Child injuries in Bergen, Norway

Identifying high-risk groups and activity specific injuries

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Contents

Genesis

Ute på randen av avgrunnsstupet
Stanset et skrik i en stjernestrupe:
”Jorden ser oss, - det lille fnugget,
skrem det ikke,
barnet som hviler i luftens vugge!”

Stjernene stanset og lyset målte,
hvor meget den lille dernede tålte.
De svingte sin bane inn i det høie
ut i rummet
for ikke å blinde barneøiet.

Sikkert visste de stjernekolosser
som rundt lik ildoceaner fosser,
at mindre lys i de store slukner
og forsvinner,
slik som dråper i havet drukner!

*

av Herman Wildenvey
fra samlede dikt III

1. Preface with acknowledgments

My interest in the field of child injuries started early in my medical career. As a new doctor at Bergen Accident and Emergency Department, Bergen Legevakt, I found it tough to treat children with burns, painful wounds after falls from bicycles or displaced forearm fractures after falls from swings. One year at the paediatric department at Haukeland University Hospital and parallel work at the child health centre made me even more aware of the importance of injury prevention. My own children, Martin and Peter, may have experienced a somewhat overprotective mother, but fortunately still enjoy physical activity. My husband, Øyvind Soleim, has supported me through my ups and downs in performing this study.

My good college at Bergen Legevakt, Knut Steen, was already doing registrations on violence and inspired me to start to register child injuries. Rolf Reitan, another good college, was my "computer guru", giving me vital ideas and help with designing the registration forms. Willy Haukeland, Finn Sørensen and our current Head of Bergen Legevakt, Frank van Betten deserve great gratitude for allowing and supporting these registrations at the expense of some of the efficacy of curative work. Eivind Damsgaard and Torbjørn Hiis-Bergh relieved me of teaching tasks while I was in the writing process. Likewise, I will express my sincere thanks to the staff at Bergen Legevakt, in particular the doctors and nurses at the surgical division and the radiographers under the leadership of Arve Standenes, for their enthusiasm and long-term support of registrations. Sissel Martinsen has been an invaluable secretary with her accurate work. Kari Schrøder Hansen deserves thanks for helping me conduct registrations at Haukeland University Hospital. Good colleges and staff at Fana Legekontor also helped me conduct a local and parallel study of child injuries in a Bergen district consulting room. I'm very grateful to Erin Cassell, Director of the Victorian Injury Surveillance Unit at Monash University in Melbourne, Australia, for revising and supplementing my drafts on this thesis with new angles and language improvements.

None of this would have been possible without the inspiring support and guidance of my supervisor Professor Leiv M. Hove.

2. List of papers

This thesis is based on the following papers:

Paper I: Brudvik C. **Child injuries in Bergen, Norway**. Injury 2000;1:761-7.

Paper II: Brudvik C, Hove LM. **Childhood Fractures in Bergen, Norway: Identifying High-Risk Groups and Activities**. J Pediatr Orthop 2003;3:629-34.

Paper III: Hove LM, Brudvik C. **Displaced paediatric fractures of the radius and ulna**. 2006. (Submitted).

Paper IV: Brudvik C. **Rulleskøyte- og rullebrettskader blant barn i Bergen**. Tidsskr Nor Lægeforen 2001;121:19-22.

Paper V: Brudvik C. **Skader ved bruk av sparkesykkel**. Tidsskr Nor Lægeforen 2003;123: 3222-3.

Paper VI: Brudvik C. **Injuries Caused by Small Wheel Devices.** Prev Sci. 2006;Jun 14: [Epub ahead of print]

3. Abbreviations

AED: accident and emergency department
AIS: abbreviated injury scale
BMD: bone mineral density
CI: confidence interval
DXA: dual energy x-ray absorptiometry
EU: European Union
FCI: functional capacity index
GP: general practitioner
HUS: Haukeland University Hospital (Haukeland Universitetssykehus)
ICD10: international classification of diseases, injuries and causes of death.
ICPC: international classification of primary care
ISS: injury impairment score
IVP: injury and violence prevention, WHO
MRI: magnetic resonance imaging
NISS: National Injury Surveillance System
NOK: Norwegian krowns
NOMESCO: Nordic Medico-Statistical Committee
NPR: Norwegian Patient Register
OECD: Organization for Economic Cooperation and Development
OR: Odds ratio
QALY: quality adjusted life years.
QUS: quantitative ultrasound
RSC: rating system for serious consequences
SF-36: medical outcome study Short-Form 36 health survey
UNICEF: United Nations Children’s Fund
WHO: World Health Organisation

4. Sammendrag (Norwegian summary)

Formålet med denne studien var å undersøke forekomsten av barneulykker i Bergen sammenliknet med forekomsten andre steder innenlands og utenlands. Vi ønsket å undersøke hvilke barn, karakterisert ved alder, kjønn eller andre faktorer, som oftest pådro seg ulike skader. Det var også et mål å analysere hvilke skader som oftest oppsto under ulike typer aktiviteter, og om nye aktiviteter medførte nye skadetyper. Det var en målsetting at undersøkelsen ville gi velbegrunnete anbefalinger vedrørende forebygging av skader på barn. Det var også av interesse å se på utfallet av vår behandling av en vanlig, men komplisert skade, nemlig underarms- og håndleddsbrudd med feilstilling.

Hovedregistreringen har foregått ved Bergen Legevakt og Haukeland Universitetssykehus i løpet av 1998 og danner grunnlaget for artikkel I, II, III og IV. I denne registreringen ble det brukt elektroniske påminnere til legevaktens helsepersonell for å sikre at den ble mest mulig komplett. Mer detaljerte og avgrensete registreringer av både gamle og nye aktiviteter har foregått ved Bergen Legevakts røntgen- og såravdeling fra 2000 til 2002 og danner grunnlaget for artikkel V og VI.

Det ble registrert rundt 7.000 nye skader på barn under 16 år, hvorav 1.725 var bruddskader. Den totale årlige skadeinsidens var 9 per 100 barn under 6 år og 13 per 100 barn mellom 6 og 15 år. De yngste barna pådro seg oftest hodeskader mens de eldste fikk mest armskader. De fleste skader var av mild eller moderat alvorlighetsgrad, men 4 barn døde. De alvorligste skadene oppsto i trafikken. Hodeskade, inklusiv hjernerystelse, var den hyppigste innleggelsesdiagnosen i sykehus. De fleste skader oppsto hjemme eller nær hjemmet. Brannskader var hyppigst blant barn under 4 år og skyldtes oftest skolding fra varm drikke. Jenter fra etniske minoriteter hadde en høy andel av de alvorligste brannskader i dette registreringsåret. Skoleskader, inklusiv voldsskader, oppsto oftest i friminuttene og når barna var uten voksent tilsyn. Blant aktiviteter hadde fotball den høyeste årlige skadeinsidens (11 per 1000 barn), fulgt av sykling (8 per 1000 barn). Den årlige insidensen av brudd blant barn i Bergen kommune (245 per 10.000) var betydelig høyere enn tidligere påvist i andre norske byer (Harstad, Stavanger, Drammen og Trondheim). Gutter i alderen 13-15 år hadde en dobbelt så høy forekomst av brudd sammenliknet med jenter i samme alder. Mens 1/3 av fotball- og sykkelskadene var brudd, utgjorde de hele 2/3 av rulleskøyte- og snøbrettskadene og rammet oftest håndleddet. To spesielle bruddtyper forekom hyppigere i nye aktiviteter. Det gjaldt bruddskader i håndrotens skafoidbein, som ellers forekommer svært sjelden hos barn og unge, men som forekom i en høyere andel av bruddskadene ved bruk av rulleskøyter og rullebrett enn i andre aktiviteter. En høy andel underarms- og håndleddsbrudd med volar vinkling ble identifisert i forbindelse med bruk av sparkesykler. I begge tilfellene må det vurderes om vanlig håndleddsbeskyttelse også kan forebygge disse bruddtypene. Sparkesykler ble svært populære i 2000 og medførte mange skader dette første året, men skadeantallet begynte å falle allerede året etter. Det var ellers interessant å merke seg at håndleddet også var det vanligste bruddsted hos unge fotballspillere, og harde ballskudd var årsaken i hele 40% av tilfellene. Dette gjør det logisk å skulle beskytte håndleddet så vel som skinneleggen under denne aktiviteten.
Vi vurderte også funksjonen i håndledd og underarm til barn og unge som syv år tidligere hadde hatt brudd med feilstillinger som måtte korrigeres. Våre behandlingsresultater var svært gode, selv der det var en resterende feilstilling på 15 grader eller mer ved gipsfjerning. Kontrollene indikerte en stor evne til remodellering av disse barnebruddene. Kun noen få med høyere underarmsbrudd hadde redusert funksjon til tross for normale røntgenbilder.

5. General introduction

5.1 Definition of injury

An injury is a bodily lesion at the organic level resulting from acute exposure to energy (mechanical, thermal, electrical, chemical or radiant) interacting with the body in amounts and rates that exceed the threshold of physiological tolerance.[57, 58] Injury may also result from an insufficiency of a vital element (drowning, strangulation, freezing). The time between exposure and the appearance of the injury needs to be short.[5]

5.2 Classifications of injury

Injuries may be classified as unintentional (accidental) or intentional (interpersonal- or self-harm).
In this study the patients themselves defined the reasons for injury as either: [Appendix 1]

- accidental
- due to pushing, hard holding, kicks or other reasons during play or sports
- fights or other forms of deliberate violence
- self-harm

Defining an injury is not difficult when it comes to the upper end of the severity scale, i.e. the more severe lesions. It is, however, harder to define at the lower levels of severity. In our study the patients or their parents initially defined whether they had an injury or not, but cases were excluded from the study if the lesion proved to be due to an illness. Only injuries receiving medical treatment by a physician were included. Dental injuries were not included. Only new injuries, not treated elsewhere, were included.

5.3 Injury severity

In the injury registration from 1998 the severity of injury is defined according to where the medically recommended site of treatment is. The lowest level severity rating is accorded to injuries that could be treated at home, mild severity rating to injuries that could be treated by a GP, moderate severity rating to injuries in need of treated at Bergen AED and the highest level to injuries in need of treatment in a trauma hospital. In the injury registrations from 2000 to 2002 the Norwegian modified version of AIS, abbreviated injury scale [3], was used. Different classification systems have been developed to describe the injury-related impact on health, and AIS classifies injuries according to immediate threat to life of injured persons. The AIS range from 1 (minor injury) to 6 (fatal injury). The overall injury severity score (ISS) is often used for patients with multiple injuries and is the sum of the squares of the AIS scores of the three most severely injured body areas. The vast majority of patients in our studies were registered with single injuries so we did not use this otherwise useful injury score.

5.4 High-risk groups

A high-risk group is defined as a part of the population, characterized by age, sex or other factors, with an increased incidence rate of injuries compared to other groups.

5.5 Activity specific injuries

Special types of injuries prevalent in certain activities in a higher percentage of injures than prevalent in other activities is called activity specific injuries.

6. Child injuries in perspective

6.1 The global and national size of the child injury problem

Child injuries are an important public health problem in both developed and developing countries.[128, 184] Except for the first year of life, mortality from accidents is the leading cause of death in children worldwide.[157, 184] Approximately 1 million children under 15 die every year due to accidents in the developing countries. A survey of the worlds 26 richest nations in 2001 by UNICEF revealed that 40% of all deaths in children aged 1-14 were due to injuries.[178] Studies from Sweden have shown that large socio-economic differences within a country predispose for higher child mortality.[45, 124] For example, the US and Bulgarian unintentional child mortality rates were found to be equal, even though the US gross national product per inhabitant is 30 times higher. Sweden had “the best results” in 2001 with only 5.2 deaths per 100,000 children. Great Britain, Italy and the Netherlands had less than 7 deaths per 100,000 children per year, while Norway had 7.6 deaths per 100,000 children.[160] If our child death rate was as low as in Sweden, we would save 23 children from dying every year, and 1,600 children’s lives could have been saved in the European community. Contrary to children in the other OECD and European countries, the child death rate in Norway increases with age. Among Norwegian children aged 10-14 the annual death rate is 8.7 per 100,000 compared with 8.1 per 100,000 among the 1-4 years old. By contrast, among British children aged 10-14 the death rate is 6.4 per 100,000 compared with 7.3 per 100,000 among the 1-4 years old. The reason for this difference is not fully understood.
The risk of dying from an injury has become lower in the last years due to better medical emergency service, especially in the western world. The death rates are still only the top of the injury iceberg. [110, 178, 184]

6.2 Injuries and deaths in the child population related to the adult population

In Norway, approximately 40 per 100,000 people die from unintentional injuries every year.[160] Children under 15 account for one fifth of these deaths (n<50). National data from the Norwegian National Injury Surveillance System (NISS) estimated in 1990 an incidence of 9.1 injuries per 100 persons treated in AED’s and hospitals, and a total incidence of 12.8 per 100 per year when combining injuries treated by the primary health care and occupational health service.[56] Children and youth aged 10-20 and elderly above 70 years of age are often over-represented in injury data (Fig.1).

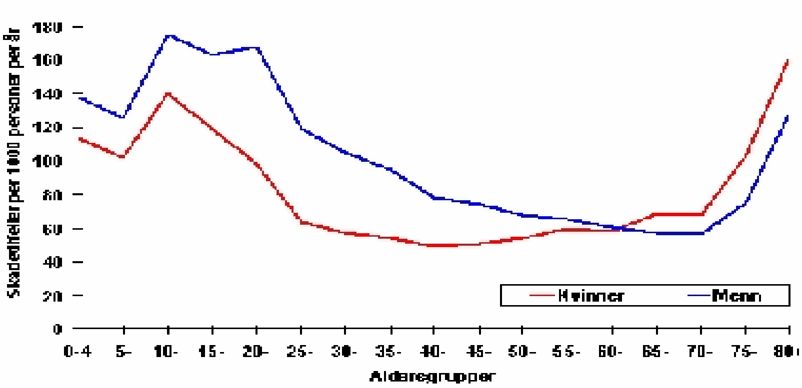


Figure 1. Injuries by age and gender distribution (Source: NISS; Trondheim, Harstad, 2000-01)

6.3 Health consequences of injury

The majority of children recover quickly from injuries. Some injuries, however, produce long-lasting physical and psychological consequences, not to speak of the fatal injuries. Children with the same diagnosis may differ significantly in terms of injury severity and consequences. The AIS and ISS injury scores describe the injury's immediate threat to life.[3] The Rating System for Serious Consequences (RSC), the Injury Impairment Score (IIS) and the Functional Capacity Index (FCI) are classification systems that try to quantify the disability following an injury based on professional evaluation of the problem. Others prefer to evaluate the health-related quality of life conceptualised by the general public as in the medical outcome study Short-Form 36 health survey (SF-36). This is a self-administered questionnaire on eight dimensions of life, but is not applicable for those under 16 years.[84] Injuries also affect children and families by reducing their quality of life. Families who lose a child to injury, suffers years of mental anguish. Children who are permanently disabled by injury may experience lifelong pain, loss of motor abilities or loss of cognitive function. These less quantifiable consequences of childhood injuries can be valued in non-monetary terms as Quality Adjusted Life Years (QALY), or the new health indicator called disability adjusted life years (DALY).[184]

6.4 Economic consequences of injury

The economical implications of injuries are important to calculate in order to illustrate the burden that they cause, both to the individual and to the social economy. In this way the price of effective prevention can be shown to be economically worthwhile.[108] According to a study by Kopjar,[83] the average direct medical cost per injury was estimated to NOK 3,807 (1994 price level) or US$ 163. The cost per hospitalized patient was NOK 24,831 and per outpatient NOK 1,011. Per-injury costs were found to increase with age, and were the highest among nursing home, home and traffic injury cases. Sports, school and day care/playground injuries were the least expensive. Injuries sustained during childhood may, however, impact the productivity of both children and their caregivers over time. Children who are disabled from an injury may be unable to work in the future, imposing a large financial burden on society. Because of the high frequency of small injuries that keep children at home from school for a few days with one of their parents, the total work loss for the adult is a major cost for society. Using analysis of US national and state datasets, Miller et al [108] found that childhood injuries accounted for approximately 15% of medical spendings from ages 1-19. Fatal injuries involved less than 1% of all injuries in 1996, but accounted for more than 17% of injury related costs. The least severe injuries, where the child was not hospitalised, accounted for nearly 99% of all childhood injuries, but were associated with 58% of the estimated lifetime costs. This means that the most common and least severe injuries account for more than half of the total injury costs.

7. Injuries - why do they happen?

7.1 Inter-disciplinary understanding of injury

Research during the last decades has given us a better understanding of the nature of injuries. Like infectious diseases, injuries occur in certain patterns, with stable frequency, and in the presence of certain risk factors. John Gordon, an epidemiologist at Harvard in 1950, demonstrated the non-randomness of injury events and described injuries as being the result of forces from three sources; the host, the agent and the environment.[181] In 1961 James Gibson suggested that "energy interchange" was the agent of injury harm.[181] William Haddon, an American physician and engineer showed that not all injuries are "due to physical energy transfer to human tissues in amounts and rates that damage cellular structure, but also to the absence of necessary energy elements – such as oxygen or heat occurring in drowning or hypothermia".[58] His definition of an injury is still in use today.
Research in injury biomechanics involves multiple disciplines like engineering, physiology, medicine, biology and anatomy. Mechanical injuries have been found to happen in three ways: crushing, impulsive impact by violent motion, or acceleration of the skeleton and tearing of internal organs. The force of the injury is the product of the mass and velocity involved. Other disciplines like psychology, sociology, health education, anthropology, economy and political sciences are just as important as the physical sciences in the understanding of injury.[5]

7.2 The historical shift in the understanding of whom to blame for injury

Unintentional injuries were once regarded as due to unavoidable accidents. During the last century the ideas of responsibility for injuries have changed from blaming the individual to blaming the engineering and community planning.[18] Earlier the mother was accused of not looking after the child. In the 1950s the child's accident-prone personality with a lack of coordination would often be found to be a reason for injury. In the 1970s inadequacies in the location and surroundings were held responsible. Waller's and Klein's mismatch theory from 1973 states that if the margins between the individual ability to master an activity and the environmental demands are small, then only a small change in either factor is needed for an injury to happen.[181] Later, an even wider perspective was used in the explanation of injury, where the lack of community planning or safety improvements was held responsible for creating injuries. In the last 10 years behavior factors have become accredited again. New research are now done on differences in risk perception, risk taking, and behavioral responses to safety improvements among different segments of the population, particularly among people or groups at highest risk of injury (Fig 2).

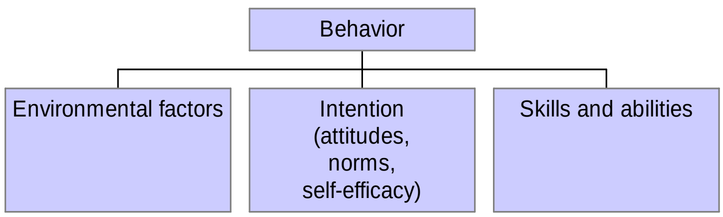


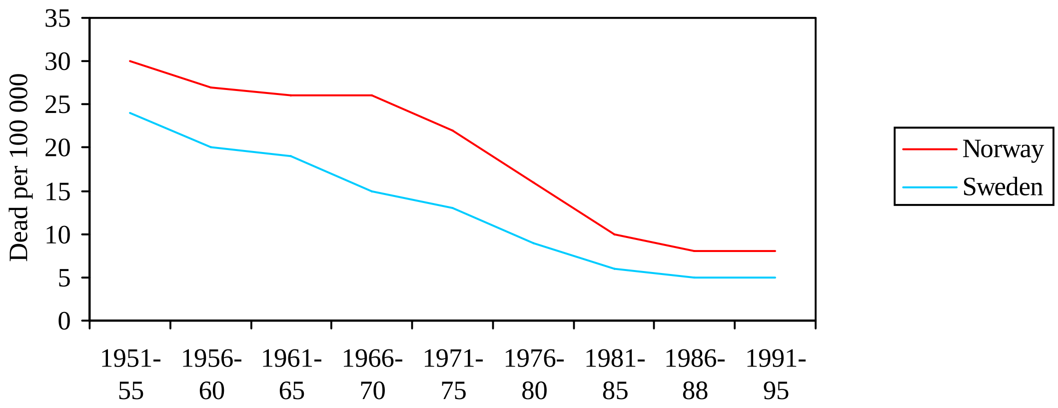
Figure 2. Behavior approches to injury control (Source: Fishbein M, conference proceedings Seattle, Washington, 2003).

7.3 Why are Swedes best at injury prevention?

Swedes have the world's lowest injury rates among children aged under 15.[178, 184] The protection of children has been an integrated part of the Swedish community planning since 1950 and resulted in separate pedestrian and bicycle paths, safe school roads and safety-tested home products. The approach to child accident prevention in Sweden has been continuous, whereas the Norwegian model has been more campaign-based. Parents in Norway still agitate for safe school roads for their children. Early community based injury registrations and interventions [8, 138] and in-dept studies of children in traffic [133, 136] have contributed to the Swedish success. Swedes were also the first to develop car seats for children. Mandatory helmet-wearing for children under 15 when bicycling, was implemented from Jan 1st 2005 after many years of national helmet use promotion.

In the period from 1986 to 1988 the accident mortality was 37% higher in Norway compared to Sweden, and the total incidence of accidents was almost twice as high. The differences between our neighbouring country and us were more obvious before, as illustrated when child death rates are compared (Fig 3).

Figure 3. Trend in injury death rates in children < 15 years in Norway and Sweden, 1951-1988.



Lund J et al. Barnesikkerhetsarbeidet i Norge 1988-90. Oslo: Samarbeidsutvalget for barnesikkerhet, 1991.

The difference has mostly been related to motorized vehicle accidents outside of roads (tractors, snow scooters), followed by suicides, burn injuries, drowning and different reasons for suffocations. Norway's longer coastline may account for higher child drowning rates, and the high proportion of old wooden houses with old electrical equipment may have caused more fire-related deaths.[56]

Differences might also have to do with adult attitudes towards what children should manage. An American study from 1991 indicated that Swedes protect their children more in accordance with the children's actual abilities.[9] They assume that children's injury risk commensurate with their developmental level and the environmental demands. The Swedish slogan to separate things that don't fit together, like children and traffic, is a good example.

The Norwegian attitude is rather to let children learn by trial and error. This attitude could be regarded as irresponsible if children are allowed risky activities without the necessary physiological or psychological maturity to handle them. In 1996, Norwegian media announced the many protests against the implementation of European Union demands for safe playground equipment. Norwegians feared an unhealthy overprotection of children when all dangerous playground equipment was to be replaced by 2000. Similarly, heavy protests from the bicycle association in Norway followed a recent study of bicycle injuries in Bergen, proposing a delayed debut age of bicycling. Children between 3 and 5 were found to have almost twice as high a risk of acquiring an injury during the two first years of bicycling compared to children aged 6 and older.[60]

7.4 Children with increased injury risk - do they exist?

7.4.1 Behaviour

Some researchers have found that in a simulated hazardous setting, injured children were more disruptive, active and had more contact with hazards than uninjured children.[21] A strong association between risk taking and hand fractures was found in one study.[100] Parents who reported that their children had high oppositional behaviour and aggression also had increased injury risk.[11] Children with early disruptive behaviour have been found to be at increased risk of unintentional injuries,[16, 143, 190] but other studies have failed to demonstrate a relationship between hyperactivity in school-aged boys and risk of injury.[36] An injury behaviour checklist has been developed with a 24-item measure of toddlers and preschoolers risky behaviour.[154] Many studies have shown that high scores on injury behaviour are consistent with an increased number of injuries. The checklist might assist health care providers to identify both children and youth at potential risk for injury.[16, 122]

7.4.2 Gender

Boys older than one year of age are more often injured than their female peers in almost all injury situations.[44, 110] This is mainly due to their increased exposure to injury risks in their daily activities.[128] As more girls participate in high-risk physical activities with increased physical risk, this gender difference might decrease. Still some of the difference may have to do with behavioural factors as well. This was confirmed in an interview study of boys and girls who were exposed to an equal number of street crossings. More boys than girls were injured.[132]

7.4.3 Age

As children get older their motor skills and cognitive skills develop, their environment changes and their injury risk shifts. Children are usually hurt in situations that are new to them. Critical developmental milestones that affect injury risk may include starting to crawl, walk, attend school, ride a bicycle as well as developing the ability to recognize and make decisions about dangerous situations.[49]

Piaget, a child developmental psychologist, found four distinct stages of development which occur at roughly defined ages:[121]

- 0-2 years: the sensory-motor stage
- 2-7 years: the pre-operational stage
- 7-11 years: the concrete operational stage
- 11 years and older: the formal operational stage

The shift into the next stage signals that new capabilities have emerged. Many believe that children only can be taught certain things when they are ready. Sandels [136] found in her in-depth studies of children's behaviour in traffic, that children below 7 or 8 were unsafe pedestrians because they lack the necessary cognitive abilities to be able to perform the tasks involved. These children were found to fixate on single elements of the traffic, rather than being aware of the complex interaction of different factors. Children have difficulties separating vertical and horizontal surfaces, and their ability to interpret peripheral vision is immature. They often misjudge the relationship between speed and distance. Children under 7 are unable to localise where sounds come from. This means that children have limited ability to evaluate audio- visual information and to discriminate information fast enough to avoid accidents.[49] Their low height is also a handicap.

