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## Epidemiology of Distal Forearm and Childhood Fractures in the Skåne Region, Sweden

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# Epidemiology of Distal Forearm and Childhood Fractures in the Skåne Region, Sweden

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# Epidemiology of Distal Forearm and Childhood Fractures in the Skåne Region, Sweden

Daniel Jerrhag



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DOCTORAL DISSERTATION

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April 27, 2018 at 9:00.

*Faculty opponent*

Professor Lars Adolfsson

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Dept of Orthopaedics and Clinical Sciences Skåne University Hospital, Malmö SE – 205 02 Malmö	April 27, 2018	
Daniel Jerrhag		
Epidemiology of distal forearm and childhood fractures in the Skåne region, Sweden		
<p>Fractures are common injuries especially in children and elderly, and the most common fracture in humans, regardless age, is the distal forearm fracture. The epidemiology of fractures has been described episodically since the 1950s and is constantly changing. Childhood fractures are associated with lower peak bone mass and higher adult fracture risk. By examining time trends in childhood fracture epidemiology it may be possible to estimate the vector of fragility fracture risk in the future. As few large epidemiological studies have been presented lately we set out to describe the landscape of fractures in children in the south of Sweden with special focus on the distal forearm fracture.</p> <p>Distal forearm fracture epidemiology in adults has been described frequently around the world since the 1950s, and so also in Malmö, Sweden. Generally the incidence increased until the 1980s but then plateaued or decreased. The reports so far have generally focused on the elderly population. The treatment of distal forearm fractures has the recent decades become more aggressive with a higher proportion of patients undergoing surgery, and also with more expensive procedures. Up to date data on incidence and time trends may present valuable knowledge to foresee societal costs.</p> <p>Two different study designs were used. In paper I, II and IV an ICD 10 diagnosis register covering in- and out-patient data in the Skåne region were used to describe the epidemiology of fractures between 1999 and 2010. In study III, hospital data at Malmö University Hospital were used to identify children with a distal forearm fracture. This included X-rays and medical records which were reviewed to ascertain and include cases and examine etiology of fractures. In all studies official population data were obtained from Statistics Sweden to calculate incidence.</p> <p>In children there was an annual increase in average age standardized i) over all fracture incidence rate of 2.6% (95% CI 2.4, 2.8) and ii) distal forearm fracture incidence rate of 2.2% (1.7, 2.6) between 1999 and 2010. There were 37% higher annual fracture numbers in 2010 compared with 1999. The incidence of distal forearm fractures in Malmö were more than 40% higher 2005 to 2006 compared with 1950s data from Malmö and the most common etiology was sports accidents.</p> <p>In adults (≥17 years) the annual age standardized distal forearm fracture incidence rate increased with 0.7% (0.1, 1.4) per year for men and 0.9% (0.5, 1.3) for women. Likewise there was also an increase in the subgroups men and women 17-64 years of 0.8(+0.0, 1.5) and 2.1%(1.5, 2.8), respectively. Expected demographic changes including a 25% population increase, may result in 38% more distal forearm fractures in adults until year 2050 compared with 2017. This thesis provides politicians and officials in health care important information on recent fracture data and clues on how to estimate the future resource demands. The reasons behind the incidence changes are however unclear and further research is needed in order to find ways to prevent fractures among both children and adults.</p>		
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# Epidemiology of Distal Forearm and Childhood Fractures in the Skåne Region, Sweden

