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. For Cycling UK's formal policy on cycle helmets, see: www.cyclinguk.org/campaigning/views-and-briefings

Key points:

- Cycling is hugely beneficial to people's health. Those who cycle regularly in mid-adulthood enjoy a level of fitness equivalent to being ten years younger, and a life expectancy two 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 as unlikely to be killed in a mile of cycling as in a mile of walking. The Government has endorsed 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).
- Given the 20:1 ratio, telling people to wear helmets would result in a net increase in early deaths (due to physical inactivity etc.) if more than one person were 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 (regardless, that is, of 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. As mentioned, they are (and can only be) designed for minor knocks and bumps, not collisions with fast cars or lorries. There is also evidence to suggest 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 may 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 therefore be on maximising the benefits of more as well as safer cycling, through measures such as 20 mph 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 them into increasingly car-dependent and 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

Cycling UK is not 'anti-helmet' and does not take sides on whether it is a good idea for individual cyclists to wear them. Yet there is strong evidence that, by reducing cycle use, enforced helmet laws result in substantial loss for public health and our environment. This disbenefit is almost bound to outweigh any possible safety benefits from increased helmet use among the remaining cyclists, given that this benefit is uncertain and at best very limited.

We also believe there are better ways to improve cyclists' safety, and that the priorities for the police should not include enforcing helmet legislation. It is far more important that they enforce existing laws that could prevent collisions from occurring in the first place – e.g. speed limits or mobile phone use – rather than new laws which seek to reduce the seriousness of any impacts in the event of a collision.

The evidence below shows why cycle use is likely to fall if legislation is introduced. We also highlight key groups, including those who are socially excluded, who could be adversely affected. Compulsion may 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 risk of serious injury or death in a cycle collision.

Finally, we review the evidence on what causes cycling injuries and conclude that cycle safety could be effectively improved if high-quality cycle training were available to all children, and investment made in measures 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 cycle use.

2. Cycle helmet legislation: the impact on cycle use

a. The benefits of cycling

Cycling has a wide range of benefits for our personal health, our neighbourhoods, 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 the benefits of cycling for the economy, and local and national transport, see our series of briefings at: www.cyclinguk.org/campaignsbriefings

b. Overall reductions in cycle use due to helmet laws

Evidence shows that helmet laws, where enforced, have consistently deterred large numbers of people from cycling.[1] Reductions in the years immediately following legislation include:

- A 36% reduction in New South Wales, Australia, two years post-law, including 26% among adults at road intersections (in Sydney and rural areas);[2]
- A 36% reduction among all cyclists in Melbourne between 1990 (pre-law) and 1991 (post-law);[3]
- A 26% reduction in Perth across two entry point bridges in October 1992 compared to the same month in 1991 (continuing to almost 40% below pre-law levels after three years);[4]
- A 60%+ reduction in Nova Scotia, Canada, during 1997 (the year the law came in) compared to 1995/96;[5]
- Following the introduction of a helmet law in 1994, cycling trips in New Zealand initially fell by 26%, but continued falling to 51% below their pre-law levels by 2006.[6]

Helmet laws elsewhere have had similar results.[7]

Recreational cycling, mainly amongst adults, has recovered in some countries or states, while improved infrastructure has encouraged more people to cycle in some cities, but where the law is kept enforced, cycle use is undoubtedly compromised. Australia as a whole failed to meet its target to double cycling participation between 2011-2016, and their last survey continues to return very disappointing results.[8]

Having looked at the evidence, NACTO (National Association of City Transportation Officials) in the US, has stated: "The impact of mandatory adult helmet laws on bike share and general bike ridership is large and negative." It also says: "In Seattle, the only U.S. city with a mandatory helmet law [i.e. city with a bike share scheme as well], bike share ridership has been well below expectations, less than one ride per bike per day."[9]

Perhaps most alarmingly, such laws have reduced cycling specifically among:

- Cycle commuters
- Children travelling to school
- Teenage cyclists

Fewer cycle commuters and children cycling to school is a major concern because such 'utility' cycle trips, if stopped, are a) unlikely to be substituted by other forms of exercise and b) likely to be replaced with car journeys. This contributes to rising levels of obesity and, by increasing both pollution and congestion, is costly for the environment and the economy.

c. Children and teenagers

Teenagers are a key target group for efforts to encourage physical activity, and cycling is an important part of this. If children can be persuaded to keep cycling in their teens, the habit will probably last into their adult years. Conversely, if they are put off cycling, they are much less likely to go back to it.

One strong deterrent, according to evidence, is helmet legislation. Moreover, it does not necessarily result in higher levels of helmet use: teenagers, especially girls, seem particularly unwilling to wear helmets, even when it is mandatory, while the enforcing the law against them tends to be problematic:

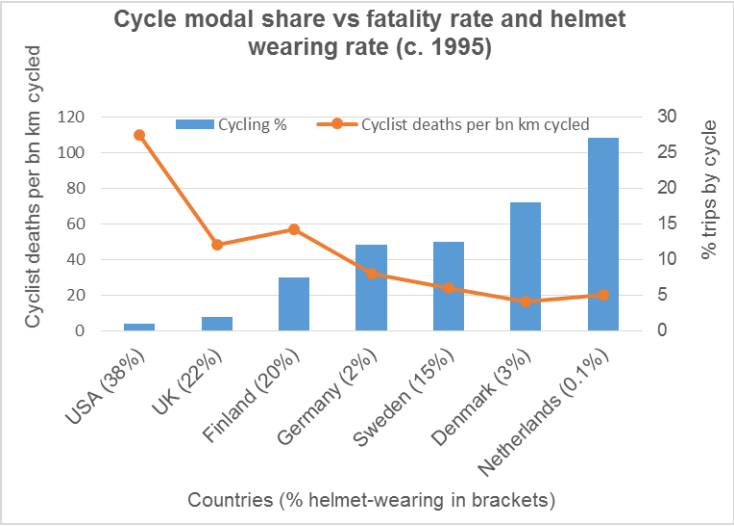
- In New South Wales, Australia, the law came into effect in January 1991 for adults and in July 1991 for children. Figures from a major study, involving counts at 120 locations in Sydney (city and rural), found that numbers of under-16 cyclists dropped by around 50% at road intersections and by 47% at school gates between 1991 and 1993. A smaller but still significant 32% fall was evident in recreational areas. The counts also showed a 90% drop among female pupils cycling to secondary school in Sydney.[10] As noted above, the law's aftermath saw fewer utility cycling trips among adults, but the drop amongst those made by children was even more severe.
- In Victoria State, a cycle helmet law was introduced in July 1990. Another major study, involving counts at 64 locations in Melbourne, found a 46% drop in cycle usage amongst teenagers (12-17-year-olds) by 1991, and 43% by 1992, even though their numbers had been rising prior to the introduction of the law.[11]
- Australia's 2019 cycling participation survey found that the proportion of people of all ages who cycled in the previous week dropped by 4.4% between 2011 and 2019 (from 18.2% to 13.8%) and by 1.7% between 2017 and 2019. This is statistically significant. Austroads says that the trend appears "to be driven primarily by declines among children of both genders, teenage males and young adult males, and this has not been fully compensated by an increase in teenage female cycling and among those aged 50 and over."[12] The drop has occurred despite investment in promoting and encouraging the activity, and Australia's ambition to double participation between 2011 and 2016. Critics strongly believe that mandatory helmet laws are implicated. [13]

