

Brief Research Report

Potential impact of mandatory helmet when biking

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ABSTRACT

INTRODUCTION. Head injuries are a common and severe outcome of bicycle-related incidents, but they are preventable with a helmet. In Denmark, helmet use is not mandatory, and only half of cyclists wear helmets. Estimating the prevention potential of mandatory helmet use may inform evidence-based injury prevention policy. We aimed to estimate the number of preventable head injuries and severe head injuries under mandatory helmet use in 2020 and 2024.

METHODS. We conducted a retrospective study using emergency department data from Odense and Svendborg University Hospital, where helmet use is systematically recorded. Cyclists treated for head injuries (minor or major) following bicycle-related incidents were included. The potential impact of mandatory helmet use was estimated-, assuming a post-legislation helmet use rate of 92%, based on evidence from New Zealand. A switch fraction was applied to account for compliance, and meta-analytic-based relative risk reductions of 48% for minor injuries and 60% for severe head injuries were used to estimate the number of potentially preventable head injuries.

RESULTS. In total, 2,393 cyclists were treated for minor or major head injuries during the five-year period (1,366 (57%) unhelmeted). Overall, 57% were male, and the mean age was 38 years (SD 21 years). Severe head injuries were sustained by 511 cyclists, 275 of whom (53%) were unhelmeted. Extrapolation suggests that approximately 5,733 minor and 1,806 severe head injuries could have been prevented.

CONCLUSION. The findings support helmet use as an effective prevention strategy to reduce head injuries among bicyclists.

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Head injuries are among the most common and severe injuries resulting from bicycle incidents albeit they are largely preventable through helmet use. Everyday cycling is widely practised in Denmark; however, helmet use remains limited, with only around half of cyclists wearing a

helmet [1, 2].

Helmet use is not mandatory for either conventional or electric bicycles in Denmark. In contrast, helmets are mandatory and accepted for motorcyclists and moped riders, including 30 km/h mopeds and electric speed pedelecs (45 km/h). Electric bicycles cease motor assistance above 25 km/h, but conventional bicycles are not subject to a formal speed limit, and speeds exceeding 30 km/h are frequently observed. This discrepancy is notable given the substantial burden of cycling-related head injuries.

Helmet use reduces the risk of head injury [3-5]. Following the introduction of mandatory helmet legislation in Victoria, Australia, insurance claims for cyclists killed or hospitalised with head injuries decreased by 48% in the first year and 70% in the second year [6]. These effects have been confirmed in an umbrella review including ten systematic reviews and other publications [7-10]. Despite this evidence, helmet use remains voluntary in Denmark. We aimed to estimate the potential impact of mandatory helmet use among cyclists in Denmark, quantified as the number of head injuries and severe head injuries that could have been prevented between 2020 and 2024.

Methods

Design

Helmet use among cyclists treated in Danish hospitals after traffic accidents is not recorded routinely. However, this information is documented at the emergency departments (EDs) at Odense and Svendborg University Hospital (OUH), Denmark. The study was therefore designed as a retrospective analysis of anonymised data from these two EDs, with extrapolation to the Danish population.

Setting

The two EDs at OUH provide 24-h emergency care and manage an average of 48,117 visits annually. They are the only EDs serving the island of Funen. During the study period (2020-2024), the mean population of OUH's catchment area was 462,272 inhabitants, compared with 5,886,026 citizens in Denmark overall, corresponding to 7.89% of the national population [11]. Funen is demographically and industrially comparable to the national average, supporting its representativeness for injury and traffic-related research [12]. Patients residing in Middelfart are typically treated elsewhere and were therefore not included.

Participants

Participants were cyclists who sustained trauma to the head region (cranium, face or neck), areas which may be protected by a helmet, during a bicycle-related incident.

Data sources and measurement

Contacts for both EDs have been systematically registered and used for analysis since 1980 by the

Accident Analysis Group at the OUH. The registries include information on age, sex, injury type, mode of transport, helmet use, procedure and diagnosis codes. Head injuries were categorised by severity (minor or severe) on diagnosis codes following the same methodology used for the MOERKE tables at Statistics Denmark. Head injuries were identified using the International Classification of Diseases, tenth version (ICD-10) diagnosis registration (S00*-S09* and S10* to S19*). All patients were considered injured as we consider it unlikely that someone will seek medical attention if completely uninjured. Injuries were considered minor by default, but injuries resulting in internal bleeding, concussion, nerve injury or fractures other than of fingers and toes were considered severe following the same methodology as the MOERKE tables at Statistics Denmark [13, 14].

