

## What do we know about bicycle helmets?

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### ABSTRACT

Cycling is an excellent sustainable alternative to driving for many journeys. But cyclists have fewer safety options than car-users, with a helmet being the main safety device that is available. However, there are indications that increasing bicycle helmet usage through legislation causes confounding effects which might cancel out the positive effect of helmets on head and brain injury. Thus, increasing voluntary helmet use seems to be the most fruitful approach for now. However, current helmet design is suboptimal. Since several fields are important to bicycle helmet optimization, a combined effort involving all of these is necessary; so that a given parameter is not optimized at the cost of another. Finally, the attitudes of cyclists towards helmets must be considered if helmet usage is to be changed. Therefore a multidisciplinary approach respects the complex nature of the issue, is unique in Europe, and will provide more complete information to legislators, manufacturers, end-users, and scientists, ultimately leading to increased safety for cyclists.

**Keywords:** Bicycle helmets, In-depth accident analysis and injury statistics, Traffic psychology, Impact engineering, Ergonomics.

### 1. BACKGROUND

Increasing attention should be paid to optimizing the safety of vulnerable road users, including motorcyclists, pedestrians, and bicyclists, especially in countries in which automobile traffic guides current attitudes and practice. The bicycle is broadly regarded as an excellent and sustainable alternative to the automobile, especially for short trips, motivating several previous and current European research programs. However, cyclists are more vulnerable than automobile passengers in accidents. The public attitude towards bicycle helmets seems to have a strong emotional component. However, based on scientific knowledge it is difficult to formulate a consensus on bicycle use in general.

Cycling is an increasingly popular mode of transport in Europe, and its popularity is expected to increase, leading to environmental, economic and health benefits. However, relatively little research is being carried out focussing on the traffic safety of cyclists when compared to most other modes of transport. As a consequence many important fundamental open questions remain, as discussed below. In addition, little international coordination of research in cyclist traffic safety exists, possibly due to a lack of a relatively large industry behind this mode of transport as is the case in car driving. It was only in 2010 that the first international conference focussing solely on vulnerable road users like cyclists was held, in Jerusalem (Israel). In fact, as far as we could ascertain, the present conference is the first to focus solely on traffic safety of bicyclists.

### 2. THE CURRENT STATE OF KNOWLEDGE

One safety option for cyclists is a helmet. Several studies have directly compared head and brain injuries between helmeted and unhelmeted cyclists [1-4]. These studies found helmets to be effective in reducing these injuries, reporting a reduction of the risk of head and brain injury for all ages of up to 88% [5]. A reduction of 23% in skull fractures were observed from a German in-depth-accident study, as well as 33% fewer head injury of classification AIS 3+ [4]. Although, there is some debate on the exact potential of helmets to reduce the *risk* of head injuries, the positive effects regarding head injury are undisputed [6].

Another group of studies evaluated head injuries before and after legal changes forcing a sharp increase in helmet usage [7], and found no helmet-related effect on head injuries. In fact, these studies speculate on a reduced willingness to cycle, potentially compromising the benefits of this mode of transport. This possibly indicates that other factors change after helmet legislation is introduced, besides increased helmet use by those who continue to ride.

Cyclists constitute a substantial proportion of traffic fatalities, at a rate of 24% in the Netherlands, with several countries near 10%, as reported by the WHO [8]. Thus, improving cyclists' traffic safety will have a substantial effect on traffic fatalities. This is particularly important considering that the level of cycling as an alternative means of transport is expected to keep increasing in Europe. This is reflected, for example, by the continuous increase of bicycle sales in Europe, and by various European efforts to promote the bicycle as a means of transport. However, bicycle helmet usage is relatively low, ranging from 1% to 38% across Europe. This low rate can be attributed, at least in part, to thermal discomfort. Several European laboratories have come to an initial understanding of helmet-mediated heat loss, airflow, and physiological responses. Studies on this topic indicate that bicycle helmets do not affect physiological parameters, e.g., heart rate and core temperature (though they do affect the skin directly covered by the helmet [9-12]). Other studies indicate that the primary factors in helmet design are mainly aesthetic, and that the ventilation systems can substantially be improved in many cases. Furthermore, several methods have been developed and validated for evaluating comfort and heat transfer. Examples of these are the thermal manikin headform at Empa [13] and at Lund University [14], and the tracer-gas headform at KU Leuven [15].

Impact properties of helmets are widely studied using finite element models [16-18], with an exceptional cadaver study [19]. Although some have suggested that helmets increase the likelihood for particular kinds of injury [6, 19], the basis for this seems questionable [20]. These studies indicate the effectiveness of helmets in reducing the pressure upon impact. The impact properties of helmets have to meet standards, which dictate minimum requirements with which helmets need to comply. However, at least some experts believe these standards are suboptimal and should include, besides oblique impact, also rotational aspects [21].

The conspicuity of cyclists raises important safety issues as well. At least 40% of all fatal bicycle accidents in Europe occur at crossings [22], more than for any other mode of transport. This suggests that conspicuity or visibility of cyclists is less than optimal as many drivers report that they did not see the bicyclist in time or at all. This issue has already been identified as a factor in motorcycle accidents, and motivated part of the FP7 2-Be-Safe network. Some research activities are currently underway focussing on conspicuity of bicycle helmets in an attempt to reduce accidents.