7.4.4 Education and experience

Knowing the age related limitations some still think it is possible to teach children more selective attention in order to avoid accidents.[188] Even young children may be amenable to training and learning, provided that appropriate training methods are employed. Classroom learning work poorly, while behavioural strategies roadside can lead to significant improvements.[131, 132, 136] A frequently quoted study of the Norwegian Traffic Club by Schioldborg [141] supports this. Age adjusted traffic education through mail-outs to parents of preschool children, showed a substantial difference in road traffic accident rates between the children of members and non-members amounting to 20% in the country and 40% in the Oslo area. Parents and children were stimulated to practise traffic skills together.

7.4.5 Motor ability

In an Israeli study injuries were found to increase with increased balance and agility. This was explained by a difference in exposure to risk situations. Children with better motor ability were more exposed to hazards than children with poorer motor abilities.[52]

7.4.6 Activity versus inactivity

Does higher activity cause more or fewer injuries? The more activity and time of exposure to risk appears to be associated with increased number of injuries.[87, 163] The less experience, the more injuries is another association as injuries often happen in situations new to the child.[109] Besides, a lower bone mineral density is known to occur after immobilisation and inactivity. Especially regular weight-bearing exercise in young people is beneficial for accruing peak bone mass and optimising bone structure.[193] A study of ultra-orthodox Jewish adolescents with very little physical activity, measured in walking hours, found that the lumbal BMD was significantly decreased, especially in boys.[166] The relationship between bone mineral density and child fractures have been analysed with different results [32, 90] and is further discussed in the chapter on fracture.

7.4.7 Obesity

An increasing incidence of arm fractures during growth (45%) has been registered in US studies in the period from 1987 to 2002.[79] Childhood obesity has shown a parallel increase over the last two decades. It has been speculated whether obese children falling from height in playgrounds have an increased risk of fracture compared to normal weight children. In one study obese children were shown to be at 1.7 times greater risk of fracture compared to non-obese children.[37]

7.4.8 Nutritional factors

Both calcium and vitamin D are important for the building of bone, especially during growth. A study from Spain noted a lower incidence of fractures in cities with high calcium content in their water.[179] In Norway vitamin D deficiency has been found in children with darker skin types. Long, dark fall, winter and spring months without the sun to synthesize vitamin D in the skin has caused rickets to occur among children. Extra vitamin D intake has been recommended for these high-risk groups.[17] Even Caucasian teenage girls in northern Europe have low vitamin D levels in winter.[1] Small-scale studies indicate that high consumption of carbonated beverages, particularly colas, may reduce bone mineral accrual and increase wrist and forearm fractures in children.[99] Girls aged 12-15 years with a high consumption of carbonated soft drinks had a significantly lower bone mineral content in their dominant heel.[105] A high dietary acid loading causing increased calcium excretion or a direct effect of the phosphorous, fructose or caffeine content of these products was thought to be the mechanisms involved, and not the dietary displacement of milk. Anorexia nervosa is a high risk factor for not acquiring an adequate peak bone mass due to both dietary and endocrine reasons. In a large Danish cohort study both young and older patients with anorexia nervosa had an increased fracture risk that persisted more than 10 years after diagnosis, indicating a permanent skeletal damage.[180] An eating disorder should be suspected in underweight young individuals, primarily girls, presenting with low-energy fractures.

7.4.8 Diseases, disabilities and medication

Various diseases and medication in childhood have been associated with lower bone mineral density. Endocrine diseases, renal diseases and different reasons for malabsorption are examples. Different medication for chronic diseases in childhood like corticosteroids, cytostatic drugs and anticonvulsant drugs are also associated with low bone mineral density, and might cause a higher risk of fractures.[62,147] Children with epilepsy, and uncontrolled seizures, carry a heavier risk of injury. The seizure-related injury risk was 4 per 1,000 seizures in one study of children with epilepsy, despite helmet wear.[38] This study recommended a change of the helmet design and modifications to suit the seizure type. A large US study of children with disabilities from vision, hearing and chronic asthma showed that they had a significantly higher risk of nonfatal injuries compared to children without disabling conditions.[190] Young people with intellectual disabilities were found, in another study, to have a double risk for injury hospitalisations compared to the general population, especially in relation to fall injuries.[146]

7.4.9 Parents and family situations

The relationship between parental/family stress and childhood injury have been investigated.[119] Children in unstable families are often exposed to new and changing situations that they don’t know how to handle. Single parenthood, low maternal education and age, poor housing, parental drug or alcohol use are family characteristics that have been associated with a child being injured either unintentionally or intentionally.[45] Norwegian studies have tried to provide knowledge about various psychosocial predictors of accident-related behaviour, but much uncertainty exists.[170] In Sweden, children from lower socioeconomic groups have twice the risk of mortal injuries compared to children in higher social groups.[196] The risk of traffic injuries or falls were not found to be higher in low socio-economic regions in Sweden, but the risk of burns/scalds, poisoning, bicycle- and moped-related injuries and self-inflicted injuries were higher.[45, 126]

7.5. Intentional injuries

Intentional injuries include child abuse, violence between children, homicides or suicides. These injuries are often not random and can be just as predictable as unintentional injuries.[45] They sometimes occur in the same settings as unintentional injuries and can be prevented by the same means. Alcohol abuse and impulsivity can cause both intentional and unintentional injuries. Home visits from a health visitor to pregnant teens can help reduce both child abuse and fall from furniture.[115] The process of developing a community-based prevention program can therefore be the same regardless of the cause of an injury or the nature of the intent involved.

7.5.1. Child abuse

The definition of child abuse today includes psychological abuse, sexual abuse, neglect or improper care. In 1994, more than 3,1 million reports of child abuse were made in the US. Half of them were for neglect, 21% were child abuse and 11% sexual abuse.[48] Henry Kempe was the first to describe “the battered-child syndrome” in a report from 1962.[77] It focused on the characteristics of physical abuse, previously overlooked by health professionals. Injuries inconsistent with events described or with the child’s developmental age, bruising, burns or other injuries at unusual sites, failure to thrive, fear or apathy can be symptoms of child abuse.

A 10-year retrospective study in the US from 1988 to 1998 revealed that 10% of all blunt trauma to children younger than 5 years was due to child abuse. The almost 2,000 abused children in the study were significantly younger and more likely to have a pre-injury medical history. Abused children were mainly injured by battering and shaking, while children with unintentional injuries were hurt by falls and motor-vehicle related events. Abused children were more likely to have retinal bleeding, intracranial injury, thoracic and abdominal injury. Their injury severity were higher and survival rate lower.[40] Children with disabilities are more likely to be abused or maltreated than non-disabled peers.[146, 164]

7.5.2. Violence between children

Danish AED registrations have revealed that inter-child violence occurs much more often than violence perpetrated by an adult.[14] Comprehensive school-based strategies have been implemented, like the Olweus bullying prevention program,[116] but even though positive, evidence based results were reported in the original studies, less robust effects are often seen when implemented in routine school settings.[54]

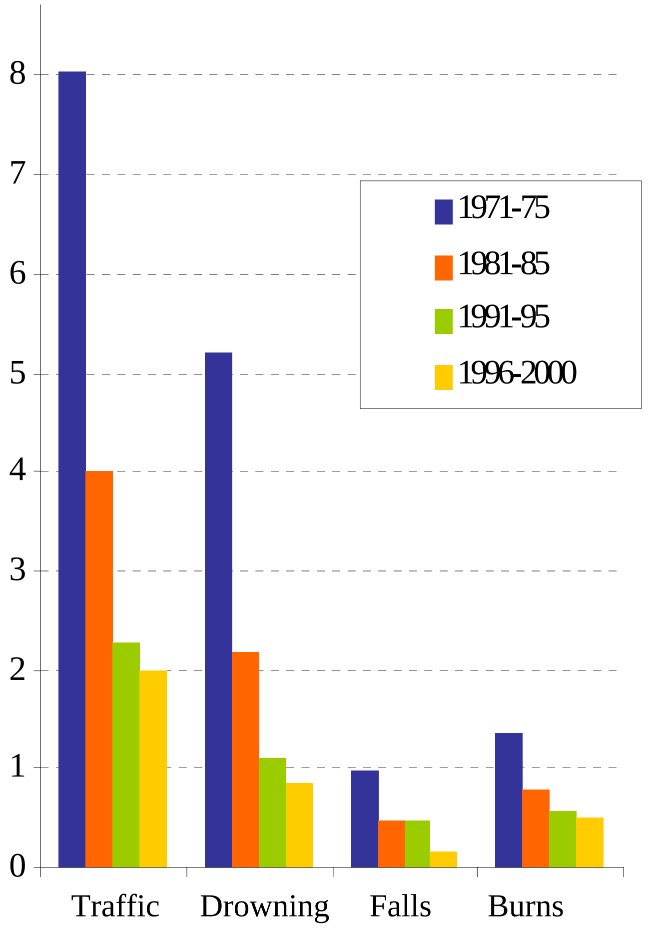
7.5.3. Self-harm

This painful practice is more common in girls. Common methods are self-poisoning and cutting. Some have suicidal intent, but this is not always the case. Reasons for self-harm might be attention-getting or the releasing of negative emotions and conflicts, often related to family, relationships and sexual problems. Many young people who do self-harm suffer from depression, anxiety, impulsivity, low self-esteem or suicidal ideation.[93]

7.6 Unintentional injury

The Violence and Injury Prevention Unit (PVI) of the WHO has identified the most important causes of unintentional injures to be road traffic injuries, burns, drowning, falls and neurotrauma.[184] These findings are reflected in Norwegian death statistics as well (Fig 4).

Figure 4. Major causes of child (0-14 years) fatalities in Norway, 1971-2000. Mean annual deaths per 100,000 children (Source: Statistics Norway).



7.6.1. Traffic
WHO reports state that traffic injuries are the leading injury-related cause of mortality among youths.[184] Child pedestrian accidents are the most serious of all injury risks facing children in developed countries. Serious traffic injuries often result in neurotrauma.

7.6.2 Drowning
Drowning is a significant cause of childhood mortality in the developed world, particularly among males and children aged 0-4 years. Open water and home pools predominate as injury locations.[152]

7.6.3 Burns
Deaths due to fire and flame related injuries declined in most European countries from 1984 to 1993.[110] A decline was also reported from Victoria, Australia[162] and the US.[48] Another US study of deaths caused by fire, found smoking material to be the most common source of ignition for residential fires. More than half of the fires started at night. Children under 11

and the elderly above 70 years constituted almost 40% of fatalities.[6] The reported decreases in mortality have partly been due to advances in burn resuscitation, and better restoration of skin damage.[66, 96] Children are more vulnerable to burn injuries as they have a low tolerance to fluid loss, high susceptibility to infections and their skin is more fragile to burns.[7] Nonfatal injuries cause not only physical but also psychological scarring.

7.6.4. Falls

Falls account for the leading cause of morbidity among children aged 5-14 years. Paediatric falls can roughly be divided into four categories:[15]

1. Falls while walking or running (from own height)
2. Falls from heights
3. Falls while participating in recreational activities like bicycling, skating or jumping on a trampoline
4. Falls during competitive sports.

In the US, falls lead to over 2 million emergency visits in 2002. Among the youngest children, falls from staircases were most common, and caused the most severe injuries.[15] Playground related falls, including those from swings, slides and monkey bars, came in second, closely followed by falls from beds. Bicycle falls were the most common fall that happened in recreational activities, followed by skateboard, rollerblades and kick scooter riding falls. The sports activities causing most falls vary between countries according to the popularity of specific sports. Basketball and American football caused most of the fall injuries in competitive sports in the US, with soccer as number three.[59] In Australia the Australian style of football, basketball, soccer, cricket, netball and rugby caused most fall injuries in sports.[47] In a Danish study boys were most often injured in soccer, skateboard, handball, gymnastics and basketball, and girls in handball, horseback riding, gymnastics, basketball and roller-skating.[165]

7.7 Shifting trends in activities related to injuries

The continuous increase in products and activities offered to children, results in increased potential injury. The introduction of new, exciting sporting activities is an important means of encouraging physical activity, but any attendant increase of the risk of injury needs to be addressed.[176, 194]

7.7.1 Rollerblades, skateboard and kick-scooter

Skateboarding was started among surfers on the US west coast in the 1960s. The activity was called sidewalk surfing. Surfers practised in the streets with the same S-shaped movements as in water surfing. Later the activity developed its own direction involving still younger children. However, in Norway the expansion of skateboarding was stopped by a ban of import and use of skateboards in the period between 1979 and 1989, in fact the only country in the world with such a ban. This is why the rollerblades and skateboard popularity did not start until 1990. Kick scooters have only been available in Norway since the year 2000.[74] They all have small low friction wheels usually made of polyurethane with different hardness.

Rollerblades used today are mostly of the inline skate type with three to five wheels in a row. The brake is a rubber tag behind the last wheel on the right foot (Fig.5).

Skateboards have a flat and rough standing surface with four low friction wheels under. The basis of most skating tricks is a jumping technique called an ollie, performed by stepping down the back part of the board (Fig.6).

Kick-scooters are usually made of aluminium with a weight below 5 kg and can easily be folded and carried. You stand on a footplate of metal holding an adjustable “T”- handlebar directly connected to the front wheel. Braking is done by depressing a metal wheel arch onto the rear wheel with your foot (Fig.7).

Figure 5. Rollerblades

Figure 6. Skateboard

Figure 7. Kick-scooter

7.7.2 Snowboard, trampoline and other new products
New products introduced to the Norwegian sport and recreational marked during the last 10 years also include snowboards, different new alpine skiing equipment, mountain bikes, trick bikes and different types of trampolines.[74] Injuries will naturally occur with these new popular products. Studies indicate that the number of injuries will not be reduced until the products become better or the safety recommendations are followed.[176]

8. Types of injury

The different types of child injuries registered depend on where in the medical system the registrations are done. A Canadian, population based 3-years, longitudinal study of more than 96.000 children between 0 and 10 years showed that nearly 84% of children received medical care by a physician for an injury over the study period.[153] The most common injuries were sprains, open wounds and superficial contusions, while fractures were less common. When it comes to children with only sports injuries, a Danish study found their injuries to be mostly contusions (37%), followed by fractures (22%), sprains (25%), wounds (10%), strains (5%) and luxations (1%).[165] A similar finding was done in a UK study of children between 5 and 15 who were injured in sports. One fifth of them sustained a fracture.[63]

8.1 Activity specific injuries.

More detailed studies of injury types related to different activities reveal certain injury characteristics. Some of these injuries are so typical that the activity is included in their name, for example; skiers thumb (involving the ulnar collateral ligament of the thumb) and boxer's fracture (involving the head of the 5 metacarpal bone). Fracture of the lateral process of the talus was a rare injury before snowboarding became popular.[191] It was reported to represent 15% of all snowboarding ankle injuries, and was reported with an incidence of 2.3% of snowboarding injuries in large epidemiological series from 1998. Landin revealed how fractures of the proximal part of the humerus were over-represented among girls due to horseback-riding falls.[89] Tibial diaphyseal fractures; often called "footballers fracture", are often due to impact during a tackle in adults.[22] Stress fractures are rare in children and adolescents, but have been registered more often in recent years due to children's earlier debut into competitive sports. Endurance sports cause stress fractures in the metatarsal bones, while sports requiring sudden stops at high speed cause tibial diaphysis stress fractures in adolescents. MRI is an important tool in imaging these injuries.[113]

8.2 Child fractures

Fracture is a common injury in childhood.[26, 33, 44, 85, 89, 128] In a Swedish study from Malmø by Landin, 8,682 fractures in children were reviewed by studying two populations 30 years apart to see if fracture patterns were changing. According to his data the accumulated fracture risk for a child up to the age of 16 was 42% for boys and 27% for girls.[89] In a Norwegian study among children aged 0-12 years it was found that the incidence rate of fractures increased linearly with age in both boys and girls. This average annual increase in incidence was approximately 14 cases per 10,000 child years.[85] Landin also found the risk of fractures to increase in children of both sexes up to 11-12 years, but in older children the risk decreased in girls and further increased in boys.[89]

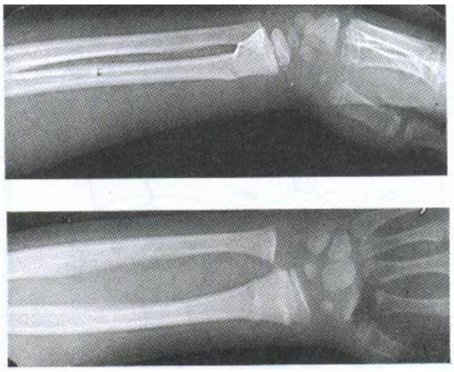
The most common fractures in children are located to the upper extremity (distal forearm, fingers, carpal and metacarpal bones and the clavicle .[85, 89, 97, 171, 187] Fractures which require in-patient hospital treatment mostly involve the distal forearm, followed by the supracondylar humerus, forearm shaft and tibial shaft.[26] Kopjar estimated that 72% of the child fractures resulted in activity restriction, with leg fractures accounting for 33% of all activity restricted days, although representing only 19% of cases.[85] This indicated that the total fracture incidence rate is a poor predictor of the amount of activity restriction.

8.2.1 Why child fractures are different from adult fractures
Childhood fractures are special due to the following factors:

- Children's bones are more immature and porous, and capable of considerable plastic deformation before they fail. This frequently results in incomplete fractures like greenstick, bowing, buckle or torus fractures. An imbalance between bone mineralization and linear growth, or between strength and mechanical challenges due to limited endocortical apposition has been postulated as explanations of the common occurrence of radius fractures during growth.[112, 129]
- Fractures in immature bone can cause growth to slow down or speed up causing overgrowth of long bones. Paediatric fractures generally heal faster than in adults.[112]
- There is greater capacity of remodelling in children, but also of misalignment depending on the number of years of growth left, the location of the fracture (especially the nearness to the growth end of the long bone) and whether the angular deformity is in the plane of movement of the adjacent joint.[51, 91]
- The epiphyseal plate in children's bone is the weakest point, and consequently a frequent site of fractures in the long bones. The epiphyseal fractures are often classified according to Salter-Harris, dividing the fractures into five subgroups. Salter Harris type II is most common and involves a fracture extending through the plate and the metaphysis. This fracture, fortunately, carries a good prognosis for healing without deformity. Both dislocated fractures through the epiphysis and compression fractures through the epihyseal plate carry the highest risk of complications. Injury to the germinal cell layer can cause premature epiphyseal plate closure with growth arrest and deformity to follow.[129] Girls, on the average, tend to be 1,5 years younger than boys with the same physeal fracture location, possibly due to their earlier growth spurt and epiphysel closure.[104]

8.2.2 Anatomic location of fractures by age
The frequencies of the most common fractures in children are consistently reported in different studies.[26, 85, 89, 97, 171, 187] Equally reported are also the changes in rates with age. The supracondylar fracture is most common in the first decade of life, with a peak at 7-8.[26, 68] Fractures of the femur are most common among the youngest children up to age 3, but the tibial bone is more often fractured than the femoral bone. In a US study, children under 10 had a greater number of long bone fractures, while older children suffered more vertebral fractures when falling from significant heights.[137] Fractures of the epiphyses are more common just before skeletal maturity.[26] Epihyseal fractures are thought to occur due to the greater difference in mechanical strength between the weaker epiphyseal cartilage and the stronger bone in adolescents.[175]

8.2.3 Common and seldom fractures in children
Fracture through the distal end of the radius is the most common paediatric fracture, and is often the result of a fall on an outstretched hand. If the wrist is extended or dorsiflexed, the distal fragment will be dorsally displaced, like in the adult Colles' type of fracture (Fig.8). This is the most common injury mechanism. If the wrist is flexed, a volar displacement will be the result. This is almost similar to the adult Smith's fracture (Fig.9). Many believe that some rotational deformity in pronation follows this volar displacement, and advice of a supinated cast immobilisation after reduction. This fracture type has a higher complication rate than the more common, dorsally displaced distal radial fracture, and can result in reduced supination. It sometimes involves a large metaphyseal fragment, which requires a longer immobilisation period to be stable.[129, 195]



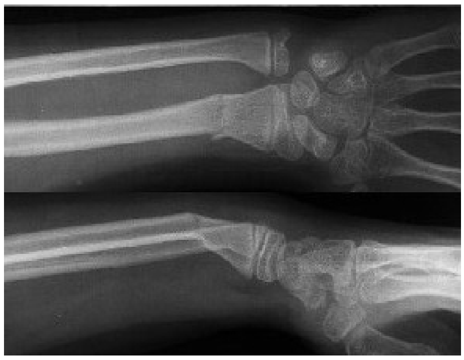


Figure 8. Colles` type of fracture

Figure 9. Smith's type of fracture

The high potential for remodelling of distal radial fractures has caused a lot of debate regarding acceptable angular deformity, which will result in total radiographic and functional correction.[51, 91, 129, 182, 195] Due to the substantial number of these fractures, even arguments involving cost analysis of whether to reduce or not have been used. One study postulated that if distal radial fractures with less than 15 degrees of angulations and less than 1 cm of shortening were not reduced, the emergency room visit would cost 50% less, and the fracture would still completely remodel.[41] Some less radical recommendations seem to be more generally accepted (Table 1).[182]

Table 1. Acceptable angular corrections in degrees

Age in years	Saggital plane in boys/girls	Frontal plane
4-9	20°/15°	10°
9-11	15°/10°	5°
11-13	10°/10°	0°
>13	5°/ 0°	0°

Some fracture types are rarely seen in children. Scaphoid fractures, although the most common carpal fracture in late adolescence and adulthood, is considered a rare injury in children below 15. In a large British study it represented 0.34% of all fractures in children before skeletal maturity.[28] In the youngest children, the thick cartilage that covers the bony ossification center in the scaphoid, protects against fractures. Most fractures in children fortunately occur in the distal third of the bone where the blood supply is best and healing good.[29] Impacted buckle fractures also occur in children's scaphoid bone.[65] Contrary to the outcome of delayed scaphoid fracture treatment in adults, nonunion and avascular necrosis are rarely seen in children. However, children with these complications have often not been correctly diagnosed and immobilized until late after the injury (Fig 10).[172] In addition to radiographic evaluation with multiple projections, MRI is often needed to identify the fracture at the initial presentation.

Figure 10. Operated non-union in a child's scaphoid fracture

8.2.4 Fracture pattern in child abuse

Abused children are often younger and more likely to have multiple fractures. It has been estimated that one in eight children under 18 months with a fracture may be a victim of abuse.[187] Akbarnia, an orthopedic surgeon, described the specific injury pattern in victims of child abuse.[2] Bone scans may reveal both current and past evidence of bone injury. Injuries to long bones are invariably spiral or oblique, often with signs of subperiostal new bone formation due to older fractures in the same region. Fractures of the bone shafts are significantly more common among abused children than metaphyseal fractures in the same bones. Fractures of the ribs in young children should also arouse suspicion. In order to avoid misinterpretations regarding abuse it's also important to know about the generalized conditions that can exist in children predisposed to fractures, like ostegenesis imperfecta.

8.2.5 Bone mineral density, bone structure and fracture

Bone mass increases throughout childhood, with maximal bone mass accrual rate occurring in early to mid-puberty and slowing in late puberty. Bone mineral density (BMD) is this lifetime amount of bone tissue accrued in the skeleton during growth. Establishment of an adequate peak bone mass is important to avoid osteoporosis and its subsequent comorbidities in later life.[166] Landin and Nilsson found that children with fractures due to low energy trauma had a lower bone density in their cortical forearm bones than children without fractures. This difference was not evident in children with fractures due to high-energy trauma.[90] Cook found no differense in bone density measured in trabecular bone between those with or without fractures.[32] Interpretation of bone density in children is done using age and sex standardized normal ranges reported as Z scores, and is usually measured using dual energy x-ray absorptiometry DXA. Fracture risk increases with 1,5 to 1,6 times per SD decrease in areal /volumetric BMD. Heel quantitative ultrasound (QUS) may also be used.[62, 193] In a prospective cohort study of girls aged 3-15 years the total body areal BMD was a predictor of new total fractures over a 4-year follow-up period. A previous forearm fracture was also a risk factor for sustaining a new fracture.[53] Another study of paired girls aged 4-15 years implicated smaller bone cross-sectional area as a risk factor for forearm fracture.[149] It was suggested that measuring BMD in children before puberty might not be an adequate measure of bone strength. More research is needed to assess the effect of BMD and bone health on children's fracture risk.

