Bicycle helmets

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Summary

A bicycle helmet is intended to protect cyclists against head and brain injuries when they are involved in crashes. The helmet does not prevent bicycle crashes (see the SWOV fact sheet *Cyclists* for general bicycle safety measures). International research shows that in case of a crash helmeted cyclists are 60% less likely to sustain serious head/brain injuries and 70% less likely to sustain fatal head/brain injuries than cyclists not wearing a helmet. Bicycle helmet effectiveness may even increase by stricter European requirements for bicycle helmet testing.

In the Netherlands, most touring and sports cyclists wear a helmet; in ordinary traffic hardly anybody does. In countries with helmet laws the percentage of cyclists wearing a helmet is (obviously) much higher, however, even in countries where bicycle helmets are not mandatory, cyclists wear helmets more often than in the Netherlands.

Reasons not to wear a helmet are that the bicycle ride is too short and a helmet 'therefore not needed', that the helmet is uncomfortable (too hot or too cold) and that the cyclist's peers do not wear helmets either. A public support study among (road safety) organisations showed that measures encroaching on a sense of freedom are considered most controversial. Bicycle helmet campaigns generally result in higher usage, particularly among children, although usage sometimes decreases after the campaigns have ended. People are also more inclined to wear helmets when others (peers) are seen to do this too and also when it has become a habit.

In the Netherlands, there is little general support for mandatory helmet use. Most importantly because cycling would become (far) less popular if helmets were mandatory. Some foreign studies do indeed show that bicycle use decreases after the introduction of mandatory helmet use, albeit that most studies do not find any effect or merely a temporary effect. These international studies are probably not indicative of the effect to be expected in the Netherlands since, here, bicycles are relatively more often used for 'transport' than for recreational purposes.

1 How do bicycle helmets protect against head injuries?

A bicycle helmet does not prevent crashes, but in case of a fall or a crash, a helmet protects the head by the energy absorbing foam lining of the helmet. This foam lining crushes and reduces the impact on the brain. The foam lined interior is connected to the smooth hard exterior of the helmet. The smooth shell ensures little road surface friction and it can skid so as to prevent neck injuries. The hard shell ensures that the impact of the fall is spread over a broader surface area and that sharp objects cannot penetrate. The interior of the helmet is fitted with soft padding for comfort. The straps closing under the chin ensure the helmet stays on in case of a fall [1] [2]. Head rotation during a fall may be reduced by an extra layer in the helmet that moves along with the head (the so-called Multi-Directional Impact Protection Systems - MIPS) [3] [4]. Also see the question *How may the protection offered by bicycle helmets be improved and are there any alternatives to bicycle helmets?*

To achieve optimum protection the helmet should be a good fit and should be properly fastened [5] [6]. In case of a crash or fall, its effectiveness decreases as the impact speed increases. A helmet should at least comply with European technical standards (see the question *Which requirements should a (good) helmet meet?*).

For speed pedelecs a different, more robust helmet has been developed that protects a larger part of the head (also see the question *Is helmet use mandatory for (speed) pedelecs?*).

2 How often are bicycle helmets worn in the Netherlands?

In general, bicycle helmets are not a familiar sight in Dutch streets. Objective data about bicycle helmet use in the Netherlands are not available. On the basis of the preliminary results of an international questionnaire study in 2015 among a – possibly not entirely representative – group of adult cyclists in 17 countries, some indications may be given [7]. Of more than seven hundred Dutch respondents 34% claim to own a helmet. However, only a small group (2%) always wears a helmet; the majority (70%) never wears a helmet. And if helmets *are* worn, they are often worn during sports activities [7]. That helmet use during sports activities has become commonplace in the Netherlands, is also shown by the results of a questionnaire study among Dutch touring and sports cyclists; almost all (96%) reported wearing a helmet at all times [8]. The Cycling Union NTFU stimulates helmet use and advises its members to make helmet use mandatory for all tours. As early as 2003, the International Cycling Union UCI introduced mandatory helmet use for all road cycling races.

How often helmets are worn abroad varies by age group and country and, obviously, largely depends on legal requirements [9] [10] [11] [12]. In New Zealand [13] helmets are mandatory for all age groups. The rate of helmet use has been higher than 90% for several years. This also goes for Australia (Queensland), where the rate is higher than 98% [10]. In Finland, where helmet use has been mandatory since 2003 (incidentally without active enforcement), the rate for Helsinki is 64% and nationwide 42% [14]. In European countries where they are not mandatory, helmets are also worn. In Switzerland, almost half the population and three quarters of the children up to age 14 wear helmets [15]. In Germany, the helmet use rate is 19% across all age groups [16].

3 In which countries is bicycle helmet use mandatory?

Globally, there are 28 countries where helmet use is mandatory. In some countries (or in certain states/regions of that country) it is mandatory for all cyclists, in others only for children/youngsters. Not all countries impose fines when helmets are not used. The table below provides an overview of countries where helmets have been mandatory since what effective date; if this only applies to children this is indicated by 'age limit' [17].

Table 1. Overview of countries with bicycle helmet legislation (Source: [17])

Country	Effective date	Age limit
Argentina	2004	All
Australia	July 1990 - July 1992	All
Canada	October 1995 - April 2015	All/17*
Chile	2009	All
Estonia	July 2011	16
Finland	January 2003	All
France	March 2017	12
Iceland	September 1999	15
Israel	July 2007/August 2011	All/18**
Japan	2008	13
Jersey	October 2014	12
Croatia	2008	16
Latvia	October 2014	12
Lithuania	Unknown	18
Malta	April 2004	All
Namibia	Unknown	All
New Zealand	January 1994	All
Nigeria	2012	All
Austria	June 2011	12

Country	Effective date	Age limit
Slovenia	2000	15
Slovakia	Unknown	All
Spain	2004/2014	All/15***
Czech Republic	2001/2006	15/18****
United Arab Emirates	2010	All
United States	1987-2007	Various age groups
South Africa	October 2004	All
South Korea	2006	13
Sweden	January 2015	15

* In eight of ten provinces some form of helmet use is mandatory: in five provinces it is mandatory for all age groups and in three provinces up to age 18.
** In 2007, helmet use became mandatory for all age groups. Since 2011, children up to age 18 and all cyclists on rural roads have been obliged to wear helmets.
*** In 2014, the law was adapted for all age groups; mandatory helmet use for children up to age 16 and for all cyclists on rural roads, except when cycling uphill.
**** In 2001, helmet use became mandatory for children up to age 16. In 2006, this was changed into children up to age 18.

