Road Safety Factsheet

June 2020

Cycle helmets

Cycling is becoming an increasingly popular activity on Britain's roads. In 2018, cyclists covered an estimated 3.3 billion vehicle miles, representing an estimated 2% rise in cycle traffic since 2017[1]. Cycling provides a wide range of health benefits, mainly because it is a convenient and affordable form of physical activity, and increasing physical activity reduces the risk of many forms of ill health and disease[2].

However, unfortunately, cycling does not come without risk, as everyone is exposed to risk of injury on the roads as part of their daily lives. In 2018, 99 cyclists were killed, 4,106* were seriously injured and 13,345* were slightly injured on Great Britain's roads[3]. Although cyclists suffer a number of different types of injury during accidents, head injury has been identified as an important cause of death and serious injury in cycling collisions[4]. One way in which cyclists can prevent or reduce the extent of a head injury in a cycle accident is to wear a cycle helmet.

This factsheet will cover tips for choosing a cycle helmet, the evidence surrounding their effectiveness and RoSPA's policy position on helmet wearing.

RoSPA strongly supports measures that encourage healthy and sustainable travel. The key to increasing cycling (and so gaining all the health and environmental benefits that result from cycling) is to create a safe on and off-road cycling environment, improve driver and cyclist attitudes and behaviour towards each other, and to produce safer vehicles that reduce the risk to cyclists.

RoSPA advocates the Safe System Approach, which involves designing roads and vehicles to minimise the risk of crashes occurring, and ensures that when they do occur, they are unlikely to result in death or serious injury. 20 mph schemes are a good example of the Safe System approach because lower speeds reduce the risk of crashes occurring and the severity of any that do occur.

There continues to be much debate regarding the effectiveness of cycle helmets and whether the wearing of them should be made compulsory. RoSPA's position is that we strongly recommend that cyclists wear a cycle helmet. However, it is important to remember that cycle helmets do not prevent crashes from happening. It is therefore vital that through infrastructure improvements, supported by education and training that we reduce the primary risk factors.

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Components of cycle helmets

As shown in the labelled photographs below, cycle helmets consist of a number of different parts.

A shows the plastic shell of the helmet, which can be made of a hard plastic, or a softer flexible plastic.

B shows the foam section of the helmet, which consists of several layers to protect and cushion the cyclist's head in the event of an impact.

C shows the vents in the helmet, which allow the air to flow through the helmet, keeping the cyclist's head cool.

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D shows the chin strap, which ensures that the helmet stays in place.

E shows the retention system, which can be adjusted to get the best possible fit.

F shows a light on the rear of the helmet. A helmet with a light can improve other road user's visibility of the cyclist.

