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Cycling-related injuries at Sørlandet Hospital, Kristiansand

ORIGINALARTIKKEL

ODD MJÅLAND
E-mail: odd.mjaland@ous-hf.no
Department of Gastro and Paediatric Surgery
Oslo University Hospital, Radiumhospitalet
He has contributed to the collection of data, analysis, drafting of manuscripts, tables, figures and bibliography.
Odd Mjåland, MD and senior consultant
The author has completed the ICMJE form and declares no conflicts of interest.

ANDREAS NYGAARD
Division of Vascular Surgery
Sørlandet Hospital, Kristiansand
He has contributed to the collection of data, analysis, drafting of manuscripts, tables, figures and bibliography.
Andreas Nygaard, senior consultant
The author has completed the ICMJE form and declares no conflicts of interest.

CHRISTOPHER STORM-LARSEN
University of Oslo
He has contributed to the collection of data, analysis, drafting of manuscripts, tables, figures and bibliography.
Christopher Storm-Larsen, medical student
The author has completed the ICMJE form and declares no conflicts of interest.

TOR BROMMELAND
Division of Orthopaedics
Sørlandet Hospital, Kristiansand
and
Department of Neurosurgery
Oslo University Hospital, Ullevål
He has contributed to the collection of data, analysis, drafting of manuscripts, tables, figures and bibliography.
Tor Brommeland, MD and senior consultant
The author has completed the ICMJE form and declares no conflicts of interest.

BACKGROUND

It is a policy objective to increase the percentage of journeys made by bicycle in Norway from the current 5 % to 10 %. Kristiansand is one of the most active cities in Norway in terms of cycling. We wished to identify the extent of injuries among cyclists admitted to the hospital.

MATERIAL AND METHOD

We reviewed the medical records of patients with cycling-related injuries who were admitted to Sørlandet Hospital, Kristiansand in the period 1 January 2012 to 31 December 2015. Patient, accident, injury and treatment characteristics were recorded, as well as any sequelae after 12 months.

RESULTS

Altogether 224 adults and 53 children (<16 years) were registered with cycling-related injuries, most of which (n=192, 69 %) were mild/moderate. Very severe and critical injuries were recorded in 6 (11 %) children and 22 (10 %) adults. Fractures (n=179, 65 %) and minor head injuries (n= 78, 28 %) dominated the injury panorama. Surgical treatment was undertaken in 107 (48 %) adults and 19 (36 %) children. A total of 12 (4 %) patients were transferred to the trauma centre at Oslo University Hospital Ullevål. Four adults had significant sequelae after 12 months, all related to severe head/neck injury.

INTERPRETATION

A considerable proportion of serious and complex injuries require that the national guidelines for use of a trauma team be followed. Systematic and ongoing registration of cyclists' injuries in the form of a national registry could help increase our insight into the circumstances surrounding accidents and the extent of injuries related to these.

In Norway, it is currently estimated that a bicycle is the mode of transport used in 5 % of all daily travel (1). Clear policy objectives have been set to increase the percentage to 10 %, and to 20 % in cities (2). Increasing the percentage of cyclists is beneficial to health, the environment and traffic, but the flip side of the coin may be more extensive injuries. The Institute of Transport Economics (TØI) has produced statistics on the number of cycling-related injuries in Norway, but these are uncertain due to underreporting by the police, hospitals and emergency clinics (3). The estimated underreporting stands at 1:8, and TØI has also estimated that Norwegian hospitals and emergency clinics treated almost 5000 cycling-related injuries in 2005 (4). However, Oslo University Hospital's Orthopaedic Emergency Section alone registered 2200 such injuries in 2014, 2 % of which resulted in the cyclist being admitted to Ullevål Hospital (5).

In the National Trauma Registry's annual report from 2017, transport accidents were reported to be the most frequent cause of serious injuries in Norway, and 18 % of these were cycling-related (6).

