Th3/A3: Helmet Laws: Creating Consensus from Controversy and Contradictions

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Countries where cycling is safest – those with low fatality rates per cycle-km – typically have high cycling rates but low helmet wearing. This indicates that helmets make only a minor contribution to overall cyclist safety. In fact a review of the best quality data (where enforced elmet laws produced increases of at least 40 percentage points in helmet wearing) found no evidence of reduced head injury rates in response to the increases in helmet wearing.[1]

Despite the lack of evidence, there is increasing pressure for governments to introduce helmet laws. Helmets have been mandatory for many years in Australia and New Zealand, as well as some Canadian and US jurisdictions, either for all cyclists or just children. Other US jurisdictions introduced legislation more recently, as did Alberta (Canada), Finland, Spain, the Czech Republic, Sweden and Iceland.

The substantial pressure for compulsory helmets is illustrated by a well-funded campaign of Safe Kids Canada. Their website urges visitors to click a button to send a fax to politicians, or mail a letter addressed to (and with arguments tailored for) the minister of transport in the visitor's province or territory. A review of unintentional injuries (Safe Kids, 2006) has seven recommendations to improve bicycle safety: 1) Wear a bike helmet; 2) Increase the use of bike helmets through legislation and education; 5) Enact bike helmet legislation in all provinces and territories; 6) Educate the public about the importance of bike helmets through increased education and enforcement.[2] Other recommendations – 3) Keep children under age 10 off the road; 4) Reduce traffic speeds and 7) Create safer environments for cyclists – together occupy only half the space devoted to recommendations for helmets and helmet laws.[2] Potential drawbacks such as reduced cycling, reduced Safety in Numbers and risk compensation are not mentioned.

This paper discusses the evidence for bicycle helmet laws in the context of the benefits and drawbacks of legislation and the effort spent promoting them compared to other, perhaps more effective measures.

1. Introduction

Governments are under increasing pressure to introduce helmet laws. Well funded organisations such as Safe Kids Canada, the Bicycle Helmet Initiative Trust, and the WHO Helmet Initiative all actively promote and lobby for helmet laws, some claiming that helmets prevent 85-88% of critical head and brain injuries.[3]

Advocates of helmet laws generally ignore their drawbacks. Regular exercise such as cycling is beneficial to health and non-helmeted commuter cyclists have lower mortality than non-cyclists.[4] Helmet laws would be counterproductive if they discouraged cycling, increased car use and reduced Safety in Numbers for cyclists. Wearing helmets may also encourage cyclists to take more risks, or motorists to take less care when they encounter cyclists.[5]

The undesirable consequences of helmet laws, including risk compensation, reduced cycling and reduced Safety in Numbers, can be studied only by examining what happens when helmet laws are passed. This has been a much neglected area. Many jurisdictions introduced helmet laws, but few provided funds to evaluate them. Ideally, laws would not be introduced without any reliable information on the consequences.

Consequently, there was a clear need for a systematic review of all available data on helmet laws. To maximise the statistical power of detecting any effects, I concentrated on jurisdictions where helmet wearing increased by more than 40 percentage points within a year.[1] Five jurisdictions with hospital admissions data for head and non-head injuries satisfied this criterion. Percent helmet wearing (%HW) averaged 35% pre-law, increasing to a post-law average of 85%. If helmets reduced head injuries by the claimed 85%, increased helmet wearing from 35-85% would reduce the percentage of cyclists with head injury (%HI) by more than 60 percent, a reduction so large it would be obvious in time series data.

2. Highly effective road safety measures

Many road safety initiatives have yielded substantial benefits. For example, random breath testing (RBT) in New South Wales (**NSW**), Australia, produced an obvious, sustained reduction in all road fatalities. The response is convincing; it started as soon as RBT was introduced and continued for several years (Fig 1).

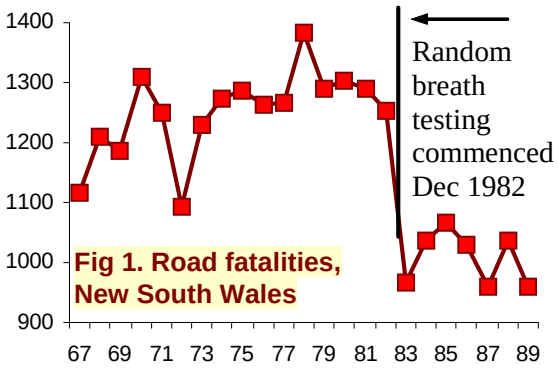


Fig 1. Road fatalities, New South Wales

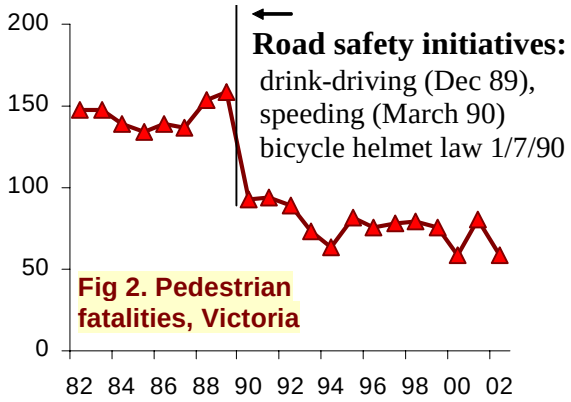
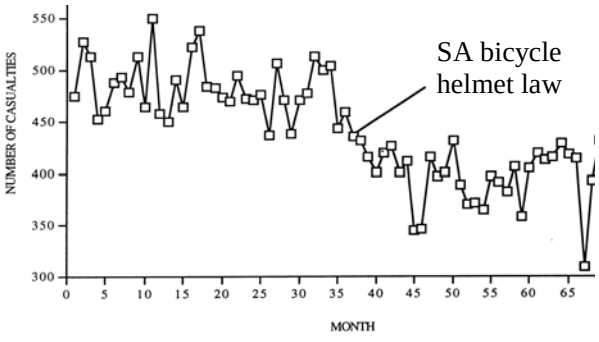


Fig 2. Pedestrian fatalities, Victoria

In Victoria, Australia, a campaign against speeding and drink-driving coincided almost exactly with the helmet law. The first 3 calendar years of the helmet law had 43% fewer *pedestrian* fatalities than the 3 calendar years before legislation (Fig 2). Accident costs were reduced by an estimated £100M for an outlay of £2.5M.[6] Again, there is a convincing downward step in pedestrian fatalities coinciding with the start of the campaign.

Helmet laws were passed in most Australian states because the Federal Government threatened to reduce funding to states that failed to comply with a 10-point road safety program including bicycle helmet laws. Consequently, other road safety measures were often introduced at the same times as helmet laws. In NSW, the 3 calendar years after the bike helmet law had 34% fewer pedestrian fatalities than the 3 calendar years immediately before the law.