4 Why do cyclists choose (not) to wear bicycle helmets?

In the Netherlands, no research into the general motives to wear or not to wear a bicycle helmet has been carried out. The evaluation of a bicycle helmet campaign in the Dutch province of Zeeland provides some information concerning children. It showed that, for both children and parents, safety is the most important reason to have children wear bicycle helmets [18] [19]. The most important reason for children to stop wearing helmets is that their peers do not wear helmets and the parents do not want their children to stand out. Other reasons for parents not to have their children wear helmets are that they think their child is careful and cycles safely enough, and the school route is thought to be safe.

International research identifies different reasons to wear or not to wear bicycle helmets. A legal requirement is an important reason for helmet use. Thus, the introduction of legislation considerably increased the share of helmeted cyclists, the actual increase varying from 37% to 91% across different countries (Australia, New Zealand, United States) [20]. In Finland, helmet use increased by approximately 20 percentage points after the introduction of legislation (without enforcement) [14].

Reasons not to wear a helmet are the lack of comfort (too hot or too cold) and/or the short trip length making a helmet 'therefore unnecessary' [21] [22]. A Dutch public support study among (road safety) organisations showed that measures encroaching on a sense of freedom are considered to be most controversial [23]. International research into the motives to wear or not to wear a helmet has mainly been done among children and youngsters [20] [21] [22] [24] [25] [26], but there appear to be few differences between children and adults. Both groups are less inclined to use a helmet for short rides and are influenced by helmet use among peers [21] [22]. Since cycling culture and helmet use abroad are different from culture and usage in the Netherlands, it remains unclear how these results could be translated to the Dutch situation.

5 How effective are bicycle helmets in preventing (fatal) head injuries among cyclists?

In case of a fall or crash, the use of a bicycle helmet was found to reduce serious head/brain injury[1] by 60% and fatal head/brain injury by 71% on average. These are so-called 'best estimates', meaning that it has been established with 95% certainty that the risk reduction for serious head/brain injury is between 54% and 65% and for fatal head/brain injury between 44% and 85%. This has become apparent from the most recent meta-analysis by Høye [28]. This study compared injuries of helmeted and non-helmeted cyclists by combining the data of 55 (primarily) case-control studies from different countries meeting strict scientific requirements. This meta-analysis is a follow-up to a previous meta-analysis by Olivier & Creighton [29] that showed similar effects: a 69% reduction of the risk of serious head/brain injury (with 95% certainty of a reduction between 63% and 75%) and a 65% reduction of the risk of fatal head/brain injury (with 95% certainty of a reduction between 12 and 86%). Both studies show that, in general, the protective effect of bicycle helmets is the same for both children and adults [28] [29].

Most studies from the aforementioned meta-analyses have been carried out in the United States, Canada and Australia, and a few in Asia and Europe; none of these in the Netherlands however. In those countries, the infrastructure and traffic composition as well as bicycle use are often different from the Netherlands. It is possible, that bicycle crashes in the Netherlands may be of a different nature, which has consequences for the protective effect of bicycle helmets. However, there is no a priori indication of a larger or smaller effect in the Netherlands.

Bicycle helmet effectiveness is based on case-control studies, which is the prevailing method of study for this subject (see below for more information). In addition, biomechanical studies, studies involving computer simulations, and time series analyses have been done (also further explained below). In general, these studies find a considerable effect on reducing head/brain injury resulting from a fall or crash, although in time series analyses the effect is smaller.

1. Cases of serious brain injury involve brain contusion resulting in prolonged loss of consciousness and in neurological disorders [27].

Case-control studies

In case-control studies, the effectiveness of bicycle helmets is established by comparing cyclists involved in crashes resulting in head/brain injuries (case) to injured cyclists without head/brain injuries (control). The major advantage of case-control studies is that they concern real crashes that have actually happened. Case-control research into the effectiveness of bicycle helmets is done when there are no data about the (differences in) bicycle kilometres travelled by helmet users and non-users (exposure). This is usually the case when cyclists with or without helmets are compared. This method has, however, also been criticised, since it could result in an overestimation of the effectiveness of bicycle helmets [30]. Yet, other researchers did not find any evidence of this overestimation ([31] for example). In general, a well-designed case-control study is considered as a reliable indication of the effect of helmets. An experimental design, for example a randomised control study, in which the researcher randomly selects who *is* and who *is not* going to wear a helmet, is inappropriate for ethical reasons. That is why case-control studies are standard in this area of research [29].

Biomechanical research

For biomechanical research, bicycle helmets are tested for shock absorption in a laboratory. During the test, a dummy head with or without a helmet falls down. It is estimated that a bicycle helmet will reduce the risk of serious brain damage in a fall from a height of 1.5 metres from almost 100% to 10%; and in a fall from a height of 2 metres to approximately 30% [32]. In these tests, helmets were used meeting the legal US requirements. The legal requirements for testing bicycle helmets differ by continent (see [33] for an overview of helmet standards).