Human behaviour is a key component of bicyclist safety but at present there are many gaps in the scientific literature. It was suggested above that increasing helmet usage may be associated with adverse factors, such as increased risk-taking behaviour [23], reduced concern of helmeted cyclists, and altered risk-taking behaviour amongst automobile drivers toward helmeted cyclists; the latter phenomenon was indeed observed in one study [24]. It is therefore important to understand how the use of a helmet influences the behaviour of both cyclists and other road users. It is also necessary to understand the circumstances under which cyclists decide to wear helmets, so that helmet design can be optimized in this respect.

There are several other miscellaneous gaps in the literature. For instance a lack of empirical data on the position of the cyclist on the bicycle; such data would aid optimization of conspicuity and visibility, and, in addition, would likely improve models of accident kinematics. Finally, there exists considerable anecdotal evidence that helmets might deter people from

cycling, but as yet no empirical data support this claim – at least over the long run. Such data are essential because the ultimate aim in promoting bicycling should be to increase the popularity of cycling while increasing its traffic safety.

Thus, although an initial level of understanding is present, still many fundamental questions remain unanswered. Therefore, a COST Action was funded aiming at increasing the knowledge about cyclists' traffic safety with special focus on the helmet, through influencing (i) new scientific studies, (ii) industry, (iii) legislators, and (iv) end-users. Previously, the fields relevant to the topic of this COST Action were not coordinated at a European level. This novel network allows sharing information which will be especially valuable since, in most relevant fields, research is largely in its infancy. It is likely that different Action members are facing similar problems and so would particularly benefit from collaborating in this COST Action. For instance, besides a clear difference between children and adults, very little differentiation is made among cyclists in the present research. This COST Action will stimulate its members to distinguish in their work among different age groups, genders, trip purposes (e.g., commuting, leisure, and sports), bicycle types, regions/cultures, and other factors.

Currently, development of commercially available bicycle helmets is heavily influenced by official standards like CEN 1078. This COST Action will be able to influence standards. In addition, the COST Action considers other modes of transport, e.g., motorcycling, which is useful in generalizing results and methods from these fields to cycling. At the same time new knowledge generated in the present Action can be found to be useful to other transport modes.

### **3. COST ACTION TU1101**

The primary reason for this COST Action is to increase knowledge about cyclist's traffic safety, with a special focus on helmets, and consequently improve cyclists' traffic safety. The state-of-the-art in each field that is related to bicycle helmet safety has reached a level of understanding that makes multidisciplinary and interdisciplinary cooperation especially fruitful. National differences in cycling culture suggest that an international perspective is needed to develop a comprehensive picture. Furthermore, uniting most European experts in the field will create a strong network with the potential of influencing legislators, industry, end-users, standardization bodies, and other target groups. The Action is organized in four working groups: (i) In-depth accident observations and injury statistics, (ii) Traffic psychology, (iii) Impact engineering, (iv) Ergonomics of thermal aspects.

In more detail, the following reasons for this Action should be mentioned:

- New field-data are needed to better understand the role of the helmet in crash causation and injury reduction, especially with respect to head injuries.
- Because wearing bicycle helmets is voluntary in most EU countries there is a need to understand the reasons people choose to wear or not to wear a helmet, and which parameters are influencing the acceptance of a helmet. This will enable an increase in the willingness to wear a helmet.
- Helmet comfort and appearance are assumed to be important factors in the choice of a helmet, and research is needed to connect the optimization of these factors with the degree of impact protection provided.
- The head orientation is not yet characterized as a function of cycle type and seat position. These parameters could allow an improved helmet design respecting different bicycle users.
- There are indications that wearing a helmet may reduce the perceived safety margin that automobile drivers assume as they approach a cyclist. At the same time the self-perception of a cyclist may be influenced by the wearing of a helmet, causing him or her to feel safer and take larger risks, possibly counteracting some of the potential safety benefits of the helmet. The degree to which culture, helmet design and colour, and other factors influence these behaviours should be investigated. Field

observations and accident studies, informed by recent methodological reviews, with matched groups of helmeted and none helmeted cyclists will shed initial light on this.

- A majority of bicycle accidents occur at intersections, suggesting that conspicuity and visibility of cyclists might be suboptimal. More conspicuous helmets, among other factors, might improve the conspicuity and visibility of cyclists as recently been shown for motorcyclists.
- The impact protection of helmets should be reassessed based on injury patterns observed in Europe. There are currently several institutional efforts in Europe, led by worldwide leaders in the field, so that European coordination of these efforts and enhancement of networking among them is timely to leverage added value and to integrate them beyond national boundaries.
- The integration of existing and new knowledge should lead to the development of new test methods for bicycle helmets.

#### 4. OBJECTIVES AND BENEFITS

The main objective of this COST Action is to increase scientific knowledge concerning bicycle helmets with regards to traffic safety and to disseminate this knowledge to stakeholders, including cyclists, legislators, manufacturers, and the scientific community. An additional aim is to stimulate international collaboration, within the domain of this COST Action. This Action focuses on head protection in the event of an accident and also in preventing accidents from occurring. The participation of experts in the primary scientific fields dealing with helmet function and bicycle traffic safety, on a European scale, is the basis of the present unique, integrative approach.

#### 5. PARTICIPATION

The Action is open to new participants, as long as both the candidate and the COST Action TU1101 are likely to benefit from the collaboration. In addition, we would be more than happy to keep you informed on the progress of COST Action TU1101. For more information, please consult our website: ([www.bicycle-helmets.eu](http://www.bicycle-helmets.eu)) or follow us on twitter (@HOPEHelmets).

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