CYCLE HELMETS – AN OVERVIEW

Introduction

Cycle helmets have been around since 1975. They were originally a 'spin-off' product from the development of expanded polystyrene foams in motorcycle helmets, intended to supersede the old 'hair net' style of head gear then used in cycle sport. However, the protection offered by cycle helmets is very much less than that provided by motorcycle helmets due to the compromises in weight and ventilation necessary in order to make them acceptable for an activity such as cycling that involves much physical exertion. Indeed, because of changes to design in order to address concerns about comfort, modern helmets with soft shells offer less protection than the original designs with hard shells.

At first cycle helmets were promoted mainly by their manufacturers, with competing claims about their effectiveness. Then, during the 1980s, reports began to be published suggesting that if cyclists wore helmets they would be less likely to suffer head injury. From that time, the promotion of helmet wearing by cyclists has been a main thrust of road safety and health practitioners in many countries.

How cycle helmets work

Cycle helmets protect the head by reducing the rate at which the skull and brain are accelerated or decelerated by an impact. The helmet acts like a shock absorber. As it is impacted, the expanded polystyrene liner dissipates the energy over a rapidly increasing area like a cone.

Helmets reduce the force of an impact only while the polystyrene liner is being compacted. Once the liner is fully compacted, a helmet offers no further protection and passes residual energy straight on to the skull and brain. There is no evidence to suggest that helmets continue to provide a reduced level of brain protection beyond their design limits.

When helmets fail, they do so catastrophically, rather than gradually, by breaking. The breaking of a helmet is not by itself evidence that it has provided useful protection to the wearer. It is common for cycle helmets to fail prematurely, before the polystyrene liner has been fully crushed. In this case, the protection experienced may have been minimal.

In cases of high impact, such as most crashes that involve a motor vehicle, the initial forces absorbed by a cycle helmet before breaking are only a small part of the total force and the protection provided by a helmet is likely to be minimal in this context. In cases where serious injury is likely, the impact energy potentials are commonly of a level that would overwhelm even Grand Prix motor racing helmets. Cycle helmets provide best protection in situations involving simple, low-speed falls with no other party involved.

See also: [1]

Standards

Cycle helmets are specified by their manufacturers as meeting one or more of the international standards for this equipment. However, there is no mandatory, third-party testing of helmets, and independent surveys have shown that a considerable proportion of the helmets on sale do not meet the standards to which they are accredited. Very few meet the more demanding standards.

The highest standards are those of the nominally independent Snell Foundation, of which the B-95 standard is the most rigorous.

The European standard EN 1078 is particularly weak and some other standards have declined over time. This is in part a reflection of the involvement in these standards committees of the helmet manufacturers, who want to minimise production costs in a fiercely competitive market. Few helmets are designed to offer protection better than that specified by the standards.

All standards prescribe tests using a flat anvil (though with greatly differing impact energies) but few include a test involving a hemispherical anvil, which is often closer to real-life crash conditions. No standard specifies tests involving rotational impacts.

See also: [1]

Cycle helmets and rotational injuries

Injuries to the head may be divided into direct, or focal, injuries and rotational, or diffuse, injuries.

Direct injuries occur as a result of linear acceleration of the skull by impact with another object, and typically lead to cuts, lacerations and concussion. Direct injuries, though sometimes painful, usually do not involve the brain and have minimal long-term effect.

Rotational injuries, on the other hand, do not necessarily involve direct contact with the head but result in the brain moving relative to the skull as a result of angular or rotational acceleration, which leads to diffuse axonal injury (DAI) and subdural haematoma (SDH). These are the most common ways that road crashes cause death or chronic intellectual disablement.

Cycle helmets may produce benefit by reducing and spreading the forces that lead to direct injuries. However, they are not designed to mitigate rotational injuries, and research has not shown them to be effective in doing so.

To the contrary, some doctors have expressed concern that cycle helmets might make some injuries worse by converting direct forces into rotational ones. These injuries will normally form a very small proportion of the injuries suffered by cyclists, but they are likely to form a large proportion of the injuries with serious long-term consequences. In this way cycle helmets may be harmful in a crash, but this harm may not be detected by small-scale research studies.

