Cycle helmets: An overview of the evidence

This briefing sets out the case, backed by evidence, for not making cycle helmets compulsory in law or the subject of promotional campaigns. CTC's policy on cycle helmets can be found at www.ctc.org.uk/campaignsbriefings.

Key points:

- Cycling is hugely beneficial to people's health. Those who cycle regularly in mid-adulthood have a level of fitness equivalent to being 10 years younger, and have a life expectancy 10 years above the average.

- By contrast, the risks of cycling are not exceptionally high, and are very small relative to the health benefits. You are in fact less likely to be killed in a mile of cycling than a mile of walking. The Government estimates that the health benefits outweigh the risks of cycling on Britain's roads by a factor of 20:1 (n.b. estimates from other countries place this ratio higher still).

- Based on this 20:1 ratio, it can be shown that telling people to wear helmets would result in a net increase in early deaths (due to physical inactivity etc) if there was more than 1 person deterred from cycling for every 20 who continue, even if helmets were 100% effective at preventing ALL cycling injuries (i.e. not just head-only injuries). Once you factor in the proportion of serious and fatal cycling injuries that are not head-only injuries, and the at-best limited protection that helmets could provide (they are and only can be designed to withstand minor knocks and falls, not collisions with fast-moving cars or lorries), it can be shown that it only takes a fraction of a percentage point reduction in cycle use for pro-helmet policies to shorten a lot more lives than they could possibly save.

  In practice, the experience of enforced helmet laws is that cycle use typically falls by at least 30%, and more among teenagers. The resulting loss of cycling's health benefits alone (let alone its environmental, economic and societal benefits) is very much greater than any possible injury prevention benefit.

- There is in any case a good deal of controversy about the effectiveness of helmets. They are (and can only be) designed for minor knocks and bumps, not collisions with fast cars or lorries. There is also evidence that some cyclists ride less cautiously when wearing them, that drivers leave less space when overtaking helmeted cyclists than those without, that helmeted cyclists suffer 14% more collisions per mile travelled than non-wearers, and that helmets increase the risk of neck injuries. It is therefore entirely possible that helmet-wearing might have a net disbenefit even in safety terms (a point also suggested by some of the empirical evidence), not to mention the health and other disbenefits identified above.

- There is plenty of evidence that cycling gets safer the more cyclists there are. Denmark and the Netherlands are good examples of this "safety in numbers" effect, yet very few people in those countries wear helmets. The emphasis should be on maximising the benefits of more as well as safer cycling, though measures such as 20mph speed limits, better designed roads and junctions, good cyclist and driver training, tougher and better-enforced road traffic law, and tackling the threats from lorries. By contrast, telling people to wear helmets merely drives people into increasingly car-dependent sedentary lifestyles. This would shorten far more lives than cycling does, while undermining the "safety in numbers" effect for those cyclists who remain.

1. Introduction

CTC is not 'anti-helmet', and does not take sides on whether or not it is a good idea for individual cyclists to wear them. However, there is strong evidence that enforced helmet laws result in a substantial loss of the health and other benefits of cycling, without compensating benefits for cyclists' safety that would justify this. We also believe that there are better ways to improve cyclists' safety, and that the police service has more important priorities, including a stronger emphasis on traffic policing to improve road safety for everyone.

The evidence below shows why cycle use is likely to fall if legislation is introduced. We also highlight key groups, including socially excluded groups, who could be adversely affected if legislation goes ahead. Compulsion could also discriminate against members of minority racial and ethnic groups and against those who hold certain religious beliefs.

This briefing also weighs up the potential health costs and benefits of compulsion, and examines whether helmet legislation is a proportionate measure in the light of the low actual risk of serious injury or death in a cycle collision.

Finally, this briefing reviews the evidence on the causes of cycling injuries, and concludes that cycle safety could be more effectively improved if high quality cycle training was made available to all children, and investment made in measures that seek to create safe, attractive cycling conditions, including 20 mph speed limits on residential roads. These measures would also have the added benefit of increasing, rather than reducing, cycling levels.

2. Cycle helmet legislation: the impact on cycle use

a. The benefits of cycling

Cycling has a wide range of benefits for our own health, our neighborhoods, quality of life and the environment. It is also good for the economy. The health benefits specifically are discussed further in section 3 below. For more on cycling's wider benefits, see CTC's *New Vision* (www.ctc.org.uk/campaigns).

b. Reductions in cycle use due to helmet laws

Evidence from Australia and New Zealand suggests that large numbers of cyclists will be deterred from cycling by helmet legislation. In particular, there is specific evidence that helmet legislation has reduced cycling in the following groups of people:

- Cycle commuters
- Children cycling to school
- Teenage cyclists

The reductions in cycle commuters and children cycling to school are of particular concern because utility cycle trips, if stopped, are unlikely to be replaced with other forms of exercise and, in addition, are likely to be replaced with car journeys. This will contribute to rising levels of obesity, and have an economic cost (in terms of increased congestion) and an environmental cost (through increased pollution).

The evidence also suggests a particularly strong deterrent effect among teenagers. Teenagers are a key target group for efforts aimed at encouraging physical activity; if children can be persuaded to continue cycling as teenagers, the habit will last into their adult years. Conversely, those deterred from cycling as teenagers are much less likely to pick up the habit again.

Helmet laws, where enforced, have consistently led to substantial reductions in cycle use[1]. Reductions in the year following helmet laws include:

- a 36% reduction in New South Wales (29% among adults, 42% among children and as much as 90% among female secondary school pupils in Sydney[2];
- a 36% reduction among child cyclists in Melbourne (including a markedly steeper reduction of 44% among teenagers[3]);
- a 20% reduction in Perth (continuing to 30-40% below pre-law levels after 3 years[4]) and
- more than a 60% reduction in Nova Scotia[5].

Helmet laws elsewhere have had similar results[6].

Some countries or states have seen recoveries of mainly adult recreational cycling. However, where helmet law enforcement is maintained, cycle use remains low, particularly among children and/or for day-to-day journeys (e.g. for school or commuter travel). Cycling trips in New Zealand initially fell by 26% following that country's helmet law in 1994, but continued falling to 51% below their pre-law levels by 2006[7].

