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SINGLE INJURY INCIDENTS AMONG PEDESTRIANS AND BICYCLISTS IN NORTHERN SWEDEN – SAFETY AND PREVENTIVE ISSUES

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ABSTRACT

Every year, in Sweden, more than 4,000 people require inpatient care for single injury incidents obtained while walking or bicycling in a traffic environment. The aim of this study is to describe causes of single injury incidents among pedestrians and bicyclists and to identify preventive strategies. The study is based on data from the injury registration database at the University Hospital in Umeå and from a complementary questionnaire containing questions regarding the causes of injury and preventive strategies. The questionnaire was distributed to all pedestrians and bicyclists injured in single incidents in a city in northern Sweden and who had visited the hospital in 2009 because of those injuries. The data set is comprised of medical data for all 367 patients (244 pedestrian and 123 bicyclists) who responded to the questionnaire. The results from this study show that the pedestrians and bicyclists differ in their reports regarding causes of their injuries and the differences seem to be related to injury severity. The pedestrians mainly referred to environmental factors as causes to their injuries, while the bicyclists referred to environmental factors, product factors, and human factors as causes of the injury incident. Regarding preventive strategies, the views of the pedestrians and the bicyclists is in line with their views of causes to their injuries. The results are useful for developing preventive strategies for differing groups of road users.

Key words: Pedestrians, Falls, Bicyclists, Single injury incidents

1. INTRODUCTION

Walking and bicycling are considered desirable activities for many reasons, e.g. improved public health and environmental friendliness. Nevertheless, in Sweden more than 4,000 people require in-patient care each year after sustaining injuries due to single incidents while cycling or walking in a traffic environment, e.g. falling or slipping on icy and snowy surfaces (Berntman & Modén, 2006). The majority of these injuries are classified as minor or of moderate character, but they account for a considerable proportion of in-patient care. Furthermore, even minor and moderate injuries can lead to severe and long-term consequences for the individuals and may have implications on their everyday life, e.g. limited mobility and economic loss. It is therefore, of vital importance to prevent these injuries as part of efficient and systematic community safety work. Research about injuries in the traffic environment has mostly focused on injuries related to motor vehicles (see e.g. Reynolds et al., 2009). Single injury incidents among pedestrians and bicyclists are less noticed than those involving motor vehicles; in particular falls among pedestrians (Björnstig et al., 1997; Öberg, 2011) and single incidents among bicyclists (Nyberg et al., 1997; Öberg et al., 1996). A reason for this may be that single incidents involving pedestrians and bicyclists are rarely reported in official traffic statistics (Björnstig & Björnstig, 2000b; Öberg et al., 1996). However, there are studies focusing on single incidents in relation to seasonal variations and living in a cold climate. Different kinds of shoes and anti-skid devices among pedestrians have been an issue in a number of studies (e.g. Berggård & Johansson, 2010; Gao, et al., 2004; Gao et al., 2008; Gard & Lundborg, 2001; McKiernan, 2005).

Research has been conducted in regard to the relation between environmental factors, particularly road conditions, and injuries. Nyberg et al. (1997) reported that nearly half of all single bicyclist crashes were caused by physical defects in the road surface and half of all single incidents among pedestrians occurred on snow and ice covered surfaces (Öberg et al., 1996). In the summertime, 25% of pedestrian injuries are caused by surface irregularities (Öberg, 2011). However, knowledge of the injury incidents or factors that could have prevented the injuries given from the perspective of those who have been injured is sparse.

In northern Sweden a hospital based injury registration has been in place since 1985 focusing on the injury incident, injury type, and injury severity. The results show that pedestrian injuries, due to slipping and tripping during the wintertime, account for over 50 percent of all in-patient days for all those injured in the traffic environment (Björnstig & Björnstig, 2000a, Larsson & Björketun, 2007). Nevertheless, there is a lack of knowledge regarding causes of various types of injury incidents and factors that could have prevented an injury incident.

The aim of this study is to describe causes of single injury incidents, for bicyclists and pedestrians, and to identify preventive strategies.