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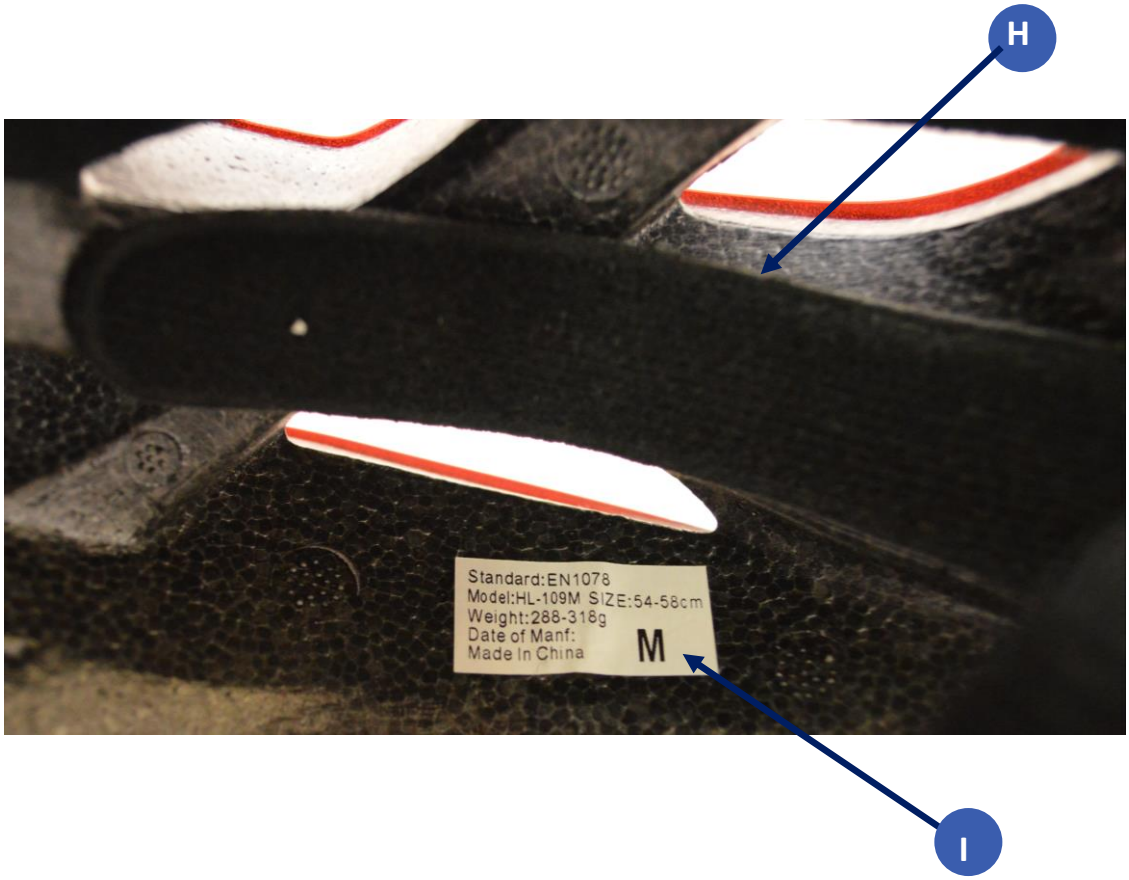

H shows the helmet padding, which again helps the cyclist to get the best possible fit and comfort. For hygiene purposes, the padding can usually be removed and washed.

I shows the cycle helmet label. The helmet must meet standard EN1078.

The law

Despite the protection that a cycle helmet can offer, currently, in the UK, there is no legislation that places any requirement on a cyclist to wear a helmet, though it is recommended by Transport for London and the Highway Code[5]. Rule 59 states that 'you should wear a cycle helmet that conforms to current regulation, is the correct size and securely fastened'.

How cycle helmets work

Bicycle helmets are manufactured from expanded foam polystyrene. This is because although polystyrene is structurally rigid, it is easy to damage by crushing because it is full of tiny air pockets. As the process of crushing absorbs energy, this makes expanded foam polystyrene the ideal material for bicycle helmets[6]. This is because if the liner material in the helmet was elastic, the impact energy that was initially absorbed would be returned to the head later in the impact, making the helmet much less effective at protecting the cyclist's head[7]. Some helmets are also made of expanded polypropylene or expanded polyurethane, which have similar properties. However, these materials are not as common because they are heavier and more expensive[8].

Modern cycle helmets also have a micro-shell, often made or plastic. This shell is usually between 0.3 and 0.8mm thick and is bonded to the liner material during the manufacturing process. The micro-shell can help to maintain helmet integrity in an impact, which is important if a second impact to the head occurs in the same accident[4]. This shell is also designed to glide along the road in a collision, rather than bringing the head to a jarring halt, which could cause further injury to the cyclist.

Choosing a cycle helmet

There are many different kinds of cycle helmets available in the UK, ranging in price. However, if you do choose to buy a cycle helmet, there are a number of things to consider.

Safety

The main purpose of a cycle helmet is to prevent or reduce the extent of injury to a cyclist's head during a collision. Therefore, the safety of the helmet must be considered. Cycle helmets must adhere to standard EN1078, which states that a helmet must be designed to withstand an impact similar to an average rider travelling at 12mph falling onto a stationary kerb-shaped object from a height of one metre[5]. To determine whether the helmet meets these standards, the helmet will go through a number of tests, looking at helmet construction, field of vision, shock absorption and the retention system. To ensure that your helmet meets this standard, look for a CE marked EN1078 sticker.