Fig 3. All road injuries, South Austral



A drop in all road casualties (attributed to speed cameras, the introduction of a .05 blood-alcohol limit and a general economic downturn) also coincided with South Australia's helmet law (Fig 3).[7] The 3 calendar years post-law had 33% fewer pedestrian fatalities/serious injuries than the 3 calendar years pre-law.

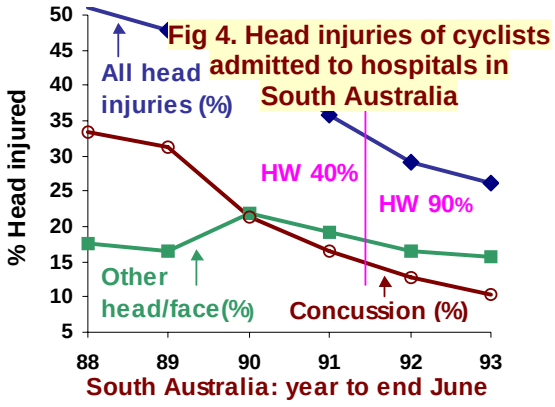
2.1 Evaluation of helmet laws

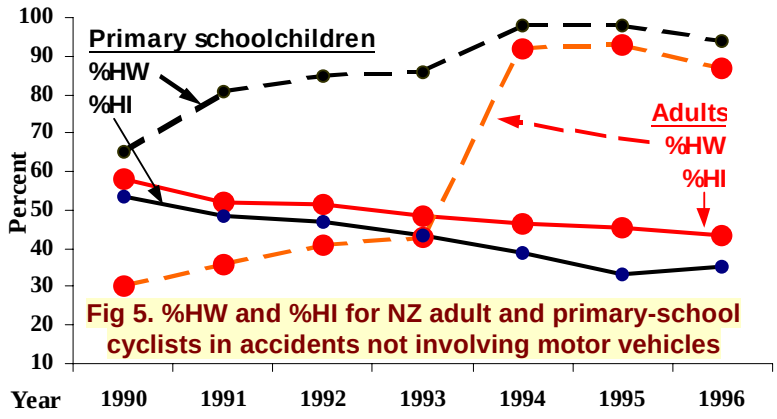
To avoid mistaking reductions in the total number of injuries (from safer roads or less cycling) with effects of increased helmet wearing, my review focused on percentages of cyclists with head injuries (**%HI**) in jurisdictions where enforced laws increased helmet wearing by at least 40 percentage points within a year.

A literature search revealed 6 jurisdictions satisfying the above: New Zealand, Nova Scotia (Canada), and four Australian states – Victoria, New South Wales (**NSW**), South Australia (**SA**) and Western Australia (**WA**). Most commonly, HI cases were classified as admissions to hospital with head wounds, skull/facial fracture, concussion, or other intracranial injury. Appendix Table 1 provides details of head injuries and sources of the data.

2.2 Effects on helmet wearing and head injuries

In **South Australia (SA)** percent helmet wearing (**%HW**) of commuter cyclists increased from 49% (1991) to 97% (1992) and 98% (1993).[7] Household surveys showed self-reported %HW increased from 15%-91% (cyclists ≥15 years) and 42%-84% (under 15s).[7] Head injury data were classified into concussions and other head and face injuries (Fig 4). A clear declining trend is evident for concussions. Similar trends were noted for other road users, and explained: "*the procedure for patients with a short episode of concussion has changed in that such patients are not now admitted routinely*."[7] However, there is no obvious departure from the overall trend in response to the substantial increase in %HW, suggesting that the law had little or no effect on %HI.





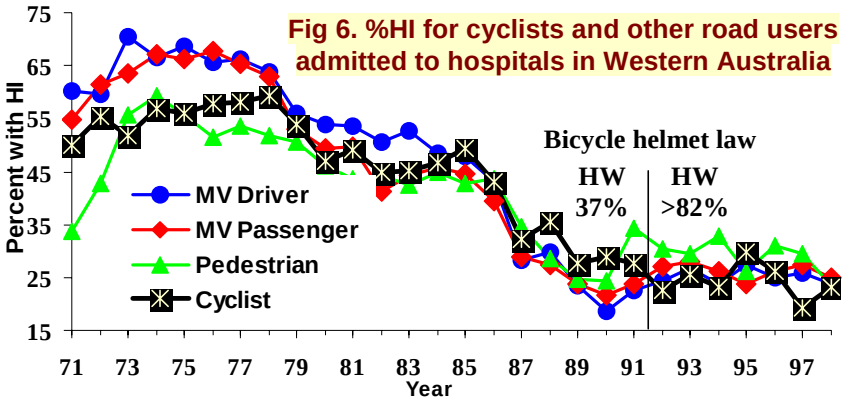
In **New Zealand**, most primary-school children were already wearing helmets (Fig 5),[8] but adult %HW increased from 43%-92%.[8 9] If helmet laws were effective, %HI of adults should have fallen substantially more than primary-school children. In fact, both had similar declining trends (Fig 5), implying that the substantial increase in adult helmet wearing was of very little benefit.

In **Western Australia**, helmet wearing increased from negligible levels before 1980 to about 37% just before the law that increased it to 82%.[10] The most dominant feature in %HI (Fig 6) is a declining trend common to all road users. Such trends appear to be widespread, e.g. the almost identical declining trends for cyclists and pedestrians in the UK[11] and Victoria.[12] Early analyses created considerable confusion by ignoring such trends,[13 14] mistakenly assuming increased helmet wearing was the only possible cause of declining %HI.

A large proportion of cyclists in WA were injured in bike-only crashes, so there is no reason to believe that, without the helmet law, %HI of cyclists would have followed the same trend as pedestrians (which increased

from 1990 to 1991 for no apparent reason). When cyclists' %HI is compared to that of all road users, there is little or no evidence of any benefit from the helmet law.

Fig 6. %HI for cyclists and other road users admitted to hospitals in Western Australia



In **Nova Scotia**, Canada, there was a downward trend in numbers of child cyclists with HI admitted to hospitals in the 3 pre-law years (29, 23 and 7 cyclists) increasing to 13 in 1997/98, the year helmets became compulsory.[15] The observational surveys were designed to measure %HW, not cycle use, but substantially fewer cyclists were counted post-law. Even before the helmet law (1995/96), only 3.6% of cyclists seeking emergency treatment at a health centre had head injuries. The downward trend was non-significant and started before the law, so there is no convincing evidence that it was caused by increased helmet wearing.