2. MATERIAL AND METHODS

The current study is based on a combination of data from the injury registration database at Umeå University Hospital and a complementary questionnaire that was distributed to all pedestrians (n=423) and bicyclists (n=310) who had been injured in single injury incidents in the city area of Umeå in 2009. All participants who received the questionnaire had visited the Emergency Room (ER). According to the NOMESCO classification (NOMESCO, 2007), the concept of pedestrians includes in-line skaters, skateboarders, scooter riders, using a kick-sledge or being transported in a wheelchair. However, in this sample almost all (388; 92%) of the 423 injured pedestrians were walking.

The injury registration database includes data from medical records and data from a questionnaire answered by injured persons who had visited the ER. This questionnaire contains a few questions about the injury incident and its causes. If the injured person was not able to answer the questions an accompanying person or the staff person could help. Additionally, available ambulance and police reports were included in the database.

The complementary questionnaire was distributed, a few weeks after the injury incident, to the pedestrians (n=423) and bicyclists (n=310) who had been injured in single injury incidents. The questionnaire requested more detailed information about the injury incident and its causes. Furthermore, the complementary questionnaire incorporated the patients' suggestions for preventive actions to be taken. Our data set is comprised of medical data from the injury registration database for all (367; 244 pedestrian and 123 bicyclists) who responded to the complementary questionnaire. Nearly six out of ten pedestrians (58%) and four out of ten bicyclists (40%) responded to the complementary questionnaire. Some significant differences were found when comparing the group of respondents to the non-respondent group among pedestrians and bicyclists. A larger proportion of females to males were found in the pedestrian respondent group when compared to the non-respondent group. Furthermore, the pedestrian responders were older, sustained more moderate or severe injuries, and had more fractures. The bicycle respondent group only differed from the non-respondents in regard to age and alcohol inebriation (see Table 1). Data concerning the influence of alcohol among the injured is based on information from the medical records or self-reported questionnaire data.

Table 1. *Proportion of age, sex, time of the year, time of incident, injury severity, fractures, and alcohol among pedestrians and bicyclists.*

Pedestrians	Total n=423	Responders n=244 (58%)	P value
Mean age	48 SD=21.70	55 SD=19.80	< 0.05
Median age	53 (2-88)	60 (4-88)	
Males	131 (31%)	58 (24%)	
Females	292 (69%)	186 (76%)	0.0002
Summertime	84 (20%)	39 (16%)	
Wintertime	339 (80%)	205 (84%)	0.02
Time of incident			
6am-8pm	277	169	
9pm-5am	68	27	0.001
Unknown	78	48	
MAIS1	255 (60%)	127 (52%)	
MAIS2	156 (37%)	111 (46%)	0.0001[1]
MAIS3+	12 (3%)	6 (2%)	
Fracture	151 (36%)	102 (42%)	0.002
Alcohol	18 (4%)	7 (3%)	0.1

Bicyclists	Total 310	Responders n=123 (40%)	P value
Mean age	37 SD 19.45	41 SD=20.5	< 0.05
Median age	32.5 (4-81)	38.5 (4-81)	
Males	168 (54%)	61 (50%)	
Females	142 (46%)	62 (50%)	0.19
Summertime	174 (56%)	63 (51%)	
Wintertime	136 (44%)	60 (49%)	0.16
Time of incident			
6am-8pm	165 (65%)	76 (76%)	
9pm-5am	88 (35%)	24 (24%)	0.004
Unknown	57	23	
MAIS1	221 (71%)	86 (70%)	
MAIS2	77 (25%)	32 (26%)	0.66[1]
MAIS3+	12 (4%)	5 (4%)	
Fracture	92 (30%)	34 (27%)	0.48
Alcohol	52 (17%)	13 (11%)	0.02

[1] P-value is based on comparison between MAIS1 and MAIS2+.

The pedestrians and bicyclists were injured outdoors in single incidents in the traffic environment or in other public places in the city of Umeå. The population of the studied area was 84,125 as of the 31st of December, 2009.