8.2.6 Changes in treatment of child fractures

A Chinese study of about 6,500 fractures found that the percentage of closed reduction and percutaneous pinning of child fractures has increased from 3% in 1985 to 22% in 1995.[25] This trend is similar in our country. The aim is to shorten the immobilization period for the child after fracture. In childhood, absolute stability of the fracture is not always necessary, but with an increasing number of 12-14 year old tall and heavy children, treatment sometimes has to mirror fracture treatment in adults. This is particularly important in the treatment of shaft fractures.[151]

9. Injury prevention

Single-cause explanations of injury events are incomplete and misleading. The more multi-cause, environmental explanations make it possible to use the public health approach to reduce the frequency of injuries. Concentrating on environmental modifications alone, however, cannot provide complete protection from injury. Educational and behavioral approaches are also needed. Injuries due to performance deficiency can be reduced by improving individual abilities, but also by lowering task demands. This wide range of possible intervention points allows for a selection of strategies likely to provide the greatest efficacy at the lowest cost.[58, 140]

9.1 Targeted injury prevention

Clinical medical work involves identifying high-risk patients for specific diseases in order to implement preventive intervention, by providing preventive advice, preventive medicine or preventive treatment. The same approach is needed in order to avoid injuries. The efficacy of injury prevention may seem higher when it involves the high-risk groups and high-risk activities for injury. This is especially true when high-risk groups contribute substantially to the overall rate of injuries. The so-called "prevention paradox" moderates this principle somewhat. The major share of injuries may sometimes come from high-prevalence groups with relatively low or moderate injury risk and be responsible for the majority of injuries.[150] Health economic considerations thus make it important to focus on both the activities with a high injury risk for serious injuries and the most common activities causing most injuries due to their high prevalence in the population.

9.2 William Haddon's theoretical approach

William Haddon is considered the "founding father" of modern-day injury prevention. He developed a model of injury occurrence called the Haddon matrix based on the infectious disease control principles.[57] The interaction between the injured (host), agent and environment could be analysed in terms of a pre-injury phase, an injury phase and a post-injury phase (Fig.11). The pre-injury phase is when primary prevention approaches can be implemented (speed limits, separate bicycle tracks). The event phase or the injury phase is when secondary prevention is possible (seatbelts, airbags, bicycle helmets). The post-injury phase is when tertiary prevention such as effective emergency medical services, minimal trauma response time or good rehabilitation programs is needed. The injured is influenced by human factors like the age, gender and behaviour of the child. The agent may be the design or construction of a car, bike or toy. The physical environment may be the design of schools, playgrounds, traffic-environment, housing situation or protective equipment. The socio-cultural environment may be attitudes or law enforcements.

Figure 11. Haddon matrix

Phases / Factors	Human factors	Agent or vehicle	Physical environment	Socio-cultural environment
Pre-injury				
Injury				
Post-injury				

Haddon identified 10 basic categories of injury prevention by which energy transfer can be controlled, modified or interrupted:

1. Prevent the initial creation of the hazard by banning the manufacture or sale of unsafe products or prohibit unsafe practices (e.g. ban production or sale of firecrackers to children).
2. Reduce the amount of energy contained in the hazard (e.g. limit the amount of gunpowder in firecrackers).
3. Prevent the release of already existing hazards (e.g. make cigarette lighters and medicine containers child resistant).
4. Modify the rate or spatial distribution of the hazard (e.g. safety valves on boilers).
5. Separate, in time or space, the hazard from that to be protected (e.g. pedestrian overpasses, bicycle tracks).
6. Separate the hazard from that to be protected by a material barrier (e.g. protective eyewear or fencing around swimming pools).
7. Modify relevant qualities of the hazard (e.g. make crib slat spacing too narrow to entrap a child, use protective surfacing under playground equipment).
8. Make what is to be protected more resistant to damage from the hazard (e.g. calcium intake to reduce osteoporosis and prevent fractures, proprioceptive training to avoid knee injuries in athletes, prohibit alcohol sale near recreational water areas).
9. Begin to counter the damage already done by the hazard (e.g. provide good quality first aid treatment and emergency medical care).
10. Stabilize, repair, and rehabilitate the object of damage (e.g. early rehabilitation after injury treatment).

9.3 The main preventive strategies

The strategy for prevention can be divided into the following different levels:[184]
1: Determine the size and characteristics of injuries.
2: Identify factors that increase the risk of injury and determine factors that are potentially modifiable.
3. Assess which measures must be taken to prevent the injuries. Information about causes and risk factors for injury must be used to evaluate interventions through new post intervention studies.
4. Implement the most promising interventions on a broad scale.

Active intervention measures, also called improvements to individual capacities, demand a change in behaviour of the individual in order to avoid injuries. Making child bicyclists use helmets is a difficult task. Many studies have shown that promotion of voluntary behavioural change tends to be the least effective among groups that are at highest risk of injury.[31] If, however, there are regulations and a high level of enforcement, substantial reductions can be achieved (e.g. seatbelts).

Passive intervention measures, need no actions by the individual to be effective. These measures give the best injury preventive results, and can be classified as:

a. Improvement of the environmental safety (better environment and equipment e.g.: intact bicycles, air bags installed in cars).
b. Changes in exposure to dangerous environment (regulatory, separate pathways for bicycles and cars).

9.4 Current documented effective injury prevention in children

Three key principles of evidence-based practice have been described in order to minimize the impact of bias in studies of effectiveness in injury prevention.[23, 133]

- It's important to know whether public health interventions are effective and do more good than harm.
- The benefits and costs of public health interventions should be described and evaluated so they can be weighted against other options for the use of resources.
- People, who make or are affected by evidence-based decisions about public health interventions, should be aware of the strengths, weaknesses and limitations of the available evidence.

Effective interventions for injury prevention need to be based on scientific evidence, normally obtained by randomised controlled trials. These kinds of studies are not often ethically easy to conduct, especially when early studies of preventive measures have proven effective against injuries. A systematic evidenced based review of prevention strategies addressing sports and recreational injury among children and youth was done in 2004.[102] This unfortunately revealed that there was sparse evidence of the effectiveness of interventions. This does not mean that current interventions are not effective, but there were few well-designed and controlled studies investigating strategies to prevent injuries. By valuing evidence from randomised controlled studies more highly than observational studies, there is a danger that interventions with limited effectiveness might be considered more worthy than effective interventions based on observation evidence.[133]

Community based models for injury prevention have become an accepted part of the overall injury control strategy, but a systematic review of the literature before 2004 revealed only nine studies that included an evaluative component and only seven with a contemporary control group.[156] The Cochrane Injuries Group has also done critical reviews of many studies.[135] An important finding from their meta-analysis of bicycle helmet wear studies is that all types of standard helmets protect against injuries to the brain.[35] However, helmets must be intact, correctly fitted (not too loose) and correctly worn (not too posteriorly located on the head) in order to protect efficiently.[4, 120] Many other injury preventive interventions also have evidence of effectiveness (Table 2).

Table 2. Evaluated effect of different injury preventive interventions

INTERVENTION	EFFECT	QUALITY RATING	EVIDENCE
TRAFFIC			
Child restraints or seat belts (education, legislation, loan schemes)	Reduce all injuries	Good	34, 42
Road safety education for children (safe places to cross and Traffic Clubs)	Reduce all injuries	Moderate	118, 131, 132, 136, 141
Cycle helmets (education, legislation)	Reduce head injuries	Good	35, 169, 183
Safer design of roads and roadside environment + 20-30 mph zones	Reduce all injuries	Good	174
SPORTS AND PLAY			
Rule changes in contact sports resulting in less body contact and less axial loading	Reduce cervical spine injuries	Good	107, 173
Helmets and face mask in ice-hockey	Reduce head and eye injures	Moderate	107, 163
Lightweight multipurpose helmet in many sports including horse-riding	Reduce head injuries	Moderate	107
Polycarbonate eye protectors in racket sports	Reduce eye injuries	Good	43
Mouth guards in contact sports	Reduce dental injuries		73, 107
External ankle support in basketball and other sports	Reduce ankle sprains		125
Wrist protectors in rollerblading and snowboarding	Reduce wrist injuries including fractures	Moderate	134,139
Shin guards in soccer	Reduce leg injuries (not fractures)	Moderate	22, 50
Swimming pool fencing	Prevent drowning	Good	76,168
Life jackets in water near activities	Prevent drowning	Good	114
Swim learning program	Prevent drowning (deaths reduced from 100 to 10 in Sweden in 1954-88)	Good	9, 13
Adult supervision of public swimming	Prevent drowning	Moderate	76
Rubber and bark surfacing in playgrounds	Prevent fall injuries	Good	111
DOMESTIC ENVIRONMENT			
Child resistant containers	Reduce deaths from poisoning	Good	130
Window bars	Reduce injuries and deaths from falls	Good	155
Smoke detector promotion programmes	Reduce burns	Good	103, 174
Reduced max. temperature of domestic water to 50°C	Reduce scalds/burns	Good	46
Burn proof clothes and nightwear	Reduce burns	Good	88
Targeted health visits in high-risk households to reduce child injuries, supported by subsidized or loaned home safety equipment.	Reduce all injuries	Moderate	78, 177
Community-Wide Strategies (Safe Communities)	Reduce all injuries	Moderate	191

9.5 Side effects of injury prevention

The design of injury prevention strategies need critical consideration as many activities, like sports, have both inherent risks as well as health benefits. Children need physical activity to develop motor abilities, avoid physical health problems and reduce tension and stress.[10, 64] Concern about the rapid increase in the prevalence of obesity in children around the world has led to renewed calls for encouraging children to be more physically active.[39] From year 2000 to 2002 the youth participation in organized sports fell from 38 to 34% in Norway.[160] Children aged nine and 15 years were found to have reduced physical condition compared to children 20 years ago. While 86% of the youngest met the recommendations of at least one hour of moderate physical activity a day, only 55% of the 15 years old did so.[82] They also weighed 3 kilograms more and spent more time in front of computer games and television.

9.5.1 Does concern about injury reduce physical activity?

Some studies have found that parental safety concerns was a barrier to sport and physical activity in their children.[12, 177] Children aged 10-12 years living near heavy traffic, with parents concerned about road safety, were more obese than children with parents who were not concerned. In Sweden there is concern that their low injury rate among children, despite the increasing number of cars, is due to children's reduced freedom of movement. Have children adjusted too well to traffic, instead of the opposite? In a British study from 1971, 80% of children aged 7-9 years were allowed to go to school without an adult. In 1990 this percentage had fallen to 15%.[67] More and more children are transported to school by car. The stated aim of the "Fourth Ministerial Conference on Environment and Health" in Budapest in 2004 was to "prevent and substantially reduce health consequences from accidents and injuries and pursue a decrease in morbidity from lack of adequate physical activity, by promoting safe, secure and supportive human settlements for all children". A successful injury prevention strategy will allow many to participate safely and not reduce injuries by reducing participation.

9.5.2 Inadequate preventive devices and interventions

Specific preventive devices may not prevent injuries when constructed wrongly, and may even cause new types of injury. Too rigid wrist braces may cause fractures above the brace top on the forearm.[55] Bicycle helmets used by young children have caused strangulations when children have become caught when playing or climbing instead of bicycling. Today most small child helmets are constructed in a way that lets the strap under the chin loosen with tension, but without falling off when needed for protection. These helmets can safely be used during play.[107]

Inadequate preventive devices can also give a sense of false security and cause the child to take unsafe risks ("risk compensation theory"). This might have been a contributing factor in an Australian study assessing the compliance of safety standards in playgrounds where children had sustained a fall-related arm fracture. Over 85% complied with all important safety recommendations, except for the soft surface depth of the ground. Only 4,7% of 402 playgrounds had the recommended 20 cm of tanbark.[144] It is important that interventions are done adequately before rejected if proven to be without effect.[134]

10. Injury surveillance

A systematic approach to injury prevention is dependent on access to accurate and reliable information. Injury surveillance is defined as "continuous analysis, interpretation and feedback of systematically collected data, generally using methods distinguished by their practicality, uniformity and rapidity, rather than accuracy or completeness. Its main purpose is to detect changes in trend or distribution in order to initiate investigative or control measures".[92, 96] A population survey is different because it usually involves a representative sample, which makes it possible to generate true rates. Both types of health data are necessary for designing, implementing and evaluating public health prevention programs.

Interdisciplinary surveillance is especially important with intentional injuries.[30] For example, data on violence collected by the police in Bergen, Norway did not match the intentional injury registrations done by the medical staff at Bergen AED.[161] Both registrations are needed to get a complete picture of the size and nature of the problem.

10.1 International injury surveillance

Many countries have some form of injury surveillance, but there is little consistency in how data are collected. Thus, few opportunities for international comparisons are available. The range of injuries, the age groups, where the data is collected, the information obtained and the coding may be different.[123] The most widely used categorisation system for causes of injuries is the " International Classification for External Causes of Injuries " (ICECI), formerly called the "E-codes", now the chapter XX codes, provided by WHO diagnostic classification system ICD-10.[184, 185] This system is a product of a collaboration between the Injuries and Violence Prevention (IVP) Department of the WHO and agencies from all continents. In the US the National Electronic Injury Surveillance System (NEISS) of the United States Consumer Product Safety Commission (CPSC) has registered consumer products associated with injury since 1972. It has recently, in 2001, been upgraded to involve the registration of all injuries. A product related system, "Home Accident Surveillance System" (HASS), was started in the UK in 1976, and an "All Wales Injury Surveillance System" (AWISS) followed in 1999. In Australia the "Victorian Injury Surveillance System" (VISS) was established in 1990. It is a population based injury surveillance system collecting data of all kinds of injuries, and is used for national injury research and control. In Canada the "Canadian Hospitals Injury Reporting and Prevention Program" (CHIRPP) has registered child injuries since 1990.[123] In Europe, the member countries of the EU formed in 1986 a "European Home and Leisure Injury Surveillance system" (EHLASS). In Denmark these data are used for national injury control purposes and research, but in many countries the data quality standards are still not reliable enough to be useful.

10.2 Norwegian injury surveillance

Since 1990 the Norwegian National Injury Surveillance System (NISS) at the National Institute of Public Health has registered injuries in a defined population in four Norwegian cities (Harstad, Trondheim, Drammen, and Stavanger) representing 7.3% of the Norwegian population.[56] These prospective case registrations have covered hospital and AED medical data. Close Nordic cooperation through ARON (Arbetsgruppen for Registrering av Olycksfall i Norden) made the NISS data comparable with the other Nordic data. The Classification for accident monitoring, provided by NOMESCO was used. The registrations were, however, formally closed in 2000 in Stavanger and Drammen, and in 2002 in Trondheim and Harstad. Lillehammer has had more limited registrations. Post-intervention registrations showing a decline in injury rates have been seen in the northern Norwegian city of Harstad.[192] This has stimulated continuous and systematic work to prevent further injuries, and some injury surveillance still continues there with local economic support. The Norwegian Patient Register (NPR), established in 1997, was supposed to identify injured hospitalised patients according to chapter XX in the ICD-10 diagnostic classification system, but the completeness of registrations has been too low to give useful information about the injury panorama in Norway.[148]

10.3 WHO and Safe Community

In 1989 delegates to WHO's first World conference on injury prevention and control held in Stockholm, recognized that there was a serious shortage of information on which to base action plans to prevent and control injury. Improving injury surveillance therefore became a priority. National data was found to be of limited value when planning regional programs, and local multidisciplinary prevention has proven more effective than national initiatives. This is why WHO has initiated the project called "Safe Community" which is meant to stimulate communities to use local injury data as a basis for targeted injury prevention. The term "Safe Community" implies that the community aspires to safety in a structured approach, not that the community is already safe.[75] In 1994 Harstad was the first Norwegian community to be accredited due to their energetic injury prevention group started by a surgeon and a public health nurse. Good quality local injury data was the springboard for their targeted interventions.[192] Today many Norwegian communities have been through a process of becoming a designated Safe Community, and some have succeeded, included Bergen (2005). Some of the registrations done in this study, together with other studies, have been used as the basis for this Safe Community accreditation.

11. Aims of the study

The aim of this study was to conduct a broad, prospective registration of child injuries in Bergen by applying an epidemiological approach to identify areas in need of targeted injury preventive actions in this community. Most data on injuries in Bergen have been published from police sources, and have mostly covered crime, traffic and the more serious injuries.[60, 61 160, 161] These data are important, but often don't give a complete picture of the injury panorama, creating headlines based on single events. General, medical injury registrations are rare, even though Bergen AED and HUS are involved in the treatment of most injuries in this community. Another interest of this study was to find out whether data from NISS (the Norwegian National Injury Surveillance System) were applicable to the child injury situation in Bergen.

From a clinical point of view, it was of interest to analyse child fractures in Bergen in order to pinpoint high-risk activities causing fractures and look for high-risk groups for such injuries. Did new activities cause certain injury types? If this were true, it would be of clinical value to physicians working with injured patients. More knowledge in this field would make clinicians more alert and targeted in their diagnostic evaluations.

We wanted to analyse one of the most common fracture types in children, the forearm fracture, to evaluate both diagnostic and therapeutic questions and procedures. A follow up of functional results seven years after treatment of the most displaced fractures was done.

Finally some further aims developed as the study progressed, and as new products causing injuries to children appeared on the market. It was of interest to register these injuries both immediately and over some time.

The more detailed study aims and questions were as follows:

1. The first study aimed at giving a description of the extent and characteristics of child injuries coming to medical attention at Bergen AED and HUS during one year. Bergen had no previous general registration of child injuries, but some limited registrations involving special types of injury existed for comparison [60, 70] (Paper I).

2. The second study was an in-depth investigation of child fractures, to see if children in Bergen suffer a higher fracture rate than elsewhere. Earlier studies of adults had shown that Bergen had the world's highest incidence of forearm injuries in women aged 60-69 years.[69] Was this the case with children too? Could specific high-risk groups for fracture be identified? Were specific activities associated with specific types of fracture? (Paper II).

3. The third study analysed the radiological data during treatment of displaced forearm fractures. The most displaced fractures were controlled seven years after the injury with new radiological and functional evaluations (Paper III).

4. The fourth paper followed up rollerblades- and skateboard-related injuries. In the first study (Paper I), these injuries were found to more likely result in fractures compared to other activities. The aim of this study was to analyse injury mechanisms and locations in order to give well-founded preventive advice (Paper IV).

5. Likewise, the introduction of new child activities, like the use of kick scooters, made it interesting to identify injuries caused by this new product (Paper V).

6. Finally it was of interest to compare injuries caused by rollerblades, skateboard and kick scooter over two years of registration. Were the injuries different? Of particular interest was to study the different injury mechanisms, the experience in the use of the devices at the time of injury and the use of protective devices (Paper VI).

12. Patients and methods

12.1 Study area and population

Bergen is the second largest city in Norway with 227,250 inhabitants in 1998, the year of the initial study. The child population below 16 years of age was 47,750, which was 5.1% of the Norwegian child population that year.[160] Bergen Accident and Emergency Department (AED) is an out patient clinic treating most of the minor injuries in Bergen, while Haukeland University Hospital (HUS) is the regional hospital receiving all major injuries and multiple injured patients from Bergen and its surroundings.

12.2 Patients and study period

The main part of this work is based on the prospective registration of all children below the age of 16 who received medical treatment at Bergen AED and/or at Haukeland University Hospital due to an acute injury. The registration period was from January 1st to December 31st, 1998.

Paper I is an epidemiological description of all the 7,041 registered, new injuries in children.

Paper II is a more detailed study of all new, traumatic fractures in the same registration period.

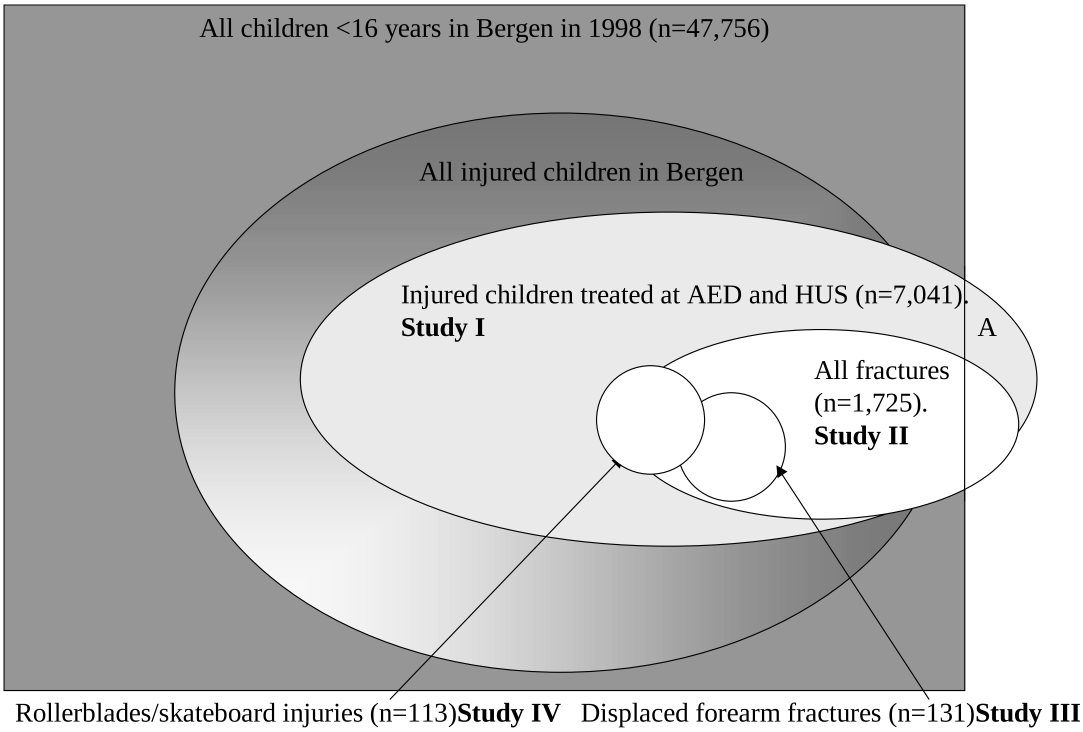
Paper III is a follow-up study of all dislocated forearm fractures acquired in 1998, seven years after the original injury.

Paper IV is a detailed study of rollerblades and skateboard injuries from 1998.

Paper V is a local study of injuries related to kick scooter riding, attending the surgical unit of Bergen AED, including all age groups. This registration was conducted during one year from September 20th, 2000 to September 19th, 2001.

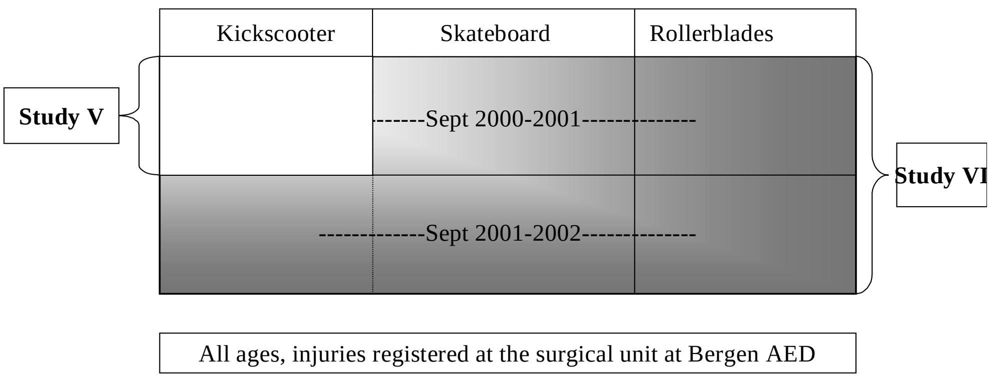
Paper VI is a similar local study conducted over two years and including all age groups. The study is a comparison of injuries related to participation in rollerblading, kick scootering and skateboarding.