Computer simulations

In studies using computer simulations, both the impact on the head as well as the possibly protective effect of a helmet are simulated in a model. On the basis of simulations of three types of single bicycle crashes, researchers conclude that helmet use may reduce the risk of concussion by more than 50% and the risk of a skull fracture by more than 90% [34]. Computer simulation of bicycle-car crashes also show that bicycle helmets may mitigate the severity of brain injuries [35]. Simulation research shows that not only the impact speed but also the impact location on the head determines the protective effect of a bicycle helmet [1] [35].

Time series analyses

By means of a(n) (interrupted) time series analysis, the effectiveness of an intervention (for example mandatory helmet use) may be determined by the number of casualties before and after the intervention. Several studies have used this method to determine the effectiveness of bicycle helmets, or rather of mandatory helmet use [36] [37] [38]. These studies looked at the share of cycling casualties with head or brain injuries before the intervention and during a series of fixed times after the intervention. In general, this kind of study finds a lower effectiveness than studies with a more experimental design. A disadvantage of this kind of study is that they have a prolonged time scale (several years) and that in this period other factors (such as other road safety measures, bicycle use) may also have had an effect on the prevalence of head and brain injuries. Since not every hospital registers whether the injured cyclist wore a helmet or not, this further complicates the design of these studies.

6 How many casualties could bicycle helmets save?

SWOV has estimated the potential reduction of cycling casualties in the Netherlands if all cyclists wore helmets at all times [39]. This amounts to an annual decrease of 85 road deaths and of 2500-2600 serious road injuries (see Table 2). The estimate has been based on bicycle helmet effectiveness from a recent meta-analysis [28]. Also see the question *How effective are bicycle helmets in preventing (fatal) head injuries among cyclists?* relative to the prevalence of (serious) head and brain injuries among cyclists. The estimate of the effectiveness of helmets has exclusively been based on international research. Considering bicycle usage and the available (cycling) infrastructure in the Netherlands, it cannot be stated with any certainty whether the effect in the Netherlands would be the same. There are, however no concrete indications for a different outcome.

Table 2. Potential effects of an increase in helmet use from 0% to 100%. The effects are rounded up to the nearest multiple of 5 (deaths) and 100 (serious road injuries). Source: [39].

Target group	Effect on road deaths (annual reduction)	Effect on serious road injuries (annual reduction)
All cyclists	85	2500 – 2600
Children (< 12)	< 5	200
Senior citizens (>70)	45 - 50	900

Head and brain injuries are relatively common among cyclists. Almost one-third of all cyclists with serious injuries after a crash sustain head or brain injuries. In crashes involving motor vehicles, almost half of the cyclists sustain head or brain injuries (47%); in bicycle crashes without involvement of motor vehicles, this goes for over a quarter of them (28%; see *Figure 1* and also SWOV fact sheet *Serious road injuries in the Netherlands*. Head and brain injuries mean brain injuries in 86% of the cases, the remaining 14% concern head injuries without damage to the brain.

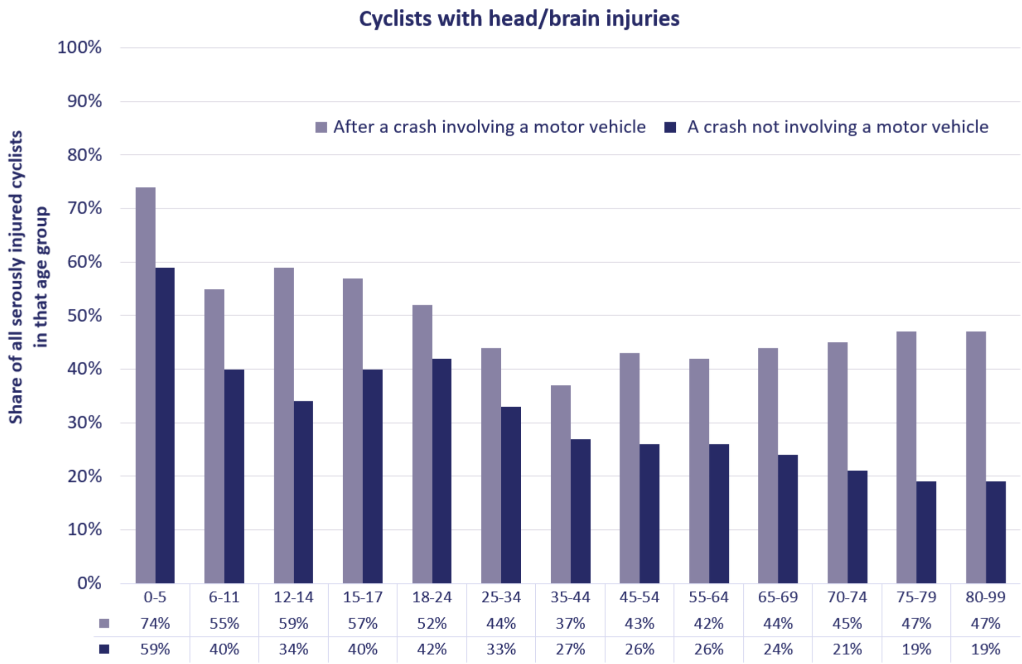

Figure 1. Annual percentage of cyclists with serious head/brain injuries (MAIS2+) as main or secondary diagnosis, the number relative to all hospitalised seriously injured cyclists in that age group; over the period 2010-2014 (Sources: Dutch Hospital Data – LMR/LBZ; CBS – Onderzoek Verplaatsingen in Nederland).