- One in five pupils at 12 secondary schools in New Zealand said they would cycle to school more often if helmet use was not mandatory. Also, the perception that cycling to school is not 'cool' was positively associated with the perception that having to wear a helmet is a barrier.[14]
- In New Zealand, estimates suggest that around 136,000 adults and children there – nearly 4% of the total population – stopped cycling in the immediate aftermath of the legislation, 47,000 being teenagers (13-18 years).[15]
- A US study of children aged under 18 found that "There was no significant change in helmet usage between before and after legislation in helmet legislation areas or over time in non–helmet legislation areas." [16]

d. Safety in numbers

Three western countries in particular – the Netherlands, Denmark and Germany – provide good evidence of the 'safety in numbers' effect, i.e. the more cyclists there are, the safer it is to cycle.[17],[18] Not only that, but none of them mandates cycle helmets and the levels of voluntary cycle helmet wearing are relatively low:

- In the Netherlands, 27% of all journeys are 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.[19]



This graph suggests that high cycle use is associated with a low cyclist injury rate, despite low helmet-wearing rates (e.g. in Denmark and the Netherlands). In fact, there is evidence, as this graph also implies, that the converse may equally be true, i.e. reductions in cycle use are associated with worse cycle safety.[20]

Note the similarities with the cycle use and obesity graph shown later.

e. The effects of helmet promotion campaigns

Simply promoting helmet wearing rather than mandating it may reduce cycle use too:

- Research commissioned by the UK Department for Transport (DfT) concluded 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".[21]

- A report for the European Conference of Transport Ministers 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".[22]
- Even picturing helmets on marketing materials designed to promote and encourage cycling appears to have an adverse impact too: Danish research found that images of cyclists wearing helmets had a negative impact on people's attitude to cycling, despite the apparently high public acceptance of bicycle helmets in Denmark. [23]

Equally, any pre-law helmet promotion campaign might serve merely to reduce cycle use even before the legislation comes into effect, rather than afterwards. This may well have happened in the case of Canada's helmet laws.

As the next section shows, whatever leads to a drop in cycle use – helmet legislation or simply helmet promotion – the net impact on public health will be serious, negative and disproportionate.

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 it must be self-evidently desirable. Consequently, they may welcome a helmet law.

The introduction and implementation of all legislation, however, not least that pertaining to public health and safety, needs to be evidence-based. That must include examining 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 by mandatory helmet laws.

a. Health benefits of cycling

The health benefits of cycling are considerable. For example:

- Cycling in mid-adulthood typically gives the fitness of a person 10 years younger,[24] and a life expectancy two years above the average.[25]
- People who do not commute regularly by cycle have a 39% higher mortality rate than those who do.[26]
- Thanks to these extra life-years, the health benefits of cycling far outweigh the risks involved[27] – by 20:1 according to one estimate.[28]

Many people find exercise easier and more palatable if they can incorporate it into their daily lives. Cycling, which doubles up as transport, is particularly useful in this respect. It also makes a positive difference quickly: a study commissioned by the UK Department for Transport found that, if people who start cycling haven't exercised before, they move from the least fit one third of the population to the fittest third of the population within just a few months.[29]

Most importantly, cycling can play a major part in counteracting obesity and physical inactivity, which is currently increasing at an alarming rate and draining the public purse.

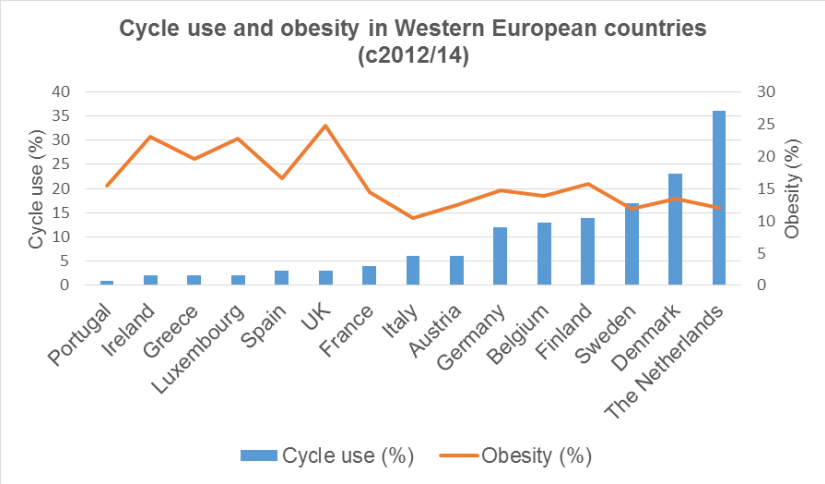
- Physical inactivity costs the English economy c£7.4 billion a year,[30] while the direct costs of obesity to the NHS and its indirect costs to the wider economy (e.g. loss of productivity etc.) also run into £billions.[31]
- A *Foresight* report for the UK Government projected that, unless action is taken to address

current trends, by 2050 the costs to society due to overweight and obesity could rise to £49.9bn annually (in 2007 prices).[32]

- Physical inactivity also contributes to heart disease and stroke, type 2 diabetes, various forms of cancer and arthritis.
- Accounting for one in six deaths in the UK, physical inactivity is as dangerous as smoking. [33]
- The UK population is now around 20% less active than in the 1960s. If current trends continue, it will be 35% less active by 2030. [34]
- Cardiovascular disease (CVD) – an umbrella term for all diseases of the heart and circulation, including coronary heart disease, stroke and heart failure – causes more than a quarter of all deaths in the UK each year (c150,000+), while around seven million people are living with the condition.[35]
- Children are spending more and more time in cars: in 2018, 36% of 5-16 year-olds were driven to school, as opposed to 30% in 1995/97.[36]

Statistics for England show that, in 2016/17:[37]

- Obesity was a factor in 617 thousand admissions to NHS hospitals (an increase of 18% on 2015/16);
- 26% of adults were classified as obese;
- One in five children in Year 6 and one in ten children in Reception were classified as obese;
- 13% of children living in the most deprived areas were obese compared to 6% of those living in the least deprived areas.