Few studies have been carried out on cycling-related injuries at Norwegian hospitals. Two hospital-based studies from Trondheim and Harstad were published in 1984 and 1990 respectively (7–8). Over the past 25 years, the general traffic profile, bicycle equipment and cyclists' behaviour have all changed considerably, in parallel with the treatment of injuries at hospitals. The purpose of this study was to examine hospital admissions as a result of cycling-related injuries over a four-year period in a defined catchment area. We sought to examine the cause, type, extent and treatment of injuries as well as sequelae.

Material and method

Sørlandet Hospital Trust covers the counties of Aust-Agder and Vest-Agder, with a total population of 280 000 (9). Flekkefjord, Arendal and Kristiansand each have an orthopaedic emergency section. The estimated catchment population for Kristiansand is approximately 180 000, in addition to an unknown number of tourists and non-registered students throughout the year.

The study was approved as a quality assurance project by the Norwegian Centre for Research Data and the departmental management (15 August 2013). Emergency admissions

(care level 'admitted') at Sørlandet Hospital, Kristiansand in the period 1 January 2012 to 31 December 2015 with classification V1n (Cycling-related injuries in ICD-10) were retrospectively identified using data from the Norwegian Patient Registry. Since medical coding is primarily the responsibility of the doctor writing the discharge report, and registering the classification was not a mandatory requirement of the Norwegian Directorate of Health during the period of the study, the degree of coding was unclear. However, the hospital had secondary control for medical coding throughout the study period, which meant that all discharge reports were reviewed after discharge. Patients treated by a trauma team during the first six months of the study period were verified against routine manual trauma records from the hospital's emergency department, and the comparison corresponded in full. We did not record the number.

The year was divided into a winter season (November to February), a mid-season (March, April, September and October) and a summer season (May to August).

Referrals, ambulance records, admission notes, observation charts, ongoing journal notes, surgery notes and discharge reports were all reviewed in terms of patient characteristics, transport modality, cause, location, time, mechanism, extent and treatment of injuries. The severity of the injury was assessed retrospectively during the review of patient records. We used the Oslo emergency clinics' injury classification from 2014 (5), which is based on the Norwegian Directorate of Health's guidelines for a common minimum dataset from 2011 (10) (Table 1). Head injuries were recorded as commotio cerebri if data indicated loss of consciousness, Glasgow Coma Scale (GCS) scores were 14 or 15 upon arrival, and the CT findings were normal (where such imaging was performed).

Table 1

Classification of extent of injury according to the Oslo emergency clinics' injury classification from 2014 (5), based on the Norwegian Directorate of Health's common minimum dataset from 2011 (10).

		Examples of injuries
1	Minor	Minor wounds, minor fractures in fingers/toes, head injuries without loss of consciousness
2	Moderate	Major wounds, head injuries with loss of consciousness, fractures in the nose/ribs, other fractures without dislocation
3	Severe	Wounds >10 cm, head injuries with more than 15 minutes of unconsciousness, dislocated fractures of larger bones
4	Very severe	Major head injuries with crush fracture, open chest injury, minor abdominal bleeding
5	Critical	Extensive head injuries with bleeding, injuries to back/neck with paralysis, major chest or abdominal injuries
6	Fatal	

The diagnostic imaging findings were recorded for patients with trauma-related CT pathology to the head. Spinal injury was noted if CT and/or MRI of the columna showed fractures, bleeding or damage to nerve structures. Facial injuries were defined as established fractures or wounds to the face requiring surgery. In addition to abdominal organ damage in CT imaging, significant abdominal wall contusions and perineal injuries were also recorded as abdominal injuries. Chest injuries included major chest wall contusions, rib fractures, pneumothorax and intrathoracic bleeding. Orthopaedic injuries were defined as fractures or wounds on extremities requiring surgery.