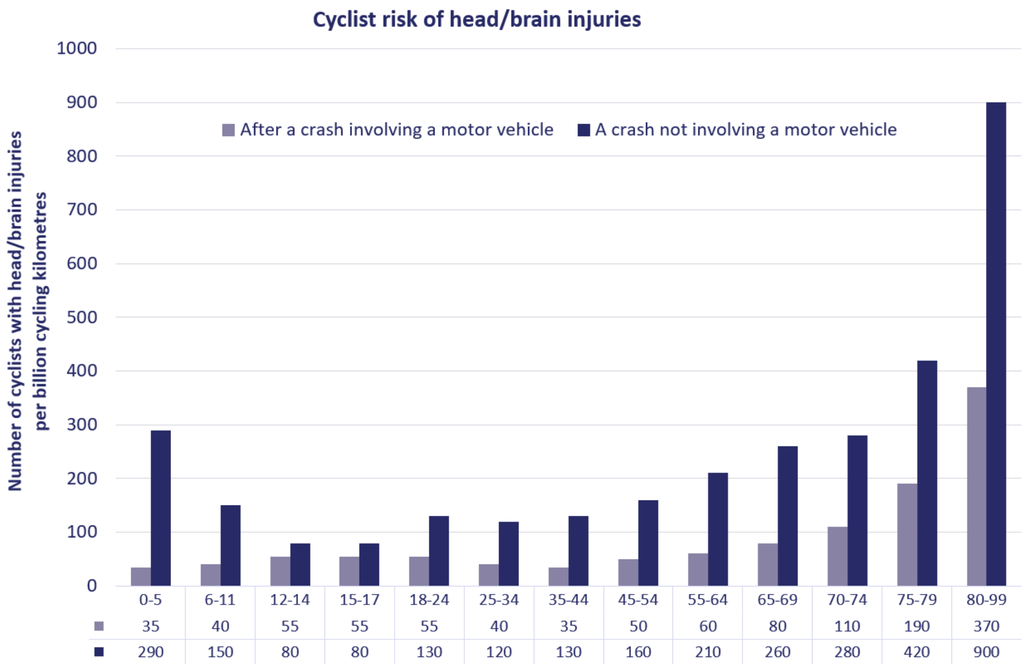

Figure 2. Annual number of cyclists with serious head/brain injuries (MAIS2+) as main or secondary diagnosis (rounded up to the nearest multiple of five) per billion cycling kilometres (risk); for different age groups over the period 2010-2014 (Sources: Dutch Hospital Data – LMR/LBZ; CBS – Onderzoek Verplaatsingen in Nederland).

In the Netherlands, there is hardly any support for general mandatory helmet use, not even among traffic organisations [23]. Often-repeated arguments against mandatory usage are that the effect is overrated, since cyclists and (other road users) will behave more unsafely; that head injuries may indeed be prevented, but that neck injuries will occur more often; and, above all, that mandatory helmet use will result in less cycling. The question *Do bicycle helmets also have adverse effects?* explores each of these arguments.

7 Do bicycle helmets also have adverse effects?

Only a few studies find indications that cyclists wearing helmets will behave less safely, or that other road users will do so in their presence (behavioural adaptation), but most studies do not find any evidence of these unintended adverse effects. The occasionally voiced assumption that bicycle helmets lead to more neck injuries lacks sufficient proof. The effect of (mandatory) helmets on the use of bicycles is not unequivocal. Below, each of these possibly adverse effects is explained.

Behavioural adaptation

Some researchers claim that the positive effects of bicycle helmets are limited because cyclists adapt their behaviour (e.g. behavioural adaptation or risk compensation, amongst others in [40]). Helmeted cyclists would supposedly feel safer and would show riskier cycling behaviour. The opposite effect of associating helmet use with safer cycling behaviour is also found. It is unclear whether cyclists behave more safely because of their helmets or, more probably, whether cyclists inclined to cycle safely anyway, use helmets more often. Systematic literature reviews [41] [42] show that empirical evidence for behavioural adaptation due to mandatory helmet use is not unequivocal.

Other road users may also adapt their behaviour: they may behave differently towards helmeted cyclists than towards unhelmeted cyclists. A British study [43] explicitly examined this. It showed that drivers of motor vehicles kept less distance to cyclists with helmets than to unhelmeted cyclists. A possible explanation is that motorists consider helmeted cyclists to be more skilled than cyclists without helmets, and therefore use smaller safety margins. However, re-analysis showed that the distance was unchanged, which therefore led to different conclusions. Further research is needed to determine how robust this (at this stage) one-off finding is (see [44] [45] for a discussion).

Neck injury

It is assumed that the extra weight of the helmet and possible friction with the road surface [46] increase the risk of neck injuries [47]. Yet, in recent meta-analyses of the effect of bicycle helmets [28] [29], no increased risk of neck injury was found.

Bicycle use

A frequently voiced argument against the mandatory use of bicycle helmets is that this would have an adverse effect [48] on bicycle use. Several international studies do indeed show a decrease in bicycle use, even though most studies do not find such an effect or only find a temporary effect [9] [42]. Also see the question *What is the effect of helmet use on the popularity of cycling?*.

8 What is the effect of helmet use on the popularity of cycling?

The effect of (mandatory) bicycle helmets on bicycle use is not clear. Several international studies show that bicycle use decreases after the introduction of helmet laws, even though most studies do not find such an effect or only find a temporary effect [9] [42] [49]. These international studies have probably little bearing on the expected effect in the Netherlands, since, relatively speaking, Dutch cyclists more often use bicycles for 'transport' and much less often for recreational purposes. Cyclists often find helmets uncomfortable, particularly for short rides (see the question *Why do cyclists choose (not) to wear bicycle helmets?*). Requiring or stimulating bicycle helmets could make cycling less popular. This would be an unwelcome development from the perspective of public health (apart from crash involvement), the environment and urban traffic flow.

