Safety Science 105 (2018) 71–76

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/safety

Cycling fatalities: When a helmet is useless and when it might save your life

Michal Bíl[a,*], Martin Dobiáš[b], Richard Andrášik[a], Martina Bílová[a], Petr Hejna[c]

[a] CDV – Transport Research Centre, Líšeňská 33a, Brno, Czech Republic
[b] Department of Forensic Medicine and Medical Law, University Hospital Olomouc and Faculty of Medicine and Dentistry, Palacký University Olomouc, Hněvotínská 3, Olomouc, Czech Republic
[c] Department of Forensic Medicine, Charles University, Faculty of Medicine and University Hospital, Hradec Králové, Czech Republic

ARTICLE INFO

Keywords:
Bicycle
Helmet
Efficacy
Head injury
Fatality
Crash

ABSTRACT

Autopsy reports of 119 cyclists who died in two Czech regions between 1995 and 2013 as a result of traffic crashes were studied. In all the study cases, pathologists analyzed whether a helmet could have helped the cyclists survive the crash or not. The crash circumstances from the police reports were then evaluated.

The results indicate that helmets could have helped the most in cases of single-vehicle crashes when cyclists fell off their bicycles or hit obstacles and in certain cases when an intracranial injury was the primary cause of death. Altogether 44 cyclists (37%) from this study could have survived if they had been wearing helmets during the crashes.

Helmets would not have helped cyclists in most high-energetic crashes, especially when motor-vehicles or trains were involved. Some rear-end crashes outside urban areas also resulted in injuries when a helmet would not have helped.

This study concludes that cyclists should wear helmets, but they should also be aware that it cannot protect them in particular situations. These facts should be incorporated into safety campaigns to prevent cyclists from feeling protected in such situations when helmets cannot help. Our results also support the building of cycling paths separate from traffic, particularly outside of urban areas.

1. Introduction

Cycling fatalities constitute a significant proportion of overall fatalities in traffic (IRTAD, 2014). While the safety of car drivers has been improving, the safety of cyclists can only be ameliorated partially. Helmets are the most commonly recommended equipment for enhancing the personal safety of cyclists (e.g., Cherington, 2000; Gomei et al., 2013; McNally and Whitehead, 2013; Zibung et al., 2015). Additional safety measures are focused on the physical separation of cyclists from traffic (Bíl et al., 2010; Kaplan and Prato, 2015), marking separated cycling lines (e.g., Hamann and Peek-Asa, 2013) or calming of traffic when sharing the same place with cars (Chen and Shen, 2016).

Numerous studies and meta-studies have investigated the contribution of helmets to the prospects of cyclists after crashes (e.g., Uibel et al., 2012; Bambach et al., 2013, Gomei et al., 2013; Dinh et al., 2015), either focusing on specific head injuries (Finvers et al., 1996, Jacobson et al., 1998; Attewell et al., 2001; Gomei et al., 2013), or including intracranial ones (Wasserman and Buccini, 1990; Shafi et al., 1998). Whereas some studies have been based on statistical data analyses (where helmet use ranked among the parameters), other studies involved theoretical conducting simulations (e.g., McNally and Whitehead, 2013) or were based on laboratory testing (e. g., Mills and Gilchrist, 2008; Pang et al., 2009; Mattei et al., 2012; Cripton et al., 2014).

In contrast to other relevant studies, our analysis also employed the autopsy protocols of all individuals within the research file (autopsies were carried out by a member of our team – M.D.). Accordingly, we might assess if a helmet could have helped them survive or not. Our study fills the gap which exists in the relevant literature concerning the potential effect of cycling helmets on cyclists who were not wearing them at the time of the fatal crashes. The evaluation was based on a detailed autopsy investigation of sustained trauma.

2. Data and methods

We analyzed 119 fatal cycling crash data from two Czech regions. They contain cyclists who died in single vehicle crashes (SVC) or as a result of bicycle-motor-vehicle (BMV) crashes. The principal reasons why we only worked with fatalities were that they form a complete dataset, in contrast to other outcomes of cycling crashes where large

* Corresponding author.
E-mail address: michal.bil@cdv.cz (M. Bíl).

https://doi.org/10.1016/j.ssci.2018.02.005
Received 1 February 2017; Received in revised form 3 January 2018; Accepted 5 February 2018

Table 1
Overview of 119 cycling fatalities.

	Bicycle motor vehicle crashes	Single vehicle crashes		Crashes with train	Total
		Lost control	Fall of a tree		
Men	64	27	1	3	95
Women	19	4	1	0	24
Total	83	31	2	3	119

Table 2
Age and gender of victims.

Age	Gender		Total
	Men	Women	
1–10	0	2	2
11–20	2	1	3
21–30	7	1	8
31–40	10	1	11
41–50	20	2	22
51–60	28	2	30
61–70	15	6	21
71–80	12	8	20
> 80	1	1	2
Total			119

underreporting exist. We were able to individually evaluate each particular case in the terms of potential helmet benefit. Details about the data can be found in our previous study where we identified the general circumstances leading to the deaths of cyclists (Bíl et al., 2016) and in the following Tables 1 and 2.