See also: [2]

Attitudes to cycle helmets

The active promotion of helmet use by cyclists is a fiercely controversial and often emotional subject, with views put forward with great conviction both for helmets and sceptical of their value (very few people argue against the voluntary use of cycle helmets per se). Controversy is particularly acute with regard to mandatory helmet laws.

The arguments in favour of helmet use are invariably based upon the premise that in the event of a fall, a helmet can substantially reduce the incidence and severity of head injuries. A relatively small number of medical research papers are cited in support of this premise, most based on case-control studies. One 1989 paper is cited more often than any other, with its claim that helmets reduce head injuries by 85% and brain injuries by 88%.

Proponents of helmet use include people from within the medical and road safety professions and also people who believe that a helmet has already saved them, or a relative or acquaintance, from serious injury.

Helmet-sceptic arguments are more varied. Originally based largely on issues associated with personal liberty, the balance of helmet-sceptic arguments changed during the 1990s as the health benefits of cycling became more acknowledged and as independent research started to be undertaken into the outcomes of rising helmet use and, in particular, the effects of cycle helmet laws.

Principal helmet-sceptic arguments are:

- there is no real-world evidence that helmets have reduced the likelihood or severity of head injuries among whole populations of cyclists;
- helmet promotion (and especially compulsion) reduces cycling and the health benefits of cycling. Less cycling increases risk for those who do cycle;
- the risk of serious head injury is small and frequently overstated;
- much pro-helmet research and promotional material is flawed;
- cyclists should not be singled out for helmets when other groups, especially pedestrians, are more prone to head injury.

Helmet sceptics include cycling organisations (especially those that have undertaken their own research), public health doctors and other professionals concerned with cycling safety, encouraging cycle use and helmet analysis. Most cycle users are also not convinced of the net benefits of helmet wearing as fewer than a third of people choose to wear one when use is voluntary.

In recent years many individuals and cycling organisations have swung from pro-helmet to helmet-sceptic as a result of experience with helmet laws and the growing breadth of evidence.

Case-control studies suggest that helmets are effective

Most published medical research that has studied the effectiveness of cycle helmets has been based on case-control studies, where groups of cyclists, with and without helmets, have been compared. This research has led to predictions of very large reductions in head injury through the use of cycle helmets – Table 1 shows the predictions of some of the most frequently cited papers.

Dorsch, 1987	-90% fatalities
Thompson, Rivara, Thompson, 1989	-85% head injuries, -88% brain injuries
Wasserman, 1990	-29% concussions, -82% skull fractures
McDermott, 1993	-39% head injuries, but no significant reduction for adults
Thompson, Rivara, Thompson, 1996	-69% head injuries, -65% brain injuries

Table 1
Injury savings predicted by case-control studies

Three meta-analyses of case-control studies have also found strongly in favour of helmet effectiveness.

Although a considerable number of papers have been published in the medical journals expressing support for helmet use, very few have been based upon primary research into helmet effectiveness. The majority are either dependent upon the results of earlier research, or are concerned with secondary matters such as the promotion of helmet use.

See also: [3], [4]

Other types of evidence do not generally support helmet effectiveness

As early as 1988 Rodgers studied 8 million cases of injury or death to cyclists in the USA over 15 years - the largest survey of its kind ever undertaken. He concluded that there was no evidence that hard shell helmets had reduced head injury or fatality rates. Indeed, he found that there was a significant positive correlation between fatalities and helmet use (i.e. helmeted riders were more likely to be killed).

A decade later, Kunich analysed cyclist and pedestrian fatalities in the USA and concluded that there was no evidence that cycle helmets were effective in reducing deaths.

Spaite found that bare-headed cyclists more often had severe injuries. However, this was true even when cyclists without major head injuries were analysed as a group. The implication being that people who do not use helmets tend to be in higher impact collisions than helmet users, since injuries are more severe to all parts of the body.

In 2001, the US Consumer Product Safety Commission reported that although helmet use had risen over a decade from 18% to 50% of cyclists, head injuries had also gone up by 10%. There was no clear evidence that cycle use had increased.

An analysis of cyclist and pedestrian fatalities in Canada from 1985 to 2003 showed that trends for both modes were similar and the number of deaths fell in both cases. However, although cycle helmet use had grown from virtually zero to 50% over the period, there was no detectable impact on cyclist fatalities compared with pedestrians.