Not all patients have undergone routine outpatient monitoring. All journal notes up to one year after admission were reviewed retrospectively. If there was information on persistent impairment, pain or other sequelae from the accident at the last hospital check within this 12-month period, the patient was reported to have sequelae. Patients who did not receive a

check-up after discharge, or who clearly indicated complete recovery at the last control, were considered to have no sequelae. Six patients were transferred to another hospital in Norway or abroad, and for information about these, the relevant hospital or patient was contacted. The sequelae were judged to be mild (mild pain, minor functional impairments in individual joints, etc.), moderate (moderate to severe pain, impaired function affecting daily living, etc.) or severe (significant functional impairment, persistent major paralysis, etc.).

A review of patient records was carried out in DIPS. Nine of the injuries were found to have occurred on scooters or tricycles, and in two cases, the injured person was riding pillion. These were excluded, along with ten cases where injuries were sustained abroad or outside the hospital's natural catchment area – and therefore mostly admitted to hospital several days later.

Results

In the period from 1 January 2012 to 31 December 2015, 277 patients were registered as admitted to Sørlandet Hospital, Kristiansand as a result of cycling-related injuries. Patient characteristics are summarised in Table 2.

Table 2

Characteristics of hospitalised patients with cycling-related injuries at Sørlandet Hospital, Kristiansand in the period 1 January 2012 to 31 December 2015. Percentages of children, adults and the dataset as a whole, unless otherwise stated.

	Children (n = 53)	Adults (n = 224)	Total (n = 277)
Gender, child/adult	62	67	66
Age (mean)	11	48	41
Length of hospital stay			
No. of days, median	1.0	1.6	1.3
≤1 day	70	34	41
>1 day	30	66	59
Other road user(s) involved[1]	13	24	22
Transport to hospital			
Ambulance	38	66	61
Air ambulance	6	2	3
Via emergency clinic	34	19	22
From GP	23	8	11
Directly	-	4	4
Trauma team upon arrival	23	39	36
Location of injury			
Abdomen	15	4	6
Chest	-	13	10
Commotio cerebri	34	27	28
Intracranial bleeding	-	6	5
Spine[2]	<5	6	5
Facial fracture	8	8	8
Collarbone fracture	-	16	13
Fracture of upper extremity	36	36	36
Fracture of lower extremity	9	16	15

[1]Motor vehicles, other cyclists or pedestrians who were directly involved in the accident.

[2]CT/MRI established fracture, haemorrhage or nerve damage in the columna

Transportation via ambulance from the scene of the accident was the most common means of transport for adults (148, 66 %), while the corresponding figure for children was 20 (38 %). Upon arrival, 87 (39 %) adults and 12 (23 %) children were treated by a trauma team. The median stay in the hospital in Kristiansand for adults was 1.6 days, compared to 1.0 days for children. Information on whether a cycling helmet was used was available for 30 (57 %) of the children and 147 (66 %) of the adults. Of these, 18 (60 %) of the children and 92 (63 %) of the adults used a helmet.

WHEN DID THE ACCIDENT TAKE PLACE?

A total of 30 (11 %) of the injuries occurred in the winter season, 91 (33 %) in the mid-season and 156 (56 %) in the summer season (Figure 1a). Injuries were evenly distributed between the days of the week (Figure 1b). Figures 1c–d show the variation throughout the day. Bicycle accidents on weekdays during the rush hours, 07–09 and 15–17, accounted for 24 % among both adults and children.

