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Incidence and costs of bicycle-related traumatic brain injuries in the Netherlands

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ABSTRACT

The main cause of death and serious disability in bicycle accidents is traumatic brain injury (TBI). The aim of this population-based study was to assess the incidence and costs of bicycle-related TBI across various age groups, and in comparison to all bicycle-related injuries, to identify main risk groups for the development of preventive strategies.

Data from the National Injury Surveillance System and National Medical Registration were used for all patients with bicycle-related injuries and TBI who visited a Dutch emergency department (ED) between 1998 and 2012. Demographics and national, weighted estimates of injury mechanism, injury severity and costs were analysed per age group. Direct healthcare costs and indirect costs were determined using the incidence-based Dutch Burden of Injury Model.

Between 1998 and 2012, the incidence of ED treatments due to bicycle-related TBI strongly increased with 54%, to 43 per 100,000 persons in 2012. However, the incidence of all bicycle-related injuries remained stable, from 444 in 1998 to 456/100,000 in 2012. Incidence of hospital admission increased in both TBI (92%) and all injuries from cycling (71%). Highest increase in incidence of both ED treatments and hospital admissions was seen in adults aged 55+. The injury rate of TBI per kilometre travelled increased (44%) except in children, but decreased (−4%) for all injuries, showing a strong decrease in children (−36%) but an increase in men aged 25+, and women aged 15+. Total costs of bicycle-related TBI were €74.5 million annually. Although bicycle-related TBI accounted for 9% of the incidence of all ED treatments due to cycling, it accounted for 18% of the total costs due to all bicycle-related injuries (€410.7 million). Children and adolescents (aged 0–24) had highest incidence of ED treatments due to bicycle-related injuries. Men in the working population (aged 15–64) had highest indirect costs following injuries from cycling, including TBI. Older cyclists (aged 55+) were identified as main risk group for TBI, as they had highest ED attendance, injury rate, injury severity, admission to hospital or intensive care unit, and costs.

Incidence of ED treatments due to cycling are high and often involve TBI, imposing a high burden on individuals and society. Older cyclists aged 55+ were identified as main risk group for TBI to be targeted in preventive strategies, due to their high risk for (serious) injuries and ever-increasing share of ED visits and hospital admissions.

1. Introduction

Cycling is a popular form of transport and recreation worldwide, and especially in the Netherlands, where there are more bicycles than residents (BOVAG RAI Foundation, 2013; Ministry of Transport and Fietsberaad, 2009). In the Netherlands, cycling is a common mode of transport among all age groups and socio-economic classes, in both urban and rural areas (Ministry of Transport and Fietsberaad, 2009). The Netherlands has a good cycling infrastructure with cyclists enjoying segregated cycle facilities and protected intersections (Godefrooij, 1997; Ministry of Transport and Fietsberaad, 2009). Despite the high levels of road safety, in the Netherlands (with 16.7 million inhabitants) approximately 350,000 injuries occur due to cycling each year (Consumer and Safety Institute, 2011).

Traumatic brain injury (TBI) is the main cause of mortality and severe morbidity among bicycle accidents (Airaksinen et al., 2010;

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Amoros et al., 2011; Chen et al., 2013; Eilert-Petersson and Schelp, 1997; Hefny et al., 2012; Rivara et al., 1997; Scheiman et al., 2010; Veisten et al., 2007), which is most often seen in children (Chen et al., 2013; Eilert-Petersson and Schelp, 1997; Rivara et al., 1997), adolescents (Eilert-Petersson and Schelp, 1997) and older adults (Chen et al., 2013; Eilert-Petersson and Schelp, 1997; Scheiman et al., 2010; Stone and Broughton, 2003). Almost all survivors of TBI experience some level of impairment or disability (Tagliaferri et al., 2006), which drastically reduces their health-related quality of life (Andelic et al., 2009; Dijkers, 2004), increases their requirement of specialised healthcare (Berg et al., 2005), and often restricts adults in returning to full employment (Holtslag et al., 2007; Radford et al., 2013). TBI therefore imposes significant direct healthcare costs in terms of pre-hospital care, emergency care, hospitalisation, long-term outpatient care and rehabilitation, and indirect costs due to loss of productivity (Scholten et al., 2014).

Although the literature on the epidemiology and consequences of bicycle-related TBI is growing, by our knowledge, detailed population-based information on the costs of bicycle-related TBI is scarce and often limited for use in studies on the cost-effectiveness of bicycle helmet campaigns or laws (Hansen and Scuffham, 1995; Kopjar and Wickizer, 2000; Taylor and Scuffham, 2002). Such information is however vital for the development of prevention programmes that are aimed at patient groups at greater risk of TBI. This article presents the results of a population-based study in the Netherlands. It provides demographics and national, weighted estimates of the injury mechanism, injury severity and costs, by age group, of all patients with bicycle-related injuries and TBI in specific, who visited Dutch emergency departments (EDs). The purposes of this study were to:

1) assess the incidence, direct costs and indirect costs of bicycle-related TBI between 1998 and 2012 across various age groups,
2) compare these estimates with all bicycle-related injuries treated in Dutch EDs between 1998 and 2012,
3) identify main risk groups to develop preventive strategies that target bicycle-related TBI.