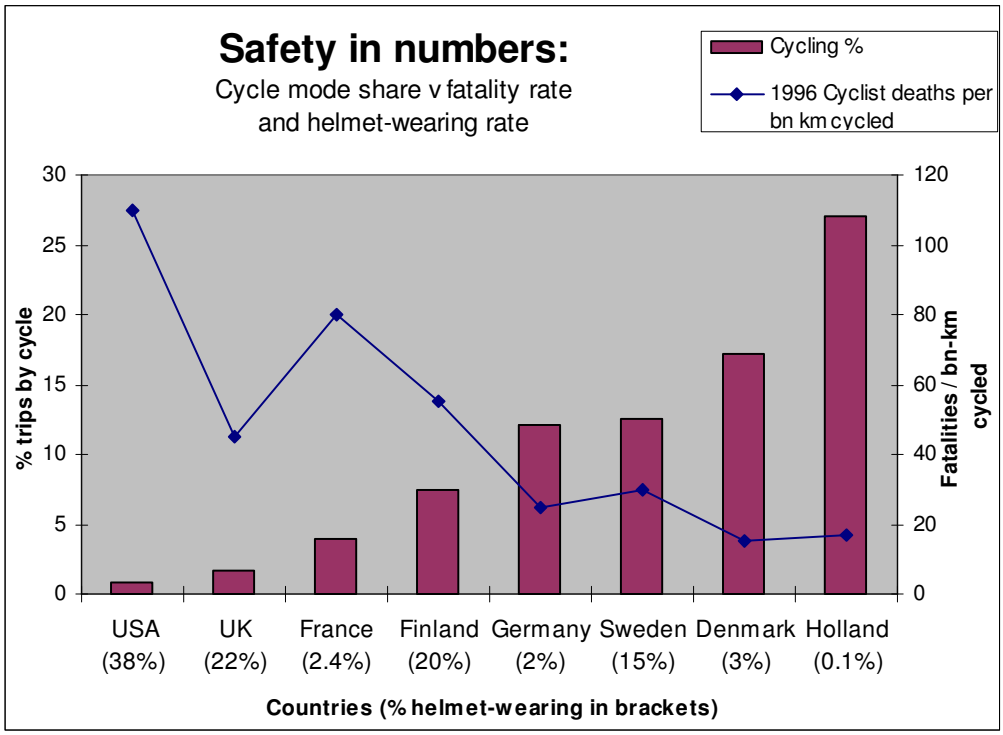
It is estimated that a total of 136,000 adults and children in New Zealand – nearly 4% of the total population – stopped cycling in the immediate aftermath of the introduction of cycle helmet legislation in 1994[8]. A high proportion of this figure was teenagers (13-17 years), who accounted for 47,000 of those who were stopped.

There is also evidence of sharp falls in cycle use among young people in the immediate aftermath of the introduction of legislation in New South Wales and Melbourne in Australia. In New South Wales, the law came into effect in January 1991 for adults and in July 1991 for children. Figures from a major study, involving pre-law and post-law counts at 120 locations, showed that there was a 49% fall in child (under 16 years) cyclists counted at road intersections and a 48% drop in child cyclists counted at school gates between 1991 (pre-law) and 1993. There was also a smaller but still significant 32% fall in recreational areas[9]. Thus, the greatest deterrent effect appears to have related to utility cycle trips made by children.

In Victoria State, which includes Melbourne, a cycle helmet law was introduced in July 1990. Another major study, involving counts at 64 locations in Melbourne, found that there was a 46% drop in the number of teenage (12 – 17 year old) cyclists in the wake of the implementation of the legislation, despite the fact that their numbers had been rising prior to the introduction of the law.

By contrast, three Western countries with some of the highest rates of cycling have relatively low levels of cycle helmet wearing. In the Netherlands, 27% of all journeys are carried out by bike and less than 1% of cyclists wear helmets. In Denmark, the proportion of journeys made by bike is 18%, and less than 5% of adults wear helmets. In Germany, 10% of trips are carried out by bike, and just 2% of adults wear helmets.[10]

The graph below is one of many examples of the 'safety in numbers' effect – the more cyclists there are, the safer it is to cycle[11] [12]. For instance, the last 10 years have seen a 117% increase in cycling on London's main roads, together with a 24% fall in absolute numbers of fatal and serious cycling injuries in the capital[13]. There is also evidence that the converse is also true, i.e. reductions in cycle use are associated with worse cycle safety[14].



High cycle use is related to a low cycle injury rate, despite low helmet-wearing rates in countries like Denmark and the Netherlands. The opposite applies in countries like the UK and USA. Note the similarities with the cycle use and obesity graph shown later.

c. The effects of helmet promotion campaigns

There is also evidence that even the voluntary promotion of helmet wearing may reduce cycle use. Research commissioned by the UK Department for Transport found that, in areas where a helmet campaign was held, *"a larger increase in helmet wearing was found than in the areas which had not held such a campaign. However, this increase was found to be strongly linked to a decrease in*

the numbers of cyclists observed: in those areas where a campaign had been held and the numbers of cyclists had increased, helmet wearing fell" (emphasis in the original)[15].

Similarly, a report for the European Conference of Transport Ministers (ECMT) noted that, *"From the point of view of restrictiveness, even the official promotion of helmets may have negative consequences for bicycle use, and that to prevent helmets having a negative effect on the use of bicycles, the best approach is to leave the promotion of helmet wear to manufacturers and shopkeepers"*[16].

Equally, any pre-law helmet promotion campaign might serve merely to bring forward the reduction in cycle use to before the law, rather than after it – indeed this may well have happened in the case of Canada's helmet laws. As the next section shows, there could still be very serious negative public health impacts from such a campaign, far greater than any possible benefits.

3. Is legislation a proportionate measure?

For anyone whose life has been affected by a fatal or disabling injury, it is a very understandable reaction to feel that anything that might have prevented the tragedy must be self-evidently desirable, and who would therefore strongly welcome a cycle helmet law.