Table 3.
The relationship between study I, II, III and IV



A: Injured children <16 years from outside the community of Bergen in 1998 (n=1573)

Table 4.
The relationship between study V and VI



12.3 Data collection and study design

In the main prospective registration, providing data to the first four studies (Paper I, II, III and IV), we included all children below the age of 16 years, who received medical treatment for an acute injury in the period from Jan 1st 1998 to Dec 31st 1998. All new injuries less than a month old were included. A computerised reminder used in our registration at Bergen AED helped the staff to remember to hand out a standard questionnaire to all injured patients or their parents when the child was aged below 16 years. The questions investigated the current accident, earlier accidents, and whether or not patients or parents thought the injury could have been prevented. The child or its parents were also asked whether the injury was caused by an accident, due to hard physical contact during sports or play, by fighting or other intentional violence or intentionally by the child itself (appendix A). The physician answered some additional questions about the severity of the injury, and whether child abuse was suspected. A computerised reminder helped the doctors to fill in the medical evaluation of the injury. Information was registered directly into each patient's own computerised medical record and saved on a separate screen page (ILOK0003.PRL) in the Infodoc medical journal system used at Bergen AED. Statistical data was transmitted directly from the screen page in Infodoc to the Epi Info Statistical Program, version 6 for analysis. Only de-identified demographic data were recorded like year of birth, gender and community number.

Information from Haukeland University Hospital was collected manually from similar questionnaires handed out to patients or their parents on arrival to the hospital. Some of the data from the hospital records had to be extracted retrospectively through weekly screening of incoming data.

Children seeking medical treatment for different injuries at different times during the registration year were registered each time. In this way the same person could be counted more than once, but not for the same injury. Controls or re-admittance for the same injury were not registered. The number of children injured were registered, not the number of injuries, when calculating the incidence of events. When children had two or three simultaneous injuries, we registered the most serious injury for the epidemiological analysis. Fractures were always included by an additional question about the need for reduction treatment or not, in case of a fracture injury.

In the third study (Paper III) we analysed and classified the radiological findings in displaced forearm fractures from 1998. Due to a large remaining degree of displacement after reduction, eleven of them were controlled with new X-rays and functional evaluation by the authors, seven years after the injury.

In the two prospective studies leading to Paper V and VI, data were collected from Sept 20, 2000 from questionnaires handed out to the relevant patients by the radiographers and nurses at the surgical unit of Bergen AED. These data were supplemented with the medical diagnosis and injury severity, coded by the author, before being de-identified and transmitted to the statistical analysis program. Study V was conducted during one year (to September 19, 2001) and study VI during 2 years (to Sept 19, 2002). Computerised reminders to staff were not used in these studies. In both of these studies the number of injures was also counted, not only the number of patients, when describing the pattern of injury.

12.4 The statistical program and analysis:

The Epi Info Statistical Program, version 6 b to c, 1997,[24] was used to analyse the data in studies I, II, IV, V and VI. The SPSS statistical package, version 13.0,[157] was used in study III.

Descriptive statistics were used for the epidemiological registrations. The results are given as median and odds ratio (OR) with Cornfield 95% confidence intervals (95% CI).
Chi-square tests in cross table models were used to demonstrate differences between ordinal and nominal variables. Statistical significance was chosen at $p<0,05$.

12.5 Ethics

Before the 1998 registration at Bergen AED and Haukeland University Hospital (HUS), the project was verbally discussed with the chairman of the Regional Committee for Medical Research Ethics in 1997. The project was at that time not found to require further ethics committee review. The questionnaire used contained detailed questions to the patient about the injury to make the medical history structured and complete. The information from the answered questions was to be incorporated as an anamnestic part of the patient's own medical journal. Additional information to be answered by the treating physician would further improve the quality of the medical injury record (e.g questions regarding whether the described injury event was in concordance with the actual injury, and whether child abuse could be suspected). No interventions or identification of patients were done.

The same principle was used in the smaller registrations about injuries due to rollerblades, skateboard and kickscooter. These data were not contained in the data journal, but directly transferred anonymously to the Epi Info statistical package.

The data transferred to the Epi Info program from both the 1998 registration and the 2000-2002 registrations is contained as an integrated part of Bergen AED's internal network. Data are locked and cannot be exported to other locations. Data from Bergen AED is also separate from the hospital data. At HUS the data only contained age, gender and community number as personal information. To get the surveillance complete, some data was gathered a few days retrospectively from attendance data, but again only containing de-identified information.

The Regional Committee for Medical Research Ethics accepted the retrospective gathering of X-rays from children who suffered from a dislocated distal radial fractures in 1998. They also granted permission to let us interview and send them questionnaires about their previous injury. These data were used in study III.

13. Summary of the papers

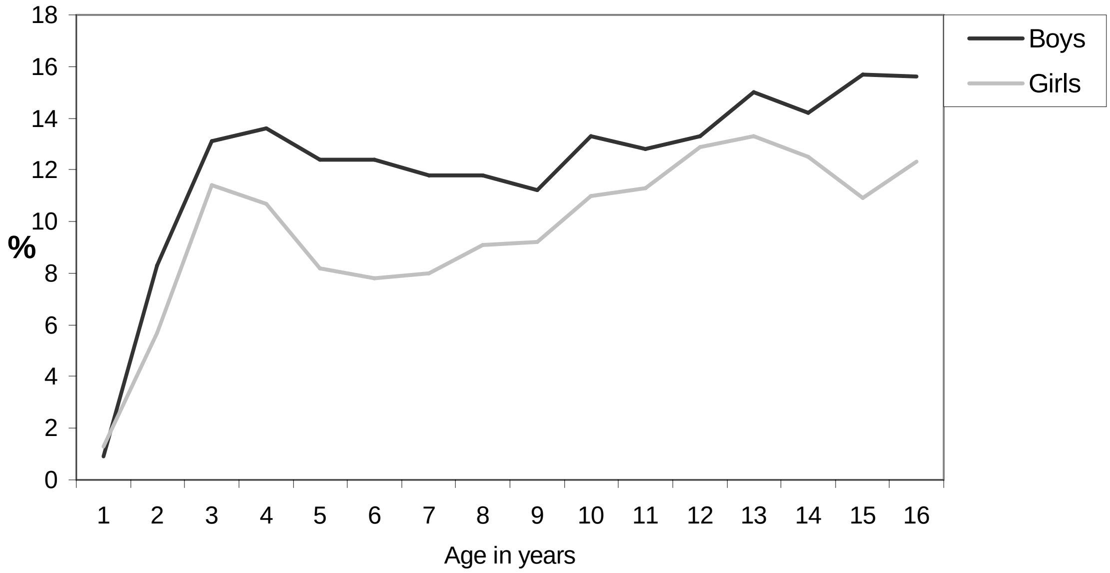
13.1 Paper I

Child injuries in Bergen, Norway
Brudvik C. Injury 2000;31:761-7.

The aim of this study was to conduct a survey of medically treated injuries in children aged less than 16 years in Bergen, Norway. This was done as a prospective registration from January 1st to December 31st 1998, limited to injured children presenting to Bergen AED and HUS.

A total of 7,041 new injuries were registered. The annual incidence of injuries was 9% for pre-school children below six years of age, and 13% for elementary school children, living in the community of Bergen. Boys were injured more often than girls with a ratio of 1.3:1. While boys were injured equally in all age groups, girls were injured more often by the age of two and when between ten and twelve (Fig.12).

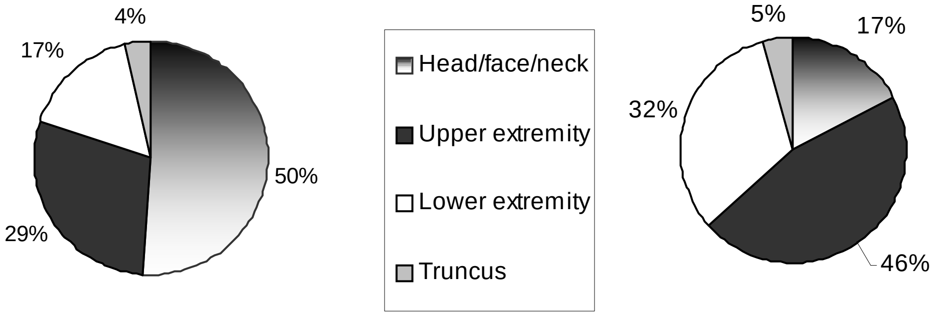
Figure 12.
Incidence of injuries per 100 children by age attending Bergen AED in 1998.



Most injuries were classified as mild or moderate, but four children died and twelve were critically and very seriously injured over the 12-month study period. Traffic caused the most serious injuries, 50% of the children injured in traffic accidents had head, face or neck injuries. Bicycles were involved in 38% of the traffic injuries, and almost 50% of cyclists were not wearing a helmet. Concussion was the most common cause of hospital admission (n=160), eleven children had head fractures, six had additional intracranial injury and two died. Another 286 patients attended the AED with a head injury, 14% were related to bicycling.

Injuries to pre-school children were mostly to the head or face (51%), while school-aged children mostly injured their upper extremity (46%) (Fig.13).

Figure 13.
Distribution of injuries across body region by age group.



Children aged under 6 years. Children aged between 6 and 15 years.

Most injuries were registered in May and September. The lowest number of injuries was found in July and December, but fracture injuries occurred more evenly throughout the year. Injuries in the pre-school children peaked in the afternoon, and injuries in school-aged children had bimodal peaks at noon and in the evening (Fig.15).
Injuries mainly occurred outdoors (63%), but pre-school children were mostly injured indoors. School injuries often happened during the breaks, followed by gymnastic lessons. Organised sports caused 10% of injuries in school children (Fig.16), but the percentage was higher when unorganised sport activities were included. Of all sports, the highest injury incidence in children this year was observed in soccer (11 per 1,000), followed by bicycling (8 per 1,000) (Fig.17). The incidence of injury in bicycling had significantly fallen from 9,3 per 1,000 children in 1991 ($p<0,05$). Playground falls had an incidence of 5.7 per 1,000 children and accounted for almost 5% of all injuries (n=274). Traffic injuries had an incidence of 2.2 per 1,000 this year and affected 126 children.

Figure 14.
Seasonal variation in the number of injured by fractures and other injuries

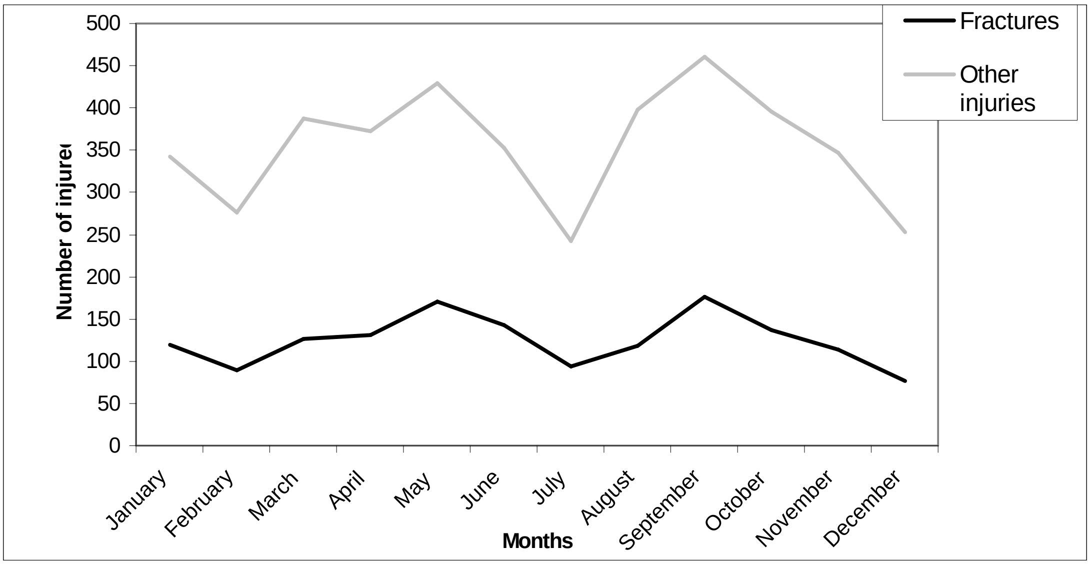


Figure 15.
Percentage of injuries occurring at different hours a day in children by age groups (0-5 years: n=1,640, 6-15 years: n=3,825)

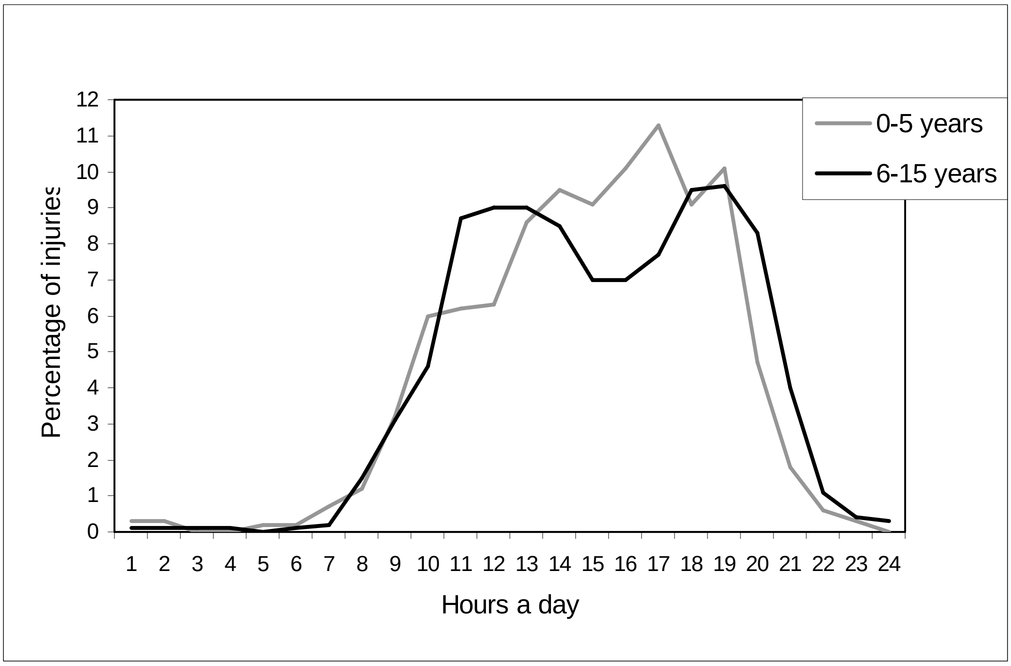


Figure 16.
Frequency of children injured by age group and location.

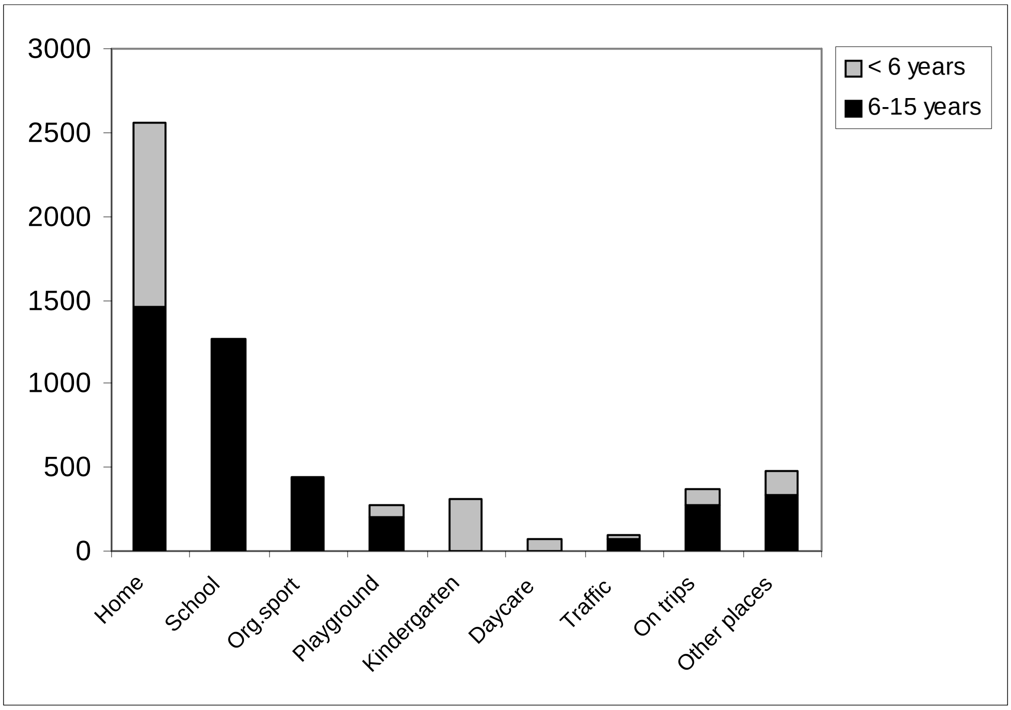
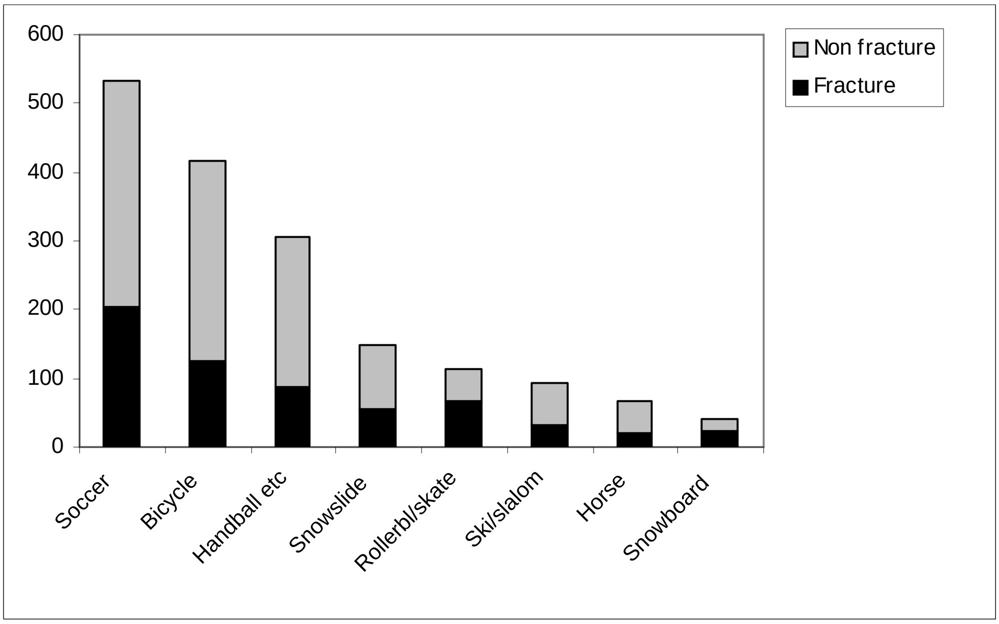


Figure 17.
Frequency of children injured by sport and active recreational activities.
Proportion of fractures in each activity is marked.



Twelve percent of the injured children informed of having had more than four previous injuries that needed medical treatment, and about 1% had more than ten such previous injuries.
Hot drinks like coffee, tee and soups caused one third of the 136 burn injuries treated at Bergen AED in 1998. According to the parents, half of these injuries could have been prevented. The National Burn Centre at HUS received 15 children from the community of Bergen with major burns. One third of them were girls of foreign ethnic origin.

An accidental cause of injury was noted for 86% of the children. A further 12% of injuries were due to physical contact with others during sports or play, while 1.2% were caused by intentional violence from others. Child abuse or neglect accounted for seven verified and 16 suspected cases in our registration (0.33%). This gives an incidence of 0.48 per 1,000 children per year. Only 0.2% of injuries were self-inflicted.

We found that the use of double computerized reminders, both at attendance and before leaving Bergen AED, made our injury registration quite complete.

Conclusively, this study revealed areas in need of preventive actions by presenting an overview of the child injury panorama in Bergen. Most injuries occurred at home or near home, traffic accidents caused the most serious injuries, and soccer play followed by bicycling were the activities associated with most injuries in the community of Bergen. The large number of head injuries (n=446), particularly in the youngest children, was mostly caused by falls, but traffic and bicycling caused the most serious head injuries. The registered fall injuries from playground devices supported the authorities efforts to secure these devices better. The high number of burns called for a need to intensify prevention, especially from hot liquid scalds. The introduction of new recreational and sporting activities in children like rollerblades, skateboard and snowboard seemed to cause a high fraction of fractures. This indicated a need for further research on injuries in these activities.

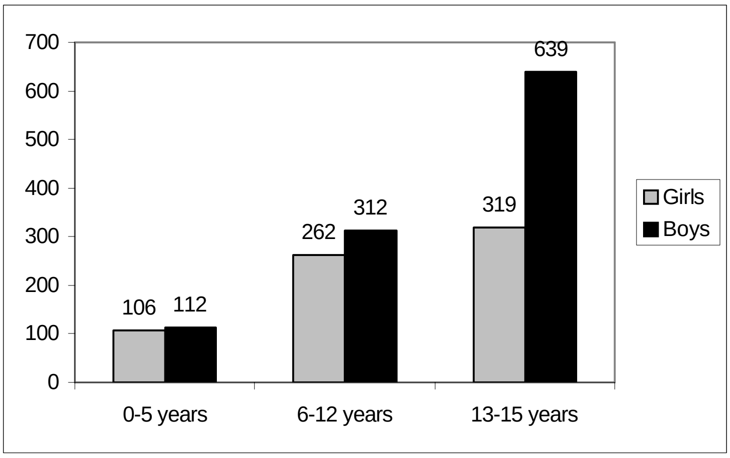
13.2 Paper II

Childhood fractures in Bergen, Norway: identifying high-risk groups and activities.
Brudvik C, Hove LM. J Pediatr Orthop 2003;23:629-34.

The aim of this study was to register and analyze all child fractures in the Bergen child population in order to find high-risk groups or high-risk activities for acquiring fractures. We wanted to study each fracture type related to injury mechanisms and to identify activity specific injuries.

We registered a total of 1,725 children below 16 years with fractures in 1998. The fracture incidence was 245 per 10,000 this year, when only patients from the community of Bergen were included. One fifth of the fractures needed reduction before casting. Boys acquired almost 60% of the fractures, but boys aged 13-15 years had the double incidence of fractures compared to their female peers, with 639 fractures versus 319 per 10,000 (OR: 2,07, 95% CI: 1,80-2,38, P<0,001) (Fig.18). This gender difference in fracture incidence was also found to be significant in the age group 6-12 years, with 341 versus 262 per 10,000 (OR: 1,31, 95% CI: 1,11-1,55, P=0,001). Only at age 10 did girls have more fractures than boys. In the youngest age group, below six years, there was no significant difference in fracture incidence (112 in boys versus 106 per 10,000 in girls).

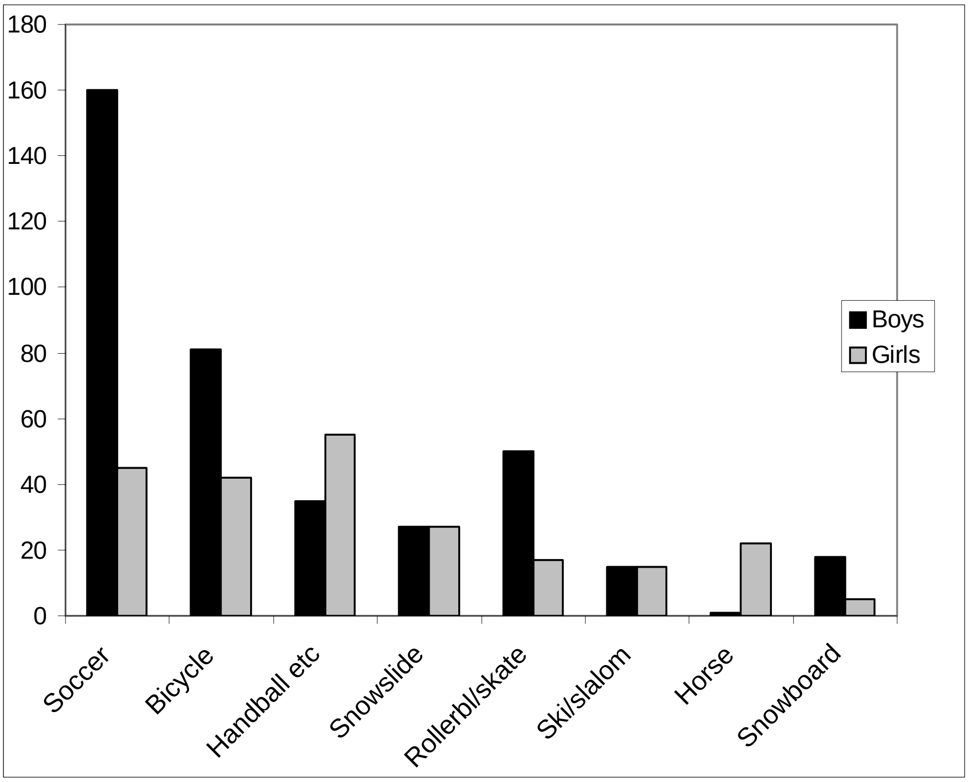
Figure 18.
Incidence of fractures per 10,000 children in different age groups



More than two thirds of all fractures involved the upper extremity. The distal end of the radial bone was the most common fracture site, accounting for 27% of all fractures. The greenstick type was the most frequent subgroup (56%) followed by Colles' type (20%), physeal fractures (19%) and the Smith's type (5%). Falls from bicycles caused half of the Smith's type of fracture with a volarly angulated displacement of the distal radius.
Of all children injured in 1998, 20% had a history of earlier fracture. In children aged 6-15 years, 26% had a history of earlier fracture, while 36% of the 580 children aged 15 had an earlier fracture (OR: 1,57, 95% CI: 1,30-1,89, P<0,05).