New South Wales (NSW). Fig 7 shows %HI for adults in NSW and children under 16.[12] Enforcement increased adult %HW from 26% (September 1990) to 77% and 85% (April 91 and 92).[16] There was no response in %HI. Trends from 1989-90 and 1992-93 (when %HW did not change) were as large as the years surrounding the law. For children under 16, there could be a potentially small effect in %HI, but *total injuries increased* relative to overall road safety conditions and the amount of cycling.[12]

In Victoria, the official analysis of 3 years post-law data found %HI was no different to that predicted from pre-law trends.[17] A subsequent analysis of 4 years data, cited as significant evidence for legislation,[18] reported *numbers* of head injuries were 40% lower than before the law.[19] However, the authors explained they could not tell whether the main cause was increased helmet wearing or reduced cycling because of the law.[19] Fig 8 shows non-head injuries fell by almost as much as head injuries. This strongly suggests the main mechanism was reduced cycle-use, with perhaps some benefit from the measures to reduce speeding and drink-driving.

Fig 7. %HI for child cyclists (<16 years) and adults admitted to hospitals in NSW

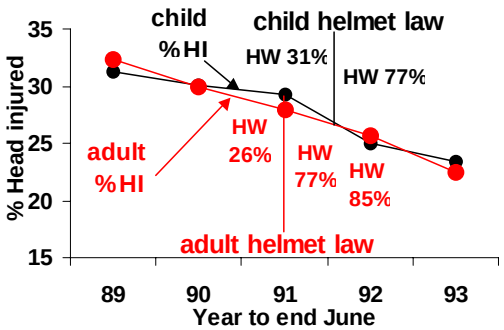
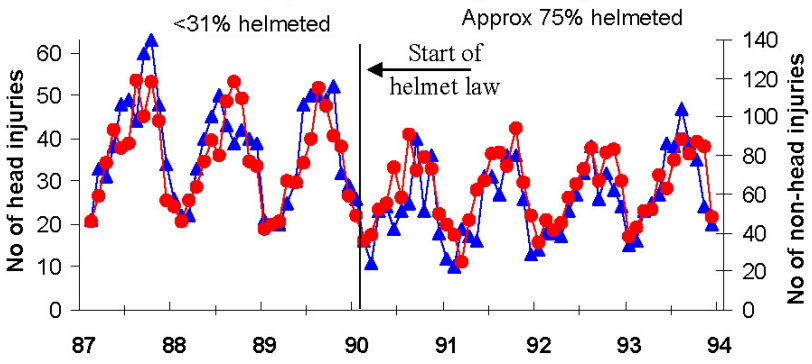


Fig 8. Numbers of cyclists admitted to hospitals in Victoria with (▲) and without (●) head injuries



2.3 Effect on numbers of cyclists

The obvious reduction in non-head as well as head injuries (Fig 8) strongly suggests that Victoria's helmet law discouraged cycling. Additional evidence was provided by comprehensive surveys designed to assess the amount of cycling in the capital city, Melbourne.[20]

Table 1. Number of cyclists counted (N) and wearing helmets (NH) in Melbourne, Victoria, pre-law (May 1990) and in years 1 and 2 of the helmet laws (May 1991 and 1992; from Finch *et al.* 1993)[20]

Year	Pre law		1st law year		2nd law year	
	N	NH	N	NH	N*	NH
Child cyclists	1554	442	905	485	994	637
Change from 1990			*-649*	*+43*	*-560*	*+195*
Adult cyclists	1567	564	1106	818	1484	1247
Change from 1990			*-461*	*+254*	*-83*	*+683*
All cyclists	3121	1006	2011	1303	2478	1884
Change from 1990			*-1110*	*+297*	*-643*	*+878*

*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, a total of 27% fewer cyclists were counted in 1992 than 1990.

Table 2. Counts of child cyclists in NSW before and in the first 2 years of the bicycle helmet law (from Walker, 1992; Smith & Milthorpe 1993).[16 21]

Location	1991(Pre law)		1st law yr (1991)		2nd law yr (1992)	
	N	NH	N	NH	N	NH
Road Intersections	1741	440	1188	874	881	582
Change from 1991			*-553*	*434*	*-860*	*142*
Recreational areas	1742	709	1236	899	1184	872
Change from 1991			*-506*	*190*	*-558*	*163*
School gates	2589	761	1433	1156	1349	1025
Change from 1991			*-1156*	*395*	*-1240*	*264*
Total child cyclists	6072	1910	3857	2929	3414	2479
Change from 1991			*-2215*	*1019*	*-2658*	*569*

N = number of cyclists counted; NH= number wearing helmets

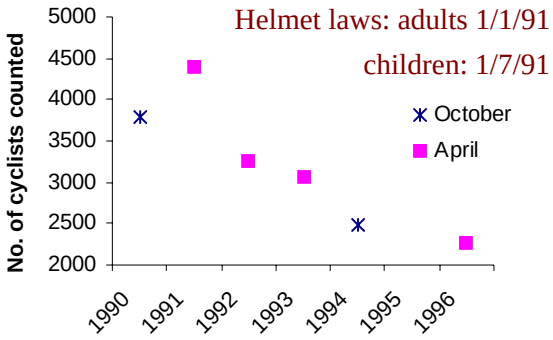
64 sites (chosen as a representative sample of the roads) were observed for two 5-hour periods sampled from 4 time blocks of weekday morning, weekend morning, weekday afternoon and weekend afternoon, a total of 640 hours.[20] There were identical surveys in May 1990, 1991 and 1992.[20] The weather was similar, with 1992 slightly better than 1990 and 1991 slightly worse. In 1990, 442 children wore helmets voluntarily (Table 1). With the law, 43 more wore helmets, but 649 fewer were counted.[12 20] This supports the evidence in Fig 8 that the main effect of the law was to discourage cycling, rather than encourage helmet wearing. Compared to before the law, 42% fewer child and 29% fewer adult cyclists were counted.