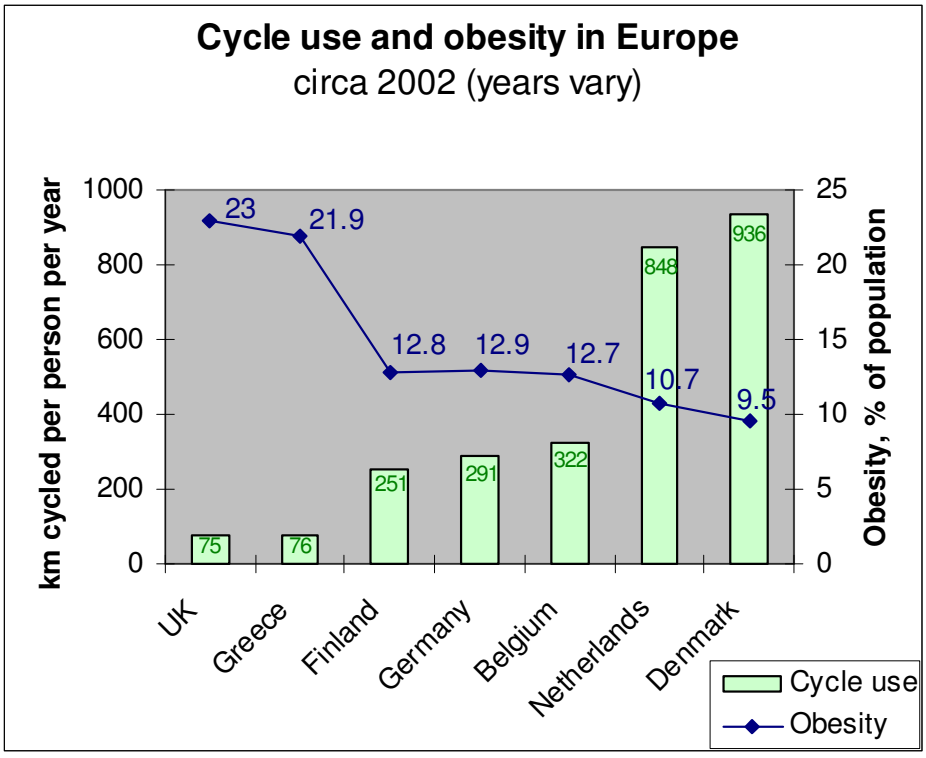
However, the introduction and implementation of all legislation, not least that pertaining to public health and safety, needs to be done on the basis of the available evidence. That must include an examination of the actual risks of serious head injury or death while cycling, vis-à-vis the health and other benefits lost if large numbers of people give up or are deterred from cycling as a result of any helmet legislation.

a. Health benefits of cycling

Cycling can confer considerable health benefits and can play a major part in counteracting obesity, which is currently increasing at an alarming rate and is a drain on the public purse. It is estimated that physical inactivity costs the UK economy £8.2 billion a year, while obesity represents a further economic cost of around £3.5 billion[17]. A *Foresight* report for the UK Government projected that, unless action is taken to address current trends, then by 2050 the costs to society due to overweight and obesity could rise to £49.9bn annually (in today's prices)[18].

The health benefits of cycling are substantial[19]. Cycling in mid-adulthood typically gives the fitness of a person 10 years younger[20], and a life expectancy 2 years above the average[21]. People who do not commute regularly by cycle have a 39% higher mortality rate than those who do[22]. Thanks to these extra life-years, the health benefits of cycling far outweigh the risks involved[23] – by 20:1 according to one estimate[24].

It is estimated that physical inactivity costs the UK economy £8.2 billion a year, while obesity represents a further economic cost of around £3.5 billion[25].



Although not demonstrably a causal relationship, international comparisons suggest an apparent link between cycle use and obesity rates.

Physical inactivity also contributes to heart disease and stroke, type 2 diabetes, various forms of cancer and arthritis. Cardiovascular disease is the UK's biggest killer, it is estimated that 2.6 million people in the UK suffer from the condition, and it causes 94,000 deaths annually[26].

Children are spending an increasing amount of time in cars. In England, nearly 40% of 5-10 year olds are driven to school, compared to 22% in the mid-1980s, while just 37% of all men and 25% of women are active at the levels recommended by the Chief Medical Officer of 30 minutes of moderate exercise per day for adults and 60 minutes for children[27].

The easiest and most acceptable forms of physical activity are those that can be incorporated into our everyday lives – cycling is well-suited for this purpose[28]. A study commissioned by the UK Department for Transport found that, when people who haven't previously exercised start cycling, they move from the least fit one third of the population to the fittest third of the population within just a few months[29].

For more on cycling and health, see CTC's briefing at www.ctc.org.uk/campaignsbriefings

b. How safe is cycling?

The evidence clearly shows that the risks of serious injury or death from cycle are relatively low. Mile for mile, the chances of being killed if you choose to cycle are about the same as if you choose to walk[30]; and young people aged 17-20 are more at risk of death during a mile of car travel than a mile of cycling[31].

One calculation, based on Australian data, concludes that cycling without a helmet carries only slightly more risk of death or serious injury per hour than driving[32]. It has also been estimated that the risk of injury per hour when playing football, squash, basketball or soccer is much higher than when cycling[33]. A further study found that the injury risk per hour is lower for cycling than for gardening[34].

Despite cycling being the second most common form of physical activity for children[35], it typically accounts for just 7-8% of the head injuries for which children are admitted to English hospitals[36]. Of these injuries, it is estimated that just a quarter were to parts of the head that might be protected by a helmet – and it is likely that some of these injuries were suffered by children who were wearing helmets anyway. Another UK-wide study found that cycling accounted for 10% of child injury admissions, but that pedestrians accounted for 36%, while falls accounted for a further 24%[37].

Nor are cyclists' injuries particularly likely to be head injuries, or to be serious, or both. Australian data suggests that the proportion of injuries requiring hospitalisation was about the same for cyclists (27.4%) as for drivers and pedestrians (28.5%)[38]. Among children admitted to hospitals in England in 2002-3, head injuries accounted for 37% of cycling injuries but 43% of pedestrian injuries (see ref 36). Danish data has shown that, compared with pedestrian and car occupant injuries, cycling injuries result in the shortest hospital stays and are least likely to be serious[39].

c. Helmet legislation: a net health benefit or cost?

In determining whether or not cycle helmet legislation is the right way forward, it is vital to factor in the health benefits of cycling – and the cost to both the health of individuals and to the health service should cycle use fall as a result of the legislation.