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

Source: Cycle use (% of people who said they used a bicycle more often than any other mode on a typical day): EC *Special Barometer 422a - Quality of Transport* / Obesity: OECD *Obesity Update June 2014.*

For more facts on cycling and health, see Cycling UK's briefing at
www.cyclinguk.org/campaigning/views-and-briefings/health-and-cycling

b. How safe is cycling?

Evidence clearly shows that the risks of serious injury or death from cycling are relatively low. For example:

- People in Britain are about as unlikely to be killed in a mile of cycling as in a mile of walking;[38]
- One calculation from 1996, based on Australian data, concluded that cycling without a helmet carried only slightly more risk of death or serious injury per hour than driving.[39]

The prevalence of head injuries among cyclists:

Evidence suggests that cyclists' injuries are not particularly likely to be head injuries, or to be serious, or both; and that pedestrians face an equal, if not greater, risk of head injury. Furthermore, despite cycling being one of the most popular recreational activities among children,[40] it typically accounts for only a small proportion of head injuries leading to hospital admission:

- Researchers who identified 5,700 head injury cases among under-15s admitted to 216 UK hospitals for more than four hours over a seven-month period (2009-2010), found that 403 (7%) were involved in motor vehicle incidents, principally among children of primary school age. Only 35 of these were cyclists (0.6%), while 279 were pedestrians (5%) and 89 in cars (1.6%). Twenty-four children out of the total 5,700 died (0.4%), 14 of whom were involved in a motor vehicle incident. The rest were due to other mechanisms (around two-fifths). Of the 14 involved in a motor vehicle incident, eight were pedestrian-related (33%), three passenger-related and another three were cyclists (12.5% each). (The researchers were not examining helmet-use, so it is impossible to say whether any of the cyclists were helmeted).[41]
- An earlier study of hospital admissions from the mid-1990s to 2002/3 found that just 7-8% of the head injuries for which children under 16 were admitted to English hospitals were cycling-related. The authors estimated that just a quarter of these were to parts of the head that might be protected by a helmet – and it is likely that some were suffered by children who were wearing helmets anyway. They also found that head injuries accounted for 37.6% of cycling injuries, but 43.7% of pedestrian injuries.[42]
- A UK-wide study (February 2001-August 2003) found that cycling accounted for 10% of child traumatic brain injury (TBI) admissions, but that pedestrians accounted for 36%, while falls accounted for a further 24%.[43]
- Having examined 67,000 records of bicycle-related injuries among 5-17-year-old children admitted to emergency departments in the US, researchers estimated that nationally: the most commonly injured body region was the upper extremities (36% - most often to the wrist), followed by the lower extremities (25% - most often to the knee); and that TBI represented just 11% of the total, and was the second, not topmost common injury for the 4.2% who were hospitalized (43.4% were hospitalized for a fracture, 31.9% for a TBI). [44]
- A study to determine how important head injuries in cyclists are as a cause of road death in England (2007-2012) concluded that it depends on the metric used: "Pedestrians and drivers account for five and four times the number of fatal head injuries as cyclists. The fatal head injury rate is highest for cyclists by time travelled and for pedestrians using distance travelled."[45]
- Australian data from 2003-04 suggested that the proportion of head injuries requiring hospitalisation was about the same for cyclists (27.4%) as for drivers (26%) and less than pedestrians (33.3%).[46]
- A German Federal Highway Research Institute report from 2009 found that the rate of serious head injuries amongst cyclists, pedestrians and car occupants is similar.[47]
- Danish data have shown that, compared with pedestrian and car occupant injuries, cycling injuries result in the shortest hospital stays and are least likely to be serious.[48]

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

In determining whether cycle helmet legislation is the way forward, it is vital to factor in the health benefits of cycling (see 3a above), plus 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,[49] Cycling UK estimated in 2009 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 DfT's estimate of helmet effectiveness (n.b. Cycling UK does not accept this estimate). This excludes the costs to the remaining cyclists of purchasing helmets (we estimated 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.[50] De Jong has developed an algebraic model showing 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."[51]

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.**

Another study (2014) that analysed the costs and benefits of introducing a cycle helmet law in Germany concluded that it would be a waste of the country's resources because the benefits of such a law would be about 0.714 of the costs.[52] The author took into account: the benefit of increased security when cyclists wear a helmet or use a transport mode that is less risky than cycling; the cost of purchasing helmets, reduced fitness when cycling is replaced by a motorized transport mode; the discomfort of wearing helmets; and environmental externalities.

d. How effective are cycle helmets?

In light of the above, it will be apparent that the debate about whether cycle helmets are effective or not is almost certainly academic. In any event, is important to note again that helmets are (and can only be) designed to withstand forces equivalent to falling from a stationary riding position[53] – i.e. they are not designed for impacts with motor vehicles, especially not heavy vehicles or those moving at speed.

Nonetheless, much research has been carried out into how effective cycle helmets are at preventing or mitigating injury. Indeed, the topic continues to be investigated and, often, hotly disputed:

- A study from 2007 says: "There is evidence of increased accident risk per cycling-km for cyclists wearing a helmet. In Australia and New Zealand the increase is estimated to be around 14%." [54]
- Calling it a "paradoxical observation", researchers who looked at the prevalence of bicycle injuries in a large urban hospital in California concluded that: "The prevalence of significant head trauma was 35% in the group of patients with helmet and 34% in the group without helmets [...]." They also noted that "... the prevalence of all significant trauma was 26% in the group of patients with helmet and 20% in the group without helmets [...]. The overall mortality was 1%. There was no difference in mortality between helmeted and non-helmeted patients." [55]
- A US study of bicycle use and cyclist safety following Boston's cycle infrastructure expansion (2009-2012) found that "... individuals with documented helmet use were found to have 1.85 [...] times the odds of non–helmet users of being involved in an injury-related accident." [56]
- A four-year review of bicycle injuries (2009-12) published in the European Journal of Trauma and Emergency Surgery (2014) concluded that: "Bicycle helmets may have a protective effect against external head injury but its protective role for intra-cranial hemorrhage is questionable." [57]
- A review of helmet evidence commissioned by the DfT noted that it was "impossible to definitively quantify the effectiveness or otherwise of cycle helmets based on the literature reviewed." [58]
- UK evidence shows no detectable link between changes in helmet use and cyclists' safety, either for cyclists in general[59] or for children in particular.[60] The study focusing on children (published in

2005) states: "head injuries are falling among child pedestrians and cyclists in the UK as a proportion of all injuries requiring hospital attention", but that "the time series are inconsistent with helmet wearing data". In other words, the fall could not be explained by helmet wearing.[61]

- A study of 119 cyclist fatalities in two Czech regions (1995-2013) concluded that 44 of them (37%) would have survived if they had been wearing helmets, mostly in single-vehicle crashes and in certain cases where an intracranial injury was the primary cause of death. It follows, however, that helmets would not have helped the other 63%. The authors also concluded that helmets would not have helped in "most high-energetic crashes, especially when motor-vehicles or trains were involved," or "in some rear-end crashes outside urban areas." [62]

On the other hand, looking specifically at research conducted in the UK:

- A study of children admitted for head injuries to a Nottingham intensive care unit (January 2011-June 2018) concluded that they were significantly less likely to be wearing a helmet than the 'general population'. None of the 22 injured children, in fact, was wearing a helmet.