Daniel Jerrhag



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*To Whom It May Concern*



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## Original Papers

- I. **Increasing wrist fracture rates in children may have major implications for future adult fracture burden**  
**A registry study involving 2.8 million patient years based on the Skåne region of Sweden, 1999–2010**  
Jerrhag D, Englund M, Petersson I, Lempešis V, Landin L, Karlsson, MK, Rosengren, BE  
*Acta Orthopaedica 2016; 87(3): 296–300.*
- II. **Epidemiology and time trends of distal forearm fractures in adults – a study of 11.2 million person – years in Sweden**  
Jerrhag D, Englund M, Karlsson MK, Rosengren BE  
*BMC Musculoskeletal Disorders. 2017; 18: 240.*
- III. **Time trends in childhood distal forearm fracture epidemiology during six decades in Sweden**  
Lempešis V, Jerrhag, D, Rosengren BE, Landin L, Tiderius CJ, Karlsson MK  
*Submitted*
- IV. **Landscape of fractures in children and adolescents – A register – based study of 3.5 million person-years in Sweden 1999 – 2010**  
Jerrhag D, Englund M, Karlsson MK, Rosengren BE  
*Submitted*

## Abbreviations

ALF	Avtal om Läkarutbildning och Forskning (Agreement on Compensation for Medical Education and Research)
APC	Age Period Cohort
BMD	Bone Mineral Density
BMI	Body Mass Index
CI	Confidence Interval
DXA	Dual-energy X-ray Absorptiometry
FRAX	Fracture Risk Assessment Tool
FoUU	Forskning, Utveckling och Utbildning (Science, Development and Education)
ICD	International Classification of Disease
IRR	Incidence Rate Ratio
PBM	Peak Bone Mass
PY	Person Years
RR	Rate Ratio
SAS	Statistical Analysis System. SAS is now a registered trademark
SBU	Statens Beredning för medicinsk och social Utvärdering (Swedish Agency for Health Technology Assessment of Social Services)
SD	Standard Deviation
SEK	Swedish Crowns
SHR	Skåne Healthcare Register
SPSS	Statistical Package for the Social Sciences
WHO	World Health Organization
X-fix	External fixation



# Introduction

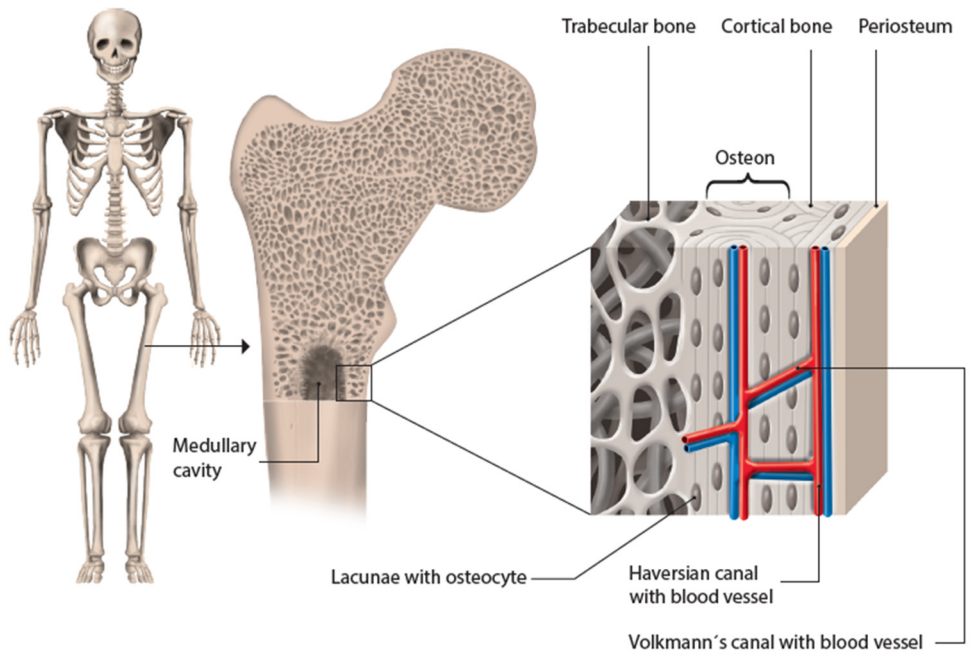
## Bone

The human skeleton consists of more than 200 different bones with four main functions. These are to serve as support for muscles and tendons, to provide protection for vital organs, provide space for the hematopoietic tissue in bone marrow, and finally as storage for minerals such as calcium, magnesium and phosphate.