There are two international review studies of the effect of mandatory helmet use on the use of bicycles, both dating from 2018 [9] [42]. The first study [42] shows that the available research results are not unequivocal. It states that mandatory helmet use could indeed result in a decrease of the number of cyclists, but that this need not always be the case and that, if the number of cyclists initially decreases, that need not be of long duration. The second study is a mostly qualitative analysis of the available literature [9]. Based on their findings, the researchers conclude that there is little to no evidence of a substantial decrease of bicycle use due to the introduction of mandatory helmets. They have examined 23 studies/data sets and conclude that 2 of these studies support the hypothesis that mandatory helmets lead to a decrease of cycling, whereas 13 studies do not, and 8 studies show mixed results.

The abovementioned review studies only concern research done abroad, in particular in Australia and North America. The results probably have little bearing on the expected effect in the Netherlands. Moreover, the only Dutch study on this subject, a study among children aged six to eight, did not find any indications of an effect of bicycle helmets on bicycle use [18].

9 How effective are bicycle helmet campaigns?

Bicycle helmet campaigns generally lead to an increase of helmet use, but sometimes the effect is only temporary. A review study mentions results of 19 studies about campaigns stimulating helmet use [50]. Most were carried out in the United States and Canada and mainly concerned children. The studies showed different results, yet the researchers conclude that

- promotional campaigns generally increase helmet use;
- the largest effect is reached among young children and particularly among girls;
- helmet discounts have a positive effect on purchase and usage.

The latest large-scale campaign in the Netherlands (in the province of Zeeland) also showed an effect, but only in the first year of the campaign [18]. During this helmet campaign, 32 thousand helmets were distributed free of charge among children aged four to eight between 2010 and 2015, accompanied by educational activities. The purpose of this campaign was to stimulate young children to wear helmets voluntarily and thus to reduce head injuries. During the first year of the campaign almost five times as many children (aged four to eight) wore helmets: an average increase of 3.3% to 15.7%. In the control area, helmet use remained unchanged (at virtually 0%). In subsequent years, helmet use again decreased, but remained slightly higher than it was at the start. The scale of the impact was strongly associated with the intensity of activities in the annual campaign .

10 Is helmet use mandatory for (speed) pedelecs?

In the Netherlands, helmet use is not mandatory for pedelecs (pedal assistance up to 25 km/hour), since pedelecs are classified as 'ordinary' bicycles. For speed pedelecs (pedal assistance up to 45 km/hour), however, helmet use has been mandatory since 1 January 2017. Since then, speed pedelecs have been categorised as mopeds according to European regulations (until 1 January 2017 they were classified as light mopeds). The speed pedelec helmet can be an 'ordinary' moped helmet that complies with the ECE22.05 standard, or it can be a helmet that complies with the NTA8776:2016 standard [51], which was specifically developed for speed pedelecs. Helmets for speed pedelecs have a number of specifications that differ from those for 'regular' helmets: the helmet has been designed to withstand higher impact speeds and protects a larger part of the head (the temples and the back of the head) [51].

11 Which requirements should a (good) bicycle helmet meet?

Bicycle helmets sold within the European Union should comply with European directives. An approved helmet has a CE marking on the inside, followed by the number of the European standard: EN-1078 for adults and EN-1080 for children's helmets. The difference between the two is the way the chin strap is fastened: the chin strap of children's helmets snaps off in case the helmet snags, which prevents the child from choking [52].

In compliance with the European standard, the effectiveness of bicycle helmets is tested by having the helmet impact on a flat surface ('flat anvil') at a speed of approximately 20 km/hour and on a 'curb' surface ('curb anvil') at a speed of approximately 17 km/hour. In this way, the speed at which the head impacts the surface during a fall (single bicycle crash) is reproduced; a fall from a height of 1.5 metres (relating to an impact speed of 20 km/hour) and from 1 metre respectively (relating to an impact speed of 17 km/hour) [2] [53].

According to several researchers [54] [55] [56] [57] [58], the European standard for bicycle helmets, and thus the Dutch standard, is not strict enough. It is also less strict than standards in the United States and Australia, for example. Different organisations have therefore called for an improvement of the European quality standard for bicycle helmets (see [59], for example) and the *Landelijk Actieplan Verkeersveiligheid 2019-2021* (National Action Plan Road Safety 2019-2021) also mentions improvement of the quality standard as one of the actions called for. Different concrete proposals for new and better bicycle helmets have already been made (e.g. [60]) (see the question *How may the protection offered by bicycle helmets be improved and are there any alternatives to bicycle helmets?*).

12 How may the protection offered by bicycle helmets be improved and are there any alternatives to bicycle helmets?

In the Netherlands, bicycle helmets have to comply with the European quality standards (see the question *Which requirements should a (good) bicycle helmet meet?*). According to different researchers [3] [53] [54] [55] [56] [57] [58] [60], the test procedure should be extended to include an 'angled impact' or 'oblique' test. In addition, a cyclist's airbag might offer better and additional protection against head and brain injuries [4] [61]. Finally, there are developments towards intelligent helmets that would not only provide physical protection but would also help prevent crashes. The fact sheet *Cyclists* provides a broader discussion of cyclist safety and measures to improve it.

Extension of test procedure for bicycle helmets

Different researchers [3] [53] [54] [55] [56] [57] [58] [60] advocate extending the test procedure to include an 'angled impact' or 'oblique' test, in which helmet effectiveness is tested by dropping it from a certain height on a slanted surface. These tests measure the effect of the helmet on head rotation. This is important because this so-called 'rotation effect' is closely related to the occurrence of brain injuries [1] [4] [61] [62] [63]. Today, there are several organisations already carrying out these tests (e.g. Certimoov and Folksam) and there are helmets on the market that offer better protection against rotational forces on the head in case of a fall. These have an extra layer inside the helmet which moves along with the head during impact (so-called Multi-Directional Impact Protection Systems - MIPS) reducing the rotation of the head [3] [4].