In Greater London, helmet use is now around 50%, but there has been no noticeable benefit on cyclist casualties recorded by the police. Indeed, the severity of injuries increased during the same period as increases in helmet use.

For Great Britain as a whole, the rate of head injuries fell more from 1995 to 2001 for children than for adults. Yet, whilst adult helmet use increased by more than 50% over the period, child helmet use fell markedly.

So far as can be determined, nowhere in the world has an increase in helmet use resulted in a fall in head injuries relative to cycle use.

See also: [5], [16]

The effect of enforced helmet laws: less cycling and no effect on the proportion of head injuries

Helmet laws in Australia provided excellent data sets with which to test the effectiveness of cycle helmets because a principal effect of the laws was to increase substantially over a short period of time the proportion of cyclists wearing helmets. This enabled a comparison of a very large number of individuals not wearing and then wearing helmets, eliminating most of the other variables present when comparing different people or dissimilar riding conditions.

At first, reports suggested that legislation had achieved its aim of reducing head injuries. But the researchers did not take into account the very large decline in cycle use brought about by the laws. Robinson found that although more than 75% of cyclists wore helmets post-law, the reduction in cyclists counted was substantially greater than the increase in numbers wearing helmets. Thus the main effect of the law was apparently to discourage cycling rather than encourage cyclists to wear helmets. Although cycle use fell by about 30%, head injuries fell by only 13%, so the risk of head injury per cyclist would appear to have increased. Furthermore, the proportional reduction in head injuries for cyclists was very similar to that for unhelmeted pedestrians over the same period.

In 1999, the Australian Road Accident Prevention Research Unit compared head injury rates of cyclists, pedestrians and other road users. All followed similar declining trends, and the data *(see Figure 1)* suggests that there was no enduring benefit at all for cyclists. The report concluded that the law had not been cost-effective.

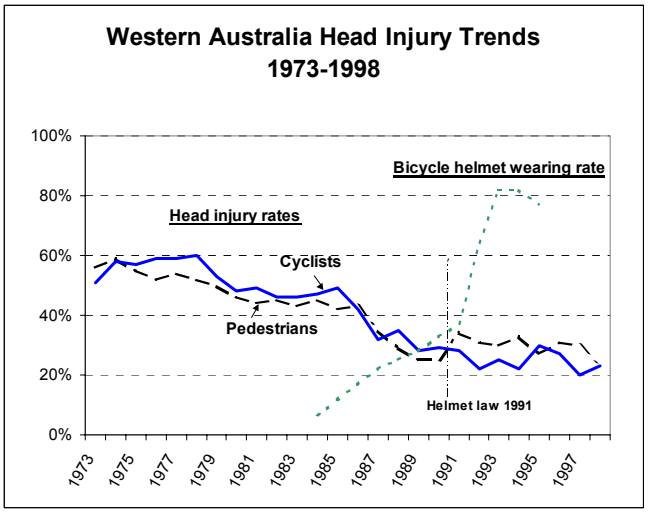

Figure 1 Western Australia Head Injury Trends

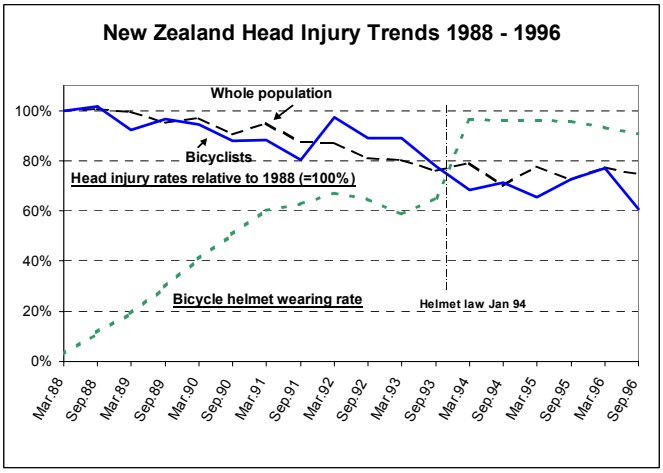

Figure 2 New Zealand Head Injury Trends

New Zealand followed Australia with a mandatory helmet law. This law was also found not to have been cost effective and the head injury rate did not decrease more than for the population at large. *(See Figure 2)*

In Canada, too, where helmet laws have been enforced, no benefit is apparent. In British Columbia and Nova Scotia there was no change in the proportion of cyclists suffering head injuries post-law, although cycle use fell markedly. In part of Alberta, the rate of head injuries was reported to have doubled in the first 6 months of its law.