Using the World Health Organisation's HEAT (Health Economic Assessment Tool) methodology[40], CTC estimates that a UK-wide law would result in 263 extra deaths annually due to increased physical inactivity, and that the net public health cost would be £304-415m, even based on the UK Department for Transport study's estimate of helmet effectiveness (n.b. CTC does not accept this estimate). This excludes the costs to the remaining cyclists of purchasing helmets (we estimate this at around £180m initially, plus replacement costs of around £45m annually).

Interestingly, this is close to the $400m (or c£260m) disbenefit of a UK helmet law estimated by Australian statistician Professor Piet de Jong[41]. De Jong has developed an algebraic model that, he states, shows that that "*Even with very optimistic assumptions as to the efficacy of helmets, relatively minor reductions in cycling on account of a helmet law are sufficient to cancel out, in population average terms, all head injury health benefits.*"[42] The slight possibility of a small positive health benefit depends on improbably optimistic assumptions about a very low reduction in cycle use, a very high level of risk due to cycling relative to its health benefits, and helmets providing very high levels of protection against those risks. This model is outlined more fully in **Appendix A.**

d. How effective are cycle helmets?

Based on the information above, it will be apparent that the debate about the effectiveness or otherwise of helmets is almost certainly academic. Nonetheless, the topic continues to be hotly disputed. However the following points are worth noting:

- Helmets are (and can only be) designed to withstand forces equivalent to falling from a stationary riding position[43] – i.e. they are not designed for impacts with motor vehicles, especially not heavy vehicles or those moving at speed.
- One study found that cyclists with helmets have a 14% higher injury risk per mile travelled than non-wearers[44].
- A systematic review of the evidence from places with helmet laws (e.g. Australia and New Zealand) shows no link between increases in helmet-wearing and improvement in cyclists' safety[45].
- Similarly, UK evidence shows no detectable link between changes in helmet use and cyclists' safety, either for cyclists in general[46] or for children in particular[47].
- A review of helmet evidence commissioned by the UK Department for Transport noted that it was *"impossible to definitively quantify the effectiveness or otherwise of cycle helmets based on the literature reviewed."*[48]

Appendix B of this briefing provides a more detailed overview of the evidence on helmet effectiveness.

4. Enforcement

To increase helmet-wearing rates, countries have needed to invest heavily in promoting and then enforcing their helmet laws. In Queensland, cyclists were 3 times more likely per mile travelled to receive a penalty for not wearing a helmet than all other road users for all other traffic offences put together[49].

Meanwhile, in the Australian State of Victoria there were 19,229 Bicycle Offence Penalty Notices and 5,028 Bicycle Offence Reports issued in the first year of the state's helmet law alone. These represented 2.6% of all traffic offence notices, and the risk per km cycled of being cited for a helmet-related offence was higher than for all other traffic offence notices together[49].

As the next section shows, it is people from lower income groups who are least likely to own or to wear helmets. To enforce a ban on cycling without helmets will be seen as unfairly targeting a minority group, simply because their healthy and sustainable transport option or leisure activity is unreasonably perceived as 'hazardous', when in reality the risks they face are mostly imposed on them by drivers.

It would be wrong and unpopular to penalise parents of children who are cycling while not under parental supervision. For example, a child may leave the house wearing a helmet and then remove it when out of sight of their parents. This would still mean the parents were open to criminal prosecution.

5. Why legislation could exacerbate social exclusion

There is evidence that the following groups are less likely to wear cycle helmets, and therefore more likely to be deterred from cycling if helmet legislation is introduced:

- Children from socially-deprived areas
- Minority ethnic groups

In addition, there is evidence that cycle helmets already have a deterrent effect on women which would be exacerbated.

a. Children from socially deprived areas

There is also evidence that cycle helmet legislation has little long-term impact on helmet wearing among children in lower income areas. A large study in Toronto, which examined the impact of cycle helmet legislation, found that children in lower and mid-income areas were consistently less likely to wear helmets than their counterparts in more affluent areas[50].

A study carried out in Quebec found that a four-year helmet-wearing campaign was less effective in more socially deprived areas, despite innovations such as discount coupons for the purchase of helmets[51]. The researchers concluded that, for families in these areas, the purchase of a helmet, even at a discounted price, might well have been beyond their budget.

Similarly in Britain, a study carried out among more than a thousand 9-10 year-old children in Nottingham found that those who lived in a deprived area were less likely to own a helmet[52].

During its 'Bike It' programme in Northern Ireland schools, Sustrans observed that there was a marked difference between helmet-wearing rates at schools in relatively affluent areas and those in more socially deprived areas. For example, at one relatively affluent school in Newtownabbey, 103 of the 106 pupils arrived at school with cycle helmets. By contrast, at a school in a socially deprived part of west Belfast, just 5 of the 96 pupils turned up with helmets[53].

Hence there is a risk that helmet enforcement activities will exacerbate tensions between police and deprived communities (see also next section). It could also increase health inequalities by making it unaffordable for people from deprived neighbourhoods to cycle in accordance with the law.

b. Minority ethnic groups

A major survey of cycle helmet-wearing rates in Great Britain, carried out by the Transport Research Laboratory for the Department for Transport in 2008, found that 'white' cyclists were more likely to wear a helmet than those of other ethnic origins[54].

One particular concern is the potential impact of the proposed legislation on migrant workers. Circumstantial evidence suggests that many migrant workers use bicycles, particularly to commute to and from work. However, helmet usage among this group appears to be low. Given that not all migrant workers speak or read English fluently, there is clearly a risk that some will be penalised for non-compliance with a law of which they are not aware.

Furthermore, some people wish to wear the headwear prescribed by their religions, e.g. Sikh turbans.

On the above grounds, helmet laws would discriminate against members of minority racial and ethnic groups and against those who hold certain religious beliefs.

c. Women

While the proportions of men and women who cycle in mainland Europe are broadly equal, in Great Britain, men are three times as likely to cycle as women.[55]

It would appear that the perception of cycling as a "dangerous" activity is a deterrent to women – a clear correlation has been found between levels of cycle use in different areas and the proportion of cycle trips which are made by women[56]. Conversely, the way to encourage more women to cycle is to promote it as a safe and stylish activity which can be undertaken in whatever clothes women feel comfortable wearing.