A standard has also been designed for younger children's helmets, known as EN1080. The difference between this and the EN1078 standard is that the chin strap is attached differently to an EN1080 standard helmet. With these helmets, the chin strap is designed to snap off during a collision to prevent the child from choking or being strangled if the helmet snags[9].

However, it is important to note that helmets are not tested or expected to offer full protection to cyclists who collide with a moving vehicle. This is because in collisions with a motor vehicle, speeds can be far higher and the forces that can result from a collision are unpredictable. Therefore, it is much more difficult to calculate the degree of protection the helmet can offer in these situations.

Investing in a helmet with multi-directional impact protection system, known as MIPS can also be considered. This adds an extra layer of protection within the helmet shell, which helps to redirect dangerous rotational forces that the brain can be subjected to during a fall or collision. These helmets often look and feel the same as other helmets, but have a thin yellow liner inside the helmet. If a collision occurs, this liner slips back minimally and redirects any twisting forces to protect the brain[10]. Similar technologies such as SPIN (Shearing Pad INside) and WaveCel are also available.

A bicycle helmet report commissioned by the Road Safety Trust and [11] published by Folksam Insurance Group in 2020 tested 26 conventional helmets and 1 airbag helmet and identified eight 'recommended' cycle helmets, four of which are readily available on the UK market.

In a bicycle helmet testing study, Research Institutes of Sweden (RISE) tested helmets that had been approved according to the CE standard, which means that the energy absorption of the helmets has been tested with a perpendicular impact to the helmet. As in a bicycle fall or collision, the impact to the head is often oblique, testers attempted to simulate this in their tests.

26 helmets sold on the Swedish and UK market were tested. Five physical tests were conducted, two shock absorption tests with straight perpendicular impact and three oblique impact tests and computer simulations were carried out to evaluate the risk of concussion.

The safety level of a helmet was then rated relative to the average test result for all helmets tested. To obtain the best overall result and thereby be awarded the "Recommended" label, the helmet needed to perform better than the median in both the shock absorption test and the oblique impact test.

Fit

It is also of paramount importance that the helmet fits well, as the majority of helmets come in a variety of sizes. If a helmet is too small, it will sit too high and fail to protect the lower part of the head. If it is too big, the helmet will not be securely fitted to the cyclist's head and could shift during a collision, exposing the cyclist's head to damage. Although helmets can be purchased online, it is recommended that you visit your local bike shop to be correctly fitted for a helmet.

Although helmets do come in a variety of sizes, features such as a retention system and padding can ensure that you get the best fit.

Many helmets will have a retention system to allow the cyclist to adjust the helmet to fit their head. Some of these systems include a ratchet at the rear of the helmet that slides in and out to adjust the fit for comfort and security. The best retention systems are usually micro-adjustable and can be used with a single hand, which is useful if you need to adjust your helmet during a ride. These systems usually involve an easy-to-use dial ratchet that you can twist to adjust. Some more advanced retention systems also adjust in multiple directions to fit the cyclist's head shape[7].

Padding can also be added to the helmet to get a better and more comfortable fit. For convenience, it is best to purchase padding that can be easily removed and washed. However, it is important to note that if you need to use thick padding, your helmet may be the wrong size or shape for your head[9].

The helmet should fit snugly around the head, but it should not feel tight and should not move more than an inch in any direction. The straps should form a 'V' under the earlobes and the cyclist should not be able to fit more than two fingers between their chin strap and chin. Once the chin strap is secured, it must not pull off. The helmet also needs to be positioned correctly. It should not be tilted forwards or backwards and there should be a gap of no more than two fingers between the cyclist's eyebrows and the helmet[9].

Ventilation

In terms of comfort, a well-ventilated helmet is important. The more vents that are on the helmet, the cooler the helmet will keep you and the lighter the helmet will be[12]. More expensive cycle helmets will often be designed to reduce weight, while offering full protection. Reducing the weight of the helmet allows you to climb and accelerate faster and conserve energy as you ride. It can also allow you to move your head more easily, allowing you to be more aware of what is going on around you and to spot potential hazards[7].

Visibility

When buying a helmet, it could be a good idea to get a white or brightly coloured helmet to increase other road user's visibility of you[13]. If riding on the road, it is also advisable to purchase a helmet that has a rear light, as this can be particularly useful in the darker months of the year[9].

