

## **Cyclist Injuries Treated in Emergency Department (ED): Consequences and Costs in South-eastern Finland in an Area of 100 000 Inhabitants**

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**ABSTRACT** – In the present study, data of bicycle crashes leading to medical attendance in acute hospital or to death which occurred between June 1<sup>st</sup> 2004 and May 31<sup>st</sup> 2006 were analyzed. The final results consisted of injury data and patient records obtained from Kuusankoski Regional Hospital and from the road accident investigation teams. The total number of cases was 216. The severity of the injuries was classified according to the Abbreviated Injury Scale (2005). The majority of the bicycle crashes considered occurred when the injured was alone, without another party. Crashes were often alcohol-related (31%). Over one third of all cyclists' injuries were head injuries. Only 13% of the injured cyclists wore a helmet. 15% of those who wore a helmet sustained a head injury and, correspondingly, 43% of those who did not. Two bicyclists died. The number of bicycle crashes in the hospital data was at least fourfold compared to the number found in the official police statistics. Systematic collection of data on bicycle crashes in hospital emergency departments should be advanced in order to gain reliable information for prevention.

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### **INTRODUCTION**

In Finland, the traffic safety assessments are based on the official traffic accident statistics reported by the police. At the time of the present study there were two data sources as regards official statistics on traffic accidents in Finland: Statistics Finland and the Finnish Road Administration. Fatalities are reported correctly but for example the coverage of bicyclists' non-fatal single crashes is insufficient [Statistics Finland, 2008]. There is only little if any detailed information of the non-reported cases because data on the bicycle crashes leading to medical care are not systematically collected in hospital emergency rooms. However, these crashes cause a noticeable amount of injuries and costs.

There are only few earlier Finnish studies based on hospital data concerning bicycle accidents. Falls by pedestrians and cyclists were studied in 2000 [Vuoriainen, Helenius, Heikkil  et al., 2000] in four cities in Finland. The data were collected from primary health care, EDs and private hospitals during the years 1999-2000. Injuries, their consequences and costs were analyzed. Another Finnish study [Olkkonen, 1993] concerning bicycle accidents based

on hospital data was performed in 1983, in which the data were collected in 1980, 1985-1986, 1982-1986 and 1982-1988. In that study [Olkkonen, 1993] the risks and consequences of bicycle crashes were examined. The data consisted of patient records, questionnaires and interviews.

The objective of this study was to describe the epidemiology, consequences, outcome and costs of bicycle crashes among patients treated in ED at a regional hospital, and to determine the accuracy of the official statistics on bicycle related crashes.

### **METHODS**

The purpose of the Centre for Injury and Violence Prevention ([www.tapaturmahanke.fi](http://www.tapaturmahanke.fi)), located in Kouvola, south-eastern Finland, is to compile statistics on injuries by using the data base developed for this purpose, and to use the data for injury prevention. Data gathering started in May 2004 [Nurmi-L uthje, Karjalainen, Hinkkurinen et al., 2007]. For the present study, all first attendances due to an acute injury registered in the emergency department at Kuusankoski Regional Hospital, during the first two years were analyzed. The hospital is

responsible for an area of nearly 100 000 inhabitants. The International Classification for Diseases, 10th Revision (ICD-10- Finnish Modification, FM) for public hospital use in Finland was used.

In the primary two-year injury data (n=5553) all the missing ICD-10 codes (12%) as regards the external cause of injury and the type of injury were checked in the patient records and the data were complemented. After this procedure, the accuracy of the total two-year hospital injury data, (n=5553) was controlled with a 10-percent random sample by comparing the injury data with the medical records of the patients. The data appeared to be accurate [Nurmi-Lüthje et al., 2007].

In the present study, hospital data consist of the information on patients who were involved in a bicycle crash during the two-year period from the 1<sup>st</sup> of June, 2004 to the 31<sup>st</sup> of May, 2006. The patients were referred to the hospital either directly or via the local health center. The bicycle crashes were identified according to the external cause of injury (codes V10-V19 in ICD-10, FM). In addition, the following data were gathered: age, sex, date and time of accident, type of accident (ICD-10), trauma diagnoses (ICD-10, a maximum of 3 diagnoses), treatment of injury, admittance to the hospital or, further, to the central hospital, or treatment as out-patient. Breath alcohol concentration (BAC) at the attendance was routinely tested with a breathalyzer by the staff of the ED and expressed as g/L. Similar data collection has not been accomplished previously in Finland.