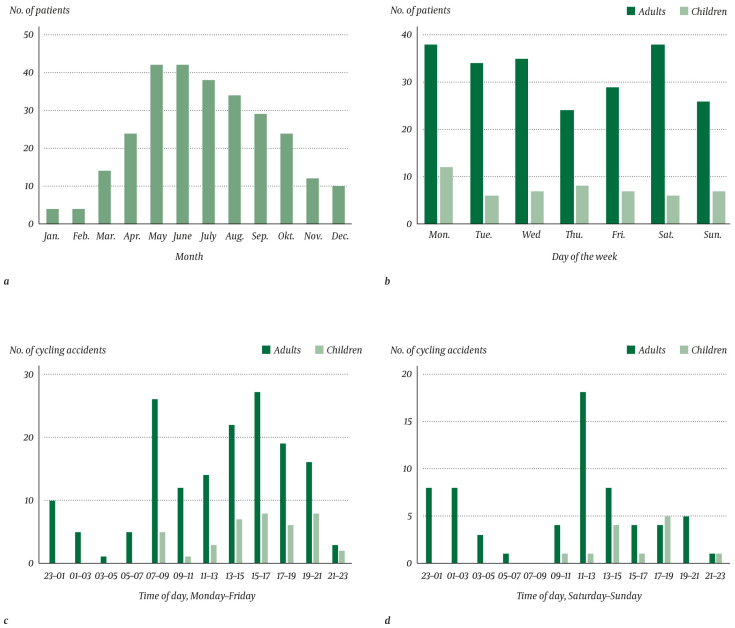

Figure 1 *Cycling-related injuries (n = 277) distributed into adults and children registered at Sørlandet Hospital, Kristiansand in the period 1 January 2012–31 December 2015. The injuries are divided into months throughout the year (a), on the different days of the week (b), time of day on weekdays (c) and time of day on weekends (d).*

HOW AND WHERE DID THE ACCIDENTS TAKE PLACE?

In the total dataset, 217 (78 %) accidents did not involve other road users. 'Toppling over' was cited as the cause of most single-vehicle accidents (n = 178), but in a smaller group, more specific causes were recorded that covered the entire panorama of external and self-induced conditions. In addition to typical incidents such as 'shoe lace in the front wheel', 'carrier bag in the front wheel', 'toppling over when checking mobile phone' etc., we also found seven accidents related to mounting and dismounting the bicycle. Among the adults, 40 (18 %) of the accidents occurred during cycle training or in a race, 30 (13 %) involved a collision with a car and 19 (8 %) involved a collision with another cyclist (including 'clipping another cyclist' during training/in a race). Four of the cyclists (median age 60 years) used electric bicycles. Among children, very few accidents (<5) involved a collision with a car.

ALCOHOL AND DRUGS

A total of 43 (19 %) of the adult patients were registered as clearly under the influence of alcohol and/or other intoxicants. The median age among these was 50 years, and 33 (77 %) were men. Three (14 %) of those who were intoxicated used a helmet among those with a known helmet status.

THE INJURY PANORAMA

Of the injuries in adults, minor and moderate injuries accounted for 151 (67 %) (Figure 2). The number of very severe and critical injuries was 22 (10 %), with severe head or neck injuries predominating. Eight adult patients met the criteria for severe multi-trauma (two or more serious organ injuries), and 53 (24 %) had injuries in more than one organ system. Among 14 (6 %) adult patients with intracranial bleeding, ten had incurred additional damage to another organ system. Patients in the older age group (>65 years) had a higher percentage of severe and critical injuries (n = 19, 59 %) than adult patients <65 years (n = 54, 28 %). Adult patients injured in single-vehicle accidents had less extensive injuries (minor/moderate injuries, n = 123, 72 %) than patients injured in accidents involving other road users (n = 28, 53 %).