Replacing your cycle helmet

It is important that a helmet is replaced immediately if you are involved in a collision or is dropped with enough force to cause structural damage. It is also recommended that a cycle helmet is replaced when it starts to show signs of aging and wear and tear. This is because collisions and wear and tear can cause internal weakness in the helmet, which is not visible to the human eye. This could mean that the helmet may not perform as well if you are involved in a collision or fall[9].

Some manufacturers offer 'crash replacement' if the helmet is under three years old, meaning that you can buy a new helmet at a reduced price if your helmet is involved in a collision.

Cycle helmet research

The effectiveness of cycle helmets

Although helmets cannot be expected to be effective in preventing or reducing the extent of head injury in all scenarios, evidence does suggest that helmets are effective in reducing injuries. The effectiveness of the

helmet is therefore dependent on the type of collision that the cyclist is involved in, the injury tolerance of the rider and the surface that the helmet makes contact with (e.g. a kerb or a car bonnet).

A Cochrane Review found that five case-control studies from different countries showed the large protective effect of helmets. The review suggested that helmets decreased the risk of injury to the head and the brain by 65%-88% and the upper and mid-face by 65%[14]. However, the review did acknowledge that little to no protection is offered to the lower face and jaw[15].

Recent studies have found that helmets do offer protection to the cyclist's head, but often to a lesser extent. A French study found that helmets contributed to a 24%-31% reduction in head injury and a 70% reduction in head injuries categorised at more than a level 2 (moderate injury) on the abbreviated injury scale[16].

One study found that in a sample of 97 patients admitted for over 24 hours with head injuries to a major trauma centre in London; those not wearing a helmet were significantly more likely to suffer a skull fracture or intracranial injury (traumatic brain injury). The study also identified that helmets may perform better in some situations than others. Results suggested that the helmet performed better from the effects of direct impact rather than shearing injuries. However, the helmeted group did experience less contusions (bruises) and subarachnoid haemorrhages, suggesting that helmets may protect from these kinds of injuries too, although further research is needed[17].

In another study, data from Finland of bicycle crashes that led to a hospital stay or death were analysed. Over one third of these cyclists had suffered a head injury and only 13% of these wore a helmet. 15% of those who wore a helmet suffered a head injury and 43% of those not wearing a helmet sustained a head injury[18].

A similar piece of research was conducted by Boufous et al (2012) who obtained data on police reported cycling crashes over a five-year period from the Road Authority of Victoria. This included 6,432 cyclist crashes, which were reported to the police between 2004 and 2008, with 2,181 resulting in severe injury of the cyclist. Analysis showed that a number of cyclist characteristics (e.g. helmet use and age) as well as crash and road characteristics were associated with the severity of injury of a cyclist involved in a traffic collision. Not wearing a helmet increased the risk of severe injury in police-reported cyclist traffic crashes by 56%[19].

In a study by McIntosh et al (2013), head responses in impacts were analysed and compared against helmet use, impact location, impact severity and helmet adjustment. A series of laboratory tests were undertaken using an impact rig and a dummy head and neck. The head struck a horizontally moving striker plate and head linear and angular acceleration and striker plate force were measured. Results showed that helmets reduced peak linear and angular acceleration. Results also showed that a cyclist without a helmet would suffer at least a concussion or mild traumatic injury in the least severe impact and have a greater than 30% chance of suffering a serious skull or brain injury in the impacts of higher severity. Although in certain situations, the wearing of a helmet can reduce linear and rotational acceleration of the head upon impact, it cannot show that this will be the case in every scenario[20].

A study conducted by McNally and Whitehead adopted an approach in which they created individual computer simulation models of a bicycle, cyclist (with and without helmet) and a vehicle. They then modelled four accident scenarios: loss of control, kerb impact, side impact by a vehicle and rear impact by a vehicle. Helmets were found to be effective at reducing the severity of head injuries over the full range of simulations. Where the head impact did occur, the risk of sustaining an injury of above level three on the abbreviated injury scale (serious injury) was reduced by 40%. However, as other studies have shown, McNally and Whitehead

acknowledge that cycle helmets will not protect in all situations. They found that in four of the 21 simulations (19%) with a head injury, a helmet did not reduce the severity of an injury. Each of these cases were high-energy impact involving a vehicle and were fatal whether a helmet was worn or not. Despite this, the simulations showed that a fatality could be prevented in one third of cases by wearing a cycle helmet[21].

