from the road safety campaigns should be contrasted with the lack of obvious effect on head injuries from helmet laws. Yet helmet laws were far more expensive. All published cost-benefit analyses of injury rates before and after helmet laws show the cost of helmets exceeded any estimated savings in healthcare costs.[7 20]

Contributors and sources: DLR cycles almost every day. She is interested in statistical modelling and the consequences of fitting incorrect or inappropriate models.

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1 BMA Board of Science and Education. *Legislation for the compulsory wearing of cycle helmets, 2004.* www.bma.org.uk/ap.nsf/Content/cyclehelmetslegis (accessed Feb 2005).
2 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;160:1621-8.
3 Adams J, Hillman M. The risk compensation theory and bicycle helmets. *Inj Prev* 2001;7:89-91.
4 Lawlor DA, Davey Smith G, Ebrahim S. The hormone replacement-coronary heart disease conundrum: is this the death of observational epidemiology? *Int J Epidemiol* 2004;33:464-7.
5 Powles JW, Gifford S. Health of nations: lessons from Victoria, Australia. *BMJ* 1993;306:125-7.
6 Marshall J, White M. *Evaluation of the compulsory helmet wearing legislation for bicyclists in South Australia Report 8/94.* Walkerville: South Australian Department of Transport, 1994.
7 Hendrie D, Legge M, Rosman D, Kirov C. *An economic evaluation of the mandatory bicycle helmet legislation in Western Australia, 1999.* www.officeofroadsafety.wa.gov.au/Facts/papers/bicycle_helmet_legislation.html (accessed 2 Mar 2006).
8 Hewson PJ. Cycle helmets and road casualties in the UK. *Traffic Inj Prev* 2005;6:127-34.
9 Robinson DL. Head injuries and bicycle helmet laws. *Accid Anal Prev* 1996;28:463-75.
10 Robinson DL. Changes in head injury with the New Zealand bicycle helmet law. *Accid Anal Prev* 2001;33:687-91.
11 Carr D, Skalova M, Cameron M. *Evaluation of the bicycle helmet law in Victoria during its first four years.* Melbourne: Monash University Accident Research Centre, 1995.
12 Lardelli-Claret P, de Dios Luna-del-Castillo J, Jimenez-Moleon JJ, Garcia-Martin M, Bueno-Cavanillas A, Galvez-Vargas R. Risk compensation theory and voluntary helmet use by cyclists in Spain. *Inj Prev* 2003;9:128-32.
13 McGuire L, Smith N. Cycling safety: injury prevention in Oxford cyclists. *Inj Prev* 2000;6:285-7.
14 DiGuisseppi CG, Rivara FP, Koepsell TD. Bicycle helmet use by children. Evaluation of a community-wide helmet campaign. *JAMA* 1989;262:2256-61.
15 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. *J Trauma* 1991;31:1510-6.
16 Thompson D, Rivara F, Thompson R. Helmets for preventing head and facial injuries in bicyclists. *Cochrane Database Syst Rev* 2000;(2):CD001855.
17 Jacobsen PL. Safety in numbers: more walkers and bicyclists, safer walking and bicycling. *Inj Prev* 2003;9:205-9.
18 Kraus JF, Fife D, Conroy C. Incidence, severity, and outcomes of brain injuries involving bicycles. *Am J Public Health* 1987;77:76-8.
19 Maimaris C, Summers CL, Browning C, Palmer CR. Injury patterns in cyclists attending an accident and emergency department: a comparison of helmet wearers and non-wearers. *BMJ* 1994;308:1537-40.
20 Taylor M, Scuffham P. New Zealand bicycle helmet law—do the costs outweigh the benefits? *Inj Prev* 2002;8:317-320.