See also: [6]

The effect of unenforced helmet laws: diminished respect for laws generally

In some jurisdictions, helmet laws have been enacted which are rarely enforced. These laws often have less impact on either cycle or helmet use than enforced laws. There is no evidence that they have resulted in a lower risk of head injury.

On the other hand, unenforced laws can erode public respect for the rule of law generally, and traffic laws in particular, especially amongst the young people at whom most helmet laws are targeted.

See also: [6]

A conflict of evidence

There is a stark conflict between the predictions of widely-publicised pro-helmet research, which suggests that helmets can deliver savings in head injuries of 65% to 90%, and data from other sources that suggest no benefit at all at a population level from cycle helmet use.

All data sources are subject to error and data collection practices vary widely. But simple data errors are unlikely to account for the large disparities between prediction and the real-world.

Many of the studies urging helmet use rely on gross extrapolation. For example, Dorsch's study predicted a 90% reduction in deaths but didn't actually include a single fatality in its dataset and the majority of helmets in her study were the old-fashioned leather hairnet type. Thompson et al. (1989) studied generally minor brain injuries such as concussion in cyclists treated in emergency rooms and used two different methods to estimate the benefits of helmets: 70% reduction in head injury comparing with non-head injured cyclists treated in the same emergency department, 88% comparing with cyclists in a Healthcare co-operative who simply fell off their bikes. Helmet campaigners invariably focus on the latter estimate although the statistical base is weak, and it assumes that helmets are equally effective at preventing fatalities and very serious brain injuries as minor concussions. The much more modest results from an Australian hospital admission study (McDermott 1993), that found no significant reduction in head injuries for adult cyclists, are hardly ever mentioned.

Most of the frequently cited pro-helmet research has been criticised for fundamental methodological shortcomings, particularly with regard to case-control techniques. Although randomised case studies are a well-regarded research tool, in cycle helmet research randomised studies have not been practical. Non-randomised studies are much less robust and are subject to bias from socio-economic factors not under the control of the researcher. Cyclists choosing to wear helmets may be very different from those who do not.

By contrast, large population time-series surveys derived from multiple sources are subject to fewer biases, and data based on large changes in helmet-wearing behaviour after helmet laws are especially robust.

In theory, meta analyses minimise bias by basing their analysis over a spread of the scientific research. This has not occurred with the analyses on cycle helmets. Two of the three meta analyses are based on the same 16 studies whilst the third analysis is based on a subset of 7 of the same studies. The latter work, published by the normally respected Cochrane Review, is dominated by its authors' own work and no reference is made to the many criticisms of this. All three meta analyses are based solely on case-control studies; there is no reference to, or analysis of, studies that reached more sceptical conclusions.

See also: [5], [12], [13]

Epidemiological research – an area of increasing controversy

Cycle helmet research is not the only area of research where such conflicts exist, as evidenced by an increasing number of papers in epidemiological journals drawing attention to this problem. There have been issues with studies of the effect of hormone replacement therapy on heart disease, vitamin supplements, antibiotics and the MMR triple vaccine. Findings that had appeared robust subsequently turned out to be unreliable or simply wrong.

The parallels between these other areas and cycle helmets are considerable, as is the 'snowball effect' that takes place whereby weak research is cross-referenced and becomes the conventional wisdom. A particular problem with helmets is that much of the helmet sceptic data and research come from outside the medical sector and is little known inside it.

See also: [7]

… But, a helmet saved my life!

Powerful support for cycle helmets comes from people who believe that a helmet has already saved them – or a relative or friend – from serious injury.

This is a very common experience, very much more common than the actual number of life-threatening injuries suffered by bare-headed cyclists. As there is no evidence that helmets save lives or serious injury at all across cyclists as a whole, most of these perceptions of helmet benefit must be mistaken.