Further, for the present study, patients' hospital records were manually checked in order to obtain more accurate information about the type of injury, the injured body region, alcohol status at the time of the injury, and duration of hospital stay as well as duration of work absence (P.L.).

In addition, a questionnaire was sent to all injured patients in which the length of sick leaves and the patients' opinions on the causes of the crashes and on the circumstances of the traffic environment were inquired. The scenes of the accidents were, if possible, clarified from the ambulance service documents.

The severity of the injuries was classified retrospectively by using the Abbreviated Injury Scale (AIS 2005) (P.L.).

The treatment costs of the in-patients were collected from the economic division of the hospital. The costs of the out-patient visits were calculated with the help

of the hospital district price list. Sick leave costs to employers were estimated on the basis of the Finnish average labor costs and salary statistics. The costs of ambulance services were calculated on the basis of debiting principles and by interviewing ambulance service companies.

The total incidence per 100 000 inhabitants was calculated using the actual number of inhabitants living in the study area at the time of the study.

Ethics approval was obtained from the ethics committee of Kymenlaakso Health Care District.

In statistical analysis the Pearson's chi-square test was used.

## RESULTS

During two years in the study area a total of 216 cyclists involved in crashes leading a total of 300 injuries. Two cases were fatal. Slightly less than two-third (62%, n=133) of the cases occurred in males. The mean age of the patients was 39 years (males 37 years and females 42 years). 78 patients answered the questionnaire, the response rate being 36%. The total incidence of bicycle crashes was 130 per 100 000 persons per year.

### Injuries

Over one third (35%) of all injuries were head injuries (Table 1). The head injuries were most often minor but there were also few serious and one fatal injury (Table 2). 33% (n=100) of all injuries were located in the upper and 20% (n=61) in the lower extremity (Table 1). The most serious injuries were head, hip and thigh, chest and knee and leg injuries (Table 2).

Table 1. Anatomical location of injuries

Anatomical location of injuries (n=300)	n	%
Head	104	35
Neck	2	1
Chest	17	6
Abdominal, lower back and pelvic	16	5
Shoulder and upper arm	44	15
Elbow and forearm	32	11
Wrist and hand	24	8
Hip and thigh	15	5
Knee and leg	38	13
Ankle and foot	8	3
<b>Total</b>	<b>300</b>	<b>100%</b>

Table 2. The injured body region according to the severity of injury (Abbreviated Injury Scale 2005).

Anatomical location of injuries (n=300)	Severity of injury					
	AIS 1	AIS 2	AIS 3	AIS 4	AIS 5	AIS 6
Head	73	24	5	1	0	1
Neck	2	0	0	0	0	0
Chest	10	3	3	0	0	1
Abdominal, lower back and pelvic	11	4	1	0	0	0
Shoulder and upper arm	9	34	1	0	0	0
Elbow and forearm	14	18	0	0	0	0
Wrist and hand	16	8	0	0	0	0
Hip and thigh	9	1	5	0	0	0
Knee and leg	17	17	3	0	1	0
Ankle and foot	8	0	0	0	0	0
<b>Total</b>	<b>169</b>	<b>109</b>	<b>18</b>	<b>1</b>	<b>1</b>	<b>2</b>

The majority (91%) of the bicycle crashes led to minor or moderate injuries (MAIS 1 or 2). Sixteen cases (7,4% of all crashes) led to serious injuries (MAIS 3) and two to severe or critical injuries (MAIS 4 and 5). Two cases (1%) were fatal (MAIS 6). (Fig 1)

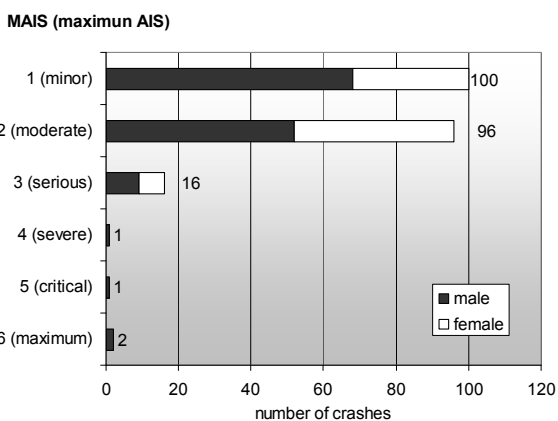


Figure 1. Severity of the most serious injury (MAIS) of bicycle crashes (n=216).