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Arguments against helmet legislation are flawed

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Robinson's opposition to helmet laws is contrary to published evidence on the effectiveness of bicycle helmets.[1] At least six independent studies have reported a protective association between wearing bicycle helmets and head injuries.[w1-w6] Furthermore, systematic reviews of the relation have all noted a protective effect of helmets.[2–4] Similarly, six studies have examined the relation between helmet laws and head injuries, and all found a reduction in head injuries after legislation was enacted.[w1 w7-w11]

What do the data show?

Robinson suggests that the percentage of bicycle related injuries that are head injuries seems to be declining and that this decline started before the enactment of the law. However, her figures also show that helmet laws are successful in increasing helmet use and seem to be associated with a decrease in the percentage of head injuries. The effect of helmet use is most evident in her fig 2, where the increase in the percentage of cyclists wearing helmets corresponds with a decrease in the percentage of head injuries. The correlation coefficient for the percentage helmet use and percentage head injury is -0.8 for children and -0.9 for adults. The corresponding r^2 of 0.64 for children and 0.81 for adults suggests that much of the variation in the percentage of head injuries is explained by helmet use. Thus, as the proportion of helmeted cyclists increases, the proportion of bicycle related head injuries decreases.

This relation is also apparent in the New South Wales data on bmj.com. Bicycle related head injuries in children declined by 1.2% and 0.8% in the two years before the enactment of the helmet law and then by 4.3% immediately after the law. The decline of 1.6% in the following year was still greater than in the two years before the law.

ED PRITCHARD/STONE/GETTY IMAGES

Beware of confounders

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P+ *References w1-w11 are on bmj.com*

Strength of evidence

All of her data are based on time series or ecological designs, without any concurrent comparison groups. Such studies are considered to provide weak evidence.[5] With ecological studies, investigators cannot determine whether all cyclists sustaining head injuries were wearing helmets. Confounding variables may also influence both the exposure and outcome variables in the context of a time series or ecological study. For example, a fall in the number of bicyclists in the 1990s may simply reflect an increase in in-line skating or other recreational activities.

Robinson dismisses the evidence from all the case-control studies because of problems adjusting for confounders in observational studies leading to what she believes to be biased, misleading results.[1] The studies in the Cochrane review[4] that Robinson criticises deal with the issue of helmet effectiveness, not evaluation of helmet legislation. In this context, what might be the latent confounder that supposedly accounts for the helmet effect in case-control studies? Robinson suggests several characteristics may be responsible, including lower impact crashes caused by more safety behaviours by helmet users.[1] Yet Thompson and colleagues adjusted for motor vehicle involvement in addition to type of surface hit, speed of bicycle, and damage to bicycle in their follow-up case-control study,[w6] the results of which confirm those of the 1989 study.[w5]

We contend that adjustment for these crash related characteristics eliminates the influence of extraneous factors and results in a fair contrast of head injury risk between helmet users and non-users. Thus, whether a helmet user has a more cautious personality does not matter when they are compared with a non-user for head injury risk under the same crash circumstances. There is no plausible reason to believe that cautiousness would affect whether a cyclist has a brain injury or another kind of injury, once in a crash.[6]

Risk compensation

Finally, Robinson invokes the idea of risk compensation, suggesting that wearing helmets may encourage cyclists to take more risks or motorists to take less care when they encounter cyclists.[1] However, she also cites studies showing that, if anything, helmet users take fewer risks than non-helmeted cyclists.[7–9] A recent study fails to support a risk compensation effect (greater risk taking behaviour or injury severity) in children's activities, including bicycling, with the use of protective equipment.[10] However, if risk compensation were operating, the bike helmet studies in the Cochrane review would have greatly underestimated the protective effect of helmets. Furthermore, adjustment for crash circumstances (such as motor vehicle involvement) in Thompson and colleagues's study would remove any risk compensation effect. The notion that driver's take less care when encountering helmeted cyclists is pure speculation.

Health arguments

Robinson's position rests on the assumption that the evidence points to a reduction in cycling after legislation and the adverse fitness consequences that she assumes follow. Although we disagree with the science, let's assume legislation does discourage a large proportion of cyclists. The crucial question is whether the decision not to ride, for however long, truly diminishes physical fitness. In other words, is the trade-off between head protection and fitness worth it?