Outcomes

The primary outcome was the total number of potentially prevented head injuries. The secondary outcome was the number of potentially prevented severe head injuries.

Analysis and statistics

Descriptive statistics were used to summarise characteristics of participants with minor or severe head injuries. Continuous variables are reported as means with SD, and categorical variables as frequencies and percentages. All analyses were conducted using STATA/IC version 19.0.

National estimates were derived by extrapolation, assuming that cycling exposure and injury risk in OUH's catchment area were representative of Denmark as a whole. Estimates from the OUH cohort were multiplied by 12.7, corresponding to the inverse of the catchment population proportion [1]. To estimate the potential impact of mandatory helmet legislation on helmet use, New Zealand was used as an empirical reference. Following the introduction of enforced helmet legislation, helmet use in New Zealand increased from 43% to 92% and has remained at this level [15, 16]. A post-legislation helmet-wearing rate of 92% was therefore assumed.

Compliance with helmet legislation was accounted for using a switch fraction, defined as the proportion of cyclists not wearing a helmet at baseline who were assumed to adopt helmet use to achieve the 92% post-legislation rate. This fraction was applied to limit the effect of helmet use to the preventable proportion of injuries among baseline non-helmeted cyclists. Meta-analytic estimates indicating an average relative risk reduction (RRR) of 48% for head injuries and a 60% RRR for severe head injuries were applied to the estimated number of injuries among cyclists not wearing helmets [17]. Results are reported as the total number of potentially prevented head injuries and severe head injuries.

Trail registration: not relevant.

Results

In total, 2,393 cyclists were treated at the emergency departments at the OUH for a head injury

during the study period, of whom 1,366 (57%) were not wearing a helmet. Overall, 1,372 cyclists (57%) were male, and the mean age was 38 years (SD 21 years). Among the 1,882 cyclists with non-severe head injuries, 1,091 (58%) were not wearing a helmet. Severe head injuries were sustained by 511 cyclists (21%), of whom 275 (53%) were not wearing a helmet.

With mandatory helmet use, we estimated that approximately 451 minor head injuries and 142 severe head injuries would have been prevented at the OUH during the five-year study period. When extrapolated nationally, this corresponds to approximately 5,733 minor and 1,806 severe head injuries that could have been prevented in Denmark during the period.

Discussion

The findings of this brief retrospective cohort study with national extrapolation support the hypothesis that mandatory bicycle helmet use could reduce the number of minor and severe head injuries among cyclists treated in Danish emergency departments. Although causal conclusions cannot be drawn, the results are consistent with national and international evidence. Helmet use has repeatedly been associated with a markedly reduced risk of head and severe head injuries, and a causal relationship is supported by observational studies and meta-analyses [3, 8, 18, 19]. The completeness of traffic incidents registration in the Danish emergency departments are uncertain but this extrapolation indicate some underreporting.

The proportion of adult cyclists wearing a helmet in Denmark increased from 6% in 2006 to 51% in 2024, but has remained largely unchanged since 2020 [1]. This increase has primarily been achieved through long-term promotional strategies, including coordinated media campaigns [2]. National behaviour-change initiatives, such as the Viking campaigns, have consistently framed helmet use as normal and sensible [20], and school-based traffic safety programmes have encouraged early helmet adoption, which may persist into adulthood [2]. Despite these efforts, our findings show that a substantial number of minor injuries and severe head injuries continue to occur among cyclists who do not wear helmets. The observed stagnation in the increase in helmet use, combined with the estimated number of preventable head injuries identified in this study, suggests that further gains through voluntary measures alone may be limited. Legislative action mandating helmet use may therefore be necessary to achieve additional reductions in cycling-related head injuries in Denmark and advance the European Vision Zero commitment.

Conclusion

The study findings support helmet legislation as an effective primary prevention strategy to reduce head injuries.

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