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Evaluation of Risk Factors for Accidental Injuries in Children and Adolescents

Abstract

The primary goal of this investigation was to determine the relative risk of traffic accidents in students. In a two year period, a survey amongst 2,325 students was carried out, and 3,645 injuries sustained by students treated at our hospital were analyzed. Moped-riding in adolescents were associated with a 23.75-fold increased risk for injury as compared to biking. Children who ride bicycles have a 2.2-fold increased risk for an injury sustained by traffic accidents compared to pedestrians. None of 50 injured bicycle riders with helmet had an AIS for head injuries of more than 2. 24 of 233 injured bicycle drivers without helmet had an AIS for head injuries of more than 2. The use of a protective helmet significantly reduced the severity of head injuries. The level of awareness towards danger and a history of previous accidents correlate with the likelihood of future accidents. Due to the severity of traffic accidents, more adequate prevention measures (wearing of bicycle helmets and better education for moped riders) are urgently needed.

Introduction

Injuries are the most prominent health problems that young people face during school-going years. They are the leading cause of death among youth. Each year in Germany alone 300 to 400 children under the age of 15 suffer a fatal injury [1]. Between 47% and 60% of Canadian youth experienced at least one injury per year that required medical treatment [2].

However, data on injuries only provide valid information on the actual risk of each injury causing activity when taken into consideration the relationship with actual activity exposure data [3, 4]. Hence, the primary goal of this investigation was to determine the relative risk of traffic injuries in children and adolescents. We also considered the influences of social and personal risk parameters which led to the injury and which may also influence the subsequent recovery process.

Materials and Methods

Two different surveys were linked together to make a differential analysis of injuries in the region of Dresden, Germany.

Medical Survey: In the period between 01.01.1999 to 31.12.2001 a total of 3,645 injured children and adolescents were treated in the Surgical Emergency Department of the University Hospital Dresden. Data were acquired only after written informed consent of the parents.

The following data were evaluated: personal, social, medical, psychological and injury describing variables.

School Survey: 2,325 children (from 6 to under 15 years old) and adolescents (from 15 to under 18 years old) and respective parents were interviewed and questioned about leisure behaviour, living and housing settings, and history of injuries in the past three years. The sample size was calculated after the following formula $n=u^2 \times p \times (100 - p) / e^2$ [5].

Statistical Analysis

All statistical analyses were performed using a SPSS for Windows Software (SPSS 10.0, Chicago, Ill., USA). Statistical significance was assumed at $p<0.01$ for the employed Chi-square test and F-test.

An exposure-dependent risk factor was calculated through a ratio of: injury (%)/activity (%) [percentage of injuries caused by a specific activity within all injuries (data from the medical survey) divided by the percentage of a specific activity within all activities (data from the school survey)].

The ratios among the risk factor are relative risks, making it possible to derive relative risks for all studied activities. Ratios of more than one indicate an increased relative risk for injury, while ratios less than one a below average relative risk for injury. The population of both surveys were nearly identical.

Results

Injuries in children and adolescents (Medical Survey)

620 (17%) out of 3,645 patients were admitted into the hospital and 3,025 (83%) were treated as out-patients. The most frequent diagnosis of the hospitalized patients was a cerebral concussion in 211 cases (34%), followed by fractures of the lower extremity in 118 cases (18.5%). The most frequent diagnosis of the outpatients was a contusion of the upper extremity in 635 cases (21.3%) followed by fractures of the upper extremity and contusions of the lower extremity (454 cases each, 14.9%). Males (n=2187) aged 6 to 17 suffered significantly ($p<0.01$) more injuries than females (n=1,458).

36 out of 3,645 patients had been seriously injured (ISS over 13). The most frequently injured body part was the head (83.3%), followed by the thorax (63.9%), upper extremities (36.1%), and abdomen (30.6%). 30 patients suffered an injury from traffic accidents and six by from fall height.

Injury-describing variables (Medical Survey)

43% (n=1,567) of all injuries occurred during leisure time and 41% (n=1,495) of all injuries happened on the way to or from school, or at school itself. 35% of the school related injuries occurred during physical education classes, 32% happened during other curricular activities or during the breaks, 17% during after-school-care for children.