Large declines were also noted in identical surveys in NSW. Before the law, 1910 children were observed wearing helmets (Table 2). In the first and second years of legislation, 1019 and 569 more children wore helmets, but 2215 (36%) and 2658 (44%) fewer were counted.[12]

Automatic counters in Perth, WA averaged 16326 cycle movements/week in October-December 1991 (pre-law). The same months post-law had 13067 (1992), 12470 (1993) and 10701 (1994) movements/week, reductions of 20%, 24% and 35%.[12] Recreational use was assessed by counts on Sundays with fine weather. Average daily counts fell by 38% from 1662 (Oct-Dec 1991), to 1026 (Oct-Dec 1992).[22]

This was not a transient decline. There is no evidence that cycling "recovered". Fig 9 shows a series of counts over 6 years at 25 sites in Sydney. Both adult and child cyclists were counted.[23] Two surveys (1990 and 1994) were in October, the other four in April. More cyclists were observed in April than October, perhaps because autumn weather may be more conducive to cycling. However, by 1996, there were 48% fewer cyclists than 1991. This is in complete contrast to the situation before the law, when, in the Sydney metropolitan area "cycling increased significantly (+250%) in the 1980s".[24]

Fig 9. Numbers of cyclists (children and adults) counted at 25 sites in Sydney (Walker, 1996)[8]



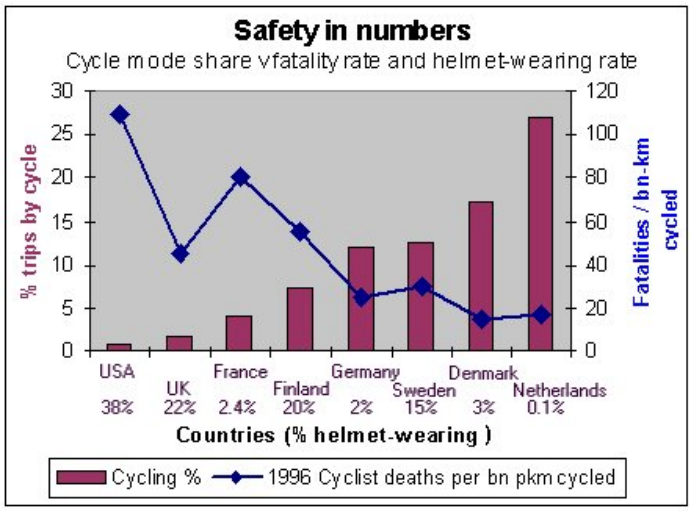
Before helmet laws, cycling was increasing. Australian census data show cycling to work increased by 47%, from 1.11% (1976) to 1.63% (1986). There is no reason to believe this trend wouldn't have continued without the laws. Indeed, the average proportion cycling to work in states without enforced helmet laws increased in 1991, but declined on average in other states. By 1996 when all states had enforced laws, only 1.19% of journeys to work were by bike, with a similar proportion in 2001. People often cited helmet laws as a reason for not cycling. The equivalent of 64% of adult cyclists in Western Australia said they'd ride more except for the helmet law. In New South Wales, 51% of schoolchildren owning bikes, who hadn't cycled in the past week, cited helmet restrictions, substantially more than other reasons, including safety (18%) and parents (20%).[1]

3. Safety in Numbers

Countries where cycling is safest – those with low fatality rates per cycle-km – typically have high cycling rates but low helmet wearing. The phenomenon is known as 'Safety in Numbers.' The graph shows that a non-helmeted cyclist in Denmark or Holland is many times safer per cycle-km than a helmeted cyclist in the US. This pattern is also reflected in injury statistics. US cyclists with 38% helmet wearing suffer 30 times as many injuries per million cycle km as Dutch cyclists with 0.1% helmet wearing.[25]

Thus at best, the benefits of helmets are too small to be apparent in across-country comparisons. At worst, helmet laws reduce Safety in Numbers and distract attention away from what's really important, reducing the risk of bike/motor vehicle collisions, the cause of the majority of debilitating head injuries to cyclists.[26]

The Safety in Numbers comparison holds not only for across-country comparison, but within countries.[27] Fig 10 shows that Australian states with the most cycling also have the least fatalities per cycle km.[28]



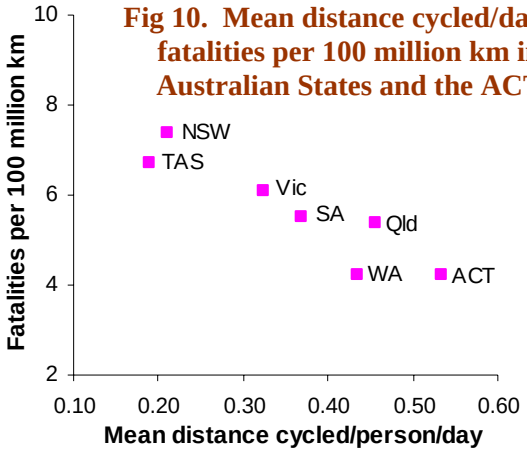


Table 3. TAC (Transport Accident Commission) data for average numbers of deaths and serious head injuries (DSHI) and all serious injuries (ASI) per year in Victoria

Injuries due to collisions with motor vehicles (average number per year)	Cyclists			Pedestrians		
	DSHI[1]	ASI	%DSHI	DSHI	ASI	%DSHI
Pre-law (1988/90)	72.5	274.0	26.5	285.5	828.0	34.5
Post-law (1990/92)	41.0	165.0	24.8	211.0	660.0	32.0
2 post-law yrs as % of 2 pre-law years	56.6	60.2	93.6	73.9	79.7	92.7
Adjusted for 31% fall in cycling	82.3	87.6				

[1]DSHI as defined by TAC (skull fracture or brain injury excluding concussion).

There is some evidence of increased injury rates following helmet laws. For example, after adjusting for the 36% fall in child cycling, the helmet law in NSW resulted in an increased injury rates per child cyclist relative to child pedestrians.[12]

Table 3 implies that Victoria's helmet law also reduced Safety in Numbers. There were 73.9% as many deaths or serious head injuries to pedestrians in the two years post-law as the previous two years. With 36% and 27% fewer cyclist in the first and second years of the law (an average of 69% fewer over the 2 years), even if helmets had no benefit whatsoever, we would expect deaths and serious head injuries to fall to (69% x 73.9% = 52% of pre-law numbers simply because of the decline in cycle-use and the safer road conditions enjoyed by pedestrians. Table 3 shows that the reduction for cyclists was only 57% – less than would be expected if helmets had no benefit whatsoever. This implies that the average cyclist in Victoria had a higher risk of death or serious injury than would have been expected without the helmet law.

Cycling is beneficial to health. In Denmark (where only about 3% of cyclists wear helmets), the modest amount of daily cycling needed to ride to work reduces mortality by 40%.[4] A report from the British Medical Association estimated that on average regular adult cyclists have a fitness level equivalent to non-cyclists aged ten years younger.[29] A UK study of mainly non-helmeted cyclists found that the health benefits of cycling, measured in years of life gained, outweigh the injury risks, measured in years of life lost, by about 20 to 1.[30]

In the US, 71% of men and 61% of women are overweight or obese.[31] Regular exercise such as cycling improves health and reduces the risk of heart disease and brain damage from strokes, two of the three most common causes of death in western countries.

Reduced Safety in Numbers is yet another detrimental effect of helmet laws, to be added to the list of other detrimental effects such as risk compensation and lost health and environmental benefits.