  The authors' estimate of children's helmet-wearing rates (17.3%), however, was based on observations made of only 133 individuals at six local schools, and their decision to use this figure in their calculations is questionable. For instance: there is no guarantee that the helmet-wearing rate they quote really does reflect the habits of the 'general population' - children who wear helmets to school may be less likely to wear helmets when cycling for other purposes (their schools' cycling policy, for example, may have influenced them); similarly, there is no way of telling whether the type of cycling the injured children were doing, or their riding environments, was comparable with school trips; also, over two-thirds (15/22 or 68%) were hit by a motor vehicle (i.e. the type of impact that helmets are not specifically designed to mitigate.[63]

- A 2019 study of cyclists (aged 16+) admitted to UK hospitals with major injuries over a five-year period concluded that there is a "significant correlation between use of cycle helmets and reduction in adjusted mortality and morbidity associated with TBI and facial injury."

  After excluding patients whose injuries did not reach a certain threshold of severity, along with over 4,500 seriously injured cyclists for whom no data on helmet use was recorded, the authors were left with 6,621 cases. Of these, 4,075 were wearing helmets and 2,546 not (suggesting that more helmeted cyclists were admitted with major injuries than un-helmeted cyclists – it is not possible to tell if this is a reflection of wearing rates in the general population as the authors do not cite them).

  The study also found that: "There was a statistically significant increase in chest, spinal, upper and lower limb injury in the helmeted group in comparison with the helmet group". For example, 10.7% of helmeted cyclists suffered serious spine injuries, compared to 5.4% of un-helmeted cyclists.

  Although they knew that most of their subjects were male (84.7%), they had no idea what type of cycling they were doing (e.g. MTB or urban commuting), or what type of helmets they were wearing and could not take account of evidence suggesting that cyclists who wear helmets differ from those who do not.

  They did, however, record at least one other disparity in the two groups: around 15.6% of their un-helmeted cyclists had alcohol in their system as opposed to only 2.1% of those who were helmeted. Yet they do not acknowledge that this finding strongly implies that their un-helmeted subjects were far more likely to crash than their helmeted subjects in the first place and, as such, their decision to ride un-helmeted was not the only salient difference between them and the helmeted group.[64]

Looking at research conducted elsewhere:

- A study to determine whether helmets could offer a protective advantage even in a "dense urban setting with a commitment to road safety" - New York in this case – states that the protective impact "remains significant."[65]
- Researchers, also in the US, who examined 67,000 cases of bicycle-related injuries among children (5-17 years, 2006-2015), concluded that traumatic brain injuries – which included concussion, fracture to the head and internal organ injury to the head – were more frequent among non-helmet users and children with injuries sustained in collision with a motor vehicle. (This conclusion was not based on all 67,000 cases, however, but 9,600 (14%), because the records did not always state whether or not a child was wearing a helmet). [66]
- Over time, other researchers in the US have variously concluded that helmet use protects again severe traumatic brain injury and/ or head and neck injuries (see endnotes [67, 68] for example).
- A meta-analysis concluded that helmets were protective against facial injury.[69] Other studies have also looked at whether helmets help protect against facial injuries, but come to opposing views.[70, 71, 72]

It is important to note that many of the above studies were hospital-based, i.e. they looked at hospital data only and directly compared injury outcomes among helmeted cyclists with those among un-helmeted cyclists.

This points to an inherent shortcoming: their conclusions are based on the assumption that the absence or presence of a helmet is the only difference between the two groups in the context of injury outcomes. This means they ignore other differences that may well be correlated with the chances of a cyclist falling and suffering a head injury *in the first place*.

For a more detailed discussion of confounding factors, plus commentary on why the evidence on helmet effectiveness is so often contrary, see **Appendix B**.

e. What impact do helmet laws have on head injuries among cyclists?

Much evidence refutes the argument that helmet laws materially improve cyclists' overall safety. Indeed, where fatalities decline, it is probably because the number of cyclists has declined too, thanks to the deterrent effect of the law. In some cases, injuries may have been trending downwards anyway:

- 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.[73]
- In Western Australia, both cyclists and pedestrians benefitted from reductions in head injuries in around 1990. The sharp increase in helmet-wearing among cyclists following the introduction of a helmet law in 1992 made no apparent difference to this.[74]
- In New South Wales (NSW), a 44% reduction in children cycling was observed two years after the law, but only a 32% decline in serious and fatal injuries in 1993 compared to 1990 (pre-law).[75]
- Also, a researcher who examined original cyclist count data from NSW concluded that the reduction in fatalities after helmets were made compulsory was probably due to reductions in cycle use in general, along with the fact that significantly fewer children were cycling, i.e. a group who accounted most frequently for cycling-related fatalities before the law. The researcher also found that fatalities were already dropping pre-law for cyclists, pedestrians and motorcyclists, and that the law coincided with road safety improvements (e.g. mobile speed cameras, random breath testing and 'black spot' remediation), and "... the construction and increasing use of both on- and off-road cycleways and shared paths".[76] All of these factors could have contributed to fewer cyclist fatalities in the years following the introduction of the helmet law.
- In New Zealand, the percentage reduction in cyclists' head injuries differed very little from the

reduction in head injuries overall (road users and others), with no effect detectable in 1994, the year the law was introduced, despite a very sharp increase in adult and teenage helmet-wearing rates that year.[77]