Soccer, the most common sport activity among children in Norway, was the activity in which most fractures occurred (12%). Three quarters of these were located in the upper extremity, making it logical to protect the wrist region as well as the shin when playing soccer (Fig.20). Fall on an outstretched hand was the most common mechanism of injury, but 40% of the distal radial fractures in soccer were caused by hard ball-shots against goalkeeper hands. Seven percent of fractures occurred in bicycling, 5% occurred in handball, volleyball and basketball together and 4% in rollerblades and skateboard. Even though most fractures occurred in soccer and bicycling, the proportion of fractures relative to the total number of injuries caused by these activities was 35%. This proportion of fractures was as high as 60% when it came to rollerblading, skateboarding and snowboarding activities (Fig.17). Handball activities and horseback riding were the only activities related to more fractures in girls than in boys (Fig.19).

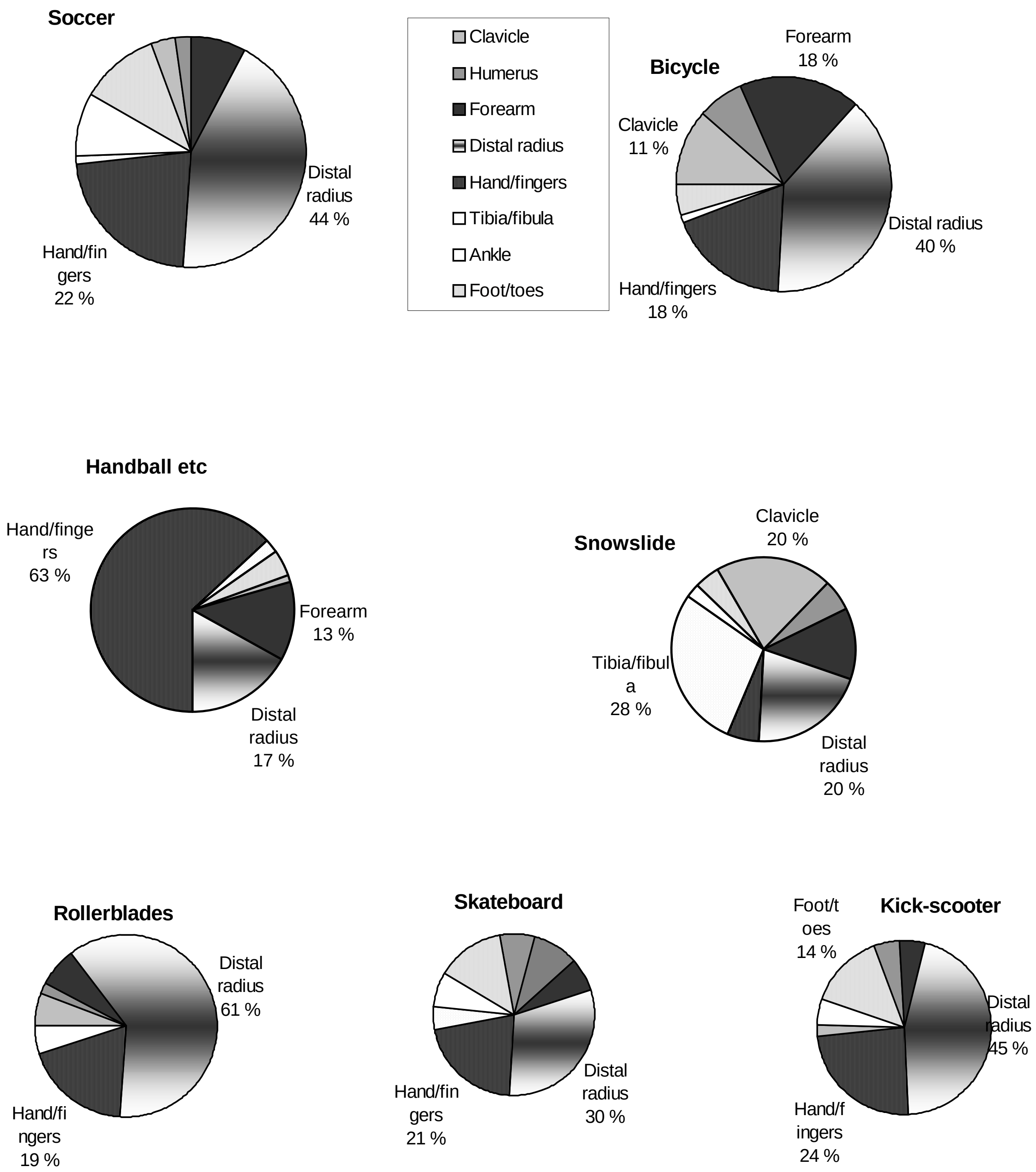
Figure 19.
Number of fractures associated with different activities by gender



During the first months of snow, February and March 1998, every second child attending the AED had an injury related to snow-sliding. Fracture of the tibial bone, caused by hitting an object in their way, was a common injury (Fig.20).

Our data indicates that boys aged 13 to 15 and high-risk activities like rollerblading, skateboarding and snowboarding should be the targets for fracture-preventive actions. Protection of the distal radial bone is the most important countermeasure, as it has the potential to reduce most fractures. Soccer and bicycle related fractures, also mostly located in the distal radius and forearm, should be evaluated for preventive actions due to their substantial number. Likewise, the Bergen tradition of snow-sliding down the city mountains requires better planning regarding covering of objects to be hit on the way.

Figure 20.
Percentile distribution of fracture location in each sport and active recreational activity.



13.3 Paper III

Displaced paediatric fractures of the radius and ulna
Hove LM, Brudvik C. 2006 (Submitted)

The aim of this study was to do a follow-up study of children, who sustained a displaced forearm fracture in 1998. It was of interest to evaluate our indications for reduction and choice of operative treatment. The 131 children were initially treated at Bergen AED or HUS. We described their fractures according to detailed classifications, and measured the pre- and postreduction and follow-up radiological variables. Patients with a large remaining malangulation at union were re-examined after seven years to assess the degree of spontaneous remodelling. We also evaluated the functional outcome in their affected arm.

We registered 88 fractures located in the distal radius and 43 in the forearm shaft. The displaced fractures of the mid-third of the forearm were significantly more common in the younger age group, and the fracture site tended to move distally with increasing age. The median angulation before reduction of the distal radius fractures was 18 degrees (range 5-90°) (Fig.21); after reduction 5°, and at union 6°. The median angulation before reduction of the mid-shaft radius fractures was 22 degrees (range 5-60°) (Fig.22); after reduction 4° and at union 4°. Eight patients with distal radial fractures and three with forearm shaft fractures had more than 15 degrees of malangulation at union. These eleven children had new x-rays taken, and the authors controlled their wrist range of movement, grip strength and skin sensibility. Both arm lengths were also compared. All of them had radiologically remodelled to an almost anatomically perfect forearm position, and all but one had normal functional outcome. Despite normal X-rays without rotational deformity, this one patient with a mid-shaft forearm fracture lacked almost all pronation. He had been treated with a flexed above-elbow cast with the forearm in a supinated position for 6 weeks after reduction.

Five patients (12%) with mid-shaft fractures were primarily operated. Indications were irreducible fractures with more than 15 degrees of angulation. Three had percutaneous fixation of the radius with intramedullary pins after closed reduction, and two had open reduction and plating of the ulna and intramedullary pins of the radius. Another patient had a corrective osteotomi done 3 months after injury due to both functional and cosmetic reasons, and subsequently regained normal range of movement.

Conclusively, the routines of mostly non-operative treatment from 1998 achieved good results in the vast majority of patients.

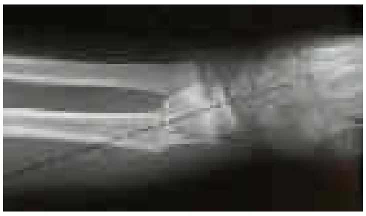


Figure 21. Displaced distal radial fracture in need of reduction

Figure 22. Mid-shaft radial fracture

13.4 Paper IV

Rulleskøyte- og rullebrettskader blant barn i Bergen
(Rollerblading and skateboarding injuries among children in Bergen, Norway)
Brudvik C. Tidsskr Nor Lægeforen 2001;121:19-22.

The aim of this study was to conduct an in-depth analysis of rollerblading and skateboarding injuries that occurred in 1998. We identified 113 injuries in children below 16 years, representing 1.6% of all child injuries recorded that year. Three quarters of the injured children were boys; nine out of ten were older than ten years of age. The upper extremity was injured in two-thirds of cases. Almost two-thirds of all injuries were fractures (n=67), representing a higher fracture rate than seen in other activities. Most fractures were in the distal end of the radial bone, but scaphoid fractures, a rare fracture in children, accounted for 9% (n=6) of all rollerblading and skateboarding fractures. It is important that the medical staff at the AED is aware of the occurrence of this fracture type even in children complaining of pain in the wrist after a fall on rollerblades or skateboard. Instant cast immobilization is important to avoid nonunion of fractures in this bone. As fractures of the carpal region and wrist accounted for 40% of all injuries, effective hand and wrist protection seems to have the best potential for the prevention of injuries in these sports.

13.5 Paper V

Skader ved bruk av sparkesykkel
(Injuries caused by the use of kick-scooters)
Brudvik C. Tidsskr Nor Lægeforen 2003;123:3222-3.

The aim of this study was to give an early overview of injuries caused by this new activity for children. The registration started shortly after the first kick-scooter related injuries had been presented to the AED, and was conducted at the surgical unit at Bergen AED.
Most kick-scooter injuries happened in September. We found 62 injured patients. Half of them had wound injuries to their face or knees, and 45% had fractures. The Smith's type of radial fracture constituted 20% of the fractures. This is a much higher percentage than seen in other activities. Most injuries happened because of falls in downhill slopes, loss of control when braking or steering and because of uneven ground. The mean time of treatment for the injuries was 3 weeks. Only five kick-scooter riders had used protective devices like helmets and wrist guards.

13.6 Paper VI

Injuries caused by small wheel devices, a comparison of injuries due to rollerblades, skateboard and kick-scooter

Brudvik C. Prev Sci 2006; Jun 14: [Epub ahead of print]

The aim of this study was to look for characteristics in injuries related to rollerblading, skateboarding and unmotorised kick-scooter riding in order to recommend more targeted injury prevention strategies and measures. From September 2000 we undertook a two-year prospective registration of all small wheel device injuries attending Bergen AED's surgical unit.

We registered a total of 273 injuries, fairly evenly distributed between the three activities. There were 83 rollerblading injuries, 101 skateboarding injuries and 89 kick-scootering injuries. The injury patterns were different. Rollerblading was associated with a significantly higher proportion of fractures (69%) compared to skateboarding (48%) and kick-scootering (49%) (Fig.23). Rollerbladers were more prone to fractures in their hands and arms (Fig.24), especially in the distal radius (Fig.20). The scaphoid fracture is rare in children, but in this study it was recorded in 4% of fractures due to rollerblading and skateboarding. Still, this was less than the 9% found in our study from rollerblading and skateboarding injuries in 1998 (Paper IV). The use of more wrist protectors might be the reason for this decline in scaphoid fractures. We had expected to find more serious injuries among skateboarders as they perform high jumps with possible high-energy traumas as a consequence, but they had the lowest injury severity among the three activities measured by AIS. Ankle sprains were the most frequent injury type in skateboarding. The most experienced performers of skateboarding had no higher proportion of fractures than the less experienced. Kick-scooter riders had significantly more wounds than injured participants in the other activities, mostly to the face and knees (Fig.23). They also had a higher frequency of distal radial fractures with volar angulation, the Smith's type of fracture. This type of fracture accounted for 20% of the fractures in kick-scootering.

There were obvious age and gender differences among the injured in the user groups; 2/3 of injured rollerbladers were boys, mostly aged 12; a typical, injured skateboarder was a young male aged 13; and the typical injured kick-scooter user was an 11-year-old child of either sex.

We had anticipated an increased frequency of injuries due to kick-scootering over the two years of study, but noted a significant decline from 62 the first year of registration to 27 in the second year. In 1998 we feared that the number of fractures due to rollerblading and skateboarding would increase if the interest level in these activities continued. The number of fractures has instead declined from 67 in 1998 to an average of 42.5 in the two-year period of this study.

In conclusion, our study indicates that the use of effective protection of the wrist region has the potential to prevent most injuries in both rollerblading and kick-scootering. Due to the high instability of small wheel devices on uneven grounds resulting in falls, these activities should be banned in traffic and discouraged after dark. Preventive advice should preferably be targeted to children aged 11 to 13.

Figure 23.
Distribution (%) of injury types caused by different small wheel devices

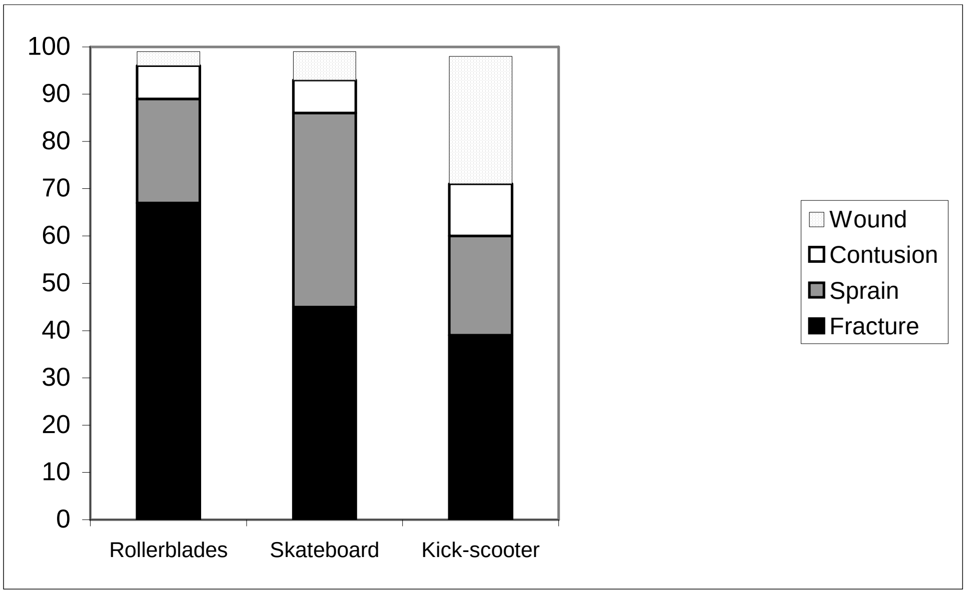
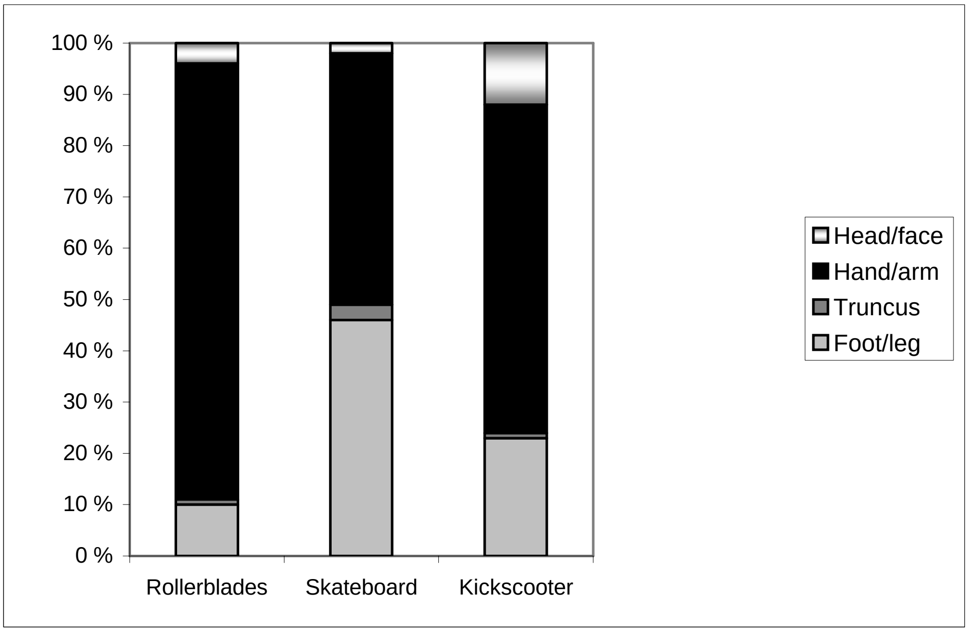


Figure 24.
Distribution (%) of body region injured due to different small wheel devices



14. Methodological discussion

14.1 Inclusion and exclusion criteria

Our registrations were defined as AED and in-patient studies involving only Bergen AED and HUS. We did not register injured children treated by the approximately 175 general practitioners in Bergen in 1998, but did some pre- and post-study inquiries. In 1998 it was common practice that injured patients contacted the centrally located AED directly or through their GPs. At the end of 1998 we contacted some GPs in the central region of Bergen, and they verbally reported that they had not treated any children during the year. We also did a small study in 1998 involving three GPs, including the author, working in a district consulting room on the periphery of Bergen community boundary. This practice was close to a school and a kindergarten, and was anticipated to treat more injuries than other consulting rooms. We treated 44 minor injuries during the registration year of 1998, including 13 wounds in need of suture and one minor fracture referred to the AED. In Oslo, GPs were estimated to treat about 20% of adult and child injuries in 2001, an average of less than one injury a week per doctor.[94] These and other data confirm that the total incidence of injuries in need of medical treatment is higher than found in an AED and hospital setting.[44, 56, 95, 117] Because fractures usually come to medical attention, the registration of this injury type is more accurate than more general injury registrations in an AED setting.[96] A study from the UK revealed a fall-off in AED attendances with increasing distances to the AED or hospital for all injuries with the exception of fractures.[97] This indicates that fracture incidence is a good indicator of injury occurrence in surveillance systems using AED and hospital databases. Even though minor fractures, especially in fingers and hands might be under-reported, we still expect that most minor fractures in the region were treated at Bergen AED.

Minor injuries presented to Bergen AED, which did not need treatment or evaluations by a physician, were excluded.

We chose not to do any injury registrations at the second hospital in Bergen, Haraldsplass Deaconal Hospital. Before we started our registrations, this hospital informed us they treated very few new injuries, mostly adult cases. Infrequent events are easily missed in registrations.

Birth fractures were excluded from this study, as they are mostly detected during the child's stay at the birth clinic, and not registered in patient incoming data.

Dental injuries were also excluded. When the patient presented with combined facial wounds and tooth injuries, only the facial injury was registered.

14.2 Diagnostic classifications

During the injury registration in 1998 the International Classification for Primary Care (ICPC) diagnostic system was used at Bergen AED. ICPC has limited diagnostic accuracy, but the diagnostic spectrum was expanded to accommodate the needs of an AED in order to give more detailed diagnostic descriptions. This made it possible to compare injuries before and after April 1999, when Bergen AED changed to the more detailed and more widely used diagnostic classification system, the WHO International statistical Classification of Diseases and related health problems (ICD version 10).[185, 186] Diagnostic comparison was used in study VI when ICD10 diagnoses from 2000 to 2002 were compared to the ICPC diagnoses used for study II.

In study III a more precise diagnostic evaluation was done of all displaced forearm fractures that occurred in 1998. The fractures were classified according to the definition of the AO group.[112] This is why some of the subdividing classifications reported in study II are different from the more correct and reviewed classifications done later, when the X-rays were re-examined.

Bergen AED's employed physicians treat most injured patients. Since February 1998 about 150 general practitioners in Bergen County have assumed responsibility for the injury care in the AED at night. More injuries are also treated at locally established casualty centres in the community. General practitioners staff these services in the evenings, and the ICPC diagnostic system is used. This makes a general injury registration more difficult to conduct today. All fracture injuries are, however, still treated at Bergen AED, and remain easy to follow through the injury registration system. In the registrations conducted from 2000 to 2002 (article V and VI), some non-fracture injuries might have been treated by GPs at these casualty centres, and consequently not be captured in our data.

In both the ICPC and ICD10 it is possible to identify specific diagnostic codes corresponding to specific injuries. ICD10 has a chapter XX with the codes V01-Y37 dealing with external cause of injury (E-codes). This chapter is considered too detailed by clinicians, which has hindered its adoption in the Bergen AED. Consequently we could not use these codes in the 2000 to 2002 registrations. Even though the Norwegian National Board of Health published a modified Norwegian version in 1996, by 1999 only 39% of hospitalised injury patients in Norway were coded using the cause of injury codes in ICD-10.[148] The registration was complete in only 23% of cases, making it impossible to use the Norwegian Patient Register (NPR) data to get an overview of the injury panorama causing hospitalisations in Norway.

14.3 Registration bias

We might have missed a few injured children who were not given the questionnaire by AED staff in 1998, but we consider this number to be low. With two computerized reminders both at registration by the medical secretary at the time of presentation to Bergen AED and at the end of treatment by the physician, we believe that the ones missing during the initial presentation were recognized before leaving the AED.

We had 262 incomplete or incorrect registrations (4%). Most of them lacked information about identity, some only received treatment by a nurse, some patients left before they had any treatment, and some patients should have been coded to a disease rather than an injury. Most of the registrations had acquired an injury near or at home (n=116) and 47 had a school related injury. These injuries probably represent mostly minor injuries that could be treated either by a GP, other medical staff or at home. In this respect the bias effect is similar to the exclusion of minor child injuries treated by GPs in the rural regions of Bergen.

Ingestion of or putting foreign bodies into natural body orifices should have been included as injuries. We registered only 21 such injuries in our 1998 study, compared to about 120 registered in earlier years. This indicates that we probably lost about 100 cases because staff failed to consider these cases as injuries.

It is difficult to do registrations when injuries are very serious. The most serious injuries arriving directly at HUS, bypassing the AED, had to be registered retrospectively based on the short presentation data at the emergency entrance. These were checked weekly, but more detailed data could be missed in some of these registrations.

Many children from Bergen practise their skiing skills at the skiing resorts at Voss, a city situated 1.5 hours drive from Bergen. Voss hospital treats some of the Bergen child population's alpine injuries, including fractures. We did no registrations of these injuries, and lost the fracture follow-ups at Bergen AED as we only included new injuries in our registration. This is a bias that very well could make the number of skiing and snowboarding injuries, and thus also fractures, higher than we reported for the Bergen child population. We expect, however, that all injuries occurring at the nearest skiing resorts, at Eikedalen and Kvamskogen, were included in our registrations. Injuries occurring during vacations, travels or trips out of the city would also be lost if they were primarily treated at others sites.

The registrations from September 2000 to September 2002 were conducted at the surgical unit at Bergen AED, biasing the data towards fractures. Some minor wounds and contusions might have been treated elsewhere. The size of this bias is probably similar with all three small wheel activities, and would therefore not affect comparisons between the activities. Supporting this assumption is the finding that the median time of injury treatment in the groups was the same. Likewise, some major injuries might have missed being registered at the AED, including some head injuries. The conclusion that skateboarding injuries had the lowest injury severity among the three small wheel devices may have been affected by this source of bias.

14.4 Information bias

Both the patient questionnaire [Appendix 1a] and the doctor questionnaire [Appendix 1b] used in the 1998 AED and HUS study were specifically developed for the purposes of the study. Our questionnaire had not been formally validated, but was partly based on the general injury questionnaire used by NISS, validated by NOMESCO. Our questionnaire was adapted for children, with more detailed child activities mentioned, and checked for language appropriateness, with examples of responses in brackets. It was piloted the month before the actual registration began and worked well.
The 2000-2002 questionnaires [Appendix 2] were less extensive and contained only a few key questions probing the injury mechanism, history of participation in the activity and the use of protective devices. The 2005 questionnaire for children [Appendix 3], who had sustained displaced forearm or wrist fractures seven years earlier, was based on short versions of different pain measurements, functional evaluations and illustrated instructions to measure forearm function.

