ARTICLE IN PRESS

Safety Science xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Safety Science

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

Special Issue Article: Cycling safety

Helmet use and injuries in children's bicycle crashes in the Gothenburg region

Eva Olofsson[a,b,d,*], Olle Bunketorp[b,d], Anna-Lena Andersson[b,c,d]

[a] Paediatric and Adolescent Medical Care, Skaraborgs Hospital, Skövde, Sweden
[b] Department of Orthopaedics, Institute of Clinical Sciences, Sahlgrenska Academy, University of Gothenburg, Sweden
[c] Traffic Safety, Swedish Transport Administration, Gothenburg, Sweden
[d] The Traffic Injury Register, Department of Orthopaedics, Sahlgrenska University Hospital/Mölndal, Gothenburg, Sweden

ARTICLE INFO

Article history:
Received 15 October 2015
Accepted 28 November 2015
Available online xxxx

Keywords:
Bicycle accident
Children
Helmet
Injury severity
Upper extremity injury
Head injury

ABSTRACT

Aim: To investigate the use and protective effect of helmets in children injured in bicycle crashes and changes in injury patterns during a period of increased helmet use.
Method: Injuries in 4246 children below 16 years of age, who attended an A&E ward after a bicycle crash in the Gothenburg region during 1993–2006, were analyzed. The injury severity was classified according to the Abbreviated Injury Scale. The occurrence of skull/brain injuries and facial injuries was analyzed for 3711 children with respect to injury severity, helmet use and demographic and crash-related factors. Changes in injury patterns during the period were analyzed for 4246 children with no regard to helmet use. The ratio of the number of subjects with head injuries to the number of subjects with extremity injuries of any severity and of at least moderate severity was used to estimate the protective effect of helmet at a population level.
Results: Helmets were used by 40% of the injured children at the beginning of the period and by 80% at the end; much less frequently by teenagers, especially girls. The adjusted odds of serious or more severe skull/brain injuries and moderate or more severe facial injuries with a helmet were about one fourth of those without a helmet. The proportion of children with skull/brain injuries did not change significantly during the period. Serious or more severe skull/brain injuries were noted more often during the latter half of the period, most often in children without a helmet. The proportion of children with facial injuries decreased, and the proportion with injuries to the upper extremities increased, also for moderate and severe injuries. The ratio between the number of children with head injuries and the number with extremity injuries decreased for injuries of any severity and for moderate or more severe injuries.
Conclusions: Bicycle helmets have an obvious protective effect against head injuries in children, regardless of the crash circumstances. Teenagers must be informed about the high risk of skull/brain injuries in bicycle crashes without a helmet. The increasing occurrence of injuries to the upper extremities needs attention.

1. Introduction

In Sweden, the risk of being killed in road traffic as a cyclist is about six times that of car occupants and, since 2008, cyclists make up the largest group of severely injured road users (hospitalized at least 24 h) (Road Traffic Injuries, 2010). The annual number of fatally injured cyclists below 20 years of age was low (less than seven or 0.14/100000) during 1997–2012 (The National Board of Health and Welfare). An annual average of 3578 (185/100000) children below 18 years of age were severely injured in road traffic crashes during 2005–2009, with cyclists being the largest group (64/100000). An additional 10300 (537/100000) children, injured as cyclists, attended accident and emergency (A&E) departments (mean value per year) during 2007–2009 (The National Board of Health and Welfare, 2011). Increased cycling may be one explanation.

Abbreviations: A&E, accident and emergency; AIS, Abbreviated Injury Scale; CI, confidence interval; ICD, International Classification of Diseases; MAIS, maximum AIS; OR, odds ratio; SPSS, software package used for statistical analysis; STRADA, Swedish Traffic Accident Data Acquisition.

* Corresponding author at: Paediatric and Adolescent Medical Care, Skaraborgs Hospital Skövde, SE 541 85 Skövde, Sweden. Tel.: +46 500 432279; fax: +46 500 438479.
E-mail address: eva.m.olofsson@vgregion.se (E. Olofsson).

http://dx.doi.org/10.1016/j.ssci.2015.11.024
0925-7535/© 2015 Published by Elsevier Ltd.

Cyclists most commonly receive injuries to the head and upper extremities (The National Board of Health and Welfare, 2011). Injury prevention programs have resulted in a steady increase in helmet use among school-age children, from about 5% in 1988 to about 40% in 2004 (Larsson, 2013). Helmet legislation was implemented in Sweden in January 2005 for children below 16 years of age. Despite this, only about 60% of the children used a helmet in 2012 when cycling to and from school (Larsson, 2013), and only about 40% of 13–15-year-olds (Larsson, 2013).

Although many studies have shown that bicycle helmet use reduces the risk of head (Thompson et al., 2009; Attewell et al., 2001; Larsen, 2002; Hansen et al., 2003; Heng et al., 2006; Bambach et al., 2013; Persaud et al., 2012; Amoros et al., 2012; Bergenstal et al., 2012; Mattei et al., 2012; Elvik, 2011), face (Thompson et al., 2009; Attewell et al., 2001; Heng et al., 2006; Amoros et al., 2012) and fatal injuries (Attewell et al., 2001; Persaud et al., 2012), this conclusion has also been challenged (Hooper and Spicer, 2012; Phillips et al., 2011; Curnow, 2003, 2005). Arguments such as 'the brain can be injured without impact to the head' (Curnow, 2003, 2005), 'helmets may not provide significant protection in collisions with other vehicles' (Hooper and Spicer, 2012), 'car drivers take less care when maneuvering around cyclists who wear a helmet', and 'helmeted cyclists take more risks than non-helmeted cyclists', may explain why helmets fail to reduce effectively the overall level of head injuries and death (Hooper and Spicer, 2012; Phillips et al., 2011). Some previous studies on risk-taking behavior have produced contradictory results (Bambach et al., 2013; Pless et al., 2006).