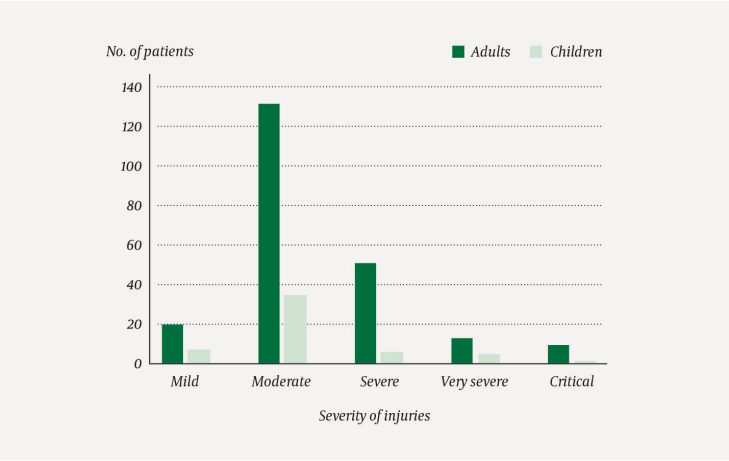

Figure 2 *The severity of cycling-related injuries (n = 277) registered at Sørlandet Hospital, Kristiansand in the period 1 January 2012–31 December 2015, distributed into adults and children. The extent of injury is classified according to the Oslo emergency clinics' injury classification from 2014, based on the Norwegian Directorate of Health's common minimum dataset from 2011 (Table 1) (5, 10).*

A total of 60 (27 %) adults had commotio cerebri and 151 (67 %) had one or more fractures. The most common location was the forearm/elbow (n = 47), followed by collarbone (n = 35), rib (n = 21), femur (n = 19), face (n = 18), fingers/hand (n = 17) and calf/ankle/foot (n = 17).

In children, 41 (77 %) of the injuries were minor or moderate, while 6 (11 %) were very severe or critical. A total of 28 (53 %) children had at least one fracture, 15 of which were forearm/elbow fractures. Five (9 %) children had injuries in more than one organ system, and 18 (34 %) had commotio cerebri. Table 2 summarises the recorded injuries by anatomical location.

TREATMENT OF INJURIES

Of the 224 adult patients, 103 (46 %) underwent surgery at Sørlandet Hospital, Kristiansand and 10 (4 %) had injuries requiring transfer to Oslo University Hospital, Ullevål. Among those operated on locally, fractures to the extremities (71 %) and the collarbone (22 %) predominated. Of 53 hospitalised children, two were transferred to Oslo University Hospital, Ullevål and 19 (36 %) received surgery locally, of which 15 (79 %) were for extremity injuries. Among the 12 patients transferred to Ullevål, head or neck injuries were the main cause in nine of the cases.

LONG-TERM RESULTS

In the retrospective patient record review of check-ups up to 12 months after hospitalisation, 29 (13 %) adults were considered to have sequelae. Four had significant sequelae, all arising from an extensive head or neck injury. The other patients were considered to have mild or moderate sequelae due to pain or minor functional impairment following orthopaedic fracture treatment. No serious sequelae were found in children. Three children (6 %) had moderate sequelae in the form of pain and/or impaired mobility.

We have not recorded data on the number of patients followed up or the length of time they were followed up.

Discussion

We found that 69 % of patients admitted to hospital with cycling-related injuries had minor/moderate injuries. Despite 10 % having very severe and critical injuries, only four adult patients were reported to have significant sequelae after their accident.

Our data represent an almost complete overview of all patients admitted to hospital for cycling-related injuries for a four-year period at a medium-sized Norwegian hospital. We believe we have captured the vast majority of cycling injuries due to the hospital's secondary control of the data. The main weaknesses are that we have not registered injuries treated at outpatient clinics either in our own hospital or in the remainder of the catchment area, and that the patients were not systematically followed up.

In two similar hospital studies from Trondheim in 1984 and Harstad in 1990, patients treated at outpatient clinics were also included, which means it is difficult to make direct comparisons (7, 8). In addition, both the diagnosis and treatment of injuries have changed significantly since then. CT and MRI are now available at all Norwegian hospitals, enabling a quick and detailed overview of injuries. Interdisciplinary trauma teams have also been established as standard at all Norwegian hospitals. Both Lereim's and Wasmuth's studies describe a cyclist population that is appreciably different from today, especially in view of the fact they found the highest injury rate among children. Lereim also identified a risk group among patients in their 30s, possibly as a result of a growing percentage of adult cyclists in a more urban setting. As in our study, they observed that approximately 15–20 % of injuries were related to training or racing. This is probably a minimum figure, as a large number of cyclists use their daily commute to and from work as a training session. We have not specifically registered the percentage of journeys to and from school and work, but the 24 % reported for the two peak injury times during the morning and afternoon rush hours (figure 1c) is in accordance with figures from the national cycling accounts report from 2016 (11) and Leirem's figures.