Bone, however, is not only a supporting structure, but a living tissue itself. As such, it is also far from the general picture of it as a scary leftover preserved long after the death of the individual it served during life. It is a specialized form of connective tissue, distinguished by its ability to mineralize and become extremely hard and suitable for its protecting and supporting tasks.

Like other connective tissues it consists of cells and extra cellular matrix (bone matrix). The cells are of three kinds: osteoblasts, osteoclasts and osteocytes. Osteoblasts are responsible for forming the bone by secreting bone matrix, while osteoclasts resorb bone. Within the bone matrix there are innumerable spaces called lacunae, each containing an enclosed former osteoblast, now an osteocyte. The lacunae are connected to each other by microscopic channels, canaliculi, through which the osteocytes can network with each other and help to maintain bone function. This network of lacunae and canaliculi is surrounded by bone matrix mineralized by hydroxyapatite crystals. Bone tissue is organized in two ways. The hard densely calcified external portion of a bone is called cortical bone or cortex, while the inside, still consisting of the same components, is organized in a less dense network of trabecula, giving space for bone marrow. The latter is called trabecular or cancellous bone.

Around the bones there is a thin membranous tissue called periosteum, supplying the bones with blood vessels via Volkmann's and Haversian canals in the cortex (Figure 1). The periosteum also supplies the bone surface with nerves.



**Figure 1:**  
Overview of the human skeleton and main bone structure

A main characteristic of bone is its ability to resorb and rebuild. This constantly ongoing process is performed by a cluster of mainly osteoclasts and osteoblasts referred to as the bone-remodeling unit. The osteoclasts resorb bone leaving a resorption pit then filled with bone matrix by the osteoblasts. In this manner, about 10 % of the total bone volume is exchanged annually, with a higher rate (20 – 25%) in trabecular bone than in cortical bone (3 – 5%). With increasing age the resorption of bone tends to be greater than the production, resulting in a weaker skeleton; this is referred to as a negative bone turnover.

## Fractures and bone strength

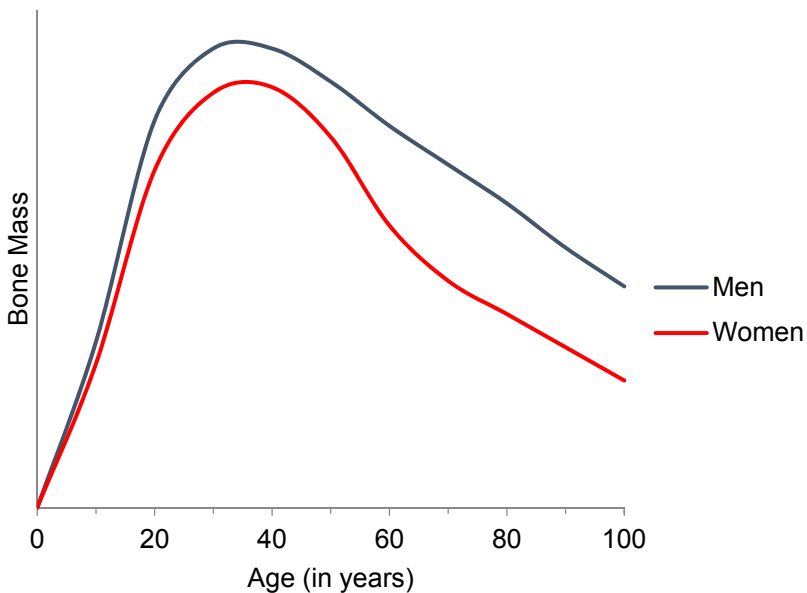
### Growing bone

The bone during childhood is in many ways different from the adult bone. Due to certain characteristics childhood fractures are also different from adult fractures. The infantile skeleton is mainly composed of cartilage that is gradually mineralized and grows harder as the child grows older. Along with a thick periosteum this makes

the bones more prone to be incompletely fractured with deformation rather than complete fractures. The long bones in children also have growth zones adjacent to the joints that are weak points, and often affected by fractures, until they are closed as the growth stops some years after puberty.