14.4.1 *The 1998 patient questionnair* [Appendix 1a]

Some questions involved personal interpretation. For example, the question about the reason for injury gave a choice between "accidental", "push, hard holding or kick during play or sports" or "intentional injury". In the patient questionnaire we also asked for retrospective information and this information could have been either forgotten or exaggerated. This recall bias could have affected the questions about previous injuries or fractures. Sometimes the child did not attend the AED with their parents, and some information might have been missed or even be wrong, for example the responses about chronic diseases or regular medication taken.

14.4.2 *The 1998 physician questionnaire* Appendix 1b

The physician had to do an evaluation of injury severity using a locally adapted severity score. This score was an indirect measure of severity based on the predicted level of medical care needed for the patient. If "hospital" was the response to the question it was a more serious injury, and it also helped us exclude AED data when patients were referred for hospitalisation for the same injury, in order to avoid double registrations. New doctors may have misunderstood part of this severity score even though they were personally informed of how to interpret the response. The AIS score of injury severity was not used to assess severity score in this study.

14.4.3 *The 2000-2002 rollerblades, skateboard and kick scooter questionnaire* Appendix 2

In this questionnaire the injury mechanism had to be described in free text. This made the categorisation of mechanisms dependent on the patient's own phrasing and the author's subsequent interpretation and categorisation of the information given by the patient. Patients injured in rollerblading and skateboarding also had to write down how many times they had practised the activity before, in order to estimate their experience in the activity. Unfortunately patients sometimes just answered with "many times", which was interpreted by the author as experienced.

14.4.4 *The 2005 control after radius and ulna fractures questionnaire* Appendix 3

This questionnaire was based on a modified visual analog pain score (VAS)[106] and a shortened, child adapted, version of measuring the disabilities of the arm, shoulder and hand (DASH).[71] In addition to assessing the child's long-term memory, the illustrated instructions would not intuitively be understood. Some control-questions therefore had to be added. The questionnaire was tested on a few children at different ages before it was used. To ensure a correct use, the questionnaire was used during the clinical examination of the patient.

14.5 Analysing bias

The risk of an injury due to a product or an activity is dependent on the total number of users and the time of exposure. A US study related different sports- and recreational injuries to participation exposure.[87] They used the National Sporting Goods Association annual survey of nationally representative households to provide participation estimates, and used the National Electronic Injury Surveillance System (NEISS) to find that there were 8.9 injuries per 1,000 participants a year in skateboarding, which was twice as high as in rollerblading (3.9 per 1,000), but half as high as in basketball (21.1 per 1,000) and lower than in bicycling (11.5 per 1,000). Our study only registered the injury cases without relating to participation data or time of exposure in the various activities. We therefore cannot draw any conclusions on the risk of injury in the different activities involving small wheel devices or other sport activities. The participation rate in soccer, either in an organised or unorganised form, is high in Norwegian children. It is higher in boys than in girls. In a 2004 survey among 637 Norwegian children aged 6 to 15, 82% of the boys and 50% of the girls had played soccer during the last year.[160] In the same survey 41% had used skateboard or rollerblades and 87% had used their bicycles. In a 1992 survey, 96% of children aged 7-14 in Norway rode bicycles.[167]

Another related problem is whether the relative relationship between a special injury type and the total number of medically treated injuries in an activity reflects the true risk of getting the special injury in that activity. Are there any underlying, confounding biases in this approach? Perhaps the skateboarding and rollerblading group rarely seek medical attention unless they fear a fracture, whereas participants in soccer present with a broader range of injuries. Could a different medical-seeking behaviour be the reason why the proportion of fractures in injured rollerbladers was almost twice that in injured soccer players, as seen in our study? The finding of “only” 48% with fractures from the tougher skateboarding milieu attending the surgical department of Bergen AED and 69% of rollerbladers attending the same department speaks against this view. We therefore think it is possible to compare the injury panorama between these groups.

When we evaluated the fracture location in the forearms by age, we only included the distal or shaft fractures in the forearm in need of reduction. When analysing for this age trend, all forearm fractures should be included, especially because indications for reduction of fractures in young age is a larger fracture angulation, than in older children.

14.6 Internal validation.

During the study year of 1998 we did some internal validation by a retrospective search of ICPC codes for special diagnoses and age below 16. We found our registered injuries to be in accordance with the actual number of injuries.

ERRATA:

Article I. Due to some initial difficulties with registrations of the injury dates in the computerized injury registration form, some of the injuries from the test period in December 1997 were mistakenly included in the first report of injury data. These 94 injuries, including 17 fractures, were mistakenly used in article I in the listing of different injury types and fractures. This is the reason why the absolute number of fractures in articles I and II are different (1742 versus 1725). These 94 injuries involved 1.3% of the injuries and were diverse, and therefore did not cause any bias in the data for age, gender, activity or injury type. The total number of registered injuries in 1998 was 6947.
Figure 8 on page 764 does not show the real number of soccer injuries (n=534) and bicycle injuries (n=445). (Figure 17 in this thesis is a corrected version.)

Article II. The indications of dislocated and un-dislocated fractures have been switched in figure 3 and 4 on page 631.

15. Discussion of results

15.1 Incidence of injuries

The incidence of child injuries treated at Bergen AED and HUS in 1998 was 11.5 per 100 children below 16 years. We found the incidence to be 9 per 100 children below 6 years and 13 per 100 children aged 6 to 15 years. This coincides with the national data from the Norwegian National Injury Surveillance System (NISS), where injured children below 15 treated at AEDs and hospitals in four other Norwegian cities from 1990 to 1997, had an annual injury incidence of 11.6 per 100.[44] Even the ratio of injured boys to girls, were the same, namely 1.3:1. Our registrations involved 5,1%, and the NISS data 7,3% of the Norwegian child population.[56, 160] This indicates that findings from studies based on NISS data to some extent can be extrapolated to Bergen, the second largest city of Norway.

15.2 Intentional injury: violence and self-harm

We found that 1.2 per 100 injured children from Bergen had been assaulted, usually by other children. The same proportion of child injuries related to violent assaults was registered in the NISS data for children.[44, 56] Assault victims at all ages accounted for 1.3 per 100 new attendances to Bergen AED from 1994 to 1996.[161]

We found the incidence of violent injuries to be 1.3 per 1000 children per year in the community of Bergen. This is only one tenth the incidence of physical violence in the adult population in our community, estimated by Steen from combined AED and police records, a telephone interview study and a study of unrecognised assault victims at the AED.[161] It is still to be answered whether child intentional injuries also might be unreported at the AED. In our study 57% of violent incidents happened in school breaks.

Child abuse or neglect accounted for 7 verified and 16 suspected cases (0.33 per 100 injuries), which gives an incidence of 0.42 per 1000 children per year. This is a lower rate than found in a Danish study from 1993 involving reports from local authorities, schools and GPs in the region of Copenhagen.[127] The incidence of verified and suspected cases of abuse or neglect was 2.7 per 1000 children in this study, including emotional neglect. Schools often had more knowledge of cases than local authorities and very few cases came to the attention of the GP.[127] We, most likely, have an underreporting of neglect and abuse in our study, even though our registration, through the specific questions about the injuries and the injury mechanisms, would activate the treating physician's awareness of possible child abuse. [Appendix 1b] We registered 5 suicidal attempts, mostly by poisoning with medication, and 10 self-harm injuries (0.27 per 100 injuries).

15.3 Traffic injuries

The incidence of traffic-related injuries in our study from 1998 was 2.2 per 1,000 children under 16 years. Traffic injuries, involving 126 children, caused the most serious injuries in our registration. Almost one third of them were hospitalized and two died. These two deaths were half of the injury deaths in Bergen in 1998. A large study from 1984 to 1993, involving 15 EU countries, also found that motor vehicle traffic accidents caused half of the injury deaths in children below 15 years.[110] Half of the injuries were located to the head, face or neck, and bicycles were involved in 38% of all traffic injuries. According to the injured bicyclists or their parents, only 50% of the children were wearing a helmet at the time of the injury.

In 1997 Norway introduced compulsory school for all children turning 6 in the year of starting school. Traffic police and school authorities initiated campaigns to reduce the number of injuries occurring on the way to school. Free reflective vests were issued to the children and police patrolled pedestrian crossings near schools. These initiatives may have been associated with the low number of child related traffic injuries on the school roads in our study in 1998 (n=5). None of these injuries affected children in the youngest school classes.

15.4 Home injuries

Four of ten child injuries registered in 1998 occurred at home or in the close neighborhood. Children below 6 years were mostly injured inside at home (42%), followed by outside near home (20%) and in the kindergarten (15%). In 1998 about half of the Bergen child population under 6 years was attending a kindergarten,[160] so this adds weight to the argument that relatively more injuries happen at home than in the kindergartens. According to NISS data, approximately 32% of girls and 42% of boys were estimated to get an injury in home accidents in need of AED or hospital treatment during their first six years.[44] Earlier findings that the high incidence of home injuries among children and elderly was due to more exposure hours spent at home, has been challenged by Kopjar,[86] who found that the high comparative incidence of home injuries was due to a higher risk of injury in the home.

15.5 School injuries

School injuries (n=1010) were almost as frequent as home and neighborhood injuries among school-aged children. Injury incidence in this age group (6-15 years) was 36 per 1,000 in 1998, a little higher than reported from NISS data from 1995 to 1997, possibly because their data were collected before the 6 year olds started school.[44, 142] Their incidence was 32,1 per 1,000 boys and 26,2 per 1,000 girls a year (7-15 years). Like other studies of school injuries,[142, 159, 165] we registered that most injuries occurred during school breaks (n=445) and 6% of these were due to violence. Three quarters of the school break injuries in our study happened when an adult was not present. This may indicate the importance of implementing a higher adult supervision in school breaks to prevent injuries.

15.6 Sport injuries

In our study, 10% of the injuries in children aged 6 to 15 occurred in organised sports. However, this did not include injuries in school gymnastics or the more unorganised sport activities. NISS found that 34% of injuries among pupils aged 7-12 years occurred during sports activities. Among the 13-15 years old 60% of injuries were related to sports.[44] Soccer was the leading cause of sport injury in our study with an annual incidence of 11 per 1,000 children below 16 years. The high number of wrist fractures relative to fractures in the lower extremity, found in our study, indicates the need to focus more on the prevention of wrist injuries in young soccer players. Most fractures happened because of a fall, often during tackles with others players, but hard ball-shots against the goalkeeper’s hands caused 40% of the distal radial fractures in soccer. This last mentioned injury mechanism has been focused on in other studies, with a call for better age adjusted ball sizes.[101] More research is needed to address this injury mechanism, and also to consider whether wrist guards are needed or if wrist strengthening activities can prevent injury. In Bergen, many playgrounds for soccer have not always been in a good condition. Enthusiastic children often play on icy, stony, wet and bumpy grounds. Many children injured in soccer activity mentioned that bad surfacing on soccer playgrounds contributed to their fall injury in 1998.

15.7 Recreational injuries

Almost 4% of all child injuries in 1998 (n=274) occurred in playgrounds. Falls from heights were the dominant cause of injury. New research on these injuries should be followed now that new standards for playground equipment and surfacing have been implemented in Norway since our registration in 1998. The importance of monitoring that all play equipment standards have been followed before controlling for injuries has been demonstrated in earlier Australian studies.[144]

Snow-sliding down the Bergen mountains is a popular leisure activity among Bergen children as soon as the first snow appears on the ground. Hitting unpadded obstacles when the trails are not sufficiently prepared injures many children. Leg injury was common among injured snow-sliding participants; 35% of the injuries due to this activity were fractures. Head injury was also common. This activity should be a target for rapid hazard assessment as soon as snow is forecast.

Bicycling may be considered both a traffic, recreational and sports injury. Its incidence in 1998 was 8 per 1,000 children under 16 years in Bergen, a decline from 9.3 injuries per 1,000 in 1991. This trend is possibly due to more frequent use of helmets and bicycle tracks rather than less people bicycling, but needs to be investigated.

15.8 Burn injuries

Our study found that burn injuries involved the youngest children. Two-third of the children treated at Bergen AED with a burn injury were younger than four years old. Among these, more than one-third was due to hot drinking liquids causing scalds. Falls against or contact with heaters and ovens caused one fifth of burns, and another one fifth were due to burns from the cooker. Hands were mostly burnt (56%). In an earlier study of burn injuries in Bergen, conducted in 1989, the annual incidence was 3.2 per 1,000 children under 15 years.[70] When children over 15 in our study were excluded, we found a similar incidence of child burns (3.0 per 1,000 in 1998). Unfortunately, this indicated no significant fall in burn injuries over the last 9 years between 1989 and 1998 in our community. In Harstad, the incidence of burn injuries in children aged below 5 was 6 per 1,000 in 1985 and fell to 1 per 1,000 in 1993 after 8 years of interventions through a local injury prevention group.[192] Most of Haddon's theoretical injury preventive strategies [57, 58] were used: tap water temperature was reduced; cooker safeguards were promoted in stores; parental counselling by public health nurses; and promotion of parental burns first aid skills. Local media were also widely used.

Five out of 15 girls from the community of Bergen, who were seriously burnt in 1998, were of foreign ethnic background. Though based on a small number of seriously injured, this overrepresentation might indicate a need to focus more on burn injury prevention in this group. Similar findings were reported from studies of ethnic minority groups in Canada and Australia.[72, 81] The lack of post-injury prevention through correct application of immediate first aid treatment was also found to be a reason for more severe scald injuries. Media campaigns in the targeted community languages proved effective as a secondary prevention measure.[81] A Norwegian study [177] showed a significant effect of income on the adoption of burn safety measures, indicating that subsidies and loan schemes on preventive products are necessary.[177]

15.9 Fracture injuries

Fractures accounted for 24.5% of injuries attending Bergen AED and HUS, similar to the proportion found in a large population based British cohort study of children under 18, with a national covering of 6%.[33] In the NISS data the percentage of fractures was only 15% of injuries.[44] A population based study in Rogaland, Norway from 1992 to 1995 found an annual fracture incidence of 128 per 10,000 children less than 13 years.[85] We found a much higher fracture incidence of 245 per 10,000 children years under 16, possibly due to the higher fracture incidence in children aged 13-15 years in Bergen. When this age group was excluded, we still had a higher incidence of fractures, 198 per 10,000 children less than 13 years. A twofold increase in fracture incidence was found in Malmø, Sweden among children 0-16 years from 1950 to 1979, reaching an annual incidence of 212 per 10,000.[89] This increase was thought to be due to more participation in sports- and equipment-related playing activities.

In the Swedish study, 13-14 years old boys had an annual fracture incidence of 500 per 10,000, and peer girls only half the incidence.[89] In our study boys aged 13-15 had an annual fracture incidence of 639 per 10,000 children, while their female peers had an incidence of 319 per 10,000. In a UK study from south Wales in 1996,[98] boys aged 10-14 years had an even higher incidence of 770 fractures per 10,000, and their female peers 386 per 10,000. In another British study, fracture incidence in boys similarly peaked in this age group and then fell dramatically after age 15 years.[33] Our data seemed to lie somewhere between the British data and the data from other Norwegian and Scandinavian regions.

Sports and leisure related activities accounted for 36% of fractures in south Wales,[98] which is similar to our findings (37%). Rugby and soccer activities were the most common sports causing fractures in south Wales,[98] whereas soccer and bicycling caused most fractures in Bergen. Rollerblading related fractures represented 7,9% of the radius and ulna fractures in the Welsh study, and in our study the combined rollerblading and skateboarding fractures represented 6.5% of these fractures. Proportions of registered finger fractures can be used as an indicator of similar fracture registrations, as these injuries easily are underreported in surveillance studies. Finger fractures accounted for 13% of fractures in our study, 14% in south Wales, 15% in Nottingham and 19% in the Malmø study.

A Swedish follow-up study of fractures showed a decreasing incidence from 212 per 10,000 in 1979 to 193 per 10,000 in 1993/1994.[171] In a comparison study of fracture incidences in 1996, extracted from south Wales, Norwegian NISS data (Harstad, Trondheim, Stavanger and Drammen), Swedish data (Jamtland) and Finnish data (Parvoo), the Welsh: Scandinavian fracture ratio was 1.82.[98] The longer season for summer sports in south Wales seemed to outweigh the possible higher risk associated with winter sports in Scandinavia. However, over the last five years, snowboarding and other winter sport activities have increased enormously among Scandinavian children. Despite a low absolute number of injuries due to snowboarding in 1998 (n=40), the proportion of fractures among injuries was high (60%). We have already seen an increase in fracture rates due to new winter sport activities in our countries, indicating a need for new preventive actions.[176] While downhill skiing mostly cause knee and ankle injuries, the new sports seem to cause more fracture injuries in the upper extremity. [191]

15.10 Forearm fractures

Bergen women aged 60-69 years have the highest reported age-specific incidence of distal radial fractures in the world with 137 per 10,000 per year.[69] This incidence decreased in older age possibly because falls were linked to climatic conditions rather than low bone mineral density. In our study the highest age-specific annual incidence of distal radial fractures was among boys aged 12-15 years (165 per 10,000). Girls with the highest annual incidence were aged 9-12 years (113 per 10,000). Children also fall on snowy and icy grounds, but the incidence of children with radial fractures in our region was still not higher than in regions with different climates.[98] The percentage of fractures in the radius and ulna related to other fracture locations was 39% in our study (27% wrist plus 12% forearm fractures), 36% in south Wales,[98] 45% in Nottingham,[187] and 27% in Malmø.[171]

Most distal radial fractures are easy to treat with immobilization in a cast for 3-6 weeks, and rarely cause any functional dysfunction for the child. The discussion regarding the treatment of displaced distal and shaft forearm fractures is more complex. The specter of treatments ranges from almost never to reduce distal fractures to a very liberal indication for intramedullary nailing in almost all shaft fractures.[51, 91, 182] Analyzing our practice and outcome in 1998 and seven years forward revealed good results from our indications for reduction, casting and more seldom operative treatment. Acceptable angular corrections in degrees for distal radial fractures at different ages were 15-20 degrees in 4-9 years old, 10-15 degrees in 9-11 years old, 10 degrees in 11-13 years olds and 5 in those older than 13 due to a shorter period of growth before epiphyseal closure. Shaft fractures of more than 10 degrees should be corrected. Our study indicated that we mostly followed these recommendations, but in 11 patients with even larger angulations, the radiological remodeling was complete after 7 years, and all but one had normal functional results.

In our analysis of displaced forearm fractures, we registered a tendency for fracture location to migrate distally with age. Other studies have also described that adolescents more often sustain distal fractures, often involving the epiphyseal region, and younger children more often diaphyseal shaft fractures.[26, 175] The displaced fractures in our study and in other studies, were mainly the result of falls from heights, or with a forward momentum like when falling while running during soccer play, rollerblading, skateboarding or bicycling.[129, 194]

15.11 Activity specific fractures

Our findings emphasize the high percentage of verified scaphoid fractures relative to other fractures due to rollerblading and skateboarding. Nine percent of fractures were of this type in 1998. However, the recent two-year study from September 2001 showed that this percentage had fallen to four percent of fractures. The decline is hopefully due to an increased use of protective wrist devices, but unfortunately we have no data on wrist guard use among participants in rollerblading and skateboarding without injury. However, our finding in the 1998 study were published in the local newspapers and television, and skating rinks put up signs recommending that skaters wear both helmets and wrist guards. Earlier, a high proportion of scaphoid fractures in adults falling on rollerblades has been described,[19] but not in children. Carpal fractures in children are rare, representing only 0,34% of the total child fractures.[28, 189] When scaphoid fractures occur in 4% of fractures in children participating in rollerblading and skateboarding, this indicates a high proportion. Hard falls on an outstretched, dorsiflexed hand, falls with an object in the hand and “kick back” mechanism to the hands, for example from punching game machines, are other known injury mechanisms.

Researchers have through experiments shown that extremely, forced wrist dorsiflexion of more than 95 degrees results in a middle third scaphoid fracture if combined with compressive force to the radial side of the palm.[29] This occurs in falls backward, with the hand directed anteriorly, and is a common way of falling in rollerblading and skateboarding.[19] Fracture of the scaphoid might easily be overlooked by patients and physicians and mistaken for a wrist distortion. A thorough examination about the injury mechanism as well as a good physical examination is important. Even though non-union rarely happens in children, hospital data of non-union scaphoid fractures registered in other studies [172] is dominated by late diagnosed scaphoid fractures. Early diagnosis and cast immobilisation, or even better, prevention by wrist guards, is important for the outcome of a fall injury.

Kick-scootering seems to cause a high proportion of Smith's type of fracture in children, which represents one fifth of all fractures among participants in this activity. The injury mechanism is a forward fall while still holding on to the handlebars. This causes the wrist to be volarly flexed when hitting the ground and dislocates the fracture in a volar direction. This type of fracture carries a higher risk of complications.[195] The same high proportion of Smith's fractures in kick-scootering was mentioned in a later study, confirming our findings.[80]

15.12 Efficacy of injury preventive means

Few well-designed and controlled studies have investigated the efficacy of injury prevention strategies in sport and recreation activities. The development of multidisciplinary methods to identify and quantify risk and protective factors is important. Two case control studies of falls from playground equipment using an instrumented child dummy and rig, measured equipment height, surface depth, head form deceleration and quantified the arm-load.[145] It was found that playground equipment height had to be lower than 2,5 meters to avoid head injuries and lower than 1,5 meter to avoid forearm fractures when landing on sufficiently deep surfacing.

A more extended use of protective wrist braces has been proposed for many activities. However, the efficacy of protective braces has been widely debated, especially regarding adjacent injuries, the so-called splint top fractures.[27] Cadaveric studies indicate that wrist guards may have preventive effect on low-energy trauma, but with too-rigid brace systems to absorb higher amounts of energy, the risk of creating stress points is high.[55] In our 2001-2002 study we found that nine injuries in children occurred despite that they had used relevant protective devices. Six of the injuries were fractures, including one metacarpal fracture adjacent to the wrist guard. Another important point in the use of protective devices is related to the potential of increasing new injuries if they hinder mobility in steering or weakens the grip strength. The first study on this was done on young Australian school children using wrist guards designed for skating. These guards did not seem to adversely affect the children's steering of kick scooters over a test track, but limited both their bicycle steering and their grip on playground equipment measured by a hand dynamometer.[20]

The wrist region was affected in 63% of the injuries related to rollerblading in our study, including distal radius/ulna fractures, scaphoid fractures and wrist distortions. Effective protection of this region could potentially have reduced most injuries. Earlier studies have supported the effectiveness of wrist guards in preventing inline skating [139] and snowboarding forearm fractures.[134] The potential of wrist guards to prevent scaphoid fractures seems logical because the volar plate extends into the palm and covers the carpal region. Whether a volarly placed plate also can prevent volarly angulated forearm fractures after fall injuries, will require further research.

15.13 Injury registrations

A new Norwegian study has recently tested an injury surveillance system in Oslo based on a minimum dataset on many injuries using routine collection procedures within the medical care system.[94] This collection makes it possible to estimate injury incidence rates and investigate specific trends. Periodically collecting more detailed information about selected injuries by cause, severity, frequency or other factors would then make it possible to detect contributing factors to injuries and give relevant preventive advice. This so-called two-step injury surveillance system is thought to be a less resource demanding system and more likely to be implemented and sustained.
We consider our study to be an example of such a two-step system, with the initial broad injury registration (study I) followed by later more pinpointed studies on specific injuries (studies II and III), some high risk activities (study IV) and some newly introduced recreational activities (studies V and VI).

16. Main conclusions

Child injuries are the leading cause of mortality and morbidity in children in Norway. Child injuries treated at Bergen AED and HUS occurred with an incidence of 11.5% per year, which is similar to the incidence registered in other Norwegian and European regions. The incidence of fractures in Bergen was, however, higher than in other Norwegian regions. The following conclusions can be drawn from the studies in this thesis.