4. "Enthusiastic Advocacy"

A team of researchers investigated the causes of all cyclist fatalities in Auckland, New Zealand. Multiple injuries were responsible for 84% of deaths to non-helmeted cyclists, so helmets would not have changed the outcome. Only one cyclist died of head injuries in a bike-only crash, the most likely situation where a helmet might help. That cyclist died despite crashing at moderate speed and wearing a helmet. The investigators concluded: "*This study indicates that the compulsory wearing of suitable safety helmets by cyclists is unlikely to lead to a great reduction in fatal injuries, despite their enthusiastic advocacy*."[32]

From a cyclist's point of view, the phenomenon of "enthusiastic advocacy" for helmets and helmet laws is hard to understand. Below are some examples of "enthusiastic advocacy" (**EA**) and information showing that the claims are incorrect.

EA claim: "helmets prevent 85-88% of critical head and brain injuries[3]"

Although one study (published in 1989) reported an odds ratio (**OR**) of 0.15,[33] the research turned out to be seriously flawed. A detailed critique can be found at: http://www.cyclehelmets.org/mf.html?1131 But even an unbelievably low OR of 0.15 would not mean that helmets prevent 85% of head injuries. As explained in a recent peer-reviewed paper,[34] an OR of 0.15 is equivalent to helmets preventing 84% of head injuries in crashes so minor that only 5% of non-helmeted cyclists are head injured. However, in serious high-impact crashes where 99% of non-helmeted cyclists suffer head injuries, the same OR of 0.15 is equivalent to helmets preventing a mere 5% of head injuries.

Hospital data provide a simple reality check. An Australian study reported that 28.6% of approved helmet wearers over 18 who were admitted to hospital had head injuries (excluding face), as did 50% of helmeted cyclists hitting their heads after a collision with a motor vehicle.[35] If approved helmets prevented 85% of all such injuries, the rate for non wearers should have been 191% and 333%. It is not clear why "enthusiastic advocates" would be unfamiliar with this well-known study (which is almost certainly typical of head injury rates of helmeted cyclists in most hospital admissions data) or incapable of understanding this logic.

Nearly all studies concluding that helmets were beneficial compared self-selected groups (such as cyclists who chose to wear helmets *vs* those who did not). Similar methods were used to assess the benefits of hormone replacement therapy (**HRT**). A systematic review of 30 studies, comparing women who chose to take HRT with those who did not, concluded that HRT halves the risk of heart disease. Other more reliable studies (where volunteers were assigned randomly to HRT and control groups) proved beyond doubt that long-term use of HRT does not reduce the risk of heart disease. Women who chose to take HRT probably had generally healthier lifestyles and this, not HRT, was the main reason why they had less heart disease.[36]

There is no reason to believe that studies comparing cyclists who chose to wear helmets with those who did not are any more reliable than the studies of HRT. Cyclists who chose to wear helmets were observed to be more cautious than non-wearers, more likely to obey traffic regulations,[37] use lights at night, wear high visibility clothing,[38] ride away from traffic[39] and suffer a higher proportion of bike only crashes.[40]

The largest study of helmets involved 3390 cyclists treated in emergency rooms. Only 27% of head injuries involved concussion or other brain injury and only 62 cyclists (1.83%) had brain injuries of severity >AIS2, with a majority (34 out of 62) being caused by bike/motor vehicle collisions.[40] Helmets clearly prevent wounds to the head. Given the small number of serious head injuries in this study, it would be difficult to be certain whether helmets or crash circumstances (non-helmeted cyclists were 41% more likely to be involved on collisions with motor vehicles) was the main cause of the somewhat lower percentages of helmeted cyclists with concussion or other brain injury. It is also interesting to note that the raw data (e.g. 37% fewer concussions or other brain injuries for helmeted vs non-helmeted cyclists aged 20 and over) bear very little resemblance to the claims of enthusiastic advocates.

The paucity of evidence on serious brain injuries from studies comparing self-selected groups should be contrasted with the substantial amounts of data (10,479 head injuries serious enough to be listed in hospital

admissions databases) in the systematic review of helmet laws. Because they are derived from much greater numbers of cyclists, include other consequences such as risk compensation and reduced Safety in Numbers, and avoid the problem of comparing self-selected groups, helmet law data should be considered more reliable.

EA claim: "Every $1 spent on helmets saves $30 in medical expenses"[3]

Estimated head injury reductions from New Zealand's helmet law ranged from zero (if trends were fitted in the model) to about 19% (ignoring trends). A peer-reviewed paper calculated the saving in hospital costs. The most optimistic estimate for a helmet bought to satisfy the law was a saving of NZ$0.65 over its 5-year lifespan, i.e. 13 cents per helmet per year.[41]

Again there seems to be a vast difference between what happens in reality and the claims of "enthusiastic advocates".

EA claim: "Head injuries to child/youth cyclists 25% lower in Canadian provinces with helmet laws"[42]

Enthusiastic advocates point out that head injury rates were lower in helmet-law provinces, but omit the fact that *non-head* injury rates were also lower, suggesting that much of the difference could be due to fewer cyclists or safer roads. A simple way of allowing for differences in the amount of cycling is to consider %HI, which was 32.6% in 1997/98, in no-law provinces. If helmets prevented 25% of head injuries, %HI in helmet-law provinces should have been 24.5%. In reality it was 29.0% only 3.6 percentage points less than no-law provinces. Thus most of the 25% difference was not due to differences in helmet wearing.

Helmet-law provinces enjoyed substantially greater improvements in road safety, as shown by the greater declining trends in serious or fatal pedestrian injuries (Fig 11). Interested readers will contrast the trends for pedestrians with those for cyclists (Fig 12). Does Fig 11 for pedestrians represent a more convincing effect of helmet laws than Fig 12?