### Bicycle helmet

Only 13% (n=29) of the patients, of whom 48% were women and 52% men, wore a helmet and none of the helmet users was under the influence of alcohol. Over a half (56%) of the patients did not wear a helmet and over a third (35%) of the non-users was under the influence of alcohol when attending to the care. The number of the patients whose use of helmet is not known was 65 (30%) and of them 24 (37%) were drunk.

All patients saying in the questionnaire that they wore a helmet (n=19) at the time of the crash informed that the helmet had been properly fastened. In general, none of the helmet users (n=29) was under the influence of alcohol.

The proportion of head injuries were less frequent among patients who wore a helmet than among those who did not (15% vs. 43%) (Fig 2 and 3). Of the cyclists wearing a helmet 21% were injured to the head whereas among those not wearing a helmet the corresponding percentage was 46. ( $\chi^2=6.154$ , d.f.=1, p=0.013).

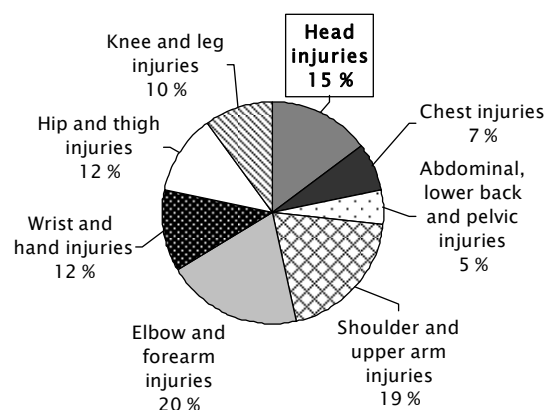


Figure 2. The location of injuries (n=41) among 29 patients who wore a helmet at the time of the crash.

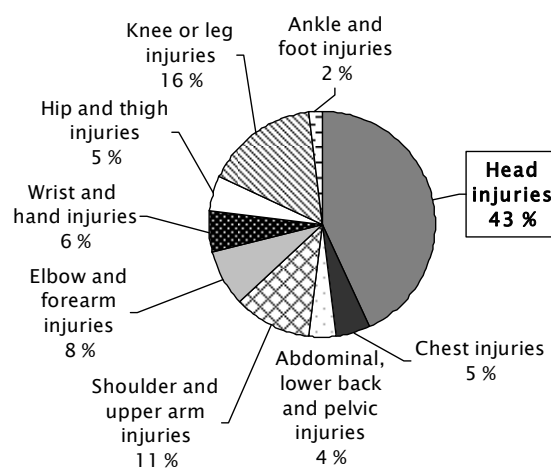


Figure 3. The location of injuries (n=164) among 122 patients who did not wear a helmet (at the time of the crash).

## Alcohol

In 31% (n=67) of the cases, the patient was under the influence of alcohol at the time of the crash. Breath alcohol concentrations were high: in 87% of those who were alcohol positive the concentration was more than 1,2 g/L. Positive alcohol concentration was more often found in males than in females (43% vs. 12%) ( $\chi^2=22.671$ , d.f.=1, p=0.000). (Fig 4 and 5)

Most (85%, n=57) of the drunken cyclists were men. Nearly half (46%, n=26) of these men belonged to the age-group of 35 to 49 years. Alcohol-related crashes led to cyclist's head injuries more often (60%) than the crashes where the cyclist was sober (29%) ( $\chi^2=18.582$ , d.f.=1, p=0.000).

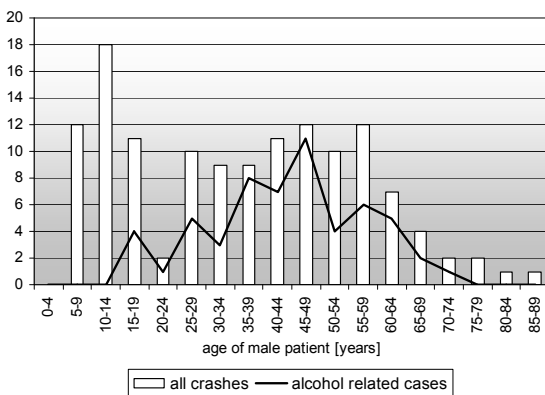


Figure 4. Distribution of all crashes (n=133) and cases with positive BAC (n=57) by age in males.