Altogether 8% of all injuries were traffic related and 8% happened at home. 59% of the accidents occurred outside and 41% within buildings. The temporal distribution of the accidents over the day showed an increased frequency between 5p.m. and 7p.m.. A quarter of all accidents occurred in these two hours. The seasonal distribution showed a relatively increased frequency of accidents in spring and summer; whereby August represents an exception (summer holidays in Saxony).

Injury risk in traffic (Medical Survey and School Survey)

Children

There is a significant age-dependent shift in the manner in which our sample population (School Survey) uses roadways. 94% of all children are daily pedestrians or walk at least several times a week. 16% of the 6 to 9 years-old, 32% of the 10 to 14 years-old children and 28.1% of the adolescents used their bicycle as means of locomotion. Public transportation is used daily by 34% of the 10 to 14 years-old children. Younger children tend to be driven by car on a daily basis (31% of the children between 6 to 9 years). Children who ride bicycles have a 2.2-fold increased risk for an injury sustained by traffic accidents compared to pedestrians [7]. The exposure dependent risk factors are shown in Figure 1.

Adolescents

There were several significant gender related differences among adolescents (School Survey). Females aged 14-17 were more often pedestrians, users of public transportation, or driven by car than males at the same age ($p<0.01$).

127 out of 601 young males used their bicycles and 21 their motor bicycles (moped) for daily travel.

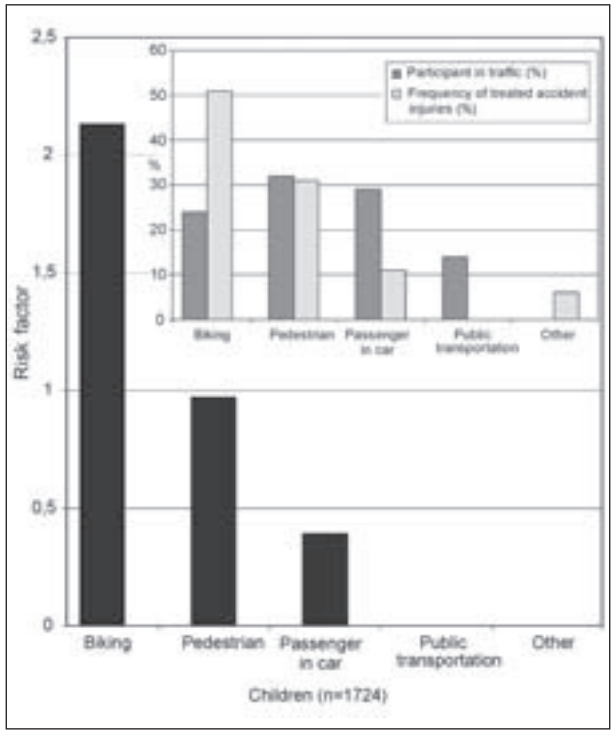

Figure 1: Exposure dependent risk factor for children in traffic

Only 3.5% of all adolescents were motorized road users. One third of all traffic related injuries comprised adolescents operating mopeds or motorcycles, thus there was a 21.1-fold increased risk for suffering an injury on the road when travelling by motorcycle or moped compared to pedestrians. Adolescents as cyclists faced a 3.7-fold increased risk of having a traffic related injury relative to pedestrians. The use of public transportation brought about the smallest risk for injury [6]. The exposure dependent risk factors are shown in Figure 2.

Bicycle accidents (Medical Survey)

283 patients suffered an injury after an accident as a bicycle rider. 233 of them did not wear a bicycle helmet at the time of injury. 24 out of these 233 patients suffered a head injury with an AIS of more than 2 points. None of 50 injured bicycle drivers with helmet had an AIS for head injuries of more than 2. The use of the bicycle helmet significantly reduced the severity of head injuries ($p<0,01$). 71% (n=202) of all (adolescents and children) injured cyclists were treated as out-patients. The average ISS of all hospitalized patients was 6.5. The most frequent diagnosis of the out-patients was a contusion in 81 cases and of the hospitalized patients, cerebral-contusion in 24 cases followed by fractures of the upper extremity in 24 cases.