- Researchers who looked at hospital admission rates (2006-2011) for cycle-related injuries in Canadian jurisdictions with different helmet laws did not find a relationship between injury rates and helmet legislation. They therefore suggested that policymakers who want to reduce bicycling injury rates in the population should focus on other factors, such as increasing cycling mode share and infrastructure. [78]
- Research also from Canada concluded that making helmets compulsory in certain provinces has had minimal impact on reducing the rate of admissions to hospital for cycling-related head injuries. Injury rates, the authors say, were already going down in the provinces that had introduced compulsion. [79]
- Two studies from the US come to opposing conclusions about the impact of helmet laws. One concluded that "Bicycle helmet safety laws are associated with a lower incidence of fatalities in child cyclists involved in bicycle–motor vehicle collisions" (Note, the authors did not address the effect of helmet laws on ridership).[80] The other study, which investigated the rate of head and intra-abdominal injury in Los Angeles County before and after helmet legislation was introduced in 1994, states that "Injury patterns did not change … with head injuries predominating" (the rate of helmet use did not change either).[81]
- Comparing the effect of helmet legislation in Seattle (introduced in 2003) with that in King Country (introduced 1994), researchers found "no significant change in the proportion of bicyclists admitted to the hospital and treated for head injuries in either Seattle [...] nor in the rest of King Country. However, bicycle-related major head trauma as a proportion of all bicycle-related head trauma did decrease significantly in Seattle [...] while there was no significant change in King County [...]".[82]
- In Halifax, Nova Scotia, where helmet compulsion was introduced in 1997, the initial 60%+ reduction in cycle use recovered to a 40%+ reduction in the second year of the law; however, the initial c50% reduction in cyclist hospitalisations bounced back up and, in the second year of the law, total admissions were 6% higher that they had been in the year prior to the law.[83] There were similar instances of cycle use apparently falling by more than cyclist casualties in Victoria, South Australia and Vermont.[84]

4. Enforcement

a. Disproportionate investment

Helmet laws are not always strictly enforced, but when they are it usually involves heavy investment – especially by the police. In Victoria, Australia, 19,229 Bicycle Offence Penalty Notices and 5,028 Bicycle Offence Reports were 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. [85] Arguably, the resources required for this would have been better directed at the threat that dangerous drivers pose to all road users.

b. Targeting minority groups

As the next section shows, it is people from lower income groups who are least likely to own or wear helmets. They are thus more likely to be penalised – and there are even suggestions that helmet laws give the police more excuse to stop and question them. [86]

Enforcing a ban on cycling without helmets thus runs the risk of targeting minority groups. This is unfair:

their chosen transport option/leisure activity is not especially hazardous, and where hazards do exist, they are mostly imposed by inconsiderate and dangerous drivers, whose behaviour genuinely needs correcting in everyone's interest.

c. Penalising parents

Likewise, it would be a wrong and unpopular measure to penalise parents if, unbeknownst to them, their children are found cycling without helmets. For example, a child may leave the house wearing a helmet, but remove it when out of sight. Nevertheless, the child's parents would still be open to criminal prosecution.

5. Why legislation could exacerbate social exclusion

There is evidence to show that children from socially deprived areas and minority ethnic groups are less disposed to wear cycle helmets, and more likely to disobey helmet laws. Their reluctance also suggests that they are more likely to be deterred from cycling should helmet legislation be introduced and strictly enforced.

Evidence also suggests that cycle helmets have a deterrent effect on women's propensity to cycle, and that this would be exacerbated by compulsion.

a. Children from socially deprived areas

There is evidence that cycle helmet legislation has little long-term impact on helmet-wearing rates 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.[87]
- A study in Quebec found that a four-year helmet-wearing campaign was less effective in more socially deprived areas, despite offering discount coupons to help buy helmets. The researchers concluded that even with a subsidy, helmets were still beyond the means of families in these areas. [88]
- Similarly, a British study carried out among over 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.[89]
- During its 'Bike It' programme in Northern Ireland schools, Sustrans observed 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 five of the 96 pupils turned up with helmets.[90]

Hence, there is a real risk that if the police engage in helmet enforcement activities, any tension between them and deprived communities will be exacerbated (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 Transport Research Laboratory survey of cycle helmet-wearing rates in GB, carried out for the DfT in 2008, found that 'white' cyclists were more likely to wear a helmet than those of other ethnic origins.[91]
- In the US, a review of court and police records in Dallas found significantly uneven enforcement of

the city's helmet law, with 96% of citations outside 'downtown' being written in neighbourhoods of colour, and 86% in areas with a large number of households below the poverty line. Findings were similar in New York City and in Tampa, Florida.[92]

- Research into helmet wearing by Los Angeles children who had been involved in cycle crashes, found a significantly lower use of helmets among children of minority background and lower socio-economic status: Whites = 35.2%, Asians = 7.0%, Blacks = 6.0%, Hispanics = 4.2%.[93]

One particular concern is the potential impact helmet compulsion could have on migrant workers, many of whom, circumstantial evidence suggests, commute to and from work by bike. 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 failing to obey a law of which they are not aware.

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

Given the above, helmet laws would almost certainly 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, men are about three times as likely to cycle as women in Britain.[94] Also, women are more likely to think cycling is dangerous,[95] although seeing other people cycle seems to encourage them – a clear correlation has been found between levels of cycle use in different areas and the proportion of cycle trips being made by women.[96]

A survey of 1,099 women, carried out by YouGov for Cycling England back in 2008, 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.[97]

This seems to suggest that one way of encouraging more women to cycle is to promote it as a safe and/or stylish activity, entirely possible in whatever clothes women feel comfortable wearing, with or without headgear.

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

We have already noted the 'safety in numbers' effect, i.e. that 'more' and 'safer' cycling can – and should – go hand-in-hand. This is consequently what cycling policy must aim to achieve in order to maximise its health, environmental and other benefits.

In turn, this means tackling 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 high-quality cycle training for adults and children alike. Helmet laws – and even helmet promotional campaigns – are ineffectual in comparison and, in fact, likely to reduce the number of cyclists and undermine the 'safety in numbers' benefits for those who remain.

As mentioned, researchers who have looked at the impacts of helmet laws, have concluded much the same:

- Academics who analysed hospital admission rates for cycle-related injuries in Canadian jurisdictions where different helmet laws applied, found no relationship between injury rates and helmet legislation. They therefore suggested that policymakers were better off focusing on other factors to protect cyclists (e.g. increasing cycling mode share and infrastructure). [98]

- The author of a paper (2018) focusing on New South Wales concluded that four particular factors explained "… the gradual, rather than abrupt, decline in cycling fatalities, the selective reduction in fatalities among teenage riders and the lack of subsequent increase despite rising population." These factors included: road safety improvements (e.g. mobile speed cameras, random breath testing and 'black spot' remediation); and "the construction and increasing use of both on- and off-road cycleways and shared paths". [99]

See Cycling UK's *Cycling and Road Safety* for the most effective ways to make cycling conditions safer and more attractive. www.cyclinguk.org/campaigns/briefings

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.

As mentioned, a 2012 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. [100] 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 and sedentary lifestyles. Instead, we recommend:

- Investing in measures to create safe, attractive cycling conditions including widespread default 20 mph speed limits;
- Promoting 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;
- Introducing high-quality cycle training for all children in Year 6/7.