The answer depends on knowing, in each age group affected, the average distance travelled and the speed at which most trips are made because both time and energy influence aerobic fitness. Morris's classic study of over 9000 British government employees showed that people between the ages of 45 and 64 had to cycle for at least an hour or for at least 40 km a week to decrease their risk of coronary heart disease compared with those who were sedentary.[11] Doyle-Baker, an expert in the epidemiology of health and fitness, notes: "It is a rule of thumb that 45 minutes of cycling six days a week (about 2000 kcal) would confer health benefits" (personal communication). It seems unlikely that most leisure cyclists, adults or children, are cycling for 45 minutes six days a week. In fact, Lippi et al,[12] commenting on a recent review,[13] state, "There is still open debate regarding intensity and type of physical activity required to achieve most favourable health changes without overwhelming favourable health outcomes."

Unfortunately, not much is known about typical cycling habits in various age groups. An extensive survey of bicycle commuters in the US show that the average distance ridden each day is 11.6 km for about 30 minutes.[14] As an aside, the survey found that 87% reported wearing a helmet "at all times." Without evidence that those who allegedly stopped cycling rode enough to confer a heart health benefit or that they did not take up another healthy activity in its place, Robinson cannot conclude that decreases in cycling are harmful to health and her argument crumbles.

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1 Robinson DL. No clear evidence from countries that have enforced the wearing of helmets. *BMJ* 2006;332:722-5.
2 Attwell RG, Glase K, McFadden M. Bicycle helmet efficacy: a meta-analysis. *Accid Anal Prev* 2001;33:345-52.
3 Henderson M. *The effectiveness of bicycle helmets: a review.* Victoria: Australia Motor Accidents Authority of New South Wales, 1995. www.bhsi.org/webdocs/henderst.htm (accessed 8 Mar 2005).
4 Thompson DC, Rivara FP, Thompson R. Helmets for preventing head and facial injuries in bicyclists. *Cochrane Database Syst Rev* 2000;(2):CD001855.
5 Borglund ST, Hayes JS, Eckes JM. Florida's bicycle helmet law and a bicycle safety educational program: did they help? *J Emerg Nurs* 1999;25:496-500.
6 Cummings P, Rivara FP, Thompson DC, Thompson RS. Misconceptions regarding case-control studies of bicycle helmets and head injury. *Accid Anal Prev* (in press).
7 Lardelli-Claret P, Luna-del-Castillo J, Jiménez-Moleón JJ, García-Martín M, Bueno-Cavanillas A, Gálvez-Vargas R. Risk compensation theory and voluntary helmet use by cyclists in Spain. *Inj Prev* 2003;9:128-32.
8 McGuire L, Smith N. Cycling safety: injury prevention in Oxford cyclists. *Inj Prev* 2000;6:285-7.
9 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. *J Trauma* 1991;31:1510-6.
10 Pless IB, Magdalinos H, Hagel BE. Risk compensation behaviour in children: myth or reality? *Arch Pediatr Adolesc Med* (in press).
11 Morris JN, Clayton DG, Everitt MG, Semmence AM, Burgess EH. Exercise in leisure time: coronary attack and death rates. *Br Heart J* 1990;63:325-34.
12 Lippi G, Schena F, Guidi GC. High-volume physical activity and related health outcomes. Electronic response to Warburton et al Health benefits of physical activity: the evidence. *CMAJ* 2006 www.cmaj.ca/cgi/eletters/174/6/801 (accessed 15 Mar 2006).
13 Warburton DER, Nicol CW, Bredin SSD. Health benefits of physical activity: the evidence. *CMAJ* 2006;174:801-9.
14 Moritz WE. *A survey of North American bicycle commuters.* www.bicyclinglife.com/Library/Moritz1.htm (accessed 13 Feb 2006).