Use of protective wear (School Survey)

There is a significant age-dependent shift in the manner in which the sample population (School Survey) uses protective wear. 55.5% (297 of 536) of children between 6 and 9 years were using a protective helmet when riding the bike. In contrast only 14% of adolescents wore a protective helmet.

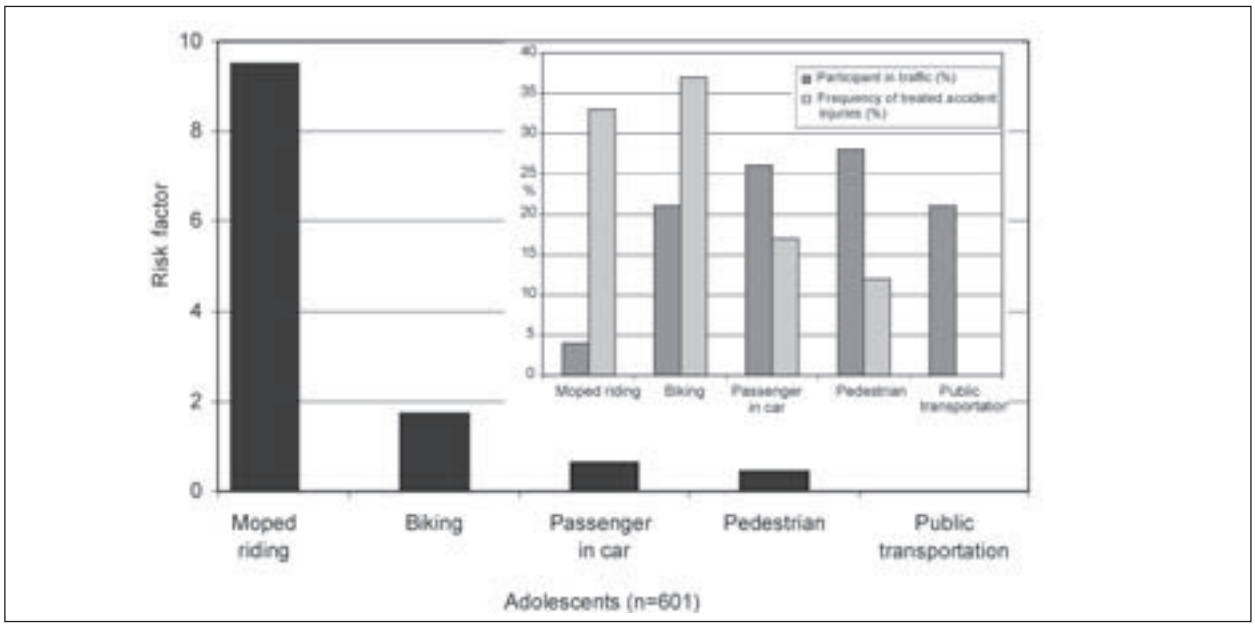

Figure 2: Exposure dependent risk factor for adolescents in traffic

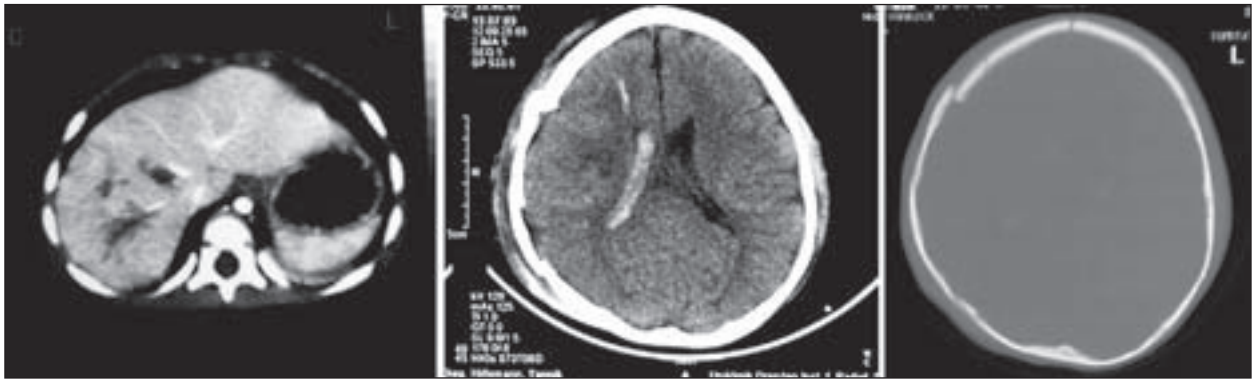

Figure 3: Year old boy after an accident as bicycle driver with a skull fracture, intracerebral haemorrhage and a rupture of the liver

With increasing age, the readiness of using protective head wear was significantly lower (p<0,01). There were no significant gender dependent differences.