The injury severity has been graded according to the Abbreviated Injury Scale (AIS) (International Injury Scaling Committee, 2005). MAIS denotes Maximum AIS (the most severe injury). Minor injuries are classified as AIS 1 (e.g., bruises, small wounds, fractured fingers), moderate injuries as AIS 2 (e.g. concussions with loss of consciousness, radius fractures), and serious injuries as AIS 3 (e.g. fractures of the femur or moderate spleen lacerations). AIS 4–6 designate severe, critical, and maximal injuries. However, in this sample there were no critical or maximal injuries (AIS 5-6).

Data from the open-ended questions in the complementary questionnaire have been analysed by content and categorized according to Haddon's Matrix (Haddon 1973; 1980), a well known model used in injury prevention and safety promotion work. The part of the matrix (Haddon 1973; 1980), used here are the three categories of the injury system as they relate to causes and preventive actions; and human, product, and environmental factors. Quotations from the responders are used in the text, as illustrative examples (see Table 2).

Table 2. *Examples of factors and quotations regarding causes to the injury and preventive suggestions.*

Pedestrians	Factors	Causes to the injury	Prevention factors
	Environment	"I was slipping on ice that was covered by snow"	"Better sanding on the pavement"
	Human	"I didn't recognize that the surface was slippery"	"If I had been more careful that wouldn't have happened"
	Product	"I slipped on the ice because I didn't use my anti slip-devices!"	"Use anti slip-devices!"
Bicyclists	Environment	"It was a crack in the asphalt"	"Better maintenance of the bicycle path"
	Human	"I was cycling too fast and had been drinking alcohol"	"Don't cycle when you are drunk"
	Product	"A plastic bag on the handle bar fell into the front wheel"	"I am going to buy a bicycle basket"

Descriptive statistics for numbers and proportions were used, as well as Pearson's Chi- Square for calculating statistical significant differences between groups. The significance level was set to .05.

3. RESULTS

3.1. Sex, age and time of injury incident

Among the 244 injured pedestrians, three out of four (n=186; 76%) were women. The median age among women was 60 years and the median age among men was 56 years. Women in the age group of 50-79 accounted for 52 % of all injured pedestrians. Among the 123 injured bicyclists, sex was evenly distributed. The mean age among male bicyclists was 42 years and 39.5 years for female bicyclists (Fig. 1).

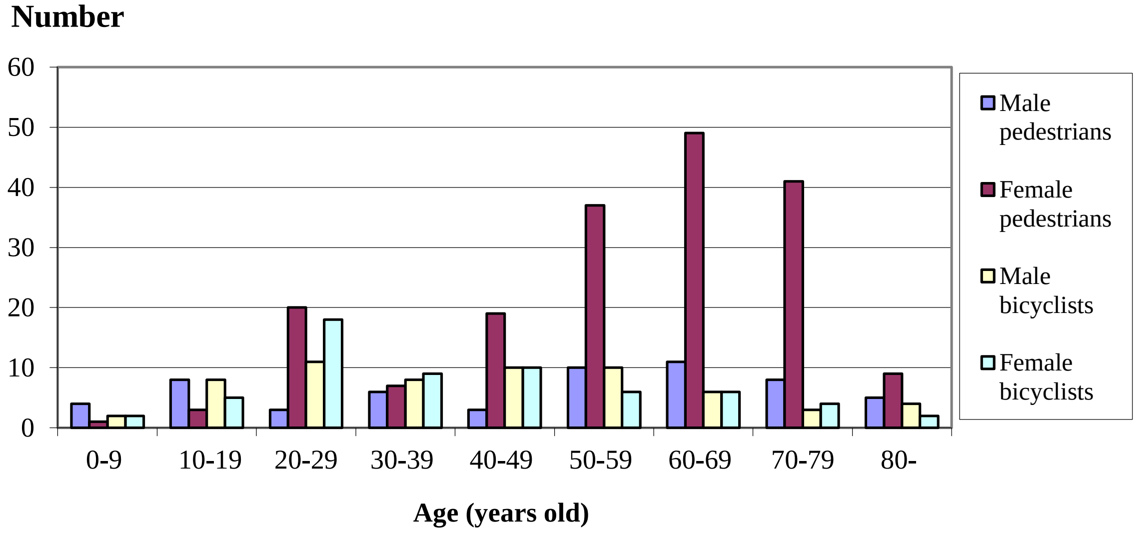

Figure 1. *Number of injured pedestrians (n=244) and bicyclists (n=123) in the response group, distributed by age and sex.*