Fig 11 (from Transport Canada, 2004). Serious or fatal Pedestrian injuries, Law vs No-law Provinces

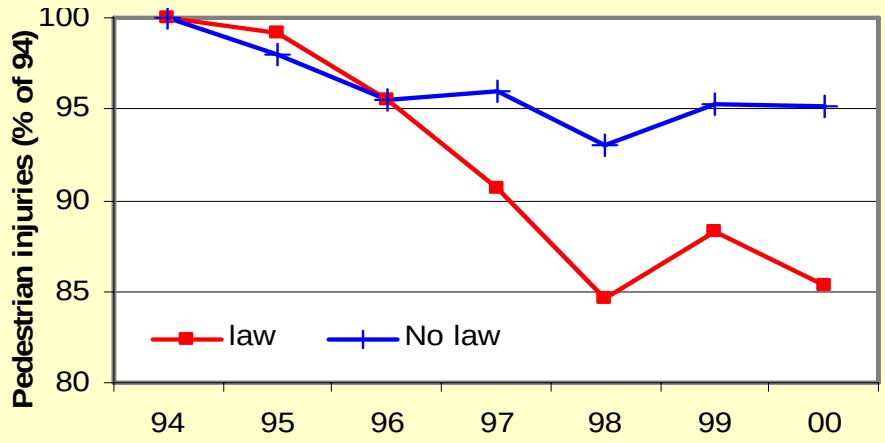
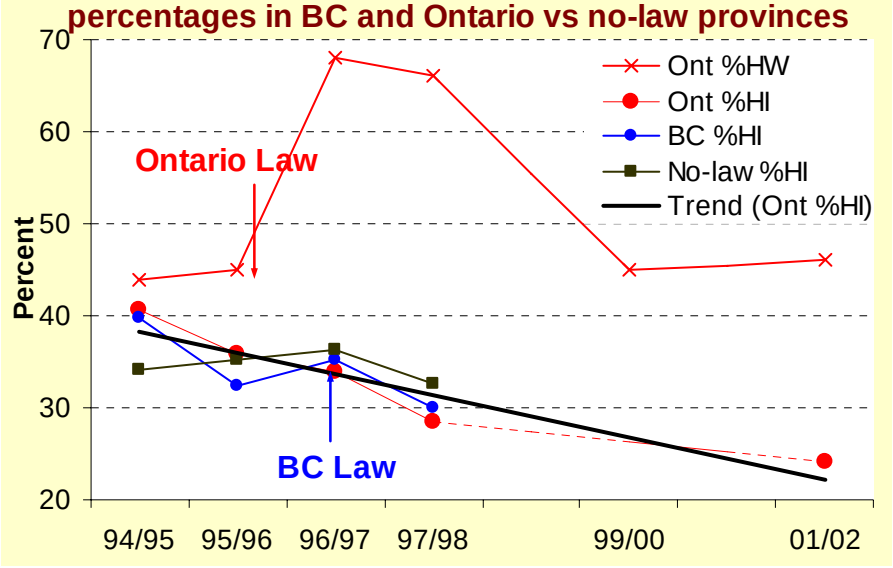


Fig 12. Helmet wearing (%HW) and head injury (%HI) percentages in BC and Ontario vs no-law provinces



To be convincing, changes in %HI should happen in response to the change in helmet wearing. Fig 12 shows that this was not the case. The greatest decline for British Columbia (BC) was a fall of 7.4 percentage points from 1994/95 to 1995/96. %HI actually increased the following year when the law was introduced (September 1996). Similarly, the greatest decline for Ontario (5.4 percentage points) was from 1996/97 to 1997/98, when helmet wearing was starting to decline. The fact that increased helmet wearing did not cause the trends is confirmed by noting that the lowest %HI injury rates in Ontario were for 2001/02 when helmet wearing had returned to pre-law levels.[34]

EA claim: Helmet laws reduce head injuries and deaths without a decline in cycling (Appendix 2)

Section 2.3 lists some very convincing evidence that helmet laws discourage cycling. Observational surveys (at the same sites, observation times and time of year) showed large declines in numbers of cyclists counted; hospital data also showed a large and immediate drop in the number of non-head injuries (strongly suggesting that cycle-use declined substantially, see Fig 8). In addition, some investigators actually asked cyclists if the helmet laws discouraged them from cycling. A significant proportion said the laws were a deterrent. Amazingly, "enthusiastic advocates" are not prepared to believe cyclists who say helmet laws deter them from cycling. Yet this is perhaps the most relevant useful information. The true effect of a helmet law is the difference between current levels of cycling and *how much there would have been without the law*. Even if cycling increases, the law might still have deterred cycling, if the increase would have been larger without legislation.

One survey in Canada (that did not use the same sites and observation times every year) reported huge variation in numbers counted. Helmet wearing increased temporarily, then returned to pre-law levels by 1999, which was a particularly sunny summer with the highest number of cyclists per hour. More detailed research would be needed to determine if non-enforced laws that don't increase helmet wearing deter some people from cycling. However, the majority of children in that Canadian study disobeyed the law, so perhaps the most significant consequence was to teach children that road safety laws need not be obeyed.

EA claim: "There is no credible scientific data to support this 'risk compensation' theory"[42]

In an attempt to support this claim, Safe Kids Canada cites a study that tried to compare risk-taking behaviour of Canadian children who chose to wear protective equipment (such as helmets and wrist guards) with non-wearers. It concluded that use of protective equipment did not increase children's risk taking.[43]

However, a peer-reviewed study that examined the behaviour of children running an obstacle course either wearing or not wearing a helmet and wrist guards found a 51% increase in risky behaviour (trips, falls and bumping into things) if a helmet and wrist guards were worn.[44]

The study Safe Kids cites is another example where totally incorrect results were produced by comparing self-selected groups. The results of direct measurement, either of risk compensation or the effects of helmets laws, are more credible. In this case, direct measurement supports the strong evidence from many other activities that people naturally tend to take more risks when wearing protective equipment, including helmets.

EA claim: 47% of cyclists treated in emergency rooms have traumatic brain injuries (Appendix 3)

In studies of cyclists treated in emergency rooms, the proportion of cyclists with head injury varied from 3.6% pre- law in Nova Scotia (see Appendix 1), 8.4% (non-helmeted cyclists in Seattle with concussion or other brain injury, 18% of crashes involving motor vehicles[40]) to 11% in the UK (28% of crashes involving motor vehicles[45]). Although there is some variation in %HI (perhaps depending on the proportion of cyclists involved in bike/motor vehicle collisions, which in the UK accounted for the majority of head injuries to adults and half of all head injuries), the claim that 47% of cyclists treated in emergency rooms have traumatic brain injury is absurd.

EA claim: "A systematic review … found that helmets reduce fatal injuries by 73%"[46]

The "systematic review" lists 6 studies that mention helmet wearing of 47 fatally injured cyclists as well as %HI of others seeking emergency room or hospital treatment. The proportion that died of head injury is not reported (though original studies report other causes of death). The review did not consider reasons why groups receiving emergency treatment might have had higher %HW, e.g. injured helmet wearers being less likely to have been hit by motor vehicles, or differences in age, riding style or socioeconomic status.

The cause of death is vitally important, because, as noted earlier, the study in Auckland reported that 84% of cyclists' deaths were due to multiple injuries and so could not have been prevented by helmets. Detailed research into the causes of fatal injuries to Australian cyclists also found that most deaths to non helmeted cyclists could not have been prevented by helmets because they involved multiple injuries, high impact speeds or rotational injuries.