Influence of physiological conditions (School Questioning)

A variance analysis was performed in order to examine the following measured variables: 'skills', 'practice in activity' that led to an accident, 'impaired hearing or vision', 'chronic illnesses' and their influence on the accident frequency. 'Age' and 'gender' were included as co-variables. The rounded results of the F-tests and the significance tests showed that children and adolescents with impaired vision had on average more injuries which needed medical treatment (p<0.01). Particularly, children and adolescents who had been described by their parents as clumsy were increasingly involved in accidents which needed medical treatment. Gender-specific influences could not be found in any of these physiological variables.

Psychological conditions	Gender				
	F=	p=	F=	p=	n
Concentration	0.80	0.50	4.93	0.03	2,245
Willingness to take risks	7.28	0.00	7.11	0.01	2,272
Independence	7.83	0.00	0.22	0.64	2,315
Activity	3.46	0.01	0.01	0.91	2,309
Behaviour while facing difficulties	3.34	0.01	0.97	0.32	2,251
Attribution of failures	0.71	0.40	7.91	0.01	2,108
Emotional impairment	0.26	0.85	2.46	0.12	2,092

Table 1: Variance-analytic (F=F-test; p=significance) investigation of the influence of psychological conditions on the accident frequency: The variables 'age' and 'gender' were included as co-variables into the analyses of variance. The variables 'willingness to take risks' and 'independence' show a highly significant influence on the frequency of accidents. Children and adolescents who were described by their parents as highly prepared to take risks had already had considerably more accidents that needed medical treatment than children and adolescents with little willingness to take risks. Additionally it was obvious that those children and young people who were described by their parents as totally dependent also showed a highly increased accident frequency

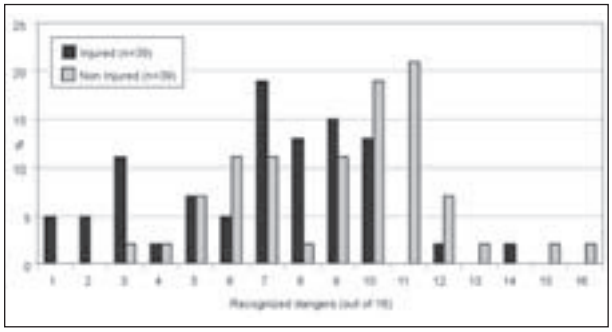

Figure 4: For a danger awareness test for children and adolescents who have suffered more than two injuries and who did not suffer any injury (control group) in the last three years an in-pair comparison was carried out. All children were shown 16 potential dangerous situations which could lead to injuries. Age- and gender-matched children and adolescents with no history of injury in the past three years recognized significantly more potential sources of danger situations [6]

Influence of the child's environment (Medical Survey)

In this segment, the influence of factors such as 'apartment size', 'whether or not the person had his/her own room', 'parents' occupation' and 'number of persons in the household' were examined. No influence on the accident frequency could be inferred from housing conditions, parents' occupation or family size of the examined children and adolescents. For example 5.7% of the children (n=59) of parents with a low occupational qualification (n=1,031) suffered 3 or more former accidents, which needed medical treatment, while it was 5% of the children (n=23) of parents with a high occupational qualification (n=463).

Discussion

The comparison of different studies of accidents in children and adolescents is quite difficult because of different age delimitations [5]. Many authors evaluate the accidents from toddlers up to adolescents altogether [3, 6, 7]. Due to the fact that the types of injury and accidents differ significantly between different age groups [8, 9, 10], we hereby tried to take a different look concerning the age and the age-dependent behaviour of children and adolescents. Certainly, we take into consideration that there were different data collection methods and different legislation in various countries. Economic aspects also play an important role and influence in the types of accidents [2].

