Do enforced bicycle helmet laws improve public health?

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Public health

Do enforced bicycle helmet laws improve public health?

While many public health specialists believe this argument has been settled in the affirmative, it remains hotly contested in some quarters. We've provided space to Dorothy Robinson to set out her arguments against legislation and asked Brent Hagel and colleagues to respond

No clear evidence from countries that have enforced the wearing of helmets

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Case-control studies suggest that cyclists who choose to wear helmets have fewer head injuries than non-wearers. Consequently, the BMA recommended that the United Kingdom introduce and enforce bicycle helmet laws.[1] However, regular exercise such as cycling is beneficial to health, and non-helmeted commuter cyclists have lower mortality than non-cyclists.[2] Helmet laws would be counterproductive if they discouraged cycling and increased car use. Wearing helmets may also encourage cyclists to take more risks, or motorists to take less care when they encounter cyclists.[3] Recent epidemiological research highlighted problems adjusting for confounders in observational studies, causing biased, misleading results.[4] Thus the best estimate of the benefits of helmet laws is what actually happens when laws are passed.

I reviewed data from all jurisdictions that have introduced legislation and increased use of helmets by at least 40 percentage points within a few months: New Zealand, Nova Scotia (Canada), and the Australian states of Victoria, New South Wales, South Australia, and Western Australia. To avoid confusing reductions in injuries (from safer roads or less cycling) with benefits of helmets, I have focused on percentages of cyclists with head injuries. Head injuries were most commonly classified as admissions to hospital with head wounds, skull or facial fracture, concussion, or other intracranial injury. The data include 10 504 head injuries, and in most cases were available as percentages of all cyclist injuries. Details of data sources and methods are given on bmj.com.

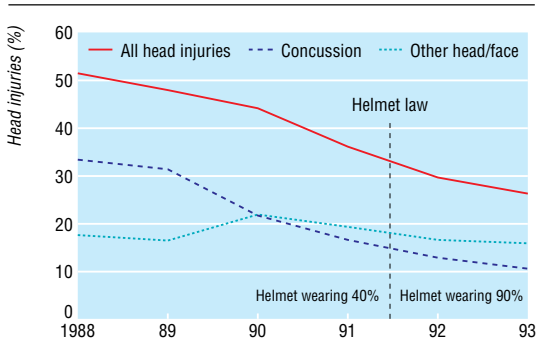

Fig 1 Head injuries among cyclists admitted to hospitals in South Australia[6]

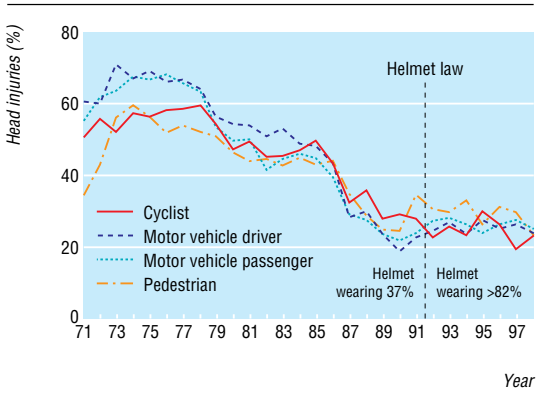

Fig 2 Head injuries among cyclists and other road users admitted to hospital in Western Australia[7]

Effects of improving road safety

Road safety initiatives often yield substantial benefits. For example, random breath testing in New South Wales produced an obvious, sustained reduction in deaths. Another campaign, about the same time as the helmet law, reduced pedestrian fatalities by 34% (see bmj.com). In Victoria, a campaign against speeding and drink-driving (also coinciding almost exactly with the helmet law) reduced pedestrian deaths by 43%. Road injury costs in Victoria were reduced by an estimated £100m for an outlay of £2.5m.[5]

A drop in all road casualties (attributed to speed cameras, introducing a 0.05 blood alcohol limit, and a general economic downturn) also coincided with South Australia's helmet law.[6] The three calendar years after the law was introduced had 33% fewer pedestrian deaths and serious injuries than the three years preceding the law.

Helmet wearing and head injuries

In contrast to the fall in all road injuries in South Australia coinciding with helmet legislation (see bmj.com),

Details of methods of data analysis, references w1-w18, and further results are on bmj.com

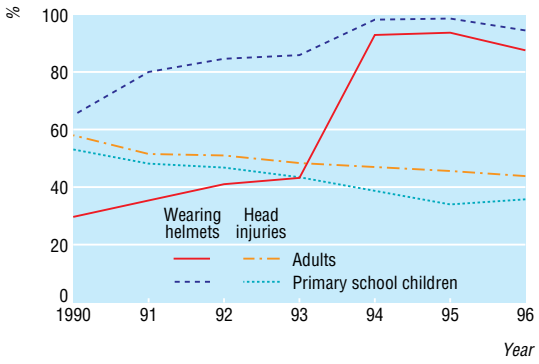

Fig 3 Percentage of cyclists wearing helmets and percentage of head injuries in accidents not involving motor vehicles among primary school children and adults in New Zealand[10]

percentages of cyclists with concussion and other head or face injuries show generally declining trends, especially for concussion, but no clear response when helmet wearing increased substantially (fig 1). Falls in concussions were also noted for other road users and explained by: "The procedure for patients with a short episode of concussion has changed in that such patients are not now admitted routinely."[6]