The injury rate over time of the year, day of the week, and time of the day showed different patterns among the injured pedestrians and bicyclists. The pedestrians were mainly injured during November-March (n=192; 79 %), and the injury rate peaked in December. In contrast to the pedestrians, the bicyclists' were mainly injured during May-October (n=74; 60%). The injury rate was highest at the beginning of the week and during the weekends, for both pedestrians and bicyclists. Regarding time of the day, the injury rate among pedestrian was highest during lunch hours (11 am to 1 pm). Among bicyclists the time of injury rate showed a blended pattern.

3.2. Injury incident, type of injury and injury severity

Two-thirds of the injured pedestrians had slipped and fallen on surfaces covered with snow or ice. Almost half of the pedestrians (n=117; 48 %) suffered from moderate or more serious injuries (MAIS 2-4). Fractures and dislocations were the most common injuries, and affected mainly the upper extremities. Six persons had serious or severe injuries (MAIS 3-4), mostly hip fractures or hemorrhages in the brain. Women had a higher proportion of MAIS 2-4 injuries (n=97; 52 %) compared to men (n=38; 34%) (p=.02). There was no significant difference (p=.26) between younger and older men (<50 years vs. 50+) in regard to the proportion of MAIS 2-4 injuries. However, among women of the same age groups, the difference was significant (p=.003), i.e. women 50 years and older had a larger proportion of MAIS 2-4 injuries. Seven (3%) of the 244 pedestrians were under the influence of alcohol.

Common injury mechanisms among bicyclists (78; 63%) were crashes due to slippery road conditions (ice, snow, and gravel on the surface), braking, and potholes/cracks in asphalt or edge of sidewalk. Thirteen bicyclists (11%) were under the influence of alcohol, and among those more than two out of three were injured during weekends and in the early hours after midnight.

Almost one third of the bicyclists (n=37; 30 %) sustained MAIS 2-4 injuries. Even though not significant, there was a higher proportion of males than females (35 % vs. 24 %; p=.17) who suffered MAIS 2-4 injuries. Upper extremities (38%), as well as, head and face (29%) were the most common injury localization. The proportion of fractures and luxations on upper extremities was 32%. The most common injuries to the head and face were wounds and contusions (66%). Five bicyclists sustained MAIS 3-4 injuries; femur/hip fractures or hemorrhages in the brain.

3.3. Causes of the injury incident and suggestions for prevention

This result section presents the responders self-reported causes of their injuries in relation to their view of preventive factors. The results are presented according to human, product, and environmental factors. The results show that pedestrians and bicyclists differ in their response pattern regarding causes of their injury incident. However, their suggestions of preventive strategies show similarities as well as differences.

3.3.1. Pedestrians

The most frequently self-reported causes of injuries among the 244 pedestrians, regardless of season, were related to environmental factors (n=151; 62%), (e.g. poor surface maintenance, in terms of a lack of sand/gravel or surfaces that were not properly scraped).

"I slipped because of poor snow clearing and sanding"

"I slipped on an icy patch which I did not recognize because snow was laying above the ice"

"It was irregularities in the asphalt"

Factors related to the impact of various products or human factors are rarely mentioned; 7 % (n=16) refer to, for example, stumbling on plastic baling strap, wires or clothing and 12 %, (n=30) refer to human factors, for example, stress, inattention, and bad luck as the cause of the incident. Nevertheless, 14 % (n=34) refer to a combination of the three factors.

"I was walking and fell when I stumbled on a plastic baling strap that was lying on the ground; my wrist was fractured."

"I slipped on the icy surface in combination with bad shoes."

"Not sanded and not using anti-slip devices"

Among those who had slipped on snow or ice (n=161), a few (n=7) reported that they had been using anti-slip devices on their shoes. However, nine out of ten reported wearing shoes with ribbed soles. The remaining group of pedestrians used shoes with smooth soles or sandals.