In our investigation, the most frequent injuries were contusions and fractures of the upper extremity. Similar results are shown by many other researches [3, 7]. As an example, an investigation of twelve paediatric emergency departments in Mexico City reported that the most common injuries were open wounds followed by fractures of the fore

arm [9]. With regard to the localization of injuries as reported by several authors, the relative increase in trauma of the upper extremities with an increase in age is well established.

Although some studies on accidents in young children (p to 8 years-old) showed that injuries of the head were most frequent [9, 11], other authors reporting on accidents in older children showed that injuries of the upper extremities were most common [6, 1]. We concur with both these data series. The findings of a study by READING [12] suggested that children from families with three or more children are more prone to accidents than those from smaller families. This, however, was not corroborated by our data. In our investigation, family size did not have any influence on the accident frequency.

Similarly to the series of HAYNES et al. [13], we have also observed that males had significantly more accidents than females. Boys often engage in more physically active games and take more risks than girls. Moreover, the higher number of accidents is due to the choice of hazardous activities: in fact, when comparing both genders in the same context, boys choose the same activities but carry them out in more hazardous ways [14]. The gender specific difference may be due to the influence of the parents and how they have been educated. In particular, parents encourage boys to take part in games requiring physical activity, while girls are encouraged towards safer and calmer activities [15].

Personal traits, such as the constant search for new and stimulating activities, play a fundamental role in children's behaviour in relation to hazards. In children between 6 and 8 years of age, this personal trait is a good forewarning of hazardous behaviour [16]. Other research studies have labelled those children who display aggressive, impulsive, hyperactive and stubborn behaviour as "accident phone" and hence they have a higher probability of personal injury [15, 17]. We can confirm this with our data.

A particularly relevant factor, as the basis of a person's behaviour, is the personal experience with risk. A longitudinal, 5-year study [18] on more than 10,000 children, has shown that: 1. children who had three or more accidents between birth and age of 5 were 5.9-fold more likely to have accidents between the age of 5 and 10 years, compared to those who had never had any accident before school age, 2. children who had one or more accidents requiring hospitalisation before the age of 5 years, were 2.5-fold more likely to have one or more accidents requiring hospitalisation between the age of 5 and 10. An analysis of data has confirmed that the number of previous accidents in children under the age of 5 is the best predictor of future accidents between the age of 5 and 10 years. In our investigation, the level of danger awareness was significantly lower in children with a frequent history of accidents.

Between 5.6% [19] and 8.0% (own data) of all treated injuries in children and adolescents were caused by a traffic accident. In both investigations, 39% of the children were involved as bicycle riders. According to the Federal Statistical Office of Germany, in the year 2000 alone 15,119 children suffered an accident as a bicycle rider [1]. In the United States, each year over 50,000 children suffer a bicycle accident [10]. The use of a bicycle helmet significantly reduces the risk for a head injury [20]. Such conclusions have been confirmed by our recently published results [21]. PARKIN [22] has reported that 75% of cyclists who suffered a fatal accident would still be alive if they had worn a bicycle helmet. Accordingly, one of the challenges in the prevention of accidents is the decreasing willingness of children and adolescents in wearing a helmet as they grow older [21]. An investigation by the Federal Institution for Roads in Germany [23] showed that children at the age of 10 have the highest ratio (40%) of wearing a helmet in comparison to all other ages.

Many of the factors that appear to influence risk evaluation and appraisal – such as gender, personal traits, psychological and physiological parameters – are closely inter-related. Of all examined factors, the history of previous accidents is a predictor of future accidents. By testing the level of danger awareness, such children can be pointed out. They may then benefit from a more intensive education towards avoiding potentially dangerous situations.

Furthermore we strongly believe that due to the severity of traffic accidents, more adequate prevention measures (wearing of bicycle helmets and better education for the moped rider) are urgently necessary.