- Males are more often injured at all ages than their female peers. This difference is most obvious in fracture injuries and among boys aged 13 to 15 years. The fracture incidence in 13 to 15 year old males is the double that in females (639 versus 319 per 10,000 children).
- Injuries to children under six years are mostly to the head and face (50% of injuries). Concussions were the most common reason for injury hospitalisation; two children died from head trauma that occurred in traffic accidents in 1998.
- Children aged six and older are most commonly injured to their upper extremity. Fracture of the distal radius is the most common fracture location in this injury group.
- Injuries mostly happen at or near home. The youngest age group of children are mostly injured indoors at home. School injuries, including violent injuries, mostly happen in the school breaks and without adult supervision.
- When comparing our study to an earlier study on burn injuries in Bergen, we found no decline in incidence of burns over the decade. Children below four years are most frequently injured, mostly from hot drinking liquid scalds. Girls from ethnic minority groups experienced the most serious burns in 1998.
- Soccer is the sport most often associated with injuries, including fractures, especially located to hands and arms. This activity accounts for 16% of all distal radial fractures, and hard ball-shots against goalkeeper’s hands is a common injury mechanism (40% of cases). Ankles and legs are seldom fractured in soccer.
- Bicycle injuries are the second most common reason for fractures. Falls from bicycles cause half of all Smith’s type of distal radial fractures. This is also found to be a common fracture type due to falls from kickscooters. Kickscooters were new in 2000, and caused more than twice as many injuries in the first compared to the second year of registration.
- Rollerblading injuries showed the highest proportion of fractures of all activities. The distal radius was mostly fractured, but a high percentage of scaphoid fractures, a fracture otherwise seldom seen in children, occurred in 9% of rollerblading and skateboarding related fractures in the 1998 study and in 4% of fractures in the 2000 to 2002 study. Effective wrist guards have the potential to prevent or reduce most of these injuries.
- The fracture sites on the forearm tend to move distally with increasing age of the child. Fracture remodelling in the most common distal radial fracture is good even with a remaining angulation of more than 15 degrees.

17. Implications for prevention and medical practice

The high percentage of **head injuries** relative to other injuries in young children should be a target for more studies and better prevention. Almost one third of **bicycle** injuries were head injuries, and children should be encouraged to use effective and well fitting helmets. Likewise, the high percentage of arm injuries in older children, especially caused by playing **soccer**, should be better examined. Preventive advice including better playgrounds, smaller and softer balls, rule modifications, better training and coaching, or perhaps wrist guards should be evaluated. Fracture in the **wrist region** is a common injury. Whether wrist or forearm strengthening training is preventive of injury has not been evaluated. More studies of the protective effect of different wrist guards should also be done and, when found satisfactory, be introduced and adapted for the use in the high-risk groups.

Boys aged 13 to 15 years are a high-risk group for acquiring fractures. The reasons are multi-factorial. This group should be the target of more intensive preventive advice without hindering their physical activity.

In addition to confirming previously documented high-risk groups of children for particular injury types and locations, this study has identified two new activity-specific fracture types that occur in children. The otherwise rarely seen **scaphoid fracture** occurs more often in **rollerblading** and **skateboarding** than other activities. The **Smith's type of distal radial fracture** with volar angulation occurs more often in **kick-scootering** than other activities. This knowledge is important for more targeted and observant diagnostic evaluations, both at the level of primary health care, the AEDs and hospitals. Early and correct treatment is important for the outcome in both of these injury types.

Conservative, non-operative fracture treatment may, according to our follow-up study of displaced forearm fractures, be regarded as the "gold standard" for most of these fractures. Open fractures and mid-shaft fractures of more than 10-15 degrees of displacement should be evaluated for treatment with intramedullary fixation. The reduced time of immobilisation might prevent the restricted range of movement, seen in a few patients. Normal radiological outcome after displaced fractures does not always reflect a normal range of movement.

This study identified more detailed information about fracture types than possible in the present ICD 10 diagnostic system. The lack of detailed diagnostic information makes us less able to analyse injuries related to different activities in the future. Hopefully, the coming revisions of the diagnostic coding system will involve important details e.g. information regarding the direction of dislocations of distal radial fractures.

By conducting a broad child injury registration in Bergen, involving 5,1% of the Norwegian child population under 16, we have supplemented the NISS data collection, which involved 7,3% of the Norwegian child population under 15. Our finding of a higher fracture incidence than in the NISS data calls for more research. We think that the use of **computerized reminders** both at attendance and at treatment made our registration more complete. This could be an important addition to later injury registrations.

This study has also tested an easy and quick way of initiating **targeted injury surveillance** very soon after the introduction of new products that were suspected to cause injuries in children. A responsive early warning system is important to have in place in the AED so that truly and well-founded protective advice can be given to the public.

18. Future reflections and recommended research

A national injury surveillance system is being planned in Norway, and this will hopefully be a permanent and continuous register. The use of interactive computerized data systems should be expanded with reminders when injury diagnostic codes are used to generate a routine assignment of external causes of injury codes. Standardizing data elements on AED logs and patient treatment records are important in order to give relevant information about injury mechanisms, products involved, human intent, body region and nature of injury, severity, different treatments and level of treatment without requiring the clinicians to do double entry. The external causes of injury data should be implemented in the anamnestic part of the patient's own medical record. In this way it would not "steal" too much of the clinicians time by already being an integrated part of the ordinary medical record.

A national injury surveillance system must be able to supply the local communities with information on their own region as the basis for implementation of local preventive strategies. This requires both frequent reporting to the communities and locally dedicated staff. In contrast to many large multi-centre studies, the close access to local data in our registration made it possible to relate the findings in the studies to local events and trends, like the boom in snow-sledge injuries during the first snowfall, and new injuries due to the sudden popularity of kick-scooters. This also made it easier to understand the limitations of the data.

Injury research and evaluations are scarce in Norway, and much of the preventive work is based on international studies. It is important that preventive interventions, which have proven effective in controlled trials abroad, are evaluated when put into practice in Norway. Further research on injury prevention in Norway must not suffer from the fear that it discourages people from physical activity. The intent of injury prevention is the opposite, to encourage safe physical activity.

A major finding of the research work covered by this thesis is the need for protection of the wrist region in high-risk activities for injuries in this body region. Protective wrist guards must, however, be proven effective in each individual activity and not cause other injuries or hinder mobility or grip strength. Further studies in the prevention of injuries in the wrist region, and especially of the very common distal radial fracture, should be initiated. Whether wrist guards sufficiently prevent the Smith's type of distal radial fractures with volar angulation or fractures in the scaphoid bone will also need further research.

19. References:

1. Andersen R, Molgaard C, Skovgaard LT et al. Teenage girls and elderly women living in northern Europe have low winter vitamin D status. Eur J Clin Nutr 2005;59:533-41.
2. Akbarnia B, Torg JS, Kirkpatrick J, Sussman S. Manifestations of the battered-child syndrome. J Bone Joint Surg Am 1974;56:1159-66.
3. Association for the advancement of automotive medicine. The Abbreviated Injury Scale (AIS). Des Plaines, IL: AAAM; 1990.
4. Attewell RG, Glase K, McFadden M. Bicycle helmet efficacy: a meta-analysis. Accid Anal Prev 2001;33:345-52.
5. Baker SP. The injury fact book. 2nd ed. New York: Oxford University Press; 1992.
6. Barillo DJ, Goode R. Fire fatality study: demographics of fire victims. Burns 1996;22:85-8.
7. Barrow RE, Przkora R, Hawkins HK, et al. Mortality related to gender, age, sepsis, and ethnicity in severely burned children. Shock 2005;23:485-7.
8. Berfenstam R, Ehrenpreis T, Ekstrøm G, Garsten P, Myrin SO. Barnolycker i Stockholm i 1955. Lækartidningen 1957;54:1950-74.
9. Bergman AB, Rivara FP. Sweden`s experience in reducing childhood injuries. Pediatrics 1991;88:69-74.
10. Biddle SJ, Gorely T, Stensel DJ. Health-enhancing physical activity and sedentary behaviour in children and adolescents. J Sports Sci 2004;22:679-701.
11. Bijur PE, Stewart-Brown S, Butler N. Child behaviour and accidental injury in 11,966 preschool children. Am J Dis Child 1986;140:487-92.
12. Boufous S, Finch C, Bauman A. Parental safety concerns - a barrier to sport and physical activity in children? Aust N Z J Public Health 2004;28:482-6.
13. Brenner RA, Saluja G, Smith GS. Swimming lessons, swimming ability, and the risk of drowning. Inj Control Saf Promot 2003;10:211-6.
14. Brink O, Villadsen I, Davidsen MT, Petersen KK, Charles AV, Sabroe S. Decline of violence in Århus. Violence registered in Århus hospital during a period of 12 years. Ugeskr Læger 1996;158:6277-81.
15. Britton J. Kids cant fly: preventing fall injuries in children. WMJ 2005;104:33-6.
16. Bruce B, Lake J, Eden V. Children at risk of injury. Journ of pediatric nursing 2004;19:121-7.
17. Brunvand L, Lindemann R. Rickets in children in Norway - an epidemic of concern for the Norwegian authorities? Tidsskr Nor Laegeforen 1999;119:1328-9.
18. Burnham J. Why did the infants and toodlers die? Shifts in American's ideas of responsibility for accidents - from blaming mom to engeneering. Journal of Social History 1996;29:817-37.
19. Calle SC, Eaton RG. Wheels-in-line roller scating injuries. J Trauma 1993;35:946-51.
20. Cassell E, Ashby K, Gunatilaka A, Clapperton A. Do wrist guards have the potential to protect against wrist injuries in bicycling, micro scooter riding, and monkey bar play? Inj Prev 2005;11:200-3.
21. Cataldo MF, Finney JW, Richman GS et al. Behaviour of injured children and their parents in a simulated hazardous setting. J Pediatr Psychol 1992;17:73-80.
22. Cattermole HR, Hardy JR, Gregg PJ. The footballer's fracture. Br J Sports Med 1996;30:171-5.
23. Centre for Evidence-Based Medicine. Levels of evidence. http://cebm.jr2.ox.ac.uk/docs/levels.html
24. Centers for Disease Control and Prevention. Epi Info [computer program]. Version 6. Atlanta: CDC; 1995.

25. Cheng JC, Ng BKW, Ying SY et al. A 10-year study of the changes in the pattern and treatment of 6,493 fractures. J Pediatr Orthop 1999;19:344-50.
26. Cheng JC, Shen WY. Limb fracture pattern in different pediatric age groups: a study of 3,350 children. J Orthop Trauma 1993;7:15-22.
27. Cheng SL, Rajaratnam K, Raskin KB et al. Splint-top fracture of the forearm: a description of an in-line skating injury associated with the use of protective wrist splint. J Trauma 1995;39:1194-7.
28. Christodoulou AG, Colton CL. Scaphoid fractures in children. J Pediatr Orthop 1986;6:37-9.
29. Cockshott WP. Distal avulsion fractures of the scaphoid. Br J Radiol 1980;53:1037-40.
30. Cohen L, Miller T, Sheppard MA et al. Bridging the gap: bringing together intentional and unintentional injury prevention efforts to improve health and well being. J Safety Res 2003;34:473-83.
31. Committee on trauma research. Injury in America. A continuing public health problem. Washington DC: National Academy Press; 1985.
32. Cook SD, Harding AF, Morgan EL, Doucet HJ, Bennett JT, O`Brien M, Thomas KA. Association of bone mineral density and pediatric fractures. J Pediatr Orthop 1987;7:424-7.
33. Cooper C, Dennison EM, Leufkens HGM, Bishop N, van Staa T. Epidemiology of childhood fractures in Britain: a study using the general practice research database. J Bone Miner Res 2004;19:1976-81.
34. Cummings P, Wells JD, Rivara FP. Estimating seat belt effectiveness using matched pair cohort methods. Accid Annal Prev 2003;35:143-9.
35. Curnow WJ. The Cochrane Collaboration and bicycle helmets. Accid Anal Prev 2005;37:569-73.
36. Davidson LL, Taylor EA, Sandberg ST, Thorley G. Hyperactivity in school-age boys and subsequent risk of injury. Pediatrics 1992;90:697-702.
37. Davidson P, Goulding A, Chalmers D. Biomechanical analysis of arm fractures in obese boys. J Paediatr Child Health 2003;39:657-64.
38. Deekollu D, Besag FM, Aylett SE. Seizure-related injuries in a group of young people with epilepsy wearing protective helmets: incidence, types and circumstances. Seizure 2005;14:347-53.
39. Dietz WH. The obesity epidemic in young children. Br Med J 2001;322:313-4.
40. DiScala C, Sege R, Li G, Reece RM. Child abuse and unintentional injuries: a 10 year retrospective. Arch Pediatr Adolesc Med 2000; 54:16-22.
41. Do TT, Strub WM, Foad SL, Mehlman CT, Crawford AH. Reduction versus remodelling in pediatric distal forearm fractures: a preliminary cost analysis. J Pediatr Orthop 2003;2:109-15.
42. Durbin DR, Chen I, Smith R, Elliott MR, Winston FK. Effects of seating position and appropriate restraint use on the risk of injury to children in motor vehicle crashes. Pediatrics 2005;115:e305-9.
43. Eastbrook M. Eye protection in racket sports. Clin Sports Med 1988;7:253-66.
44. Engeland A, Kopjar B. Injuries among children treated at emergency medical centres and hospitals 1990-97. Tidsskr Nor Laegeforen 1999;119:784-7.
45. Engstrom K, Diderichsen F, Laflamme L. Socioeconomic differences in injury risk in childhood and adolescence: a nation-wide study of intentional and unintentional injuries in Sweden. Inj Prev 2002;8:137-42.
46. Erdmann TC, Feldman KW, Rivara FP et al. Tap water burn prevention. Pediatrics 1991;88:572-7.

47. Finch C, Valuri G, Ozanne-Smith J. Sport and active recreational injuries in Australia: evidence from emergency department presentations. Br J Sports Med 1998;32:220-5.
48. Fingerhut LA, Warner M. Injury chartbook. Health. United States 1996-7. Hyattsville, Maryland: National Center for Health Statistics; 1997.
49. Flavell JH. The development of knowledge about visual perception. Nebr Symp Motiv 1977;25:43-76.
50. Francisco AC, Nightingale RW, Guilak F et al. Comparison of soccer shin guards in preventing tibia fracture. Am J Sports Med 2000;28:227-33.
51. Friberg KS. Remodeling after distal forearm fractures in children. I, II and III. Acta Orthop Scand 1979;50:537-46, 731-39 and 741-49.
52. Gofin R, Donchin M, Schulrof B. Motor ability: protective or risk for school injuries? Accid Anal Prev 2004;36:43-8.
53. Goulding A, Jones IE, Taylor RW, Manning PJ, Williams SM. More broken bones: a 4-year double cohort study of young girls with and without distal forearm fractures. J Bone Miner Res 2000;15:2011-8.
54. Greene MB. Reducing violence and aggression in schools. Trauma Violence Abuse 2005;6:236-53.
55. Greenwald RM, Janes PC, Swanson SC, McDonald TR. Dynamic impact response of human cadaveric forearm using a wrist brace. Am J Sports Med 1998;26:825-30.
56. Guldvog B, Thorgersen A, Ueland Ø. Accidents, violence and self inflicted injuries. Injury Report, National Institute of Public Health 1992;1:1-20.
57. Haddon W J. A logical framework for categorizing highway safety phenomena and activity. The Journal of Trauma 1972;12:193-7.
58. Haddon W J. The prevention of accidents. Prev Med 1967;591-621.
59. Hambidge SJ, Davidson AJ, Gonzales R, Steiner J. Epidemiology of pediatric injury-related primary care office visits in the United States. Pediatrics 2002;109:559-65.
60. Hansen KS, Eide GE, Omenaas E et al. Bicycle-related injuries among young children related to age of debut of cycling. Accid Anal Prev 2005;37:71-5.
61. Hansen KS, Morild I, Engesæter LB, Viste A. Epidemiology of severely and fatally injured patients in the western part of Norway. Scand J Surgery 2004;93:198-203.
62. Hartman C, Shamir R, Eshach-Adiv O, Iosilevsky G, Brik R. Assessment of osteoporosis by quantitative ultrasound versus dual energy X-ray absorptiometry in children with chronic rheumatic diseases. J Rheumatol 2004;31:981-5.
63. Hassan I, Dorani BJ. Sports related fractures in children in northeast England. Emerg Med J 2001;18:167-71.
64. Haugland S. School-related stress, physical activity and health related complaints in adolescence. Doctorial thesis, University of Bergen, Norway; 2001.
65. Hernandez JA, Swischuk LE, Bathhurst GJ, Hendrick EP. Scaphoid (navicular) fracture of the wrist in children: attention to the impacted buckle fracture. Emerg Radiol 2002;9:305-8.
66. Herndon DN, Thompson PB, Desai MH, Van Osten TJ. Treatment of burns in children. Pediatr Clin North Am 1985;32:1311-32.
67. Hillman M, Adams J, Whitelegg J. One false move: a study of children's independent mobility. London: PSI (Policy Institute Studies); 1990.
68. Houshian S, Mhedi B, Larsen MS. The epidemiology of elbow fractures in children: analysis of 355 fractures with special reference to supracondylar humerus fractures. J Orthop Science 2001;6:312-15.
69. Hove LM, Fjeldsgaard K, Reitan R et al. Fractures of the distal radius in a Norwegian city. Scand J Plast Reconstr Hand Surgery 1995;29:263-7.

70. Hove LM, Lindtjoern B. Epidemiology of burns in Bergen, Norway. Scand J Plast Reconstr Hand Surg 1998;32:1-5.
71. Hudak PL, Amadio PC, Bombardier C. The upper extremity collaborative group (UECG): Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand. Am J Ind Med 1996;29:602-8.
72. Jenkins HM, Blank V, Miller K, Turner J, Stanwick RS. A randomized single-blind evaluation of a discharge teaching book for pediatric patients with burns. J Burn Care Rehab 1996;17:49-61.
73. Jennings DC. Injuries sustained by users and non-users of gum shields in local rugby union. Br J Sports Med 1990;24:159-164.
74. Jian Da, Black Dragon Group Europe, import company, personal message in 2004.
75. Karolinska Institute, 2003. Indicators for Safe Communities. http://www.phs.ki.se/csp/indicators.htm
76. Kemp A, Sibert JR. Drowning and near drowning in children in the United Kingdom: lessons for prevention. BMJ 1992;304:1143-6.
77. Kempe H, Silverman FN, Steele BF, Droegemueeller W, Silver HK. The battered-child syndrome. JAMA 1962;181:17-24.
78. Kendrick D, Marsh P, Fielding K, Miller P. Preventing injuries in children: cluster randomised controlled trial in primary care. BMJ 1999;318:980-3.
79. Khosla S, Melton LJ, Dekutoski MB, et al. Incidence of childhood distal forearm fractures over 30 years: a population based study. JAMA 2003;290:1479-85.
80. Kiely PH, Kiely PJ, Stephen MM, Dowling FE. Atypical distal radial fractures in children. J Pediatr Orthop B 2004;13:202-5.
81. King L, Thomas M, Gatenby K, Georgiou A, Hua M. “First aids for scalds” campaign: reaching Sydney’s Chinese, Vietamese and Arabic speaking communities. Inj Prev 1999;5:104-8.
82. Klasson-Heggebo L, Anderssen SA. Gender and age differences in relation to the recommendations of physical activity among Norwegian children and youth. Scand J Med Sci Sports 2003;13:293-8.
83. Kopjar B, Guldvog B, Wiik J. Costs of medical treatment of injuries in Norway. Tidsskr Nor Lægeforen 1996;116:512-6.
84. Kopjar B. The SF-36 health survey: a valid measure of changes in health status after injury. Injury Prevention 1996;2:135-9.
85. Kopjar B, Wickizer TM. Fractures among children: incidence and impact on daily activities. Injuries prevention 1998;4:194-7.
86. Kopjar B, Wickizer TM. Population-based study of unintentional injuries in the home. Am J Epidemiol 1996;144:456-62.
87. Kyle SB, Nance ML, Rutherford GW et al. Skateboard-associated injuries: participation based estimates and injury characteristics. J Trauma 2002;53:686-90.
88. Laing RM, Bryant V. Prevention of burn injuries to children involving nightwear. N Z Med J 1991;104:363-5.
89. Landin LA. Fracture patterns in children. Acta Ortop Scand 1983;54:1-95.
90. Landin LA, Nilsson BE. Bone mineral content in children with fractures. Clin Orthop Relat Res 1983;178:292-6.
91. Larsen E, Vittas D, Torp-Pedersen S. Remodeling of angulated distal forearm fractures in children. Clin Orthop 1988;237:190-5.
92. Last J. A dictionary of epidemiology. 3rd edition. Oxford: Oxford University press; 1995.
93. Lowenstein LF. Youths who intentionally practice self-harm. Review of the recent research 2001-2004. Int J Adolesc Med Health 2005;17:225-30.

94. Lund J, Bjerkedal T, Gravseth HM et al. A two-step medically based injury surveillance system - experiences from the Oslo injury register. Accid Anal Prev 2004;36:1003-17.
95. Lund J. Injuries in a region of Norway during a year. Tidsskr Nor Lægeforen 1983;23;1620-23.
96. Lyons RA, Brophy S, Pockett R, John G. Purpose, development and use of injury indicators. Int J Inj Contr Saf Promot 2005;12:207-11.
97. Lyons RA, Delahunty AM, Krauss D, et al. Children's fractures: a population based study. Inj Prev 1999;5:129-32.
98. Lyons RA, Sellstrom E, Delahunty AM, et al. Incidence and cause of fractures in European districts. Arch Dis Child 2000;82:452-5.
99. Ma D, Jones G. Soft drink and milk consumption, physical activity, bone mass, and upper limb fractures in children: a population-based case-control study. Calcif Tissue Int 2004:75;286-91.
100. Ma D, Morley R, Jones G. Risk-taking, coordination and upper limb fractures in children: a population based case-control study. Osteoporos Int 2004;15:633-8.
101. Macgregor DM. Don't save the ball! Br J Sports Med 2003;37:351-3.
102. MacKay M, Scanlan A, Olsen L. Looking for the evidence: a systematic review of prevention strategies addressing sport and recreational injury among children and youth. J Sci Med Sport 2004;7:58-73.
103. Mallonee S, Istre G, Rosenberg M et al. Surveillance and prevention of residential-fire injuries. N.Engl J Med 1996;335:27-31.
104. Mann DC, Rajmaira S. Distribution of physeal and nonphyseal fractures in 2,650 long-bone fractures in children aged 0-16 years. J Pediatr Orthop 1990;10:713-16.
105. McGartland C, Robson PJ, Murray L, Cran G, Savage MJ, Watkins D, Rooney M, Boreham C. Carbonated soft drink consumption and bone mineral density in adolecence: the Northern Ireland Young Hearths project. J Bone Miner Res 2003;18:1563-9.
106. McGrath PA. An assessment of children's pain: a review of behavioral, psychological and direct scaling techniques. Pain 1987;31:147-76.
107. McIntosh AS, McCrory P. Preventing head and neck injury. Br J Sports Med 2005;39:314-8.
108. Miller TR, Romano EO, Spicer RS. The cost of childhood unintentional injuries and the value of prevention. The Future of Children 2000;10:137-63.
109. Mitts KG, Hennrikus WL. In-line skating fractures in children. J Pediatric Orthop 1996;16:640-3.
110. Morrison A, Stone DH. Unintentional childhood injury mortality in Europe 1984-93: a report from the EURORISC Working Group. Inj Prev 1999;5:171-6.
111. Mott A, Rolfe K, James R et al. Safety of surfaces and equipment for children in playgrounds. Lancet 1997;349:1874-6.
112. Murphy WM, Leu D. Fracture classification: biological significans. In: Ruedi TP, Murphy WM, editors. AO principles of fracture management. Stuttgart, New York. Thieme; 2000. p.45-57, 675.
113. Niemeyer P, Weinberg A, Schmitt H et al. Stress fractures in adolescent competitive athletes with open physis. Knee Surg Sports Traumatol Arthrosc 2005;3:1-7.
114. O`Connor PJ, O`Connor N. Causes and prevention of boating fatalities. Accid Anal Prev 2005;37:689-98.
115. Olds DL, Eckenrode J, Henderson CR Jr et al. Long-term effects of home visitation on maternal life course and child abuse and neglect. Fifteen-year follow-up of a randomized trial. JAMA 1997;278:637-43.
116. Olweus D, Limber S. Bullying prevention program. 1999. Boulder CO: Center for the study and prevention of violence.