Hypotheses requiring investigation include whether helmeted cyclists are more likely to crash. There is already evidence of greater risk-taking by some cyclists when wearing helmets, and also some evidence that a helmeted head is more likely to be hit if a crash does occur.

Risk compensation by cyclists has been confirmed in research and the empirical evidence in its support is becoming increasingly strong. However, the phenomenon remains controversial in cycling among safety professionals, although it is more readily accepted in other areas of life.

See also: [8]

Helmets and cycle use

It is now well established that enforced cycle helmet laws result in much less cycling. In Australia falls in cycle use averaged more than 30% and in Canada 28% to 40%.

However, much higher levels of abandoning cycling have been recorded among teenagers, with 90% of teenage girls ceasing to cycle at one Sydney school.

These falls in cycle use do not recover quickly and there is a long-term change in the profile of cycling. In Western Australia, concerted publicity, population growth and higher fuel prices returned cycling to its pre-law level in absolute numbers after ten years, but there was little recovery amongst children or for utility journeys. Relative to population, cycling levels remained suppressed. Cycling casualties, however, were higher than ever before.

Cycle helmet promotion, outside the context of helmet laws, has also been shown to be a strong disincentive to cycle use. As well as deterring individuals, it deters institutional support for the promotion of cycling by creating concern about liability if people who are encouraged to cycle do not wear helmets.

In European countries, cycling is one of the forms of physical exercise most frequently undertaken by children out of school and any reduction in cycling can impact significantly on children's fitness. In all the countries with enforced helmet laws, there is a high level of childhood obesity. On the other hand, in countries with high levels of cycling and low levels of helmet use, childhood obesity is much less of a problem.

It has been shown that the safety of cycling is closely associated with the number of people who cycle. Any decline in cycle use leads to increased risk for those who continue to cycle.

See also: [9]

Commercial interests

The manufacture and sale of cycle helmets is a highly profitable multi-billion dollar international business, dominated by a few large companies.

These companies have given money to campaigning organisations that seek to boost helmet use and introduce legislation.

The claims made by helmet manufacturers for their products are very modest compared with those made by lobby groups and they do not claim that a helmet will protect from death. However, the industry has been active in promulgating the results of pro-helmet research by others, even where this predicts benefits from helmet use well in excess of what manufacturers feel able to justify.

In Europe, industry campaigns to boost helmet sales in countries where helmet use is low have been driven by purely commercial considerations.

Is head injury a problem when cycling?

One outcome of the emphasis in recent years on cycle helmets and head injuries has been to brand cycling as an inherently hazardous activity, with a particularly high risk of head injury.

In fact, this is untrue. Everyday cycling, like walking, is a low-risk activity, and one where the health benefits outweigh the risk of injury by around 20:1. The bottom line is that people who cycle regularly live longer, on average, than people who do not, with healthier lives and less illness. This cannot possibly mean that cyclists are especially vulnerable to life-threatening head injury.

In England the number of children each year who experience serious head injury when cycling is no more than about 500 – out of a population of 6 million children who cycle frequently. Few of these injuries are life-threatening. The risk of head injury is little more than the average for all activities and significantly less than for pedestrians.

Safe though cycling is, the best proven way to improve the safety of cycling further is through the encouragement of more people to cycle – risk decreases by a third as cycle use doubles. Cycle helmet promotion and laws, on the other hand, discourage cycle use and thereby decrease safety.

See also: [10], [11], [14], [15]

References

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This information sheet attempts to give a concise overview of a very complex subject.

For more detailed information, including references, see www.cyclehelmets.org.

The Bicycle Helmet Research Foundation, an incorporated body with an international membership, exists to undertake, encourage and spread the scientific study of the use of bicycle helmets. Also to consider the effect of the promotion and use of helmets on the perception of cycling in terms of risk and the achievement of wider public health and societal goals.

BHRF strives to provide a resource of best-available factual information to assist the understanding of a complex subject, and one where some of the reasoning may conflict with received opinion. In particular BHRF seeks to provide access to a wider range of information than is commonly made available by those that take a strong helmet promotion stance. It is hoped that this will assist informed judgements about the pros and cons of cycle helmets.

For more information, please visit www.cyclehelmets.org.