Simply put, if, on average, about half of cyclists' deaths are due to head injury, helmets cannot possibly prevent 73% of fatalities. As noted earlier, comparisons of self-selected groups (e.g. cyclists who chose to wear helmets vs those who did not) can produce highly biased and misleading results.

More reliable data is available by examining the cause of death of fatally injured cyclists in Australia. In 1988 (when very few cyclists wore helmets), 47% of cyclist deaths were due to head injury. In 1994 (with 80% helmet wearing), 50% of cyclist deaths were due to head injury. In fact, comparing 1988 with 1994, cyclist, pedestrian and all road deaths fell by 35%, 36% and 38% respectively; head injury deaths by 30%, 38% and 42% respectively. The decline for cyclists was less than other road users.[47] This suggests that, given the fall in cycle-use, the risk of fatal injury per cyclist increased relative to other road users.

A substantial proportion of helmet wearers die of head injury. The Australian law is more strongly enforced for adults than children and this is reflected in fatality data; a higher proportion of fatally injured children were not wearing helmets than fatally injured adults. In 1988, when helmet wearing rates were negligible, children

were more likely to die of head injury (58% vs 43%) than adults. A recent report provided information on helmet wearing of 48 fatalities – "about" a third of the 30 helmet wearers and "about" half of the 18 non-helmeted cyclists died of head injury.[48] It is not known if this small difference was due to differences in crash circumstances, that the majority of non-wearers were children, or helmets.

Nonetheless the data again demonstrate how ridiculous it is to claim that helmets can prevent 73% of fatalities if a third of helmeted cyclists still die of head injuries, and the rate of head injury deaths in non-helmeted cyclists is only marginally higher and possibly due to other factors.

Other "Enthusiastic Advocacy" claims

Other "enthusiastic advocacy" claims abound. An early evaluation of helmet laws, published in an international peer-reviewed journal, stated: "*(TAC) insurance claims from bicyclists killed or admitted to hospital after sustaining a head injury decreased by 48% and 70% in the first and second years after the law ... the injury data also showed a 23% and 28% reduction in the number of bicyclists killed or admitted to hospital who did not sustain head injuries*"[49]

In fact, there were equally impressive 29% and 75% reductions in numbers of *pedestrians* with concussion in the first and second years of the helmet law. The law did not cause the reductions for pedestrians, so there is no reason to believe it caused the reductions for cyclists. Unfortunately "Enthusiastic advocates" such as Alison Macpherson continue to create confusion by citing this study as evidence that "Helmet laws have been shown to be effective in reducing head injuries in published studies from around the world".

This problem is widespread. The Cochrane review of Thompson, Rivara and Thompson[50] states: "The number of bicyclists admitted to the hospital with a head injury decreased by 40% in Victoria during the first four years after legislation (Carr 1995)." Fig 8 confirms the clear reduction in head injuries due to legislation. However, by not mentioning the concurrent drop in *non-head* injuries, the “enthusiastic advocate” authors of the Cochrane review give the false impression that the entire reduction was due to increased helmet wearing. This creates considerable confusion. Other organisations may not have time to read the original reports and, unaware of the substantial reduction in non-head injuries indicating the main effect of the law was to discourage cycling, lobby for helmet laws.

As well as claiming reductions of 48% and 70% in head injuries, the abstract of the early evaluation paper stated: “*Surveys in Melbourne also indicated a 36% reduction in bicycle use by children during the first year of the law and an estimated increase in adult use of 44%*"[49]

The counts from that survey data (Table 1) show 29% *fewer* adults cyclists May 1991 than May 1990. So why claim that adult cycling increased by an estimated 44%? Cycle use was estimated from the time cyclists took to ride through marked areas. But in 1990, adult cyclists were counted, but not timed. This should not preclude adult cycle use from being estimated, because numbers counted and estimates of cycle use are strongly correlated. For example, the first post-law survey found a decline in cycle use by teenagers of 44%, little different from the 48% drop in numbers counted. This implies that the 29% decline in number of adults counted is a valid and reasonable estimate of the change in adult cycle use.

But instead of reporting this direct estimate, the authors claimed “the 1990 survey did not cover adult bicyclists”. The claimed 44% increase in adult cycle use was obtained by comparing the post-law survey with a much earlier survey (1987/88) at a different time of year. However, as can be seen in Fig 8, cycle use has a marked seasonal variation, so the claimed “estimated 44% increase” is totally invalid. If the same “trick” of ignoring data from 1990 had been carried out for teenagers, the authors could have claimed the law reduced teenage cycle use by a mere 8%, instead of the 44% actually observed!

It is difficult to understand why the results were reported in this way, except to speculate that government-funded organisations were under considerable pressure to produce evidence to justify the laws.

The paper has other flaws, for example, its Figure 7 reports estimated bicycle use of about 60 million hours per week,[49] which for a city of 3 million, equals 20 hours of cycling per week for every man, women and

child in the city! Despite these flaws, “enthusiastic advocates” continue to cite it as evidence of the benefits of helmet laws, arguing that all governments should to pass similar legislation.

5. Conclusions

Reaching a consensus in the presence of such "enthusiastic advocacy" represents a considerable challenge to the cycling community.

Appendix 2 illustrates the efforts expended by Safe Kids in providing example letters which the public can sign and send to their local and state politicians. The letter for Quebec states: “A cross-Canada study by Dr. Alison McPherson and colleagues …” The incorrect spelling of “Macpherson” suggests the letter might have been written by someone who had not read the original paper. Claims that 4 out of 5 head injuries could be prevented if every cyclist wore a helmet stand in stark contrast to the reality of the Australian data, with little or no detectable effect when helmet wearing increased from a pre-law average of 35% to a post-law average 85%.

Safe Kids’ well-resourced advocacy program, funded by Johnson & Johnson, includes “letter writing, public speaking, working with the media, collaborating with other groups who can help to influence policy and meeting with decision-makers.” Volunteers probably speak at public meetings, encouraging people to visit the website and contact their politicians, perhaps by clicking the link to send a fax. Legislators who believe the claim that 4 out of 5 head injuries could be prevented if every cyclist wore a helmet are likely to vote for helmet laws.

Cycling advocacy groups may need a similarly well funded campaign to present the common-sense point of view. Ideally funding should be sought for additional investigations. For example, by separating the Australian data by severity of injury (severe brain injury, concussion or no brain injury) and motor vehicle involvement, it may be possible to gain further insights into the effects of legislation. Similarly, given the wealth of information available on head injuries to all road users in Canada, it may be possible to gain more insights into helmet laws by comparing %HI of cyclists and pedestrians.