We are confident that these measures will have a tangible and positive impact on the numbers of cyclists involved in road traffic incidents, and on the levels of death and serious injury resulting from them. Moreover, these measures will improve cyclists' and potential cyclists' perceptions of the activity and are likely to lead to more (and thus safer) cycling. By contrast, helmet legislation will lead to a significant reduction in cycling levels, and loss of its well-documented health and environmental benefits.

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.

We are aware of only a few attempts to weigh up the costs and benefits of helmet laws:

- An analysis of Western Australia's helmet law (1999) suggested its net impact lay in the range from a 2 million AUS$ benefit to a 10 million AUS$ disbenefit.[101]
- 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.[102] A re-analysis of the latter study found no benefit for child cyclists either.[103]
- Another study (2014) that looked at the costs and benefits of introducing a cycle helmet law in Germany concluded that it would be a waste of the country's resources because analysis showed that the benefits of such a law would be about 0.714 of the costs.[104] The author took into account: the benefit of increased security when cyclists wear a helmet or use a transport mode that is less risky than cycling; the cost of purchasing helmets, reduced fitness when cycling is replaced by a motorized transport mode; the discomfort of wearing helmets; and environmental externalities.

The introduction to this briefing noted that Government has endorsed estimates that the health benefits outweigh the risks of cycling on Britain's roads by a factor of 20:1.

Given this ratio, telling people to wear helmets would result in a net increase in early deaths (due to physical inactivity etc.) if more than one person were 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, 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.

A study by Australian statistician Piet de Jong has attempted to address the question purely algebraically[105]. 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 (or possibly between -1 and +1 in the case of e). 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, the Department for Transport has endorsed the widely quoted figure of 20:1 as a value for β in the UK. [106], [107] 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).[108] 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 briefly examines and summarises its contradictions. It also responds to claims that the experience of helmet laws in Canada shows that helmet laws can be introduced without reducing cycle use.

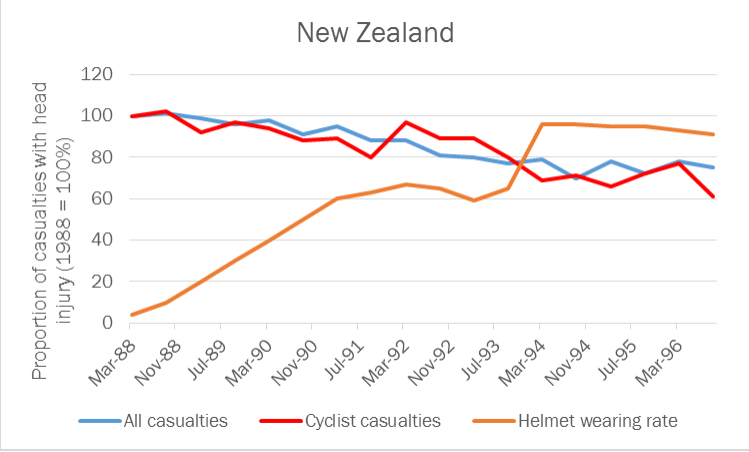
B1. 'Case-control' and population-level evidence

A number of early studies on the effectiveness of helmets reported substantial safety benefits from helmet use.[109] 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 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.[110] They are also at odds with the evidence of two papers by Hewson that found no detectable link between changes in helmet use and cyclists' safety, either for cyclists in general[111] or for children in particular.[112] 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).[113]

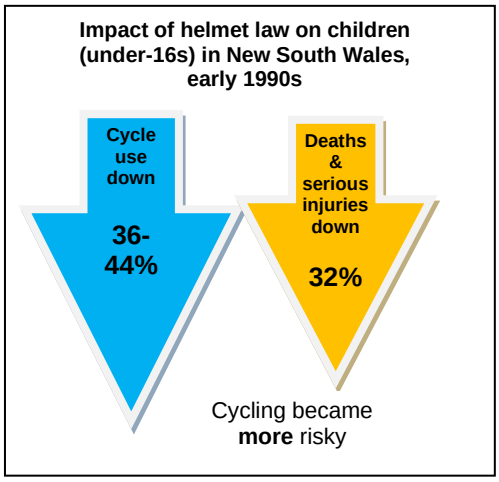
Whilst helmet laws have undoubtedly reduced the numbers of cyclist head injuries, the available evidence suggests this has been wholly or largely due to reduced cycle use, rather than improvements in cyclists' safety.[114]

In the case of New Zealand, it seems that other road safety improvements also played a part. The percentage reduction in cyclists' head injuries differed very little from the reduction in head injuries overall (road users and others), with no effect detectable in 1994, when the law was introduced, despite a very sharp increase in adult and teenage helmet wearing rates that year (see chart right).[115], [116]



This graph shows the change in the ratio of head injuries in New Zealand, relative to March 1988 (the reference date). Cycle helmets were made compulsory in 1994. Reproduced from *The bicycle helmet legislation, curse or cure?* By N. Perry, 2001. www.cyclehelmets.org/1234.html

In Western Australia, head injury percentages for both cyclists and pedestrians declined in line with each other during the mid-1980s (probably due to hospital procedures). They diverged from around 1990 (pedestrians increasing, cyclists continuing to decline), but there was no particular effect for cyclists when helmet use rose sharply as a result of making it compulsory in 1992.[117]



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 two years after the law, but only a 32% decline in serious and fatal injuries in 1993 compared to 1990 (pre-law). In the first year of the law, helmet use amongst children rose from 31% to 76%.[118]

In Halifax, Nova Scotia, the initial 60%+ reduction in cycle use recovered to a 40%+ reduction in the second year of the law; yet the initial c50% reduction in cyclist hospitalisations bounced back up and, in the second year of the law, total admissions were 6% higher that they had been in the year pre-law.[119] There were similar instances of cycle use apparently falling by more than cyclist casualties in Victoria, South Australia and Vermont.[120]

A review of helmet evidence for the UK Department for Transport 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%'.*[121]

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, we next set out why Cycling UK 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.

B2. The lack of detectable net benefits from helmets: possible explanations

a. What helmets are designed to do

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.[122], [123]

Cycle helmets are inevitably a design compromise between the desire 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). Helmet manufacturers themselves are typically very cautious about the safety claims they make for their helmets, stating only that they meet the relevant European or other standards.