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References

[1] Statistisches Bundesamt: Statistical Yearbook of Germany 2000. Wiesbaden: Metzler-Poeschel-Verlag; 2000

[2] W. BOYCE: The Health Behaviour of School Age Children: The Canadian Report. Ottawa, Ontario: Health Canada 2003

[3] C. FUNK: Unfallverletzungen bei Kindern. Thesis, University of Ulm, Germany, 1997

[4] J.A. NAVASCUES, J. MATUTE, J. SOLETO et al.: Paediatric trauma in Spain: a report from the HUGM Trauma Registry. Eur J Pediatr Surg. 2005;15(1):30-7

[5] D. MACHIN, M.J. CAMPBELL: Statistical Tables for the Design of Clinical Trials. Oxford: Blackwell Scientific Publications; 1987

[6] W. SCHNEIDERS, A. ROLLOW, S. RAMMELT et al.: Risk-inducing activities leading to accidents in a child and adolescent population of Germany. 2006 Journal of Trauma

[7] I.E. KLEMENS: Unfallursachen und Unfallfolgen im Kindesalter – eine Dokumentation zur prospektiven Unfallreduzierung. Thesis, University of Münster, 1996

[8] M.S. DURKIN, S. OLSEN, B. BARLOW et al.: The epidemiology of urban paediatric neurological trauma: evaluation of, and implications for, injury prevention programs. Neurosurgery. 1998;42:300-310

[9] M.C. HIJAR-MEDINA, J.R. TAPIA-YANEZ, R.L. LOZANO-ASCENCIO et al.: Accidentes en el hogar en ninos menores de 10 anos. Causas y consecuencias. Salud Publica de Mexico. 1992;34(6):615-625

[10] S.E. KIRSCH, N. PULLEN: Evaluation of a school-based education program to promote bicycle safety. Health Promot Pract. 2003;4(2):138-45

[11] S. SHAFI, J.C. GILBERT, F. LOGHMANEE et al.: Impact of bicycle helmet safety legislation on children admitted to a regional paediatric trauma center. Journal of Paediatric Surgery. 1998;33(2):317-321

[12] R. READING, I.H. LANGFORD, R. HAYNES et al.: Accidents to preschool children: comparing family and neighbourhood risk factors. Soc Sci Med. 1999;48(3):321-30

[13] R. HAYNES, R. READING, S. GALE: Household and neighbourhood risks for injury to 5-14 year old children. Soc Sci Med. 2003;57(4):625-36

[14] B.A. MORRONGIELLO, T. DAWBER: Toddlers' and mothers' behaviour in an injury-risk situation: implications for sex differences in childhood injuries. J Appl Dev Psychol 1998;19:625-39

[15] S.P. BAKER, B. O'NEIL, M.J. GINSBURG: The injury fact book. New York: Oxford University Press; 1992

[16] R. POTTS, I.G. MARTINES, A. DEDMON: Childhood risk-taking and injury: Self-report and informant measures. J Pediatr Psychol. 1995;20:661-8

[17] G. ZIGON, R. CORRADETTI, B. MORRA et al.: Psychological aspects of risk appraisal in asphyxiation accidents. Acta Otorhinolaryngol Ital. 2005;25:100-106

[18] P.E. BIJUR, J. GOLDING, M. HASLUM: Persistence of occurence of injury: Can injuries of preschool children predict injuries of school-aged children? Paediatrics 1988;82:707-12

[19] J. MAYR, O. RUSSE, P. SPITZER et al.: Playground accidents. Acta Paediatrica 1995;84:573-576

[20] H.R. CHAPMAN, A.L. CURRAN: Bicycle helmets – does the dental profession have a role in promoting their use? Br Dent J. 2004;196(9):555-60

[21] W. SCHNEIDERS, A. ROLLOW, S. RAMMELT et al.: Unfälle von Kindern und Jugendlichen. Unfallchirurg 2005

[22] P. PARKIN, L. SPENCE, X. HU et al.: Evaluation of a promotional strategy to increase bicycle helmet use by children. Paediatrics 1993;91(4):283-7

[23] W. SIEGENER, T. RÖDELSTAB: Continuous monitoring of road user safety behaviour [bast.de, Web site]. 1999 Available at: http://www.bast.de/htdocs/veroeffentlichung/bastinfo/info2000/info0003.htm. Acessed February 14th, 2000