117. Otters H, Schellevis FG, Damen J, et al. Epidemiology of unintentional injuries in childhood: a population based survey in general practice. Br J Gen Pract 2005;5:630-3.
118. Ozanne-Smith J. Child pedestrian injury. J Paediatr Child Health 1994;30:200-1.
119. Padilla E, Rohensow D, Berman A. Predicting accident frequency in children. Pediatrics 1975;56:819-21.
120. Parkinson GW, Hike KE. Bicycle helmet assessment during well visits reveals severe shortcomings in conditions and fit. Pediatrics 2003;112:320-3.
121. Piaget J. The stages of the intellectual development of the child. Bull Menninger Clin 1962;26:120-8.
122. Pickett W, Schmid H, Boyce W et al. Multiple risk behavior and injury. Arch pediatr adolesc 2002;156:786-93.
123. Pless B. Surveillance of childhood injuries: an international overview. CHIRPP news, issue 9, 1996.
124. Plitponkarnpim A, Andersson R, Jansson B, Svanstrøm L. Unintentional injury mortality in children: a priority for middle income countries in the advanced stage of epidemiological transition. Inj Prev 1999;5:98-103.
125. Quinn K, Parker P, de Bie R et al. Interventions for preventing ankle ligament injuries. Cochrane Database Syst Rev 2000;2:CD000018.
126. Reimers A, Laflamme L. Neighbourhood social and socio-economic composition and injury risk. Acta Paediatr 2005;94:1488-94.
127. Riis L, Bodelsen H, Knudsen FU. Incidence of child neglect and child abuse in the region of Copenhagen. Ugeskr Læger 1998;160:5358-62.
128. Rivara F. Epidemiology of childhood injuries. Am J Dis Child 1982;136:399-405.
129. Rockwood CA, Wilkins KE, Beaty JH. Fractures in children. 4th ed. Philadelphia: Lippincott-Raven Publishers; 1996.
130. Rodgers G. The safety effects of child-resistant packaging for oral prescription drugs: two decades of experience. JAMA 1996;275:1661-5.
131. Rothengatter JA. The influence of instructional variables on the effectiveness of traffic education. Acc Anal Prev 1981;13:241-3.
132. Routledge DA, Repetto-Wright R, Howarth CI. The exposure of young children to accident risk as pedestrians. Inj Prev 1996;2:150-61.
133. Rychetnik L, Frommer M, Hawe P, Shiell A. Criteria for evaluating evidence on public health interventions. J Epidemiol Community Health 2002;56:119-27.
134. Rønning R, Rønning I, Gerner T, Engebretsen L. The efficacy of wrist protectors in preventing snowboarding injuries. Am J Sports Med 2001;29:581-5.
135. Sackett DL.The Cochrane Collaboration. ACP Journal Club 1994;120 (suppl 3):A-11.
136. Sandels S. Young children in traffic. Br J Edu Psyc 1995;40:111-6.
137. Sawyer JR, Flynn JM, Dormans JP, Catalano J, Drummond DS. Fracture patterns in children and young adults who fall from significant heights. J Pediatr Orthop 2000;20:197-202.
138. Schelp L, Svanstrøm L. A model of registration and mapping of accident cases in health care. Scand J Prim Health Care 1987;5:1-9.
139. Schieber R, Branche-Dorsey CM, Ryan GW, Rutherford GW Jr, Stevens JA, O'Neil J. Risk factors for injuries from in-line skating and the effectiveness of safety gear. N Engl J Med 1996;335:1630-5.
140. Schieber RA, Vegega ME. Education versus environmental countermeasures: is it really an either or proposition? Am J Health Edu 2003;34 (suppl): S54-6.
141. Schioldborg P. Children, traffic and traffic training: An analysis of the children's traffic club. Unpublished report. Psycological Institute, University of Oslo. 1974.

142. Schuller AA, Kopjar B. School injuries among 7 to 15 years old children. Tidsskr Nor Lægeforen 2000;120:301-5.
143. Schwebel DC, Speltz ML, Jones K, Bardina P. Unintentional injury in preschool boys with and without early onset of disruptive disorder. J Pediatr Psychol 2002;27:727-37.
144. Sherker S. Ozanne-Smith J. Are current playground safety standards adequate for preventing fractures? Med J Aust 2004;180:562-5.
145. Sherker S, Ozanne-Smith J, Rechnitzer G, Grzebieta R. Development of a multidisciplinary method to determine risk factors for arm fracture in falls from playground equipment. Inj Prev 2003;9:279-83.
146. Sherrard J, Tonge BJ, Ozanne-Smith J. Injury risk in young people with intellectual disability. J Intellect Disabil Res 2002;46:6-16.
147. Sheth RD. Bone health in pediatric epilepsy. Epilepsy Behav 2004;5 (suppl 2):30-5.
148. Sjølingstad A, Alvær K, Engeland A et al. Skaderegistrering ved hjelp av ICD-10 ved norske sykehus. Tidsskr Nor Lægeforen 2001;9:1052-4.
149. Skaggs DL, Loro ML, Pitukcheewanont P, Tolo V, Gilsanz V. Increased body weight and decreased radial cross-sectional dimensions in girls with forearm fractures. J Bone Miner Res 2001;16:1337-42.
150. Skog OJ. Alcohol and the so-called prevention paradox; how does it look today? Addiction 2006;101:155-8.
151. Slongo TF. The choice of threatment according to the type and location of the fracture and the age of the child. Injury 2005;36:A12-9.
152. Somers GR, Chiasson DA, Smith CR. Pediatric drowning: a 20-year review of autopsied cases: I. Demographic features. Am J Forensic Med Pathol 2005;26:316-9.
153. Spady DW, Sauders DL, Schopflocher DP, Swenson LW. Patterns of injury in children: a population based approach. Pediatrics 2004;113:522-9.
154. Speltz ML, Gonzales N, Sulzbacher S, Quan L. Assessment of injury risk in young children: a preliminary study of the injury behaviour checklist. J Pediatr Psychol 1990;15:373-83.
155. Spiegel CN, Lindaman FC. Children can’t fly. A program to prevent childhood morbidity and mortality from window falls. Am J Public Health 1997;67:1143-8.
156. Spinks A, Turner C, McClure R, Nixon J. Community based prevention programs targeting all injuries for children. Inj Prev 2004;10:180-5.
157. SPSS for Windows. Advanced models version 13.0. Chicago, IL: SPSS inc.
158. Starfield B: Childhood Morbidity: Comparisons, Clusters, and Trends. Pediatrics 1991;88:519-26.
159. Stark C, Wright J, Lee J, Watt L. Two years of school injuries in a Scottish education sub-division. Public Health 1996;110:229-35.
160. Statistisk Sentralbyrå (Statistics Norway). Statistikkbanken.http//www.ssb.no.
161. Steen K. Violence in an urban community. An accident and emergency department perspective. Doctorial thesis, University of Bergen, Norway. 2005.
162. Streeton C, Nolan T. Reduction in paediatric burn admissions over 25 years, 1974-94. Inj Prev 1997;3:104-9.
163. Stuart MJ, Smith AM, Malo-Ortiguera SA et al. A comparison of facial protection on the incidence of head, neck and facial injuries in Junior A hockey players. A function of individual playing time. Am J Sports Med 2002;30:39-44.
164. Sullivan PM, Knutson JF. Maltreatment and disabilities: a population based epidemiological study. Child Abuse Negl 2000;24:1257-73.
165. Sørensen L, Larsen SE, Røck ND. The epidemiology of sports injuries in school-aged children. Scand J Med Sci Sports 1996;6:281-6.

166. Taha W, Chin D, Silverberg AI, Lashiker L, Khateeb N, Anhalt H. Reduced spinal bone mineral density in adolescents of an Ultra-Othodox Jewish community in Brooklyn. Pediatrics 2001;107:E79.
167. The bicycle survey 1992, issue 217. Oslo: Institute of transport economics; 1993.
168. Thompson DC, Rivara FP. Pool fencing for preventing drowning in children. Cochrane Database Syst Rev 2000.CD001047.
169. Thompson RS, Rivara FP, Thompson DC. A case control study of the effectiveness of bicycle safety helmets. N Engl J Med 1989;320:1361-7.
170. Thuen F. The contribution of health psychology to accident prevention- a review of selected studies. Nordisk psykologi 1994;46:124-37.
171. Tiderius CJ, Landin LA, Duppe H. Decreasing incidence of fractures in children: an epidemiological analysis of 1,673 fractures in Malmo, Sweden, 1993-1994. Acta Orthop Scand 1999;70:622-6.
172. Toh S, Miura H, Arai K, Yasumura M, Wada M, Tsubo K. Schaphoid fractures in children: problems and treatment. J Pediatr Orthop 2003;23:216-21.
173. Torg JS, Vegso JJ, O'Neill MJ, Sennett B. The epidemiologic, pathologic, biomechanical and cinematographic analysis of football-induced cervical spine trauma. Am J Sports Med 1990;18:50-7.
174. Towner E, Downswell T, Jarvis S. Updating the evidence. A systematic review of what works in preventing childhood unintentional injuries: Part 2. Injury Prevention 2001;7:249-53.
175. Tredwell SJ, Van Peteghem K, Clough M. Pattern of forearm fractures in children. J Pediatr Orthop 1984;4:604-8.
176. Ueland O, Kopjar B. Occurence and trends in ski injuries in Norway. Br J Sports Med 1998;32:299-303.
177. Ueland O, Kraft P. Safety measures taken by Norwegian mothers. Inj Prev 1996;2:197-201.
178. United Nations Children's Fund. The state of the world's children. New York, Geneva: UNICEF; 2001.
179. Verd VS, Dominguez SJ, Gonzalez QM, et al. Association between calcium content of drinking water and fractures in children. An Esp Pediatr 1992;37:461-5.
180. Vestergaard P, Emborg C, Stoving RK, Hagen C, Mosekilde L, Brixen K. Fractures in patients with anorexia nervosa, bulimia nervosa, and other eating disorders - a nationwide register study. Int J Eat Disord 2002;32:301-8.
181. Waller JA. Reflections on a half century of injury control. Am J Public Health 1994;84:664-70.
182. Waters PM, Mih AD. Fractures of the distal radius and ulna. In: Beaty JH, Kasser JR, editors. Rockwood and Wilkin's fractures in children. 6th ed. Philadelphia: Lippincott Williams and Wilkins; 2006. p.337-98.
183. Wood T, Milne P. Head injuries to pedal cyclists and the promotion of helmet use in Victoria, Australia. Accid Anal Prev 1988;20;177-85.
184. World Health Organization. Injury: a leading cause of the global burden of disease. Geneva, Switzerland, WHO. 1999: 1-57.
185. World Health Organization. International classification of external causes of injuries (ICECI). 2001.
186. World Health Organization. International statistical classification of diseases and related health problems, 10th revision. Volume 1: Tabular list. (ICD-10). 1992.
187. Worlock P, Stower M, Barbor P. Pattern of fractures in accidental and non-accidental injury in children: a comparative study. BMJ 1986;293:100-2.

188. Wright JC, Vlietstra AG. The development of selective attention: From perceptual exploration to logical search. Adv Child Dev Behav 1975;10:195-239.
189. Wulff RN, Schmidt TL. Carpal fractures in children. J Pediatr Orthop 1998;18,462-5.
190. Xiang H, Stallones L, Chen G, Hostetler SG, Kelleher K. Nonfatal injuries among US children with disabling conditions. Am J Public Health 2005;95:1970-5.
191. Young CC, Niedfeldt MW. Snowboarding injuries. Am Fam Physician 1999;59:131-6.
192. Ytterstad B. The Harstad injury prevention study: hospital-based injury recording and community-based intervention. Doctorial thesis, University of Tromsø, Norway. 1995.
193. Yung PS, Lai YM, Tung PY, et al. Effects of weight bearing and non-weight bearing exercises on bone properties using calcaneal quantitative ultrasound. Br J Sports Med 2005;39:547-51.
194. Zalavras C, Nikolopoulou G, Essin D, Manjra N, Zionts LE. Pediatric fractures during skateboarding, roller skating, and scooter riding. Am J Sports Med 2005;33:568-73.
195. Zimmermann R, Gschwentner M, Pechlaner S, Gabl M. Remodeling capacity and functional outcome of palmarly versus dorsally displaced pediatric radius fractures in the distal one-third. Arch Orthop Trauma Surg 2004;124:42-8.
196. Østberg V. Social class differences in childhood mortality; Sweden 1981-1986. J Epid Com Health 1992;46:480-4.

20. Appendix 1a

SKADER PÅ BARN UNDER 16 ÅR
REGISTRERINGSSKJEMA VED BERGEN LEGEVAKT

Vi har registrert flere tusen skader på barn årlig i Bergen. Vi ønsker med dette skjemaet å registrere og finne mer ut av omstendighetene rundt alle disse skadene. På denne måten vil vi forhåpentlig kunne bidra til forslag om forebygging. Opplysningene vil følge hver enkelt journal og vil bearbeides anonymt. Utfyllingen er frivillig.

Sett kryss i alle de rubrikkene som passer og svar kort !

PASIENTENS NAVN: ______________________________

FØDSELSDATO: ______________________________

1 Skadested

- ☐ hjemme / i nærheten av hjemme **HH**
- ☐ dagmamma / barnepark **DD**
- ☐ barnehage **BB**
- ☐ skole, evt
  - ☐ skolevei **SV**
  - ☐ SFO (skolefritidsordning) **SF**
  - ☐ gym.time **SG**
  - ☐ friminutt **SM**
  - ☐ annet sted på skolen ________ **SX**
- ☐ organisert idrett **I I**
- ☐ lekeplass **LL**
- ☐ trafikk **TT**
- ☐ på tur, utflukt eller ferie, hvor?____________ **UU**
- ☐ annet sted, hvor?______________________ **XX**

2 Skjedde skaden

- ☐ ute **U**
- ☐ inne **I**

3 Når skjedde skaden ?

- ☐ i dag **D**
- ☐ i går **G**
- ☐ siste uke **U**
- ☐ mer enn 1 uke siden **M**

4 Hvilke redskaper eller situasjoner var innblandet i skaden?

- ☐ sykkel
  - ☐ trehjul sykkel **V3**
  - ☐ tohjul sykkel med støttehjul **VS**
  - ☐ tohjul sykkel **V2**
- ☐ ski
  - ☐ turski **ST**
  - ☐ alpin inklusiv slalåm og telemark **SA**
  - ☐ snowboard **SB**
- ☐ akebrett **BR**
- ☐ skøyter **IS**
- ☐ rulleskøyter, rullebrett eller rulleski **RU**
- ☐ fotballspill **FO**
- ☐ håndball, basketball eller volleyball-spill **HA**
- ☐ kampsport (karate, judo, jijitsu ,etc) **KA**
- ☐ hest **HE**
- ☐ annen lek, idrett eller annet redskap, beskriv______________________ **XX**
- ☐ ingen av disse **ZZ**

Dersom ulykke på sykkel, ski, akebrett, skøyter, rullebrett, hest eller liknende brukte du hjelm ?
ja ☐
nei ☐

⇒**BESVAR NESTE SIDE OGSÅ**⇒

5 Skademekanisme

- ☐ fall på bakken /gulvet (snubling, overtråkk) **B**
- ☐ fall fra høyde, hvor høyt?____________________ **H**
- ☐ fall på glatten **G**
- ☐ klemming/klemstring **L**
- ☐ slag/spark **S**
- ☐ forbrenning, på hva____________________ **F**
- ☐ kutt på skarp gjenstand, på hva______________ **K**
- ☐ bitt/klor ☐ dyr **D**
  - ☐ menneske **M**
- ☐ annen type skade **X**

Beskriv kort hva som skjedde:____

____

6 Skadeårsak

- ☐ ulykke **U**
- ☐ dytting, hard holding, spark eller liknende under lek/sport **D**
- ☐ slagsmål eller annen bevisst vold **S**
- ☐ skadet seg selv med vilje **V**

7 Kunne skaden vært unngått ved bedre sikring på skadested (f eks komfyrvern, strøing på glatten) eller bruk av sikringsutstyr (f eks hjelm, knebeskyttelse)?

- ☐ nei **N**
- ☐ ja, hva manglet __________**J**

____

8 Var voksen person tilstede da skaden inntraff ?

- ☐ nei **N**
- ☐ ja **J**

9 Har du noen kronisk sykdom eller handikap?

- ☐ nei **N**
- ☐ ja, hva______________________ **J**

10 Bruker du faste medisiner?

- ☐ nei **N**
- ☐ ja, i så fall hvilke _________________________**J**

11 Hvor mange ganger har du vært hos lege pga skader før ? (ikke ta med kontroller)

- ☐ ingen **0**
- ☐ 1-3 **1**
- ☐ 4-10 **2**
- ☐ mer enn 10 **3**

12 Har du brukket noe tidligere ?

- ☐ nei **N**
- ☐ ja **J**

13 Datoen som skaden skjedde ☐☐☐☐☐☐

14 Klokkeslett som skaden skjedde i hele timer ☐☐ **(f.eks 2 på dagen er 14)**

Appendix 1b

LEGEN FYLLER UT DETTE:

Pasientens kjønn: m☐ k☐

Pasientens alder: ☐☐

Diagnose:____

Behandling:____

Skadens alvorlighetsgrad vurdert etter AIS skalaen (se under)

Grader 1,2,3,4,5 eller 6 ☐

1. Liten skade:	Combustio 1° til 100%, 3° til 10%. Tannskader. Distorsjoner og frakturer i fingre og tær. Mindre kutt og kontusjoner. Hodetraume uten bevisstløshet.
2. Moderat skade:	Combustio 3° 10–20%. Kutt og laserasjoner < 10 cm. Commotio < 15 min. bevisstløshet. Ikke disloserte frakturer av lange knokler, bekken og kranium. Knusning av fingre og tær.
3. Alvorlig skade:	Combustio 3° 20–30%. Kutt og laserasjoner > 10 cm. Commotio > 15 min. bevisstløshet og amnesi. Disloserte frakturer av lange knokler. Multiple costafrakturer. Pneumothorax. Luksasjon av større ledd. Nerve- eller karskade i ekstremitetene.
4. Meget alvorlig skade:	Combustio 3° 30–40%. Større og multiple kutt og laserasjoner. Commotio med amnesi > 3 timer eller nevrologiske forandringer. Multiple eller åpne frakturer. Flail chest. Traumatisk amputasjon av ekstremiteter.
5. Kritisk skade:	Combustio 3° 40–90%. Cerebrale skader med bevisstløshet > 24 timer. Intrakraniell blødning. Columnaskader med kvadriplegi. Større thoraxskader. Multiple åpne frakturer.
6. Dødelig skade:	Maksimal skade som sannsynligvis ikke overleves. Combustio 3° > 90%.

Skadens lokalisasjon

- ☐ hode/ansikt/hals/nakke **H**
- ☐ thorax /abdomen/rygg **T**
- ☐ overekstremitet **O**
- ☐ underekstremitet **U**

Hvis bruddskade - må det da reponeres, opereres eller strekkbehandles ?

- ☐ nei **N**
- ☐ ja **J**

Hvis sårskade - må det da opereres?

- ☐ nei **N**
- ☐ ja **J**

Samsvarer skaden med sykehistorien ?

- ☐ ja **J**
- ☐ nei **N**
- ☐ usikker **U**

Mistenkes omsorgssvikt/mishandling?

- ☐ nei **N**
- ☐ ja **J**
- ☐ usikker **U**

Evt. kommentarer____

Tusen takk!

Kollega Christina Brudvik

Appendix 2

Rulleskøyte/rullebrett-skader

Ditt navn ______________________________

Din fødselsdato ______________________________

Sett kryss

Brukte du

- ☐ **rulleskøyter (rollerblades)**
- ☐ **rullebrett (skateboard)**

Brukte du

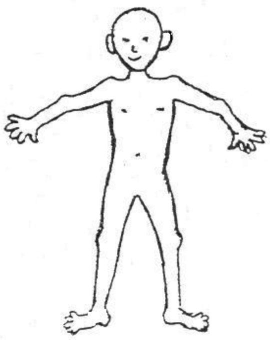
- ☐ **hjelm**
- ☐ **håndleddsbeskyttelse**
- ☐ **albubeskyttelse**
- ☐ **knebeskyttelse**
- ☐ **annet** ______________________

Hvor mange ganger har du brukt rulleskøyter/rullebrett før? __

Beskriv hvordan du skadet deg ______________________

____

Hvor på kroppen skadet du deg?
Merk av på tegningen



Takk for at du svarte. Vi vil bruke svarene anonymt som en oppfølging av en tidligere skaderegistrering. Vi vil vite om beskyttelsesutstyr kan minke skadene.
Lege/universitetslektor Christina Brudvik, Bergen Legevakt.

Appendix 3

Bergen februar 2005

Forespørsel om å delta i en studie om underarmsbrudd!

Vi ønsker å vite om behandlingen av den bruddskaden du fikk i armen i 1998 har vært vellykket ved å be deg besvare noen spørsmål. Dette er et ledd i vår fortløpende kvalitetskontroll og er et samarbeid mellom Bergen Legevakt og Haukeland Universitetssykehus. På denne måten håper vi å kunne forbedre våre tjenester.

Denne kontrollen er også en del av et forskningsprosjekt om bruddskader og barneulykker. Vi ønsker derfor å kunne skrive om funnene ved disse kontrollene i et fagmedisinsk tidsskrift. I 1998 besvarte dere et spørreskjema om hvordan skaden hadde oppstått. Vi ønsker å sammenlikne skademekanismen med skaden og til slutt med resultatet av behandlingen. Vi skal ikke bruke spørreskjemaene til noe annet.

Du trenger bare å besvare spørsmålene på neste side. Vi håper at du godkjenner å være med ved å **sette din underskrift nederst på siden**. Deltagelse er selvfølgelig frivillig og har ingenting å si for eventuell ny behandling av skaden hvis du skulle ha behov for det.
Be gjerne en voksen om hjelp hvis du lurer på hvordan du skal vri på underarmen, tegne inn streker eller noe annet på spørreskjemaet. Ring gjerne dr. Brudvik på Legevakten onsdag eller torsdag mellom kl 09 og 15 på telefon 55 568700 hvis du eller dine foreldre lurer på noe.

Svarene vil vi gjøre anonyme slik at vi bare bruker ditt kjønn og din alder. Spørreskjemaene ødelegges så snart de er dataregistrert.

Samtykkeerklæring:

Jeg, ____
underskrift
godkjenner at svarene å spørreskjemaet blir brukt slik beskrevet i teksten over. Jeg sender brevet tilbake i vedlagte konvolutt innen 15 mars 2005.

Takk for hjelpen!

Med vennlig hilsen
Christina Brudvik
Førsteamanuensis/lege

Leiv M. Hove
Professor dr. med./overlege

SNU ARKET →

Kontroll av behandling for underarmsbrudd

Sett kryss på linje eller i rute for riktig svar

ingen litt mye uutholdelig

1. Hvor store smerter hadde du da du brakk armen? |——————→
2. Hvor vond var behandlingen på legevakten /sykehuset? |——————→
3. Ville du hatt mer smertestillende medisin? ☐Ja ☐Nei ☐Vet ikke
4. Skriv gjerne hva du synes om behandlingen du fikk:

____

____

5. Har du blitt mer redd for å gå til lege etter denne skaden? ☐Ja ☐Nei ☐Vet ikke
6. Har du sluttet med aktiviteter/idrett på grunn av skaden? ☐Ja ☐Nei ☐Vet ikke
7. Hvor ofte tenker du på bruddskaden og behandlingen? ☐Aldri ☐Av og til ☐Ofte
8. Har du smerter i den skadete armen i dag? ☐Ja ☐Nei ☐Vet ikke
9. Har du svakere/forandret følelse i huden på hånden/armen? ☐Ja ☐Nei ☐Vet ikke
10. Fungerer armen dårligere enn før? ☐Ja ☐Nei ☐Vet ikke
11. Skriv gjerne noe om hvordan den skadete armen fungerer:

____

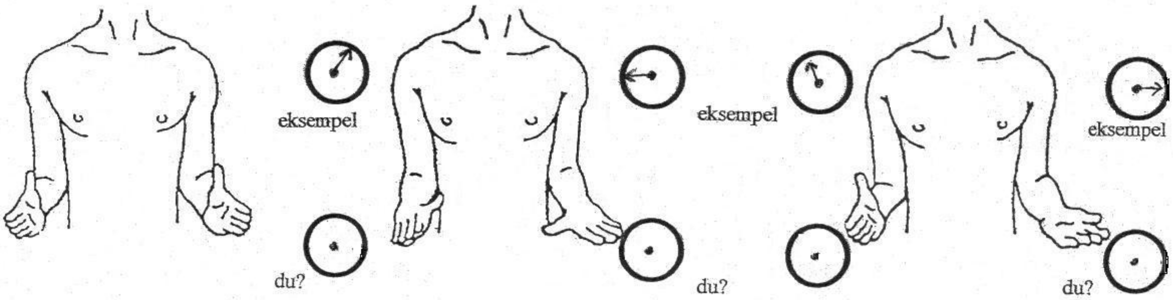
____

12. Nå skal du teste begge armene dine.

a. *Bøy i albuene, hold albuene inntil siden med tomlene opp*

b. *Vri håndflatene ned.* (sett strek på klokkene for hvor langt du klarer)

c. *Vri håndflatene opp* (sett strek på klokkene for hvor langt du klarer)



13. Klarte du å vri like mye på begge sider? ☐Ja ☐Nei ☐Usikker (Sett strek på klokkene)

Tusen takk for at du svarte på spørsmålene! Send oss svarene i den vedlagte konvolutten.

Vennlig hilsen Christina Brudvik, 1 amanuensis/lege og Leiv M Hove professor/ortoped