Figure 5. Distribution of all crashes (n=83) and cases with positive BAC (n=10) by age in females.

The proportion of alcohol related cases was similar (ca. 30%) in crashes resulting to minor (MAIS 1-2) and to serious (MAIS 3-6) injuries (Fig 6).

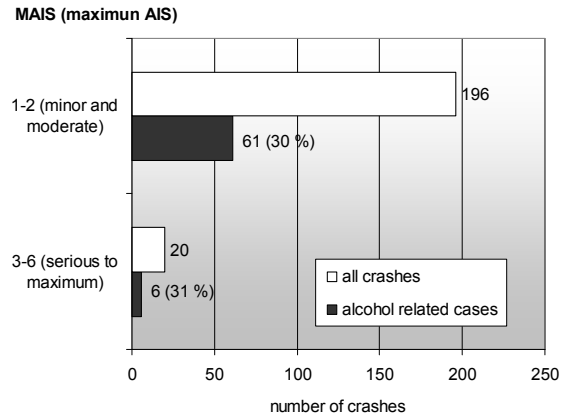


Figure 6. The number of all cases (n=216) and alcohol related cases (n=67) according to the severity of injuries (MAIS).

## Medical treatment and disability from work

Most commonly (71%) the cyclists were treated in out-patient care. A total of 262 out-patient visits (1.7 visits per patient) took place. 29% of the patients needed hospitalization. The total number of hospital days was 678. The mean length of hospital stay was 7.8 days (median 3, range 1 to 55 days). Furthermore, three of the patients who needed hospitalization were treated at ward in primary health care. After hospitalization, the patients visited in out-patient care a total of 216 times (3.5 visits per patient). Moreover, both in-patients and out-patients had several visits in primary health care, physiotherapy and private health care.

Over half of the crashes led to actual or theoretical work absence. The work absence was theoretical if the patient was e.g. out of work, in the mandatory military service, retired or a student and thereby not working at the time. 65 patients fell into actual sick leave and were unable to work for a total of 2 184 days. The mean length of work absence was 35 days per patient. Correspondingly, 46 patients fell into theoretical sick leave for a total of 1 233 days (mean 54 days per patient). A half of the theoretical work absences remained unknown.

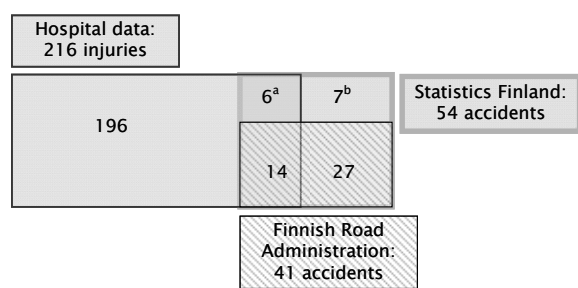
## Costs

The total cost of all cyclist injuries was 580 000 euros, 2 700 euros per patient. Most of the costs consisted of costs caused by the treatment of injuries (317 000 euros, 1 500 euros per patient) and by the patients' disability to work (235 000 euros). The majority (81%) of the medical treatment costs fell to municipalities. Further, 13% of the treatment costs fell to insurance companies and 7% to patients. Estimation of the costs in the whole country

(population 5.3 million) is 18.3 million euros per year.

### Comparison between hospital data and official statistics

The hospital injury data were compared to the official statistics of Finnish Road Administration and Statistics Finland. The comparison was made on the basis of the date, time, location and type of the cases. The number of bicycle crashes was four to five times higher in the hospital data than in the official statistics (Fig 7). Only 20 cases were identified both in the hospital data and in at least one of the official statistics, the accordance being 9.3% (20/216) (Fig 7). The differences between the two official statistics were mainly due to unequal recording of consequences of accidents (personal or property damage) (Fig 7).



<sup>a</sup> In the data of Finnish Road administration four accidents were recorded as cases resulting in property damage.

<sup>b</sup> In the data of Finnish Road administration all accidents were recorded as cases resulting in property damage.

Figure 7. The accordance of hospital data and official statistics (bicycle accidents resulting in physical injuries) in the study area.