A survey of 1,099 women, carried out by YouGov for Cycling England, found that more than a quarter (27%) of respondents in the 18-24 year old age group said they were put off cycling by the fact that cycle helmets might mess up their hair.[57] Sustrans has found that concern about 'helmet hair' is frequently mentioned by women and teenage girls as a deterrent factor.

6. Tackling the causes of road danger to encourage more and safer cycling

We have already noted that cycling gets safer the more cyclists there are – there is consistent evidence showing that cyclists gain from 'safety in numbers'. Cycling policy must therefore aim to achieve 'more' as well as 'safer' cycling, in order to maximise its health, environmental and other benefits.

This in turn requires efforts to tackle the fears that deter people from cycling, through measures such as 20 mph speed limits, cycle-friendly road and junction design, stronger and better enforced traffic laws, and the provision of quality cycle training for adults and children alike. By contrast, measures such as helmet laws – or even helmet promotional campaigns – will merely increase those fears. That would reduce the number of cyclists and perhaps also undermine the 'safety in numbers' benefits for those who remain.

CTC's briefing on *Cycling and Road Safety* sets out the most effective ways to make cycling conditions safer and more attractive, whilst our briefing on *Smarter Choices* outlines measures that help encourage and incentivise people to take up cycling. Both can be found at www.ctc.org.uk/campaignsbriefings

7. Conclusion

The relatively small risks of cycling do not remotely justify banning any age group from cycling without a helmet, while mass helmet use has not in practice been found to materially reduce those risks. What is clear is that enforced helmet legislation would suppress cycle use, and that the lost health benefits alone would be a serious net cost to society.

A recent study showed that there would be a clear net loss to public health alone from a helmet law, even if one assumed that the law would reduce cycle use only marginally, that the resulting loss of cycling's health benefits was not particularly large relative to the risks involved, and that helmets were highly effective at addressing those risks. In fact, none of these assumptions are realistic. At a time of mounting concern over the twin crises of obesity and climate change, the last thing we should be doing is forcing yet more people, especially children, into car-dependent sedentary lifestyles.

Instead, we recommend:

- Investment in measures that seek to create safe, attractive cycling conditions including the extension of 20 mph speed limits to all residential roads in towns, cities and villages
- Promotion of cycling as a healthy and enjoyable means of transport and recreation, both for the population in general, and for specific groups e.g. school and college pupils, employees, women, health patients, and various disadvantaged or minority groups.
- The introduction of high quality cycle training for all children in Year 6/7.

We are confident that these measures will have a tangible positive impact on the numbers of cyclists involved in road traffic accidents, and in the levels of death and serious injury related to such accidents. Moreover, both these measures will instill confidence in cyclists and potential cyclists, and are likely to lead to higher levels of cycling. By contrast, helmet legislation will lead to a significant reduction in cycling levels.

APPENDIX A

Weighing up the costs and benefits of helmet laws and promotion campaigns

A key issue in the helmet debate is the need to weigh up whether the possible injury savings due to helmet-wearing justify the likely reductions in cycle use and the consequent loss of its health, environmental and other benefits.

Just two attempts have been made to weigh up the costs and benefits of actual helmet laws. An analysis of Western Australia's helmet law suggested its net impact lay in the range from a 2 million AUS$ benefit to a 10 million AUS$ disbenefit[58]. An analysis of New Zealand's helmet law found a small benefit for child cyclists (aged 12 and under), but disbenefits for teens and adults[59]. A re-analysis of the latter study found no benefit for child cyclists either[60].

A study by Australian statistician Piet de Jong[61] has attempted to address the question purely algebraically. De Jong presents his central finding in the form of an equation, where a public health benefit can only arise if: $eq>\mu\beta$.

In this equation, *e* and *q* are both fractions, i.e. their value lies between 0 and 1. *q* is the proportion of the health costs of helmet-free cycling which is due to head injuries, while *e* is the proportion of those costs which could be avoided if all cyclists wore helmets. So the left hand of the equation *eq* represents the total injury costs of (helmet-free) cycling which would be avoided if all cyclists wore helmets. It is clearly less than 1, it is probably closer to 0 and it might even be negative.

The right hand side of the equation consists of two ratios. β is the ratio of the health benefits of (helmet-free) cycling relative to its risks. As noted previously (see page 5), the Department for Transport has endorsed [62] the widely quoted figure of 20:1 as a value for β in the UK[63]. The other quantity, μ, represents the ratio of cycle use lost following a helmet law to cycle use retained (n.b. this is not quite the same as the percentage reduction – for instance a 33% reduction in cycle use can be thought of as 1 unit of cycling lost for every two that remain, hence the equivalent value of μ would be 0.5).

It will be clear that, if there is to be a net health benefit, the two ratios μ and β need to counter-balance one another so that, when multiplied together, the result is less than the fractional quantity *eq*. In other words, if 20:1 is a correct value for β, then a helmet law can only yield a net health benefit if μ is less than 1:20 (i.e. there is no more than 1 unit of cycling lost for every 20 which remain), even if head injuries accounted for all of the injury costs of cycling and if helmets were 100% effective at addressing these risks (i.e. if *e* and *q* both equalled 1). So even under these implausible assumptions, a disbenefit occurs if the reduction in cycle use is any more than 4.7% (i.e. 1/21). This figure then has to be reduced further still, in proportion to the values of *e* and *q*. The value of *e* is much debated (see *Appendix B* below). However, *q* is likely to be about 0.5, given that c40% of cyclist injuries serious enough to merit admission to hospital and c80% of fatalities involved head injuries (although by no means all of these were head-only injuries, particularly in the case of fatalities)[64]. On this assumption, the allowable reduction in cycle use drops to just 2.4%. It falls by another whole order of magnitude (i.e. to 0.24%) if the effectiveness of helmets is only 10% rather than 100%.

As shown earlier (see page 5), the experience of enforcing helmet laws typically results in reductions in cycle use of the order of a third (i.e. μ = 1:2), and sometimes more than this. On that basis, and again assuming that head injuries amount to about 50% of the injury costs of cycling (i.e. q = 0.5), a helmet law would have disbenefits unless the health benefits outweighed the risks of cycling by less than about 1 to 1 – not 20:1 as estimated – even if helmets were 100% effective.