In Melhus' data from the Oslo University Hospital's Orthopaedic Emergency Section in 2014 (5), more than 2000 people were treated at the emergency clinic itself, while 2 % were transported to the trauma team at Ullevål Hospital. The Orthopaedic Emergency Section in Oslo has facilities that far exceed a normal emergency clinic, and a large number of our injuries could probably have been treated at an institution similar to this.

Four out of five accidents did not involve any other road users, according to the national cycling accounts report (11). Our age distribution corresponds to this report, but the mean age is somewhat higher than for the patients at the Oslo Orthopaedic Emergency Section; 41 years compared to 32 years (5). The city's younger population and the increased traffic may explain some of the age disparity. The seasonal and daily profiles correspond to the Oslo data (5), but the high percentage of alcohol/drug intoxication of almost 20 % among adults in our data is striking. In Swedish and Finnish studies, corresponding figures confirm our finding (12, 13), while the TØI states that among those requiring medical treatment for their injuries, 6 % were intoxicated (4).

Our data show a range in the extent of injuries, from thumb fractures to multi-traumas whose complexity necessitated an immediate transfer to Ullevål Hospital. Fractures and head injuries predominated, but injuries to virtually all body organs were registered. As with comparable literature, we found that collisions, especially with heavier vehicles, cause the most extensive injuries (14).

Our figures on helmet use are incomplete, with approximately half unknown. Among those with a known helmet status, around 60 % used a helmet. This is probably comparable to the data from Oslo's Orthopaedic Emergency Section, where approximately half used a helmet.

A meta-analysis by Olivier & Creighton showed that helmet use halved the odds of head injuries in cyclists and reduced the odds of severe head injuries by two-thirds (15). Similarly, Høye et al. found that severe head injuries were halved where helmet use was mandatory (16). One third of our patients had damage to the head region, and the low percentage of helmet use therefore represents a clear challenge to injury prevention work.

Only four of the accidents involving adults occurred on an electric bicycle. The figure is probably lower than what might be found today as sales and the use of electric bicycles have increased significantly since the completion of our study. We believe it would be useful to monitor the panorama and extent of injuries in this group. In the Netherlands, where the percentage of cyclists is high and the use of electric bicycles is rapidly increasing, both the media and medical publications warn about the risk of injury. In 2017, more cyclists than motorists were killed in the Netherlands, and the increase in fatalities occurred mainly in the electric bicycle group (17).

The injury panorama itself is affected by the cyclist's speed, clothing/protection, physique, helmet use and the surface/object being hit. Not surprisingly, children's injuries were less severe than those in adults. This is reflected in the shorter hospital stays and absence of serious sequelae. It is also worth noting that no children had chest injuries, but eight had abdominal trauma, with several needing an emergency laparotomy. The broad injury panorama and significant percentage of multi-organ injuries in children in our data are evidence that children who are injured in cycling accidents should be examined in the same way as adults. This involves a complete body examination and treatment by a trauma team if the criteria so dictate. The anatomical and physiological differences that separate children from adults must also be taken into account.

With the increased focus on the bicycle as a means of transport, the extent of injuries may change. Continuous registration of injuries and their circumstances, such as that established in, for example, Sweden in 2013 (18), could make an important contribution to the municipal and national cycling strategy. More focus on national registration of injuries has been sought for decades (19). As far back as 1995, Ytterstad showed that targeted interventions can reduce traffic accidents (20).

MAIN FINDINGS

Cycling-related injuries occurred in all age categories, the majority were single-vehicle incidents (78 %), and 66 % of the patients were male.

Half of all those hospitalised with cycling-related injuries underwent surgery, and extremity fractures were most common.

One in three patients had sustained head or facial trauma.

One in five patients had damaged more than one organ system.

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