Elvik criticised the 1999 Cochrane Review of the effectiveness of cycle helmets and stated that helmet use could be associated with a 50% decrease in head injury and a 21% reduction in fatal injury, but increases the odds of neck injury by 28%[22]. However, a recent meta-analysis suggested that neck injury is not common, is usually of a low severity and is not associated with helmet use. Across all studies in the review, the proportion of cyclists with neck injuries (2.6%) was much less than those with injuries to the head (29%), serious injuries to the head (7.4%) and injuries to the face (21.9%) [14]. For example, one study included in the review found that in a sample of 1710 cyclists, 65 had neck injuries and just four of these were more severe than a level 1 on the abbreviated injury scale (minor injury)[23].

Some also suggest that helmet use increases the chance of the cyclist suffering a diffuse axonal injury (a severe form of brain injury, which is a common cause of unconsciousness and a persistent vegetative state). However, like neck injuries, this is a rare diagnosis amongst cyclists. There is some evidence in motorcycle helmet research that suggests that there is a threshold at which a helmet turns from beneficial to detrimental in the event of a collision. However, this study estimated that this switch occurs at around 124km/h, which would not be possible on a bicycle[24].

The meta-analysis by Olivier and Creighton (2016) is based on 40 case-control studies. In these studies, 64,000 cycling casualties with and without helmet were compared. They estimate that the risk of severe head injury decreases by 69% and the risk of fatal head injury by 65%[25].

One study, published by the Institute of Transport Economics in Norway, involved carrying out a large-scale meta-analysis of 55 studies on the effects of bicycle helmets between 1989 and 2017. The main findings from the study are that cycle helmets reduce the risk of death or serious injury by 34%, serious head injury by 60%, traumatic brain injury by 53% and face injury by 23%.[26] The Dutch Road Safety Research foundation (SWOV) has used the results of the study to estimate that there would be 85 less fatalities per year if all Dutch cyclists wore helmets.[27]

The key aim of the study was to replicate the existing meta-analysis by Olivier and Creighton,[23] but with an extra 15 studies included. The study used methods for controlling for additional confounding variables (such as the idea that helmet-wearing cyclists are more sensible and safe in general, so their accident risk is likely to be inherently reduced), comparing data from hospitals and the police, and for testing publication bias (the tendency of researchers to only publish studies with positive results). Controlling for such factors means that the study is more likely to produce valid conclusions.

The methodology of the study involved the use of the logs-odds meta-analysis, meaning effect percentages were calculated with an odds ratio (OR), aka comparing the chances of a helmeted cyclist being injured in a particular way with the chances of an unhelmeted cyclist being injured in the same way. Standard errors, calculated using factors such as the number of participants in a study, were applied to the ORs in order to judge their statistical significance. Publication bias was accounted for by examining effect estimates (the extent to which an effect is present, e.g. the level of correlation between two factors) using several methods. Such methods allow the researchers to interpret results that are meaningful rather than just statistically

significant. In order to find the 15 extra bicycle helmet studies, a structured literature search was carried out across three academic search engines.

The key results from the study are as follows:

- For all injury types, large, statistically significant reductions were found between non-helmeted and helmeted cyclists. The reductions were still significant even after accounting for publication bias.
- Similarly to all injury types, head injuries also experience large, statistically significant reductions. After analyses there was no sign of publication bias affecting the results. Fatal head injuries were found to be reduced by 71%, serious (KSI) injuries were reduced by 60%, and overall head injuries by 48%. The study states that if cycle helmets do increase the risk of brain injury (e.g. via increase rotational acceleration), such risks are outweighed by the fact that the helmets reduce the overall risk of injury so much.
- A 33% reduction in face injuries was found. These results were also not affected by publication bias.
- No statistically significant effect was found for cervical spine injury.
- Bicycle helmets have a greater effect on reducing injury in the context of a single-bicycle accident, rather than a collision.