2. Methods

2.1. Study setting

This retrospective study included data on all patients with bicycle-related injuries treated at Dutch EDs and/or hospitalised between 1998 and 2012. Data on ED treatments due to bicycle-related TBI were obtained from the Dutch Injury Surveillance System (LIS) (Meerding et al., 2010). Data on hospital admissions was obtained from the National Hospital Discharge Registry (LMR) (Van der Stegen and Ploemacher, 2009).

LIS is an ongoing monitoring system which records data of all unintentional and intentional injured patients who attend the ED. LIS is based upon the registration of 13 hospitals in the Netherlands (12–15% coverage), that are considered to be representative for the total Dutch injury-related ED visits (Meerding et al., 2010). The LMR contains data from all Dutch hospitals regarding patient information from hospital admission to discharge (Van der Stegen and Ploemacher, 2009).

National, weighted estimates of bicycle-related TBI presenting to Dutch EDs were derived by calculating an extrapolation factor. This factor multiplies the number of ED treatments due to bicycle-related injury registered by the participating hospitals, by the quotient of the number of hospital admissions due to bicycle-related injury divided by the number of hospital admissions due to bicycle-related injury registered in the participating Dutch hospitals (Consumer and Safety Institute, 2005).

Data from the LIS databank was used to assess socio-demographic (age at injury and sex), injury (type of injury besides TBI, injury mechanism), and healthcare related characteristics (hospitalisation and length of stay). The LMR was used to obtain data on hospitalisation and injury severity (MAIS: maximum abbreviated injury scale).

2.2. Definitions

A bicycle-related injury was defined as an injury sustained to the cyclist either during cycling or getting on or off a bicycle. A cyclist was defined as a user of a non-motorized two wheeled vehicle, and also included electrically assisted bicycles, road bikes, mountain bikes and cyclo-cross bicycles.

TBI was defined as having a concussion (ICD10 code S06.0) or other skull-brain injury (S02.0-1, S02.7, S02.9, S06.1-9, S04.0-9, S07.1-9, T02.0, T04.0) in one of the three injuries that can be recorded in LIS. This study included all bicycle-related TBI that were registered as first, second or third injury.

2.3. Cost-of-illness

Direct costs (e.g. healthcare costs) and indirect costs (e.g. productivity loss) of bicycle-related injuries and TBI were calculated with use of the incidence-based Dutch Burden of Injury Model (Consumer and Safety Institute, 2005; Mulder et al., 2002).

Direct healthcare costs were calculated by multiplying incidence by healthcare volumes (e.g. length of stay), transition probabilities (e.g. probability of hospital admission), and unit costs (e.g. costs per day in hospital). Healthcare volumes were estimated with use of age- and injury-specific data from the LIS and LMR database, rehabilitation centres (LIVRE), nursing homes (SIVIS), and a patient follow-up survey conducted in 2007–2008 (Consumer and Safety Institute, 2005; Haagsma et al., 2012; Polinder et al., 2007). All unit costs were estimated according to national guidelines for healthcare costing (Oostenbrink et al., 2002), reflecting real resource use (Table A1 in Appendix A).

Indirect costs were calculated for all patients in the working age 15 to 65 treated at the ED or hospitalised, based on age- and injury-specific estimates on work absence and return to work from the patient follow-up questionnaire conducted in 2007–2008 (Consumer and Safety Institute, 2005; Haagsma et al., 2012; Polinder et al., 2007). A full description of the calculation of the cost per hour worked, based on data from the patient follow-up survey, has been published elsewhere (de Putter et al., 2012; Meerding et al., 2006).

All costs estimates were converted into 2012 Euros (as at 31 December 2012 €1.00 = USD $1.3203). The direct and indirect costs of bicycle-related TBI were compared with the costs of all bicycle-related injuries treated at Dutch EDs, including TBI.

2.4. Data and statistical analysis

All statistical analyses were carried out using the statistical package SPSS for Windows, version 21 (IBM SPSS Statistics, SPSS Inc., Chicago, IL). Descriptive statistics were used to provide insight in the characteristics of injured cyclists. Continuous variables were described by presenting the median and interquartile range. Chi-square statistics were used for between-group comparisons on injury mechanism variables. Univariate logistic regression analysis was used to explore the association between patient demographics and injury mechanism with regard to a diagnosis of TBI and the severity of TBI. Secondly, multivariate logistic regression analysis (enter method) including socio-demographics (block 1) and injury mechanism (block 2) was used to further identify independent predictors of bicycle-related TBI and TBI severity.