The majority of the crashes occurred when the injured was alone. If there was another party, it was most commonly a passenger car. Collisions between a cyclist and a car were mostly recorded in the official statistics. (Table 3)

Table 3. Another party in bicycle crashes

Another party	Recorded in hospital data	Recorded in official statistics
Pedestrian or roller-skater	3	0
Cyclist	9	1
Moped	4	1
Passenger car	24	14
Van	1	1
Truck	1	1
No other party	174	2
<b>Total</b>	<b>216</b>	<b>20</b>

## DISCUSSION

Our study has some limitations. The sample was recruited from one Finnish hospital only. Therefore, our results may not be generalized to the whole country. Furthermore, the incidence of cyclist injuries is based on the population of the study area. Unfortunately, there are not other reliable measures available (e.g. frequency of cycling, time spent in cycling, distance travelled etc.) to describe the incidence.

The strength of the present study lies in the accuracy of the data gathered in the hospital. The total injury data were checked by a 10% random sample, and the missing information was completed. Further, the data were manually checked in the patients' records. It can be concluded that the most important results of the present study are reliable enough to describe bicycle crashes attended in hospital care.

The response rate to the questionnaire, on the other hand, was 36%, which is not very high. Therefore the patients' opinions that were inquired do not represent all the patients. It appeared that at least those who were under the influence of alcohol at the time of the crash did not answer the questionnaire.

Bicycle crashes resulting in physical injuries are considerably more common than the official statistics indicate. Thus, official statistics do not provide reliable information on the occurrence of non-fatal bicycle crashes. As long as the prevention of bicycle crashes is based on official statistics, it is pertinent to ask: can it be efficient?

Various studies show that the problem of compiling accountable official statistics is international [Cryer, 2001; Nakahara and Wakai, 2001; Langley, Dow, Stephenson et al., 2003; Ward, Lyons R and Thoreau R, 2006; Ward, Robertson, Townley et al., 2007]. The estimates of the coverage of the official statistics vary between countries. As a rule, bicycle crashes belong to those types of crashes which end up in the official statistics most poorly. In a Norwegian study [Veisten, Sælensminde, Alvær et al., 2007] it was estimated that the official statistics reported approximately 13% of the actual cyclist injuries in Norway. In the present study, the accordance of the official statistics was 9.3%. However, there were 34 cases in the official statistics which could not be identified in the hospital data. These cases may be found in primary health care data. Even so, in the primary health care data, containing less severe injuries, there are probably a large number of injuries which cannot be found in the official statistics. Thus,

the final accordance is most probably even smaller than is shown in the present study.

In Denmark [Statistics Denmark] and Sweden [Vägverket, 2007], the data collecting by the hospitals has been developed, and in those countries the data are available more easily for research than in Finland.

The proportion of head injuries was 35%, and head injuries were less frequent among the patients who used a helmet than among those who did not. According to several studies [Attewell, Glase and Mc Fadden, 2001; Macpherson and Spinks, 2008; Thompson, Rivara and Thompson, 2008] the bicycle helmet reduces the risk of head injuries. In Finland the law obligates the cyclist and the co-passenger in general to wear a helmet. However, cycling without wearing a helmet is not punishable. Thus, the law is more like a recommendation and, it is not, in general, followed by the citizens.

According to foreign experiences, the rate of helmet use can be effectively increased by setting a law in which cycling without a helmet is punishable [Macpherson and Spinks, 2008; Vulcan, Cameron and Heiman, 2008; Wesson, Stephens, Lam et al., 2008]. In Finland (population 5.3 million), approximately 30 cyclists die every year [Statistics Finland, 2008]. According to the road traffic investigation teams, half of these deaths could be prevented if all cyclists wore a helmet [The Finnish Motor Insurers' Centre, 2008]. It was estimated that in the present data the head injuries of 35 patients and one fatal accident would have been prevented if the patients had worn a helmet.

In the present study and in earlier Finnish studies [Olkkonen, 1993; Vuoriainen et al., 2000], injuries caused by bicycle crashes were mainly minor or moderate (MAIS 1 and 2). However, in the present study area, almost 30% of patients needed hospitalization and the mean length of the hospitalization was 7.8 days. An earlier Finnish study [Olkkonen, 1993] showed that in Helsinki, during the years 1985-1986, 35% of the patients injured in bicycle accident needed hospitalization and the mean length of the hospitalization for adults was 7.6 days (median 6, range 1-29) and for children 6.4 days (median 3, range 1-69). In United Arab Emirates, in a prospective study of 200 patients, only 15.5% of patients needed hospitalization and the mean hospital stay was 6.3 (range 1-23) days. In this study, the mean length of real work disability was 35 days. In Helsinki [Olkkonen, 1993] the duration of work disability was 11 days among out-patients and 82

days among in-patients. These results show that even minor and moderate injuries caused by bicycle crashes often had long-term consequences.