A second welcome extension concerns the impact speed during testing, in other words the speed at which a cyclist's head collides with something. Current European standards for bicycle helmets are based on an impact speed of 17 and 20 km/hour and simulate a fall from a bicycle. The speeds in a collision with a motor vehicle may, however, be much higher. In this case, the collision process and the associated impacts are also much more complex and diverse. By also testing the effectiveness of bicycle helmets in these conditions, the quality of helmets may improve.

Airbag for cyclists

A different current development is the airbag for cyclists. This is a kind of collar worn around the neck. It is a Swedish invention known by the name of 'Hövding airbag'. In case of a crash the airbag inflates, which not only protects the head but also fixates the neck. The Hövding airbag had positive outcomes in different tests [4] [61]. The reason is that the airbag reduces the rotational forces on the head more than a conventional helmet does. Intelligent technologies may also be applied to cars to make cycling safer. A cyclist airbag fitted onto the car is an example of this (also see the SWOV fact sheet *Cyclists*).

Intelligent helmets

Several manufactures are developing 'intelligent' helmets. These helmets are not only intended to protect against head and brain injuries but also to prevent crashes. Intelligent helmets may for example, by means of led-signals, show other road users when cyclists are braking and which direction they are turning. One such helmet (the 'Lumos bicycle helmet') is already on the market. Helmets that warn cyclists when a vehicle approaches in their blind spot (the 'Classon bicycle helmet') are still being developed; it is still unclear when they will come onto the market and how effective they will be.

Publications and sources

Below you will find the list of references that are used in this fact sheet; all sources can be consulted or retrieved. Via Publications you can find more literature on the subject of road safety.

[1]. Verschueren, P. (2009). *Biomechanical analysis of head injuries related to bicycle accidents and a new bicycle helmet concept*. Doctoral thesis KU Leuven, Leuven.

[2]. Sandberg, M., Tse, K.M., Tan, L.B. & Lee, H.P. (2018). *A computational study of the EN 1078 impact test for bicycle helmets using a realistic subject-specific finite element head model*. In: Computer Methods in Biomechanics and Biomedical Engineering, vol. 21, nr. 12, p. 684-692.

[3]. Bliven, E., Rouhier, A., Tsai, S., Willinger, R., et al. (2019). *Evaluation of a novel bicycle helmet concept in oblique impact testing*. In: Accident Analysis & Prevention, vol. 124, p. 58-65.

[4]. Stigson, H. & Kullgren, A. (2015). *Folksam's Bicycle Helmet Test 2015*. Folksam.

[5]. Ellena, T., Subic, A., Mustafa, H. & Pang, T.Y. (2016). *The Helmet Fit Index – An intelligent tool for fit assessment and design customisation*. In: Applied Ergonomics, vol. 55, p. 194-207.

[6]. Romanow, N.R., Hagel, B.E., Williamson, J. & Rowe, B.H. (2014). *Cyclist head and facial injury risk in relation to helmet fit: a case-control study*. In: Chronic Dis Inj Can, vol. 34, nr. 1, p. 1-7.

[7]. Haworth, N., Schramm, A., Houtenbos, M. & Shinar, D. (2015). *International survey of bicycling exposure, crash involvement, behaviors, and attitudes: Preliminary results*. In: International Cycling Safety Conference, 15-16 September 2015. Hanover, Germany.

[8]. Wijlhuizen, G.J. & Gent, P. van (2014). *Race- en toerfietsen: mogelijkheden voor meer veiligheid; Vragenlijststudie en expertbeoordeling [Racing and touring bicycles: opportunities for greater safety; Questionnaire study and expert assessment]*. R-2014-24A [Summary in English]. SWOV, Den Haag.

[9]. Olivier, J., Esmaeilikia, M. & Grzebieta, R. (2018). *Bicycle helmets: Systematic reviews on legislation, effects of legislation on cycling exposure, and risk compensation*. School of Mathematics and Statistics, Transport and Road Safety Research Centre; UNSW, Sydney.

[10]. Debnath, A.K., Haworth, N., Schramm, A. & Williamson, A. (2016). *Observational study of compliance with Queensland bicycle helmet laws*. In: Accident Analysis & Prevention, vol. 97, p. 146-152.

[11]. Macpherson, A. & Spinks, A. (2008). *Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries*. In: The Cochrane database of systematic reviews, nr. 3, p. Cd005401.

[12]. Jewett, A., Beck, L.F., Taylor, C. & Baldwin, G. (2016). *Bicycle helmet use among persons 5years and older in the United States, 2012*. In: Journal of safety research, vol. 59, p. 1-7.

[13]. Ministry of Transport New Zealand (2015). *Cycle helmet use survey 2015*. Retrieved on 01-04-2019 at https://www.transport.govt.nz/mot-resources/road-safety-resources/roadsafetysurveys/cyclehelmetusesurvey2015/.

[14]. Radun, I. & Olivier, J. (2018). *Bicycle helmet law does not deter cyclists in Finland*. In: Transportation Research Part F: Traffic Psychology and Behaviour.

[15]. BfU (2018). BfU survey 2018 - *Helmet-wearing rates among cyclists in road traffic*. Schweizerische Beratungsstelle für Unfallverhütung BfU, Bern.

[16]. Evers, C. (2018). *Gurte, Kindersitze, Helme und Schutzkleidung - 2017*. Bundeanstalt fúr Straßenwesen, BASt, Bergisch Gladbach.

[17]. Esmaeilikia, M., Grzebieta, R. & Olivier, J. (2018). *A systematic review of bicycle helmet laws enacted worldwide*. In: Journal of the Australasian College of Road Safety, vol. 29, nr. 3, p. 30-38.

[18]. Boele, M., Panneman, M., Adriaensens, L., Goldenbeld, C., et al. (2016). *Fietshelmcampagne 'Coole kop, helm op!' in Zeeland; Evaluatie van de effecten*. SWOV/VeiligheidNL, Den Haag/Amsterdam.