Overall, the study found consistent and robust reductions in head injuries, particularly when those injuries are serious or fatal, despite the differences between the large range of studies that were analysed. Such results could be used for evidence when recommending that cyclists wear helmets to reduce their risk of serious injury, particularly in dangerous conditions, e.g. windy roads.[24]

Does cycle helmet legislation reduce the level of cycling?

Despite the evidence surrounding the effectiveness of cycle helmets, some studies suggest that in areas where cycle helmets have been made compulsory, the levels of cycling has fallen, thus negating the potential health and environmental benefits. This has been cited as a reason to avoid making helmet wearing compulsory:

- Western Australia's helmet law reduced cycling in Perth by 30-40%[28].
- In Melbourne, child cycling levels reduced by 36% and 44% amongst teenagers[29].

Some countries or states have seen recoveries in cycling levels, mainly of adult recreational cycling. However, in these cases, there was often little or no enforcement of cycle helmet laws or enforcement had been relaxed. In areas where police continued to enforce cycle helmet laws, levels of cycling remained low, particularly among children and for day-to-day journeys[24].

One study of institutional databases found that there are many cases wherein cycling participation is reduced as a result of mandatory cycle helmet wearing, and when this happens there is no subsequent reduction in hospitalisations, and there may even be an increase in all-body injuries. The study also states that there is lots of evidence for the idea that cycle helmets actually cause an increase in the rate of accidents/injuries – particularly falls. The authors suggest that the causes for these negative effects include the fact that cyclists may believe they are safer when wearing a helmet, causing them to act in a more risky manner. Other explanations include increased head diameter and impaired vision.[30]

Although there is relatively little research on this issue and it remains unclear whether the enforcement cycle helmet laws does reduce the level of cycling, these findings are concerning, as the health and wellbeing benefits of cycling are also lost.

Risk compensation

Others state that the protective effect of cycle helmets is exaggerated, drawing on 'risk compensation'. This is where either cyclists or motorists change their behaviour as a result of a cyclist wearing a helmet, meaning that any benefit of wearing a helmet is offset by an increase in risk in other areas (e.g. the cyclist riding faster or motorists passing closer to the cyclist)[6].

One study found that drivers showed more risky behaviour towards a cyclist wearing a helmet. Instances included the driver overtaking cyclists wearing a helmet closer than those not wearing a helmet. As a possible explanation, the author mentioned that a driver might see helmeted cyclists as more skilled than cyclists not wearing a helmet, therefore selecting smaller safety margins[31].

While some research has been suggestive of this, reanalysis and re-interpretation appears to disprove any support for this notion[32].

Policy position

There continues to be much debate regarding the effectiveness of cycle helmets and whether the wearing of them should be made compulsory. RoSPA's position regarding this is that we strongly recommend that cyclists wear a cycle helmet, as it reduces the risk of suffering a serious head or brain injury in an accident. However, cycle helmets do not prevent crashes from happening in the first place, nor guarantee survival, but they do provide a last line of defence for the cyclist's head.

RoSPA does not support calls for compulsory cycle helmet laws because it is not clear whether such a law would discourage some people from cycling, which, if it did, would mean losing the health and environmental benefits from cycling. By deterring people from cycling, they may also reduce the benefits that cyclists gain from 'safety in numbers'. For more information on the safety in numbers effect, read our factsheet.

If we are to make cycling safer, it is vital that drivers and cyclist share the road space and that driver have a greater appreciation of their vulnerability. Cyclists are most likely to be injured at junction, roundabouts, where the road narrows (pinch points) and near left turning HGVs. Cyclists are particularly vulnerable at junctions where drivers 'look and fail to see'. RoSPA has completed a free downloadable presentation, which looks at where and when cyclists are most at risk and considers what actions both drivers and cyclists can take to help make cycling safer. This can be found at: http://www.rospa.com/road-safety/resources/free/drivers/

Helmets do have a role to play, however they must be regarded as a secondary safety feature. Preventing the collision happening in the first place should be paramount.

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***Due to changes in severity reporting across some police forces since 2016, newer statistics are not comparable to earlier years. Therefore, the DfT provides both adjusted and unadjusted casualty figures in their statistical data tables. RoSPA uses adjusted figures as the DfT states that they are recommended for "the analysis of trends over time".**