoing New Zealand household travel survey 2003-2007.* New Zealand Ministry of Transport. Nov 2008.

[36] Robinson D. No clear evidence from countries that have enforced the wearing of helmets. *BMJ.* 2006;**332**:722-5.

[37] Sundahl JG. Senior Engineer, Bell Sports. Letter to the Consumer Product Safety Commission dated 19th Jan 1998. The central theme of this letter is that child helmet liners would be too rigid due to being tested with head forms that were too heavy. www.cpsc.gov/LIBRARY/FOIA/FOIA98/PUBCOM/34C7A89B.PDF.

[38] Australian Department of Transport, Federal Office of Road Safety. "Motorcycle and bicycle protective helmets; requirements resulting from a post-crash study and experimental research". Report #CR55 1987. www.infrastructure.gov.au/roads/safety/publications/1987/Mcycle_Helm_1.aspx.

[39] *Assessment of current bicycle helmets for the potential to cause rotational injury.* Commentary. www.cyclehelmets.org/1182.html

[40] British Medical Association. *Cycle Helmets*. London: Board of Science and Education, 1999.

[41] Richens J, Imrie J, Copas A. Condoms and seatbelts: the parallels and the lessons. *Lancet* 2000;**355**:400-3

[42] Allsop R, Carsten O, Evans A, Gifford R. Seatbelt laws: why we should keep them. *Significance*. 2008;**5**:84-6.

[43] Isles JE. *Seat belt savings: Implications of European statistics.* Department for Transport. Never published. Leaked by *New Scientist* magazine on 7/2/1985. Available at http://john-adams.co.uk/wp-content/uploads/2007/01/isles%20report.pdf

[44] Walker I. Drivers overtaking bicyclists: objective data on the effects of riding position, helmet use, vehicle type and apparent gender. *Accident Analysis & Prevention.* 2007;**39**:417-25.

[45] Hedlund J. Risky business: safety regulations, risk compensation and individual behaviour. *Injury Prevention.* 2000;**6**:82-89.

[46] Morrongiello B, Walpole B, Lasenby J. Understanding children's injury risk behaviour: wearing safety gear can lead to increased risk taking. *Accident Analysis and Prevention* 2007;**39**:619-23.

[47] Robinson D. Head injuries and bicycle helmet laws. *Accident Analysis & Prevention* 1996;**28**:463-75.

[48] Rodgers G. Reducing bicycle accidents: a re-evaluation of the impacts of the CPSC Bicycle Standard and helmet use. *Journal of Products Liability* 1988;**11**:307-17.

[49] *Casualty trends in Edinburgh 1980-2002. Commentary.* www.cyclehelmets.org/1070.html

[50] Burton R. *Do cyclists have an exaggerated perception of the effectiveness of cycle helmets and the risks of cycling?* MSc Thesis University of the West of England 2008.

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

[52] Macpherson et al. Economic disparity in bicycle helmet use by children six years after the introduction of legislation. *Injury Prevention* 2006;**12**:231-35.

[53] Wesson et al. Trends in paediatric and adult bicycling deaths before and after the passage of a bicycle helmet law. *Pediatrics* 2008;**122**:605-10.

[54] Wardlaw M. *Cycle helmets: an unnecessary and ineffective intervention*. eResponse to Wesson et al. http://pediatrics.aappublications.org/cgi/eletters/122/3/605

[55] Dennis J, Potter B, Ramsay T, Zarychanski R. The effects of provincial bicycle helmet legislation on helmet use and bicycle ridership in Canada. *Injury Prevention* 2010;16:219-24

[56] Bicycle Helmet Research Foundation. *Published evidence sceptical of helmet effectiveness or promotion.* (online library). www.cyclehelmets.org/1146.html (accessed 19/9/09)

[57] Robinson D. *Changes in cycle use in Australia.* Bicycle Helmet Research Foundation 2007. www.cyclehelmets.org/1194.html (accessed 28/9/09)

[58] Bicycle Helmet Research Foundation. *How helmet promotion and laws affect cycle use*. www.cyclehelmets.org/1020.html (accessed 14/2/10)

[59] Robinson DL. Safety in numbers in Australia: more walkers and bicyclists, safer walking and bicycling. *Health Promotion Journal of Australia* 2005;**16**:47-51.