[19]. Goldenbeld, C., Boele, M.J. & Commandeur, J.J.F. (2016). *Evaluatie fietshelmcampagne 'Coole kop, helm op!' in Zeeland. Effecten op helmgebruik en factoren van invloed [Evaluation bicycle helmet campaign 'Wanna look cool, wear a helmet!' in the Province of Zeeland in the Netherlands; Effects on helmet use and influential factors]*. R-2016-8 [Summary in English]. SWOV, Den Haag.

[20]. Karkhaneh, M., Kalenga, J.C., Hagel, B.E. & Rowe, B.H. (2006). *Effectiveness of bicycle helmet legislation to increase helmet use: a systematic review*. In: Injury Prevention, vol. 12, nr. 2, p. 76-82.

[21]. Finnoff, J.T., Laskowski, E.R., Altman, K.L. & Diehl, N.N. (2001). *Barriers to Bicycle Helmet Use*. In: Pediatrics, vol. 108, nr. 1, p. e4.

[22]. Lajunen, T. (2016). *Barriers and facilitators of bicycle helmet use among children and their parents*. In: Transportation Research Part F: Traffic Psychology and Behaviour, vol. 41, p. 294-301.

[23]. Aarts, L., Eenink, R. & Weijermars, W. (2014). *Opschakelen naar meer verkeersveiligheid; naar maximale verkeersveiligheid voor en door iedereen*. R-2014-37. SWOV, Den Haag.

[24]. Berg, P. & Westerling, R. (2001). *Bicycle helmet use among schoolchildren--the influence of parental involvement and children's attitudes*. In: Injury prevention: journal of the International Society for Child and Adolescent Injury Prevention, vol. 7, nr. 3, p. 218-222.

[25]. Ross, T.P., Ross, L.T., Rahman, A. & Cataldo, S. (2010). *The bicycle helmet attitudes scale: using the health belief model to predict helmet use among undergraduates*. In: Journal of American College Health, vol. 59, nr. 1, p. 29-36.

[26]. Seijts, G.H.P., Kok, G., Bouter, L.M. & Klip, H.A.J. (1995). *Barriers to wearing bicycle safety helmets in the netherlands*. In: Archives of Pediatrics & Adolescent Medicine, vol. 149, nr. 2, p. 174-180.

[27]. NVvN (2015). *Schedel- en hersenletsel*. Nederlandse Vereniging voor Neurchirurgie. Retrieved on 01-05-2019 at https://www.nvvn.org/patienteninfo/schedel-en-hersenen/schedel-en-hersenletsel/.

[28]. Høye, A. (2018). *Bicycle helmets – To wear or not to wear? A meta-analyses of the effects of bicycle helmets on injuries*. In: Accident Analysis & Prevention, vol. 117, p. 85-97.

[29]. Olivier, J. & Creighton, P. (2016). *Bicycle injuries and helmet use: a systematic review and meta-analysis*. In: International Journal of Epidemiology, vol. 46, nr. 1, p. 278–292.

[30]. Zeegers, T. (2015). *Overestimation of the effectiveness of the bicycle helmet by the use of odds ratios*. Contribution to the International Cycling Safety Conference 15-16 September 2015, Hanover.

[31]. Olivier, J. & Radun, I. (2017). *Bicycle helmet effectiveness is not overstated*. In: Traffic Injury Prevention, vol. 18, nr. 7, p. 755-760.

[32]. Cripton, P.A., Dressler, D.M., Stuart, C.A., Dennison, C.R., et al. (2014). *Bicycle helmets are highly effective at preventing head injury during head impact: Head-form accelerations and injury criteria for helmeted and unhelmeted impacts*. In: Accident Analysis & Prevention, vol. 70, p. 1-7.

[33]. Connor, T.A., Meng, S., Zouzias, D., Burek, R., et al. (2015). *Current standards for sports and automotive helmets: a review*. HEADS-ITN.

[34]. Fahlstedt, M., Halldin, P. & Kleiven, S. (2016). *The protective effect of a helmet in three bicycle accidents—A finite element study*. In: Accident Analysis & Prevention, vol. 91, p. 135-143.

[35]. McNally, D.S. & Whitehead, S. (2013). *A computational simulation study of the influence of helmet wearing on head injury risk in adult cyclists*. In: Accident Analysis & Prevention, vol. 60, p. 15-23.

[36]. Dennis, J., Ramsay, T., Turgeon, A.F. & Zarychanski, R. (2013). *Helmet legislation and admissions to hospital for cycling related head injuries in Canadian provinces and territories: interrupted time series analysis*. In: BMJ : British Medical Journal, vol. 346, p. f2674.

[37]. Bonander, C., Nilson, F. & Andersson, R. (2014). *The effect of the Swedish bicycle helmet law for children: An interrupted time series study*. In: Journal of Safety Research, vol. 51, p. 15-22.

[38]. Olivier, J., Boufous, S. & Grzebieta, R. (2019). *The impact of bicycle helmet legislation on cycling fatalities in Australia*. In: International journal of epidemiology, vol. ePub, nr. ePub, p. ePub-ePub.

[39]. Weijermars, W.A.M., Boele-Vos, M.J., Stipdonk, H.L. & Commandeur, J.J.F. (2019). *Mogelijke slachtofferreductie door de fietshelm*. R-2019-2. SWOV, Den Haag.

[40]. Adams, J. & Hillman, M. (2001). *The risk compensation theory and bicycle helmets*. In: Injury prevention: journal of the International Society for Child and Adolescent Injury Prevention, vol. 7, nr. 2, p. 89-91.