The need to encourage cycling for health and environmental reasons (including reducing greenhouse gas emissions) is now recognised by funding bodies and government agencies. Perhaps they might be prepared to provide some much-needed funds to obtain and analyse additional data that might help formulate realistic policies to enhance the safety and popularity of cycling.

A peer-reviewed paper published in Accident Analysis and Prevention lists seven conditions necessary for helmet laws to be considered beneficial.[34] The first condition is that any legislation (including helmet laws) should not be enacted unless the benefits can be shown to exceed the costs. Ideally, the benefits should be greater than from equivalent ways of spending similar amounts of money on other road safety initiatives.

Despite the claims of enthusiastic advocates, there is no evidence that helmet laws satisfy this condition. The lost health and environmental benefits of cycling and reduced Safety in Numbers probably outweigh any effects of increased helmet wearing.

Many cyclists will choose to wear helmets, especially if they do not find them uncomfortable or inconvenient. Based on their experience and riding conditions, cyclists can weigh up the risks, perhaps riding helmetless for a short trip to work or the corner shop, but making a different decision for a fast mountain descent. Allowing cyclists to choose represents the best of both worlds.

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Readers are invited to consult the Bicycle Helmet Research Foundation website (www.cyclehelmets.org) for other references, commentaries and detailed information on helmets and helmet laws.

Appendix Table 1 Dates of helmet laws and description of injury data.

Jurisdiction/publications	Source and description (ICD9 codes) of head and other injures (HI and OI)
South Australia (SA); Marshall and White[7] Helmet law 1/7/91	HI = hospital admission with principal diagnosis of skull fracture (800-802.1, 802.4-804.06) intracranial injury (850-854.16) or wound to the head (870-871, 873-873.39, 873.42, 873.52); concussions (850) were tabulated separately. OI = other admissions. Fig 1c reproduced, with permission, from Marshall and White.[7]
New Zealand; Povey et al.,[9] Robinson[8] Helmet law 1/1/94	HI = admissions with skull fracture (800–804), concussion or intracranial injury (850–855), OI = admission with limb fracture (810–829); excludes accidents involving motor vehicles.
Western Australia (WA); Hendrie et al.[10]. Helmet law 1/1/92	From 1988, HI = all hospital admissions with ICD9-CM injuries coded to the AIS body region of head. For 1979-87, HI = admission with skull fracture (800-804), intracranial injury (850-854), open wound to head (873.0-873.1), injury to blood vessels of head or neck (900) or injury to optic or other cranial nerves (950-951). To 1978, HI = IDC8 codes 800-804, 850-854, 873, 904, 950-951. OI = all other admissions.
New South Wales (NSW); Robinson[8] Adult law 1/1/91; <16 years 1/7/91	HI = hospital admissions with head injury (NSW Health classification); OI = admission with other injury; cyclists with both head and other injuries were included in both categories.
Victoria (Vic); Carr et al.[19] Helmet law 1/7/90	HI = any hospital admission with skull fracture (800-803), concussion/intracranial injury (850-854), open wound of ear or head (872, 873.0, 873.1, 837.8, 873.9).
Victoria; Robinson[28] bike-motor vehicle collisions	DSHI = death or hospital admission with skull fracture (800, 801, 803, 804) or intracranial injury excluding concussion (851-854). OI = other serious injury (599.7, 765.1, 802, 805-839, 860-869, 870.3, 870.4, 871, 878, 885-887, 895-897, 900-902, 940-957, 994.1, 994.7)
Halifax, Nova Scotia, Canada; Leblanc et al.[51] Helmet Law 1/7/97	HI = concussions, lacerations, dental injuries or other head injuries causing death or requiring follow-up, observation in the emergency department, admission to hospital or transfer to another health facility. OI = all treatments at the health centre except those listed above.

Appendix 2

Extract from: http://www.sickkids.ca/SKCPublicPolicyAdvocacy/section.asp?s=Bike+Helmets&sID=13748 and letter, available by clicking on the link for British Columbia

Bike helmet legislation is effective in increasing helmet use and reducing head injuries. It does not decrease the number of people who ride bikes. About 30 per cent of Canadians are covered by bike helmet legislation today. Six provinces currently have province-wide legislation, but only four cover all ages.

Put your Support for Helmet Legislation in Writing!

Send a letter to your local MPP and the Minister of Transport in your province or territory. This is important. Decision-makers need to be aware that Canadians support helmet legislation for all ages! Letters to all Provincial and Territorial Ministers are below.

Date:

Honourable Kevin Falcon
Minister of Transportation
Ministry of Transportation
PO Box 9055, Stn Prov Govt Victoria, British Columbia
V8W 9E2

Re: Support for all-ages bicycle helmet legislation, education and enforcement

Dear Minister Falcon,

I am writing to express strong support for the existing bicycle helmet legislation and to call on your government to support ongoing helmet use education and enforcement programs.

Research indicates that helmet legislation reduces head injuries and deaths among cyclists without causing a decline in bike riding[1]. Research also indicates however, that helmet use may decline several years following the introduction of legislation[2]. These findings point to the need for ongoing helmet education and law enforcement programs.

A head injury can permanently change the way a child or adult walks, talks, plays, and thinks. A properly fitted helmet helps protect your brain from absorbing the force from a crash or a fall cutting the risk of serious head injury by up to 85 percent[3]. This means that 4 out of 5 head injuries could be prevented if every cyclist wore a helmet[4]. Head injuries represent a significant economic burden to our citizens. These social costs far outweigh the price of helmets. Each dollar invested in a helmet saves 30 dollars in societal costs.[5]

Canadian surveys have found that the majority of people support bike helmet legislation for all ages[6]. I encourage the government to support helmet education and enforcement programs. If high levels of helmet use are sustained through education and enforcement of British Columbia's helmet law, then we will prevent more head injuries and avoid the significant medical and social costs of head trauma.

Signed,

Appendix 3

Extract from: http://www.usa.safekids.org/tier3_cd.cfm?content_item_id=24831&folder_id=301 (May 2007)

Editorial Calendar

270,000 Children Per Year Injured on Bikes

Each year, more than 130 children die from bicycle-related injuries and approximately 270,000 are treated in emergency rooms. Of these, nearly half (47 percent) have traumatic brain injuries. **Properly fitted bike helmets could reduce the risk of bike-related brain injuries by 88 percent**; however, only 15 percent to 25 percent of cyclists ages 14 and under wear a helmet. In many jurisdictions, children under age 16 are required by law to wear a helmet at all times while riding a bicycle.

May is **National Bike Month**, and Safe Kids Worldwide reminds parents and caregivers: A bike helmet is essential safety gear. Helmets could prevent an estimated 75 percent of fatal head injuries to children each year.