In short, as De Jong (see above) states, "*Even with very optimistic assumptions as to the efficacy of helmets, relatively minor reductions in cycling on account of a helmet law are sufficient to cancel out, in population average terms, all head injury health benefits*."

Finally it should be noted that these calculations take no account of cycling's wider benefits for tackling congestion, air pollution, quality of life, equality of opportunity and the climate.

APPENDIX B

Helmet laws and effectiveness: contradictory evidence

The evidence-base regarding the effectiveness or otherwise of helmets is extremely complex, with vast amounts of ink having been spilled on both sides of the debate. This appendix attempts a brief summary of the territory. It also responds to claims that the experience of helmet laws in Canada shows that helmet laws can be introduced without reducing cycle use.

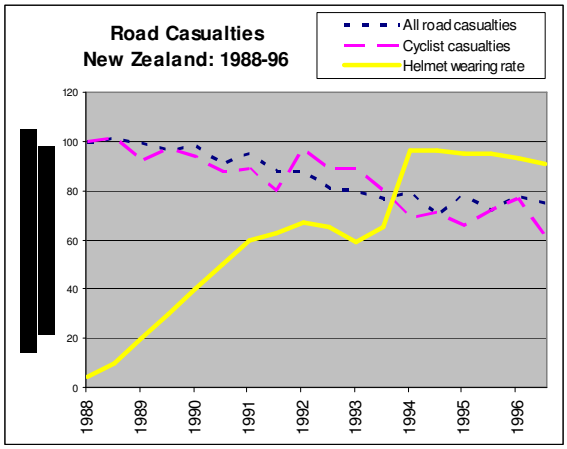
1. 'Case-control' and population-level evidence

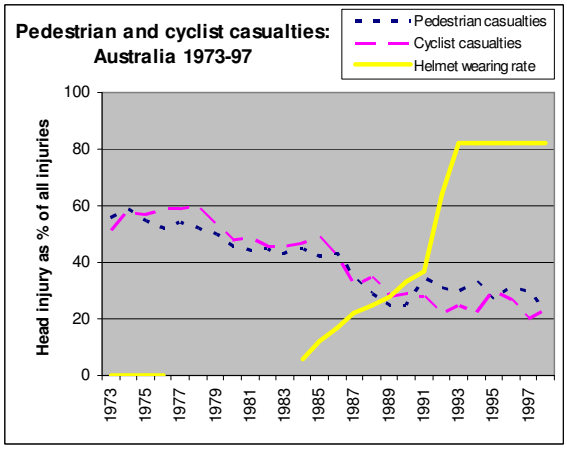
A number of early studies on the effectiveness of helmets reported substantial safety benefits from helmet use[65]. These were predominantly hospital-based 'case-control' studies, where a 'case' group (e.g. cyclists with head injuries) are compared with a 'control' group (e.g. cyclists with non-head injuries) to show whether the use or non-use of a helmet might have made a statistically significant difference to the probability (or the severity) of head injuries between the two groups.

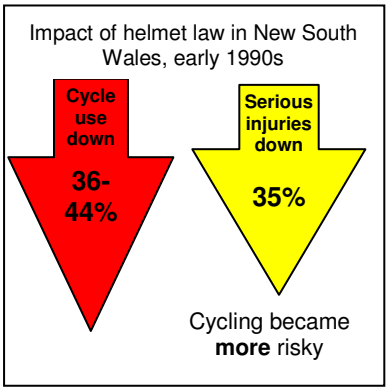
However, the findings of these studies are contradicted by a systematic review by Robinson of the evidence from places with helmet laws (e.g. Australia and New Zealand), which found no link between increases in helmet-wearing and improvement in cyclists' safety[66]. They are also at odds with the evidence of two papers by Hewson that found no detectable link between changes in cycle use and cyclists' safety, either for cyclists in general[67] or for children in particular[68]. Many of the findings of case control studies themselves are contradictory or, frankly, implausible (e.g. that helmets provide greater protection against more serious impacts than minor ones)[69].

Whilst helmet laws have undoubtedly reduced the numbers of cyclist head injuries, the available evidence suggests this has been wholly or largely due to reduced cycle use, rather than improvements in cyclists' safety[70]. In the case of New Zealand, it seems that other road safety improvements also played a part. The percentage reduction in cyclists' head injuries was no different from other road users, with no effect detectable in the year the law was introduced,

despite a very sharp increase adult and teenage helmet wearing rates that year[71] [72]. Similarly, reductions in cyclist head injuries in Western Australia and Victoria matched those gained by pedestrians – and again, there was no particular effect at the point when helmet use rose sharply.







In some places, cycle safety for the remaining cyclists even seems to have worsened, even though most of them were now wearing helmets. For instance, in New South Wales a 44% reduction in children cycling was observed 2 years after the law, but only a 32% decline in serious and fatal injuries[73]. In Nova Scotia the initial 60% reduction in cycle use recovered to a 40% reduction in the second year of the law; however the initial 50% reduction in cyclist hospitalisations bounced back up and was 6% higher after the law[74]. There were similar instances of cycle use apparently falling by more than cyclist casualties in Victoria, South Australia and Vermont[75].

A review of helmet evidence for the UK Department for Transport by the Transport Research Laboratory (TRL) found it was *'impossible to definitively quantify the effectiveness or otherwise of cycle helmets based on the literature reviewed'* (for more on this review, see below). Similarly the Parliamentary Advisory Council on Transport Safety notes that *'it is not possible to predict accurately expected injury reduction from increased rates of helmet use; estimates range between 0 and 85%'*[76].

Faced with this contradictory evidence, one has to weigh up the plausibility of the evidence suggesting higher or lower values for helmet effectiveness respectively. This cannot be settled with any certainty. However, the following paragraphs set out why CTC believes the more plausible explanations point towards a lower value for helmet effectiveness – or even the possibility that helmet use might increase the risks to cyclists of injury impacts occurring in the first place, potentially undermining any protective effect helmets might have in the event of those impacts.