In Western Australia, helmet wearing was negligible before 1980, increasing to about 37% just before the law was introduced, when it rose to 82%.[7] As in South Australia, the trend in head injuries among cyclists is similar to that for other road users (fig 2). This trend of reduced injuries seems to be widespread—for example, almost identical trends for cyclists and pedestrians were seen in the United Kingdom[8] and Victoria.[9] Early analyses created considerable confusion by ignoring these trends,[w2 w3] mistakenly assuming increased helmet wearing was the only possible cause of the fall in head injuries.

In New Zealand, most primary school children were already wearing helmets before the law,[10] but helmet wearing among adults increased from 43% to 92% after the law was enacted.[10 w4] If helmet laws were effective, the percentage of adults with head injuries should have fallen substantially more than the percentage of primary school children, but it did not (fig 3).

In New South Wales, enforcement increased adult use of helmets from 26% in 1990 to 77% and 85% in 1991 and 1992.[9 w5] Here again the rate of decline of head injuries did not change (see bmj.com). Official analyses of data from Victoria in the three years after legislation came into force also found no alteration in the trend for decreasing injuries.[w6] A subsequent analysis of four years' data reported that numbers of head injuries were 40% lower than before the law.[11] This was cited as important evidence for legislation.[1] However, the authors could not tell whether the main cause was increased helmet wearing or reduced cycling because of the law.[11] Non-head injuries fell by almost as much as head injuries, suggesting the main mechanism was reduced cycling, with perhaps some benefit from reduced speeding and drink-driving (see bmj.com).

In Halifax, Nova Scotia, use of helmets increased from below 40% in 1995 and 1996 to 75% in 1997 and over 80% in 1998 and 1999.[w7] There was a non-significant reduction in the percentage of head injuries ($P=0.06$) that apparently started before the law. A general decreasing trend cannot be excluded because the authors did not consider head injuries among other road users. The numbers of child cyclists with head injury admitted to Nova Scotia's hospitals were 29, 23, and 7 in the three years before the law was introduced and 13 in the year helmets became compulsory.[w8]

Numbers of cyclists

All jurisdictions surveyed use of helmets, but many used different sites, observation periods, or had other year-to-year differences that precluded estimating changes in numbers of cyclists. However, in Melbourne, Victoria, comprehensive surveys (at 64 sites chosen as a representative sample of the roads) were designed to assess the amount of cycling.[w1] Comprehensive surveys were also conducted for child cyclists in New South Wales, and automatic counters were installed on the cycle lanes of two key bridges funnelling traffic over the Swan River in Perth, Western Australia.

The surveys in Melbourne found 442 children wore helmets voluntarily before the law.[9 w1] Identical surveys conducted in 1991, after helmets became compulsory, counted 43 more helmet wearers but 649 fewer child cyclists (table).[9 w1] This supports the conclusion that the main effect of legislation was to discourage cycling rather than encourage helmet wearing. In the 1991 survey, 42% fewer child cyclists and 29% fewer adult cyclists were counted.

Number of cyclists counted and wearing helmets from identical surveys before the helmet law and years 1 and 2 of the law at 64 sites in Melbourne, Victoria, and 120 sites in New South Wales

	Before law		1st law year		2nd law year	
	No of cyclists	No wearing helmets	No of cyclists	No wearing helmets	No of cyclists	No wearing helmets
Melbourne*						
Child cyclists	1554	442	905	485	994†	637
Adult cyclists	1567	564	1106	818	1484†	1247
All cyclists	3121	1006	2011	1303	2478†	1884
New South Wales‡						
Road intersections	1741	440	1188	874	881	582
Recreational areas	1742	709	1236	899	1184	872
School gates	2589	761	1433	1156	1349	1025
All child cyclists	6072	1910	3857	2929	3414	2479

*Data for May 1990, 1991, and 1992.[w1]
†Counts in May 1992 were inflated by a bicycle rally passing through one site (451 cyclists counted at this site in 1992; 72 in 1991). Excluding the site with the rally, 27% fewer cyclists were counted in 1992 than 1990.
‡Data for child cyclists only April 1991, 1992, and 1993.[w5 w18]

Surveys in New South Wales also showed large declines. Before the law, 1910 children were observed wearing helmets. In the first and second years of legislation, 1019 and 569 more children wore helmets, but 2215 (36%) and 2658 (44%) fewer cyclists were counted.[9]