Nonetheless, the lack of a detectable relationship between 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.[124] There are, however, many possible explanations for these phenomena.

b. Attitudes to risk and 'risk compensation'

According to Wikipedia, the 'risk compensation theory' suggests "that people typically adjust their behaviour in response to the perceived level of risk, becoming more careful where they sense greater risk and less careful if they feel more protected". The theory obviously has important repercussions for road safety.[125]

In terms of cycle helmets, there is evidence to suggest that some cyclists ride less cautiously when helmeted because they feel more protected:

- In 2016, researchers in the UK concluded that wearing a cycle helmet does increase risk taking and sensation seeking in adults. This finding was based on an experiment in which participants were asked either to wear a baseball cap or a cycle helmet while completing a computer simulation of risk-taking activities (they were not told the real reason for their headgear).[126]
- An earlier paper found evidence of risk-compensation among male cyclists, but not among females.[127] (Note that this research has been subject to criticism in another paper[128]).
- Risk-compensation has been observed in people engaging in other physical activities: a randomised controlled clinical trial looking at American footballers concluded that: *"Helmetless tackling eliminates the false sense of security a football player may feel when wearing a helmet."* [129]
- The phenomenon has also been observed in young children asked to run through an obstacle course once while wearing safety gear (helmet and wrist guards), and once without the gear. When wearing safety gear, they ran more quickly and behaved more recklessly.[130]
- Drivers may also 'risk-compensate', as they have been found to leave less space when overtaking helmet-wearing cyclists than those without.[131]

Clearly, this evidence is a crucial consideration for anyone who supports helmet legislation, but it is important to be aware that cyclists' perceptions about how much protection cycle helmets offer and how much risk they face when riding are not homogenous.[132, 133]

For example, some cyclists feel the need to protect their heads, so willingly buy and wear helmets. They are thus more likely to be inherently 'risk averse', will always ride cautiously, take quieter routes, obey rules etc. Introducing mandatory helmet laws may not make much, if any, difference to their behaviour and attitudes to risk.

Conversely, those cyclists who choose to ride un-helmeted and will only wear a helmet if pressured into it or forced to do so by the law, are more likely to be and remain 'risk tolerant'. It may be that, if they continue to cycle and start to wear a helmet, they will 'risk compensate' and indulge in yet risker behaviour.

Involuntary wearers, therefore, should never be conflated with voluntary wearers when considering the role that the known phenomenon of risk compensation may play if helmet-wearing is made compulsory.[134] As discussed in the next section, the difference between early (voluntary) and later (involuntary) helmet adopters might partially account for findings to suggest that, in casualty terms, helmet laws become less effective as time goes on.

Indeed, an experiment in Norway, where helmets are voluntary, implies differences in perceptions of risk and riding behaviour between people who routinely wear helmets and those who do not:

- Researchers, who asked 27 participants to cycle downhill with only one hand on the handlebars, observed whether wearing or not wearing a helmet changed their cycling behaviour and "psychophysiological load". There was no significant change in speed (the researchers' proxy for risk) among non-routine helmet users, but routine users "cycled more slowly and demonstrated increased psychophysiological load" when riding helmetless.

  Given that this may be a sign of 'inverse risk compensation' (i.e. riding more cautiously when feeling less protected), the authors could not rule out the possibility that "… helmet laws may increase cycling speed among certain cyclists".

  They also found, however, that whether their participants normally wore helmets or not, "Cycling with a helmet did not lead to increased speed, or to changes in emotional reactions as would have been expected from a risk compensation perspective." (This may have been because most of the subjects (23/27) were female and, arguably, more risk adverse than males – meaning that the authors could not be sure if their results would have been different had more males participated).[135]

  Note: Wondering whether non-routine wearers' behaviour would change if given more time to get used to a helmet, the same researchers later asked a group of 30 of them to cycle downhill with and without a helmet and then, after 1-1.5 hours of helmet 'habituation', to do the same again. Although their speed did not decrease significantly when riding helmetless, they said they felt less safe. Despite this, and the fact that the habituation period was extremely short, the authors concluded that risk-compensation is irrelevant to the helmet legislation debate.[136] In the light of the above research that suggests the opposite, Cycling UK believes this to be a questionable supposition.

Finally, a German study suggests that people who voluntarily wear helmets do take a precautionary attitude to risk. The researchers examined data from cyclists in 'naturalistic' conditions, all of whom were at liberty to decide for themselves if and when to wear a helmet. They did not find that their subjects rode any faster when helmeted, but that they were more likely to wear a helmet on longer trips, which were associated with higher speeds (possibly because they were cycling for sport or recreation). (Incidentally, the authors also speculated that it would be better to look at risky manoeuvres rather than speed in risk compensation studies).

c. Increased size and weight of helmeted head

The increased size, weight or even the temperature of the head may also be another factor that helps explain the lack of detectable net benefits from helmets. 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.[137]

d. 'Rotational force' impacts

There is some evidence to suggest that for some users and in certain circumstances, helmet use may increase the risks of 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 that may be fatal or result in permanent disability). [138]

Since 2007, when the main evidence for this was published, various mechanisms for helmets have come onto the market claiming to reduce the risk of rotational brain injuries (e.g. MIPS), although independent tests are awaited.[139] In future, official standards may require all helmets to pass a test for rotational acceleration during an oblique impact.[140]

e. Incorrectly fitted helmets

Some consumers may be more interested in comfort than in buying a helmet that is designed to fit their size of head. This is important because people with heavier heads, for instance, need to buy a helmet that is capable of absorbing more energy.

Moreover, some cycle helmet 'retention systems' (i.e. straps and clips) tend to be poorly designed, making it difficult to fit and wear helmets correctly.[141] The need to wear a helmet properly 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: 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.[142]

Fourteen children are known to have been killed through strangulation by their helmet straps. [143, 144, 145]

f. Loss of 'safety in numbers' effect

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).

B3. Contradictions between population and 'case-control' evidence: possible explanations

Cycle helmets are not the only subject that has led researchers to publish contradictory results. This is true, for example, of studies into hormone replacement therapy, vitamin supplements and the MMR triple vaccine, all of which have yielded what are now known to be false outcomes.[146] Some of these studies were based on 'case-control' methodology, which is inherently flawed and prone to spurious results.[147]

Similarly, the best known of the case-control studies of cycle helmets, which was based in Seattle (*Thompson & Rivara, 1989*), reported that helmets could prevent 85% of head injuries and 88% of brain injuries.[148] This finding, however, 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: as discussed above, people from lower income and racial minority groups are far less likely to wear helmets,[149,150,151] and there is a vast literature showing that people (particularly children) from these groups face significantly higher risks of road injury.[152,153,154]

In fact, in 2013, the US Department of Transportation (DoT) agreed to stop quoting the *Thompson and Rivara* claim (i.e. that cycle helmets are up to 85% effective in mitigating head injuries) in materials it disseminated through its website. This decision followed representations from the Washington Area Bicycle Association who challenged the figure under the *Data Quality Act* and proved to the DoT that the claim was not sound.[155]