2. The lack of detectable net benefits from helmets: possible explanations

Cycle helmets are – and can only be – designed to withstand low impact forces, equivalent to falling of a bike from a stationary riding position. The old British Standard for cycle helmets (BS6863, 1987) stated that they were *"intended to give protection in the kind of accident in which the rider falls onto the road without other vehicles being involved."* Subsequent standards (including the current EU standard EN 1078) have been progressively weakened due to lobbying by the manufacturers themselves[77] [78].

Cycle helmets are inevitably a design compromise between seeking to provide protection, and designing helmets which are light, aerodynamic, well-ventilated, stylish and cheap. Yet all of these design criteria are at odds with the aim of making them strong. There is also an inevitable trade-off between designing a helmet to protect against impact with flat surfaces (e.g. car windscreens) and angular ones (e.g. the corners of kerbstones)[77]. Helmet manufacturers themselves are typically very cautious in the safety claims they make for their helmets[79], stating only that they meet the relevant European or other standards.

Nonetheless the lack of a detectable relationship between in helmet wearing rates and cycle safety may still appear counter-intuitive to many people. So too is the evidence suggesting that helmet-wearers may have a 14% higher risk than non-wearers of being involved in collisions in the first place[80]. Nonetheless, there are many possible explanations for these phenomena.

For instance, it is known that some cyclists ride less cautiously when wearing a helmet[81] [82]. This is an example of what is known 'risk-compensation'[83], and it has also been observed in young children with helmets[84]. Drivers may also 'risk-compensate', as they have been found to leave less space when overtaking helmet-wearing cyclists than those without[85]. The increased size weight or even the temperature of the head may also be factors. Indeed, it has been suggested that glancing blows to a head that has been effectively enlarged by a helmet could lead to some very serious brain or spinal injuries, in situations where an unhelmeted head would have suffered a mere glancing blow or not been hit at all[86]. There is further evidence suggesting that helmet use increases the risks of neck injuries[87], or brain injuries due to 'rotational force' impacts (i.e. those which effectively cause the brain to rotate within the skull on impact, causing subdural haematoma or diffuse axonal injury, two of the most common causes of very serious brain injuries)[86] [88]. Helmets could therefore be contributing to some of the most serious and permanently disabling spinal and brain injuries.

Cycle helmet retention systems (i.e. straps and associated clips) are poorly designed, making it difficult to fit and wear helmets correctly[89]. The need to do so is widely recognised by all protagonists in the helmet debate (indeed it is one of the few issues on which there is universal agreement). Yet this is difficult to achieve in practice – e.g. one American study found that only 4% of the 478 children examined had fitted their helmet correctly, and not one parent out of 52 in the study was able to fit their child's helmet correctly[90]. Fourteen children are known to have been killed through strangulation by their helmet straps[91] [92] [93].

There is one other very important possible link between increased helmet use and increases in the risks to cyclists of both head and non-head injuries. This is the possibility that the reductions in cycle use due to helmet laws or promotional campaigns cause a loss of the 'safety in numbers' benefits previously enjoyed by the remaining cyclists (see page 4).

3. Contradictions between population and 'case-control' evidence: possible explanations

The explanation for the contradictions in the evidence may lie in the inherent flaws of 'case-control' studies, which are known to be prone to spurious results[94]. Studies into hormone replacement therapy, vitamin supplements and the MMR vaccine, used the same type of 'case-control' methodology, and yielded what are now known to be false outcomes[95]. Similarly, the best known of the 'case-control' studies of cycle helmets, from Seattle, reported that helmets could prevent 85% of head injuries and 88% of brain injuries[96]. However, this finding has been repeatedly criticised on the grounds that it compared two unlike groups riding in different environments. The helmet-wearers were more likely to be white, affluent and to be cycling in parks, while the non-wearers were more likely to be from lower-income ethnic minority groups riding on busy streets. This is unsurprising: people from lower income and racial minority groups are far less likely to wear helmets[97] [98] [99], and there is a vast literature showing that people (particularly children) from these groups face significantly higher risks of road injury[100] [101] [102].

A second factor may be that willing helmet-wearers have a different attitude to risk. Those who readily take up helmet use (i.e. the 'early adopters' of helmets, who would have featured in the helmet studies of this period) are more likely to be safety-conscious people, who are averse to risk and therefore avoid the situations where more serious injuries might occur. By contrast, the 'later adopters' – i.e. those who only wear helmets reluctantly in response to laws or the peer-pressure that comes from helmet promotion campaigns, or who simply 'follow the trend' in adopting helmets – may be more risk-accepting. This in turn might at least partly explain why there has been a progressive decline in the estimates of helmet effectiveness from these studies[87].

A third factor is that, in the USA context, people from more affluent backgrounds are more likely to have health insurance, and thus are more likely to go to hospital following relatively minor injuries, whereas groups without insurance are more likely to go to hospital only if their injuries are serious.

It is therefore very likely that the results of the Seattle study, and others like it, are in fact due to differences between the people who do and don't wear helmets, the types of cycling they do and the environments where they cycle, rather than due to helmets themselves. To reinforce the point, it has been shown that the data and methodology used in the Seattle study could also be used to show that helmets prevent 77% of injuries to parts of the body other than the head[103].

4. Effect of helmet laws on cycle use: the case of Canada

In recent years, Canadian helmet advocates have mounted a concerted effort to argue that helmet laws there have been successful in improving cycle safety, without reducing cycle use. This followed criticism of a paper by LeBlanc et al[74] which claimed that Nova Scotia's helmet law had been successful, when the cycle count data presented in that paper showed an initial reduction of 60% in the numbers of cyclists counted one year after the law, and that by the time cycle use had recovered slightly (to 40% of pre-law use), the numbers of cyclists hospitalised was higher than before the law[104] [105].

A paper by Alison Macpherson and others in 2001 suggested that Ontario's helmet law had increased helmet wearing rates without reducing cycle use, based on a study conducted in an affluent district of Toronto[106]. However Macpherson is recorded as having subsequently acknowledged that the law had not been enforced[107 108]; while a later study by Macpherson et al (published in 2006[97]) showed that helmet use had risen only temporarily, falling back to pre-law levels within 2 years of the law's passing, while cycle use had done the opposite (i.e. it had initially fallen, despite Macpherson's denials), then recovered as cycle helmet use fell back.