Automatic counters in Perth averaged 16 326 cycle movements a week in October-December 1991 (before helmet legislation). Movements per week after legislation for the same months were 13 067 in 1992, 12 470 in 1993, and 10 701 in 1994, reductions of 20%, 24%, and 35%.[9] Counts on fine weather Sundays (used to assess recreational use) fell by 38% from 1662 during October-December 1991 to 1026 for the same period in 1992.[w9]

Analysis of cycling patterns

The Australian surveys are still the only estimates of how enforced helmet laws affect cycle use. The frequently cited example of legislation in Ontario not discouraging cycling is misleading. The non-enforced law was ineffective—by 1999 the percentage of cyclists wearing helmets returned to levels seen before the law.[w10] In Nova Scotia, considerably fewer cyclists were observed after the law was introduced,[w11] but firm conclusions cannot be drawn because surveys conducted before and after the law were not identical.

Cyclists often consider helmets hot, uncomfortable, and inconvenient. The equivalent of 64% of adult cyclists in Western Australia said they would ride more except for the helmet law.[w9] In New South Wales, 51% of schoolchildren owning bikes, who hadn't cycled in the past week, cited helmet restrictions, substantially more than the numbers citing other reasons, including safety (18%) and parents (20%).[w12]

Claims that the Australian data were distorted by a change in the driving age[1] are incorrect. The minimum age for taking the driving test remains unchanged. However, in one state (Victoria) children were allowed to start learning (under continuous supervision of a licenced driver) earlier. This seems unlikely to have caused much of the 42% fall in child cycling (and 29% in adults) in Melbourne. Driving age did not change in other states, yet, after two years of legislation, cycling by children in New South Wales was 44% lower. A longer term series of identical counts of all cyclists over six years at 25 sites in Sydney found a 48% decrease from 1991 to1996.[w13] By contrast, cycling in the Sydney metropolitan area increased significantly (by 250%) in the decade before legislation.[w14]

Before helmet laws, cycling was increasing. Australian census data show cycling to work increased by 47%, from 1.1% in 1976 to 1.6% in 1986. This trend continued in states without enforced helmet laws, where the average proportion cycling to work increased in 1991, contrasting with an average decline for other states. By 1996, when all states had enforced laws, only 1.2% cycled to work, with a similar proportion in 2001.

Thus all available long and short term data show cycling is less popular than would have been expected without helmet laws.

Effect of helmets

Cyclists who choose to wear helmets commit fewer traffic violations,[12] have higher socioeconomic status, and are more likely to wear high visibility clothing and use lights at night.[13] Helmeted children tend to ride with other cyclists in parks, playgrounds, or on bicycle paths rather than on city streets, and (in the United States) be white rather than other races.[14] Helmeted cyclists in collision with motor vehicles had much less serious non-head injuries than non-helmeted cyclists (suggesting lower impact crashes).[15] Unless case-control studies record and fully adjust for all these confounders, their effects may incorrectly be attributed to helmets.

A widely cited systematic review calculated the effect of helmets on brain injury from three studies of cyclists given emergency treatment, with a total of 347 concussions or other brain injuries (plus many superficial head wounds).[16] The data I present are based on 10 479 head injuries severe enough to appear in hospital admissions databases. The lack of obvious benefit from helmet laws may be because helmets (which prevent head wounds) are not designed for forces often encountered in collisions with motor vehicles or other serious crashes that cause most head injuries requiring hospital admission. Helmets may also encourage cyclists to take more risks, or motorists to take less care when they encounter cyclists, counteracting any benefits.[3] Cyclists compelled to wear helmets may take less trouble to wear them correctly and ensure they fit well, reducing their effectiveness.[w16]

Summary points

- Case-control studies suggest cyclists who choose to wear helmets generally have fewer head injuries than non-wearers
- Before and after data show enforced helmet laws discourage cycling but produce no obvious response in percentage of head injuries
- This contradiction may be due to risk compensation, incorrect helmet wearing, reduced safety in numbers, or incorrect adjustment for confounders in case-control studies
- Governments should focus on factors such as speeding, drink-driving, failure to obey road rules, poor road design, and cycling without lights at night

Safety in numbers

Injuries to cyclists follow a clear "safety in numbers" relation; injury rates per cyclist are lower when more people cycle.[17] Data for cyclists in collisions with motor vehicles (see bmj.com) show helmet laws increased the risk of death or serious head injury relative to the risk for pedestrians and the amount of cycling. This implies helmet laws are counterproductive.

Collisions with motor vehicles cause nearly all deaths and debilitating head injuries among cyclists.[18] A UK emergency department study found that such collisions caused 58% of head injuries to adult cyclists and 50% of all head injuries to cyclists.[19] The large benefits

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.

Competing interests: None declared.

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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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References w1-w11 are on bmj.com