The total cost of all cyclist injuries was 580 000 euros which means 2 700 euros per patient. The majority of the costs were caused by treatment of the injuries (1500 euros per patient). In Jyväskylä, Finland [Vuoriainen et al., 2000], the costs of bicycle accidents in specialized health care were approximately 320 000 euros, that is, 1500 euros per patient, which is almost equal to this study.

The number of alcohol related bicycle crashes in the present data was alarming (31%), being higher than in the 1980's (24%) [Olkkonen, 1993]. Cycling under the influence of alcohol and without a helmet produces an increased risk of serious injury and death [Olkkonen, 1993; Spaite, Criss, Terence, 1995; Li, Baker, Smialek et al., 2001;]. Referring to Li et al. (2001), even a blood alcohol concentration of 0.2 g/L increases the injury risk to sixfold and 0.8 g/L to 20-fold in comparison with the situation where the cyclist is sober. The use of helmet is approximately seven times more common among cyclists who are sober than among those who are under the influence of alcohol. In the present study none of the drunken cyclists of whom the information was available wore a helmet, and, consequently, head injuries were more frequent among them than among those who were sober. In a recent study among bicycle accident victims in a trauma center in Texas, US [Crocker, Zad, Milling et al., 2010] alcohol use showed a strong correlation with head injury (OR 3.23, 95% CI 1.57-6.63). Furthermore, drunken cyclists rarely wore helmets and, as compared to sober cyclists, were less likely to have a medical insurance and their hospital charges were double.

In the present hospital injury data, there seem to be two kinds of cyclists who are drunk when falling into the crash; those who have an alcohol problem and those who randomly drink and cycle. The patients who repeatedly fall into alcohol related crashes can be identified. Thus, recognizing patients who have alcohol problems and their referral to intervention is a part of the prevention of traffic injuries, and it should be organized in co-operation between primary health care, social welfare services and other relevant fields. Also, brief interventions in emergency rooms have proved to be efficient in order to decrease frequent trauma visits under the influence of alcohol [Gentilello, Rivara, Donovan et al., 1999]. In the sensitive trauma situation patients are willing to participate in alcohol screening and intervention [Schermer, Bloomfield, Lu et al., 2003].

In Finland, cycling under the influence of alcohol is defined as a crime only if the cyclist causes a danger to another party. Hence, drinking and cycling is generally not very objectionable. Further, as the present results indicate, most of the cyclists –the drunken cyclists as well- fell into the crash alone without another party. By criminalizing cycling under the influence of alcohol, it might be possible to influence also those cyclists randomly drinking and cycling in order to prevent the crashes and the probable head injuries, which can cause long-lasting consequences.

## CONCLUSION

The present study confirms that the official statistics on bicycle crashes are insufficient. The gap in the numbers between the official statistics and the hospital data is at least fourfold, and the accordance between the different data sources is less than 10%. The collection of data in hospital emergency rooms should be done systematically in the whole country with the goal to gain more information for the prevention of bicycle crashes. Consequently, the national traffic safety assessments should be based on the hospital statistics data compiled in the EDs which give a more accountable information on the traffic crashes and related factors.

Most of the cyclists did not wear a helmet despite of the law which requires the cyclists usually to wear it. As long as there are no punishments for non-users, the law is more like a recommendation which will not be followed by the citizens. The use of the bicycle helmet should be mandatory in order to prevent head injuries and the costs these injuries cause to the society.

The proportion of alcohol related injuries was alarming. There are models of intervention to influence on those who have alcohol problems and frequent visits in ED. The cyclists who randomly cycle under the influence of alcohol can possibly be affected by law or education.

The majority of the costs of bicycle accidents fell to municipalities and employers. Accident prevention should have a more significant role in the occupational safety programs of the companies.

## ACKNOWLEDGMENTS

The study was supported by grants from the Finnish Society of Orthopaedics and Traumatology and from The Finnish Motor Insurers' Centre.

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