In this study we carefully examined autopsy reports and focused on head injuries. In accordance with Czech Law, each deceased person was autopsied at Palacky University Hospital (Department of Forensic Medicine and Medical Law). The statement *"a cycling helmet could have helped" or "would not have helped"* survive the crash was based on autopsy reports completed by a co-author of this study and his colleagues.

We analyzed sustained head injuries and identified those cases where a helmet could have helped. A blunt intracranial injury without fracture of the skull or with minor linear (see Fig. 1) or impressive fractures (Fig. 2) were among the injuries which could be potentially prevented by a cycling helmet. It was reasonable to assume for these injuries that an even distribution of forces and force decrease due to destruction of the helmet material could significantly alleviate intracranial injury (e.g., Cripton et al., 2014).

We analyzed factors related to the circumstances of a collision as well as factors related to sustained injuries with a special focus on head damage (see Table 3).

We assigned information on the possible helmet contribution to each fatality report based on the above-mentioned approaches. Data was subsequently analyzed with statistical methods. We first investigated the potential contribution of a helmet in relation to the causes of cycling fatalities, direction of impact to the head and the type of collision using the odds ratio (OR; Simon, 2001) and its 95% confidence interval (CI). Regarding BMV collisions, we further tested the influence of the location of a collision and direction from which a vehicle hit a cyclist to the possible contribution of a helmet. However, our findings were statistically significant in only two cases.

We were only working with categorical variables. We therefore used a multiple correspondence analysis (MCA; Abdi and Valentin, 2007) to reduce the dimensionality in the data. We obtained several new variables, called dimensions. Each dimension is a linear combination of factors. Because of MCA, we reduced the dimensionality in the data and arrived at continuous variables which are uncorrelated. We subsequently built a logistic regression model with dimensions as explanatory variables and the potential contribution of a helmet to the safety of a cyclist as a dependent variable.

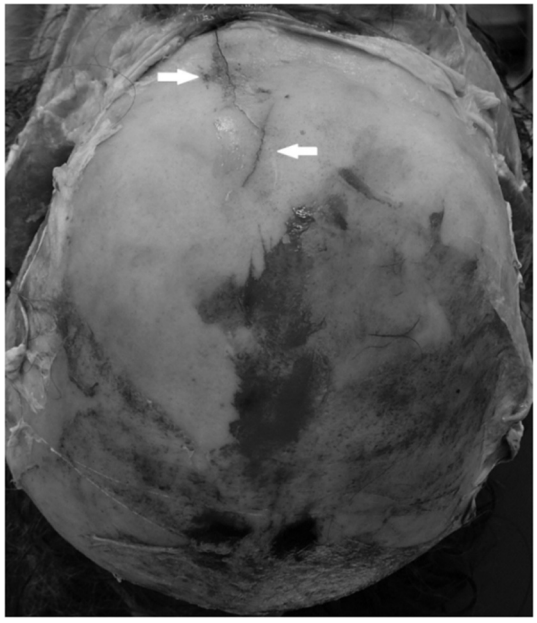

Fig. 1. A minor linear fracture of the scull vault (arrows). In this particular case a helmet could have helped alleviate the impact and could have saved the life of the cyclist.

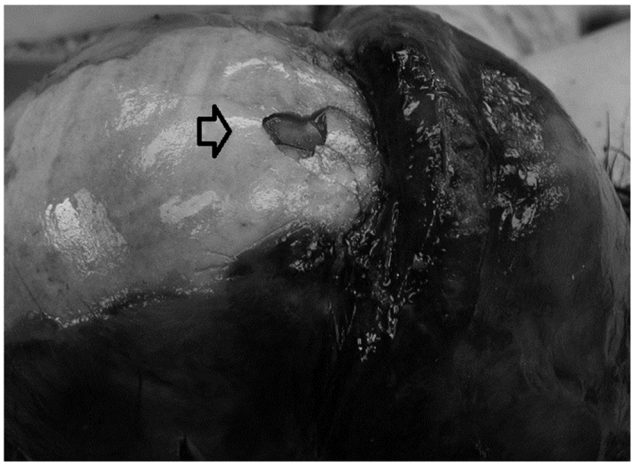

Fig. 2. A minor impressive fracture of the skull vault (see the black arrow) as another example of the injury which could have been averted by a helmet.

Due to the application of MCA, we had to reconstruct the meaning of the original factors through the coefficients of the logistic regression model and relations known from MCA. We finally arrived at the probability that "a helmet would have helped" divided by the probability of "a helmet would not have helped". We were consequently able to express in which factors a helmet could possibly mitigate the danger and how large this contribution might be. We performed our computations in R software (R Development Core Team, 2008).

3. Results

3.1. Causes of cycling fatalities

Only 5 cyclists, from the entire 119 set, wore a helmet. In all 5 cases a helmet did not help them, however, as they died due to polytrauma or other serious injuries (Table 4). The same was valid in another 80 cases when the injury was not only limited to the head (54 cases) or the head was devastated (e.g. run over by a motor vehicle).