A second factor may be that willing helmet-wearers take a different attitude to risk (see also risk compensation section above (2b). 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.[156]

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 due less to helmets than to the differences between the people who do and don't wear them, the types of cycling they do and the environments where they cycle. 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.[157]

B4. Effect of helmet laws on cycle use/injury: the case of Canada

Canadian helmet advocates argue that helmet laws there have improved cycle safety without reducing cycle use, a view influenced by a paper published in 2002 by LeBlanc et al.[158] This paper claims that Nova Scotia's helmet law was a success, despite presenting cycle count data that showed an initial reduction of 60%+ in the numbers of cyclists counted in the year the law came in, recovering slightly to 40% the year after, by which time the numbers of cyclists hospitalised was higher than before the law.[159], [160]

Likewise, a paper by Alison Macpherson and others in 2001 suggested that Ontario's helmet law for under-16s had increased helmet wearing rates without reducing cycle use. This claim was based on a study conducted in an affluent district of Toronto (i.e. amongst children who are more likely to be wearing helmets – see 5a).[161] It seems, however, that the law was not enforced,[162] which probably explains why a later study by Macpherson et al, published in 2006,[163] showed that helmet use had risen only temporarily, falling back to pre-law levels within two 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 because it did not control for variations in the time of year, weather etc., thus compromising the validity of before and after comparisons.[164] Furthermore, her team had also collected data, which they did not publish, for three years prior to the law. During this time, the population was subject to a strong helmet promotion campaign, which could have reduced cycle use in the run-up to the legislation itself – a possibility that the unpublished data may have demonstrated.

Macpherson's 2001 paper has nevertheless made an impact on the British Medical Association's (BMA) policy on cycle helmets. In 2004, it reversed its decision to support helmet promotion but not laws and, in doing so, cited Macpherson's paper.[165] The BMA has since withdrawn the paper which justified its change of policy, but has so far not reconsidered the policy itself.[166]

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.[167] 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 her 2006 paper, while the differences in injury trends between states with and without laws were as evident for pedestrian injuries as for cycling injuries. 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 valid.

Indeed, research published in the British Medical Journal (BMJ) in 2013 concluded that making helmets compulsory in certain Canadian provinces had minimal impact on reducing the rate of admissions to hospital for cycling-related head injuries. Injury rates, the authors say, were already going down in the provinces that had introduced compulsion "and the rate of decline was not appreciably altered on introduction of legislation." [168]

Similarly, a paper published in 2015, also in the BMJ, which looked at hospital admission rates (2006-2011) for cycle-related injuries in Canadian jurisdictions with different helmet laws found that "Helmet legislation was not associated with reduced hospitalisation rates for brain, head, scalp, skull or face injuries, indicating that factors other than helmet laws have more influence on injury rates."[169]

Yet researchers looking specifically at Alberta, where a helmet law was introduced for under-18s in 2002, concluded that there were "significant declines in the proportion of ED HIs [emergency department head injuries] and child, adolescent and adult bicyclist HI hospitalizations." This, they say, contrasts with "no significant trends in the proportion of ED or hospitalized HIs among pedestrians and the unexpected increases in the proportion of child and adolescent HIs for adult bicyclists [i.e. ED visits as opposed to hospitalizations]."[170] Note, however, that adult HI hospitalisations declined too (i.e. people not in the age group affected by the law); and that, according to the above-mentioned 2013 paper, the rate of hospital admissions for cycling-related head injures per 100,000 person years amongst under-18s was dropping pre-law in common with other provinces. Also, the law was not rigorously enforced, according to the authors.

B5. Re-examining the evidence: Cochrane reviews and other meta-analyses

Some studies have attempted to bolster the evidence for helmets and helmet-laws by re-analysing it. There have, for instance, been two Cochrane reviews, a process normally regarded as a benchmark of objectivity in meta-analysis of medical evidence.

The **first Cochrane review (1999)**,[171] which considered evidence on the effectiveness of helmets, was limited to 'case-control' studies, thereby eliminating any consideration of population-level evidence, such as that presented in papers by Robinson or Hewson (see above; see also section B3 on the limitations of case-control studies). Moreover, it was conducted by the same authors who had produced four of the eight head injury studies they were reviewing.[172]

Subsequent **meta-analyses by Attewell *et al* (2001)**[173] **and Towner *et al* (2002)**[174] (the latter being an evidence-review 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 (2007)**, [175] by Macpherson and Spinks, 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, which would have provided that evidence.[176]

A subsequent paper by Elvik found that early results – including the Attewell analysis and the Cochrane review of helmet effectiveness (and updates of it) – had significantly overstated the protective value of helmets. It also found that helmets may increase the risk of neck injuries.[177] (Note: Elvik's findings have been questioned by Olivier [178]).

DfT evidence review, 2010

In 2010, the UK Department for Transport attempted to 'settle' the helmet question with a second evidence review, *The potential for cycle helmets to prevent injury - a review of the evidence.*[179]

Having identified flaws in all the case-control evidence and hence the meta-analyses of that evidence, the researchers concluded that it was *'impossible to definitively quantify the effectiveness or otherwise of cycle helmets based on the literature reviewed'*.

They also identified weaknesses in the evidence of Robinson[110]110 and Hewson,[111,112] 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.

Notwithstanding, the authors of the DfT review did not explain why they assumed that helmets must have some benefits in preference to taking on board Robinson's contention that there is lack of detectable benefits (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 some helmet-wearing cyclists might be more prone to being involved in collisions in the first place e.g. due to 'risk-compensation').

The most notable feature of this study, however, 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 Cycling UK, 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).
- 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 Cycling UK's insistence). The study, and especially the 10-16% estimate, 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 a paper from 2007 which cited evidence of increased 'accident risk' per cycling-km for cyclists wearing a helmet, estimated to be around 14% in Australia and New Zealand.[124] This would therefore approximately cancel out a 10-16% benefit even if it were to prove correct (despite the lack of evidence supporting it).

Other studies

Inevitably, meta-analyses that conclude that helmets are effective in preventing injury (or certain types of injury) are simply reflecting the fact that most of the individual helmet studies they include in their reviews gloss over or ignore the negative impact that making them compulsory or promoting them is likely to have on public health (as discussed in Appendix A above).

Prominent recent examples of this include:

- *Bicycle Injuries and helmet use: a systematic review and meta-analysis published in the International Journal of Epidemiology* (2016).[180]
- *Recommend or mandate? A systematic review and meta-analysis of the effects of mandatory helmet legislation (2018).*[181]

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 may 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, in certain circumstances, of very serious brain injuries due to 'rotational force' impacts.

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 (see p20), 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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