Some authors have investigated the effect of helmets with regard to injuries to other body regions than the head (Heng et al., 2006; Bergenstal et al., 2012; Maimaris et al., 1994). In these studies, only 8–16% of the subjects used a helmet, including cyclists attending A&E departments only. As cyclists with helmets are less likely to receive injuries to the head and therefore do not seek medical care as often as cyclists without a helmet, the results may not be representative of all injured cyclists. Other authors have estimated the protective effect of helmets against head injuries at population level by relating the number of head injuries to the number of limb injuries in cyclists attending A&E departments (Povey et al., 1999; Walter et al., 2011).

As bicycle helmet use has increased among children in Sweden during the last decades, the injury patterns in bicycle crashes may have changed. The purpose of this study was to investigate the use of helmets by gender and age in children injured as cyclists and the protective effect of helmets against head injuries with respect to demographic and crash-related factors, and to examine changes in injury patterns during a period of increased helmet use.

The study has been approved by The Ethical Review Board, University of Gothenburg, Sweden.

2. Methods and subjects

This is a retrospective observation study of children who sought care at an A&E department in Gothenburg due to injuries after cycling crashes during 1993–2006.

2.1. Data collection

Recording of traffic accident casualties was introduced at the A&E departments in Gothenburg at the end of the 1970s. The date, time and site of the crash, type of road user, counterpart, type of crash, type of traffic environment, purpose of the transport, use of protective equipment, and injuries have been recorded in a structured way in the Traffic Injury Register, Department of Orthopaedics at Sahlgrenska University Hospital, Gothenburg. The procedure is used in the national information system for recording of traffic injuries in Sweden (STRADA) (Swedish Transport Agency). Two persons with long experience of the procedure recorded the accident circumstances and the injuries in the present study, which includes all casualties recorded in 1993–2006. Medical records were used to classify the diagnoses and the severity of the injuries. The diagnoses were specified according to the Swedish version of the WHO International Classification of Diseases (ICD9 and ICD10) (The National Board of Health and Welfare, 1987, 1997). The severity of the injuries was classified according to the Abbreviated Injury Scale (AIS-90) (AAAM, 1990). The localization of the injuries was assigned to the following body regions: skull/brain, face, neck (including the cervical spine), upper extremity (including the shoulder), upper trunk (including the thoracic spine), lower trunk (including the lumbar spine and external genitals), and lower extremity (including the pelvis). The AIS code includes a digit between 1 and 6, the AIS grade for each well-described injury, coarsely corresponding to the threat to life of the injury, defined on an ordinal scale as: 1 = minor; 2 = moderate; 3 = serious; 4 = severe; 5 = critical; 6 = maximum. The grades 4–6 are considered life-threatening. The maximum AIS (MAIS) is a descriptor of the overall injury severity. The MAIS can also be defined for each of the specified body regions. In this study, skull/brain injuries include superficial injuries (abrasions or contusions) and wounds to the scalp, fractures of the vault or skull base, and injuries to or bleeding in the brain or brain stem. Facial injuries include superficial injuries and wounds, fractures of the facial skeleton, and injuries to the eye and external ear. Injuries to the trunk and extremities include superficial injuries and wounds, distortions/dislocations and fractures, as well as injuries to internal organs, great vessels and nerves in the thorax and abdomen, and the spinal cord.

2.2. Statistical methods

Helmet use was analyzed with univariate models in order to identify possible connections with demographic and crash-related factors.

The odds of a skull/brain and facial injury of a specified severity with and without a helmet were derived from contingency tables. The MAIS score for the body region was used for discrimination purposes, and cases without an injury to the body region in question constituted the reference group. For example, children with at least one moderate or more severe (AIS2+) skull/brain injury were compared with children without any skull/brain injury. An odds ratio less than one indicate a protective effect of the helmet.

The occurrence of skull/brain and facial injuries was further analyzed with multivariate binary logistic regression with respect to helmet use and demographic and crash-related factors. Stratified univariate analyses were carried out in order to examine further these relationships, with regard to age group, gender, time period, injury severity, type of crash, crash setting, type of place, and type of activity.

The injury pattern was described as the percentage of children with at least one injury of a specified severity to a specified body region. Head injuries were divided into injuries to the skull or brain and injuries to the face. Changes to the injury pattern during the period 1993–2006 were analyzed with univariate binary logistic models with the accident year as the independent variable. Children with less severe injuries (than specified) to the body region constituted the reference group. For each body region, the odds of sustaining an injury of a specified severity were compared with the odds of sustaining a less severe injury during the next year. An odds ratio less than one indicate a decreasing risk of injury with time.

Please cite this article in press as: Olofsson, E., et al. Helmet use and injuries in children's bicycle crashes in the Gothenburg region. Safety Sci. (2015), http://dx.doi.org/10.1016/j.ssci.2015.11.024