[41]. Esmaeilikia, M., Radun, I., Grzebieta, R. & Olivier, J. (2019). *Bicycle helmets and risky behaviour: A systematic review*. In: Transportation Research Part F: Traffic Psychology and Behaviour, vol. 60, p. 299-310.

[42]. Høye, A. (2018). *Recommend or mandate? A systematic review and meta-analysis of the effects of mandatory bicycle helmet legislation*. In: Accident Analysis & Prevention, vol. 120, p. 239-249.

[43]. Walker, I. (2007). *Drivers overtaking bicyclists: Objective data on the effects of riding position, helmet use, vehicle type and apparent gender*. In: Accident Analysis & Prevention, vol. 39, nr. 2, p. 417-425.

[44]. Olivier, J. & Walter, S.R. (2013). *Bicycle helmet wearing is not associated with close motor vehicle passing: A re-analysis of Walker, 2007*. In: PLoS ONE, vol. 8, nr. 9.

[45]. Walker, I. & Robinson, D.L. (2019). *Bicycle helmet wearing is associated with closer overtaking by drivers: A response to Olivier and Walter, 2013*. In: Accident Analysis & Prevention, vol. 123, p. 107-113.

[46]. Amoros, E., Chiron, M., Martin, J.-L., Thélot, B., et al. (2012). *Bicycle helmet wearing and the risk of head, face, and neck injury: a French case–control study based on a road trauma registry*. In: Injury Prevention, vol. 18, nr. 1, p. 27.

[47]. Elvik, R. (2013). *Corrigendum to: "Publication bias and time-trend bias in meta-analysis of bicycle helmet efficacy: A re-analysis of Attewell, Glase and McFadden, 2001" [Accid. Anal. Prev. 43 (2011) 1245–1251]*. In: Accident Analysis & Prevention, vol. 60, p. 245-253.

[48]. Lemon, J. (2018). *Changes in participation, demographics and hazard associated with mandatory bicycle helmets in New South Wales, Australia*. In: Journal of Transport & Health, vol. 9, p. 195-202.

[49]. Rådet for Sikker Trafik / Epinion Copenhagen (2016). *Cyklistundersøgelse [Survey on cyclists]*. Radet for Sikker Trafik, Copenhagen.

[50]. Towner, E., Dowswell, T., Burkes, M., Dickinson, H., et al. (2002). *Bicycle helmets - a review of their effectiveness: a critical review of the literature*. Department for Transport, London.

[51]. Schepers, P., Jager, K. de & Hulshof, R. (2016). *Speed-pedelec wordt bromfiets: wat verandert er en wat zijn de gevolgen*. CROW.

[52]. Kemler, H.J., Ormel, W., Jonkhoff, L., Klein Wolt, K., et al. (2009). *De fietshelm bij kinderen en jongeren. Onderzoek naar de voor- en nadelen*. Stichting Consument en Veiligheid, Amsterdam.

[53]. Bourdet, N., Deck, C., Carreira, R.P. & Willinger, R. (2012). *Head impact conditions in the case of cyclist falls*. In: Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology, vol. 226, nr. 3-4, p. 282-289.

[54]. Bland, M.L., McNally, C. & Rowson, S. (2018). *Differences in impact performance of bicycle helmets during oblique impacts*. In: Journal of biomechanical engineering, vol. 140, nr. 9, p. e4040019-e4040019.

[55]. McIntosh, A., Lai, A. & Schilter, E. (2013). *Bicycle helmets: head impact dynamics in helmeted and unhelmeted oblique impact tests*. In: Traffic Injury Prevention, vol. 14, nr. 5, p. 501-508.

[56]. Mills, N.J. & Gilchrist, A. (2008). *Oblique impact testing of bicycle helmets*. In: International Journal of Impact Engineering, vol. 35, nr. 9, p. 1075-1086.

[57]. Willinger, R., Deck, C., Halldin, P. & Otte, d. (2014). *Towards advanced bicycle helmet test methods*. In: International Cycling Safety Conference, 18-19 November. Göteborg, Sweden.

[58]. Bland, M.L., Zuby, D.S., Mueller, B.C. & Rowson, S. (2018). *Differences in the protective capabilities of bicycle helmets in real-world and standard-specified impact scenarios*. In: Traffic Injury Prevention, vol. 19, nr. sup1, p. S158-S163.

[59]. Townsend, E. (2016). *The European Union's role in promoting the safety of cycling: proposals for a safety component in a future eu cycling strategy*. European Transport Safety Council Brussels.

[60]. Bogerd, C.P., Annaheim, S., Halldin, P., Houtenbos, M., et al. (2015). *HOPE: Helmet Optimization in Europe. The final report of COST Action TU1101*. Brussels, European Cooperation in Science and Technology COST, COST Action TU1101 / HOPE collaboration, 2015, 46 p. - ISBN 978-90-5986-465-8.

[61]. Kurt, M., Laksari, K., Kuo, C., Grant, G.A., et al. (2017). *Modeling and optimization of airbag helmets for preventing head injuries in bicycling*. In: Annals of Biomedical Engineering, vol. 45, nr. 4, p. 1148-1160.

[62]. Kleiven, S. (2006). *Evaluation of head injury criteria using a finite element model validated against experiments on localized brain motion, intracerebral acceleration, and intracranial pressure*. In: International Journal of Crashworthiness, vol. 11, nr. 1, p. 65-79.

[63]. Stigson, H., Rizzi, M., Ydenius, A., Engström, E., et al. (2017). *Consumer testing of bicycle helmets*. In: IRCOBI Conference, 13-15 September. Antwerp, Belgium.

Colophon

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Topics:
Transport mode - Bicycle

Figures:
Real number of cycling fatalities [Table in Dutch]

Real number of cycling fatalities per age group [Table in Dutch]

Real number of cycling fatalities per mode of transport [Table in Dutch]

Prevent crashes
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