Macpherson's count data for the 2001 study was also criticised as unreliable as it had not controlled for variations in the time of year, weather etc[109]. Finally, her team had also collected data, which they have not published, for three years prior to the law, during which time a strong helmet promotion campaign was conducted. It is therefore possible that the unpublished data might have shown a fall in cycle use during the three years of the pre-law helmet promotion campaign.

Macpherson's 2001 paper was subsequently cited by the British Medical Association as the reason for deciding to support helmet legislation[110] – they had previously supported helmet promotion but not laws. The BMA has since withdrawn the paper which justified its change of policy, but has so far not reconsidered the policy itself.

In 2002 Macpherson and other colleagues published a study comparing head and non-head injuries to child cyclists hospitalised in Canadian states with and without helmet laws respectively[111]. The paper claimed to show a benefit from helmet laws because head injuries had declined more steeply relative to non-head injuries in the helmet-law provinces, compared with the non-law provinces. However, the proportion of cycling injuries which were head injuries continued to decline even after the downturn in helmet use recorded in Macpherson's 2006 paper[112], while the differences in injury trends between states with and without laws were as evident for pedestrian injuries as for cycling injuries[113]. Hence Macpherson's attempt to link increases in helmet use with a reduction in the proportion of cyclist injuries which were head injuries cannot be considered as valid.

5. Re-examining the evidence: Cochrane reviews and other meta-analyses

More recent helmet studies have attempted to bolster the evidence for helmets and helmet-laws by re-analysing it. For instance, there have been two Cochrane reviews, a process normally regarded as a benchmark of objectivity in meta-analysis of medical evidence. However, the first Cochrane review[114], which considered evidence on the effectiveness of helmets, was limited to 'case-control' studies, eliminating any consideration of population-level evidence, such as that presented in papers by Robinson or Hewson. Moreover, it was conducted by the same authors who had produced 4 of the 7 case-control evidence they were reviewing[115]. Subsequent meta-analyses by Attewell et al[116] and Towner et al[117] (the latter being an evidence-review in 2002 commissioned by the UK Department for Transport) likewise restricted their scope to 'case-control' studies, hence it is unsurprising that they too concluded that the evidence suggested helmets were beneficial – although Towner acknowledged that helmet laws could reduce cycle use. A second Cochrane review, by Macpherson and Spinks[118], looked specifically at evidence on the impact of helmet laws (n.b. it will be noted that Macpherson was not an unbiased commentator, having previously

authored several papers advocating helmet laws). It concluded that helmets were beneficial but found no reliable evidence to determine whether helmet laws might reduce cycle use. However, it omitted to consider Robinson's 2006 BMJ paper[66] which would have provided that evidence.

In 2010, the UK Department for Transport attempted to 'settle' the helmet question with a second evidence review,[119]. The researchers identified flaws in all of the case-control evidence and hence the meta-analyses of that evidence, reaching the conclusion quoted in paragraph A5 above. They also identified weaknesses in the evidence of Robinson[66] and Hewson[67] [68], noting that they too had employed study designs which left open the possibility of confounding factors (and hence possibly to flawed conclusions). Hewson himself acknowledged this point in both his papers, noting that the absence of a detectable helmet benefit does not rule out the possibility that an effect may exist, perhaps for particular groups of cyclists and/or for particular types of cycling. However, the DfT review authors did not put forward any reasons for assuming that helmets must have some benefits, in preference to the possible alternative explanations suggested by Robinson for the lack of detectable benefits from helmets (e.g. that reductions in head injuries might be due to reductions in cyclist numbers and the consequent loss of the 'safety in numbers' effect for the cyclists who remain, and/or that helmet-wearing cyclists might be more prone to being involved in collisions in the first place e.g. due to 'risk compensation').

However the most notable feature of the DfT-commissioned study was a claim that *'A specialist biomechanical assessment of over 100 police forensic cyclist fatality reports predicted that between 10 and 16% of the fatalities could have been prevented if they had worn an appropriate cycle helmet'*. This finding has been strongly criticised by CTC, Sustrans and other members of the study advisory panel, on the following grounds:

- The 10-16% figure is based solely on notional estimates of the effectiveness of helmets in impacts with the ground (50%) and with motor vehicles respectively (10-30%). However, the authors noted that they had *'no specific evidence to support these estimates'* (p37). In other words, there was no specialist biomechanics involved in the assessment; moreover, the Department for Transport has declined to release the identities and qualifications of the individuals who carried out the assessment[120].
- The fatalities considered were not randomly selected and were acknowledged not to be representative of cyclist fatalities in general (p34).
- The study focuses on *'whether cycle helmets reduce the frequency and severity of injury* ***in the event of a collision****'* (page vi, emphasis in the original – n.b. this acknowledgement was only added at CTC's insistence). The study, and the 10-16% estimate in particular, takes no account of the possibility that helmets may increase the risk to cyclists of having a head impact in the first place. We have previously noted that another study found helmet-wearing cyclists have a 14% higher risk of injury per mile travelled[80]. This would therefore approximately cancel out a 10-16% benefit even if it were to prove correct (despite the lack of evidence supporting it).

Finally, the most recent meta-analysis found that early results – including the Attewell analysis and the Cochrane review of helmet effectiveness (and subsequent updates of it) – had significantly overstated the protective value of helmets. It also found that helmets may increase the risk of neck injuries[87].

Conclusion

From the evidence available, it is possible that helmets might perhaps provide some limited protection in the event of certain types of impact occurring (e.g. minor falls). However, any such benefits might also be undermined or even outweighed by a variety of ways in which helmet-wearing may increase the likelihood of such impacts occurring in the first place. There are some places (e.g. New South Wales and Nova Scotia) where increased helmet-wearing appears to have been associated not only with reduced cycle use but also with an increased risk of injury for those cyclists who remain. There is also some evidence that helmet use increases the risks of neck injuries, and of brain injuries due to 'rotational force' impacts. Helmets could therefore be contributing to some of the most serious and permanently disabling spinal and brain injuries. A number of children are known to have been fatally strangled by their helmet straps.

We reiterate the observation from the helmet evidence-review commissioned by the Department for Transport[119], which noted that it was *'impossible to definitively quantify the effectiveness or otherwise of cycle helmets based on the literature reviewed.'*

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