The pedestrians' suggestions of preventive actions show a more blended pattern compared to their view of the causes of injury. Regardless of season, 48 % (n=118) refer to environmental factors. Sanding was often referred to as a preventive action against slipping on snow or ice. Sanding was mentioned as a single measure or in combination with other preventive actions, e.g. anti-slip devices, better shoes, better lighting, and enhanced attention.

"There were irregularities in the asphalt. This should be fixed!"

"If the parking lot had been sanded and if I´d used anti-slip devices and been more observant."

However, 40 % (n=98) report factors related to a product, human factor or a combination of those. It is noteworthy that only one out of six among those who had slipped and fallen on snow and ice suggested using anti-slip devices.

3.3.2. Bicyclists

The most frequently reported cause of the injury among bicyclists differs between winter and summertime. Among the injured in the summertime (n=63), the single most reported cause is related to human factors and reported by 40% (n=25), for example being inattentive; riding at high speed; and being influenced by alcohol. Environmental or product related factors are reported by one fifth respectively (n=13; n=14).

"I was cycling too fast and my attention was focused on my mobile phone."

"I was drunk and there was gravel on the asphalt."

"There was sand and gravel on the road."

Among the bicyclists injured in the wintertime (n= 60), factors related to the environment, e.g. slippery surfaces, constitute half of the reported causes (n=31). Human factors or product related factors are rarely reported. Bicyclists who had slipped on snow or ice, and whose bicycle was not equipped with studded tires, constituted 45 % (n=27) of the injured bicyclists in the wintertime.

"I thought it was dry asphalt but there was a film of ice without gravel."

"There was a patch of ice in a puddle."

The bicyclists' suggestions for what could have prevented their injuries are in line with their reported causes of injury. Human factors, such as lower speed and increased attention, are the most reported factors in the summertime. Environmental factors, such as better surface maintenance (sanding and snow removal) are the most suggested preventive measures during wintertime. Among the 27 injured bicyclists, whose bicycle was not equipped with studded tires, only four suggested studded tires as a preventive measure.

"To be more attentive"

"Better scraping and sanding on the bicycle paths"

3.4. Causes of the injury incident and the injury severity

This section presents results in regard to the relation between described causes of the injury incident and the injury severity, based on the pedestrian and bicyclists self-reported causes together with data from the injury registration database.

3.4.1. Pedestrians

Pedestrians with MAIS 1 injuries tend to report environmental factors or human factors as causes of the injury, while those with MAIS 2-4 injuries tend to report environmental factors or a combination of factors. However, these differences are small and non-significant (see Table 3).

3.4.2. Bicyclists

Reported causes of injury incidents in relation to injury severity show a blended pattern among bicyclists. Environmental factors are the most reported causes of injury incidents among those with MAIS 1 injuries. Environmental and human factors dominated among those with moderate or more serious injuries MAIS 2-4 injuries. However, these are small and non-significant differences (see Table 3).

Table 3. *Numbers and percent of factors affecting the cause of injury, related to injury severity, reported by injured pedestrians and bicyclists.*

Factors	Injury severity			Total
	MAIS 1	MAIS 2	MAIS 3+	
Pedestrians				
Environmental factors	82	65	4	151 (62%)
Human factors	20	9	1	30 (12%)
Product related factors	5	11	-	16 (7%
Combination of factors	14	20	-	34 (14%)
Accident	4	4	-	8 (3%)
Unknown factors	2	2	1	5 (2%)
Total	**127 (52%)**	**111 (45%)**	**6 (3%)**	**244 (100%)**
Bicyclists				
Environmental factors	30	13	2	45 (37%)

Human factors	19	12	2	33 (27%)
Product related factors	16	4	-	20 (16%)
Combination of factors	20	3	1	24 (19%)
Accident	-	-	-	-
Unknown factors	1	-	-	1 (1%)
Total	**86 (70%)**	**32 (26%)**	**5 (4%)**	**123 (100%)**

4. DISCUSSION AND CONCLUSION

The main finding of this study is that preventive strategies may be more adaptive to fit individual travelling habits, since the injury panorama seems to differ not only in relation to age and sex, but also in relation to the time of injury (i.e. time of day, day of the week, and between seasons). Furthermore, different road users, i.e. pedestrian and bicyclists, differ in relation to injury severity and exhibit partly different views of the causes of their injury and what factors could have prevented the injury.

The results from the current study have shown that a large proportion of those injured in the wintertime had slipped and fallen on snow and ice. However, among the pedestrians, only a few reported that they used anti-slip devices at the time of injury. In addition, only one out of six mentioned the use of anti-slip devices as a preventive measure although these devices are often recommended as a preventive tool. However, the effect of anti-slip devices is not univocal, since there are various types of anti-slip devices which have different effects on different surfaces (Gard, & Lundborg, 2000; 2001). Furthermore, only a few of the bicyclists injured in the wintertime, suggested studded tires as a preventive tool, although they have been on the market for several years in the Nordic countries.

Our findings show that women aged 50 years and older dominated the injured in the pedestrian group and that they had a larger proportion of MAIS 2-4 injuries (mostly fractures), which is in line with Saveman & Björnstig (2011) and Bergström et al. (2007). Pedestrians often fall on the same level and these low-energy traumas cause suffering and long rehabilitation. Watson & Ozanne-Smith (2000) highlighted that women (65+) are almost 1.5 times more likely than men in the same age group to be injured and. Stewens & Sogolow (2005) showed that the women's fracture rate is twice as high compared to men in the same age group. Activities to strengthen muscles as well as removing dangers from the environment are discussed. Preventive strategies in the community might therefore be directed to this target group especially.

The results indicate that individuals tend to relate their injury incident to external factors, i.e. factors out of reach of their control. Others have also highlighted this when preventive actions have been discussed (Haddon & Baker, 1981). If the responders' views of the causes of their injuries are valid in relation to the actual circumstances, our findings have implications for how to develop and implement preventive strategies for at least these groups of citizens. Referring to Haddon and Baker (1981), so called passive automatic working measure are often the most effective strategies because no action is necessary from the at-risk person.

Our results indicate that individuals, being injured in traffic and public environments, exhibit various views regarding the causes and possible preventive factors, both active and passive actions. Future preventive strategies for increasing safety may require specific directed adaptations towards various groups of citizens, e.g. vulnerable groups such as older people and children, since preventive implementations may have various effects on subgroups.

The influence of alcohol is a factor that could not be neglected. Studies analysing injuries related to bicycle crashes concluded that the influence of alcohol is a risk factor (Li et al., 2000; Andersson & Bunketorp, 2002). The injury risk of an inebriated bicyclist is estimated to be at least ten-fold at blood alcohol concentrations above one permillage (1g/l) (Olkkonen & Honkanen, 1990). In the present study 11% of bicyclists were under the influence of alcohol upon arrival to the hospital. In most cases, the determination that the injured person was under the influence of alcohol is based on the physicians' assessment or based on individuals' self-reported data from the questionnaires. However, clinical examinations may not be optimal. Honkanen (1977) found that among a group of patients, being confirmed inebriated by alcohol in blood tests, physicians were able to identify about two thirds in a clinical examinations. Against this background, the proportion of alcohol inebriation reported in this study should probably be at a higher level.

METHODOLOGICAL CONSIDERATIONS

Considering the representativeness of our study, the pedestrians are a rather heterogeneous group but with a higher response frequency (58 %) than the bicyclists, who on the contrary, are more homogeneous and have a lower response frequency (40 %). When comparing the group of respondents to the non-respondent group, some significant differences were found for pedestrians regarding age distribution, sex, and injury severity. These differences have to be taken into consideration in relation to the interpretation of the results.

The question arises as to whether or not the results have been affected by the high proportion of women in the age group of 50-79 in the pedestrian respondent group. Because the respondent rate is relatively low in the age group of 10-29 (40 %), it is difficult to draw any well-founded conclusions regarding their views.

Further research should include those who have not been injured, in order to achieve deeper knowledge about preventive strategies and risk awareness, since this is a group that can be expected to have developed successful preventive actions or strategies.

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DECLARATION OF INTEREST

Per-Olof Bylund is responsible for the injury data base at the University hospital in Umeå. No conflict of interest is reported for Britt-Inger Saveman and Ewa Rolfsman.

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