## Peak bone mass

The maximum bone mass a person achieves during life is usually reached in the third decade of life and is usually higher for men than women. This point is called the peak bone mass (PBM) (Heaney et al. 2000). After PBM has been reached there is a natural loss of bone with age (Figure 2). This is an important factor as a low PBM has been found to be a risk factor for osteoporosis and sustaining fractures later in life (Heaney et al. 2000). The PBM is decided by several factors, and genetics seems to be the single most important one, accounting for about 75% of the variance (Heaney et al. 2000). Other important factors include nutrition and level of physical activity.



**Figure 2:**  
Changes in bone mass with age.



## Fracture

A force that is applied to a bone will be absorbed by it. If this force is lower than the yield point it will not change the shape of the bone. However, any force greater than the yield point will cause damage to the bone which will, if the force continues or becomes greater, finally break the bone and separate it into two or more pieces. The yield point is determined by bone strength, but what determines bone strength?

There is no unanimous definition of bone strength as many factors influence a bone's strength and ability to resist force. These include macro and micro architecture, degree of mineralization, composition of matrix and minerals, bone turnover and more. Bone Mineral Density (BMD) is at present the most reliable tool to clinically assess bone strength. With increasing age the skeleton will be weaker due to the negative bone turnover, especially in women, and osteopenia or osteoporosis may eventually develop. } A major reason for bone frailty in women after menopause is falling estrogen levels which are linked to a decrease in BMD (Ahlborg et al. 2003) (Figure 2). The BMD is measured by a radiological method called Dual-energy X-ray Absorptiometry (DXA). The World Health Organization (WHO) recommends a definition of osteoporosis as a BMD value less than 2.5 standard deviations (SD) below the mean BMD value of young healthy adults in the same population (WHO 1994), this estimate being referred to as a T-score (Table 1).

**Table 1.**

Definition of osteoporosis by use of T-score according to the WHO (1994).

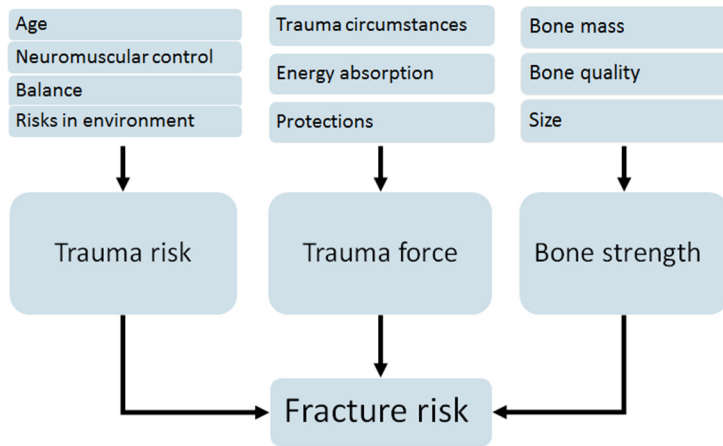
T-score	Bone Mineral Density stage
Over - 1 SD	Normal
Between - 1 and -2.5 SD	Osteopenia
Under -2.5 SD	Osteoporosis
Under -2.5 SD and $\geq 1$ osteoporosis related fracture	Severe osteoporosis

The BMD itself is however not enough to evaluate fracture risk for an individual.

## Fracture Risk

The actual individual fracture risk depends on several factors influencing the risk of falling, the trauma circumstances and bone strength. For example the risk of falling is higher if the balance is impaired or the muscles are weak. High energy trauma increases the likelihood of a fracture and a physically active life style strengthens the skeleton and might decrease the risk of sustaining a fracture. On the other hand,

a physically active lifestyle may also increase the risk of sustaining a fracture if the activity includes a high trauma risk (Figure 3).

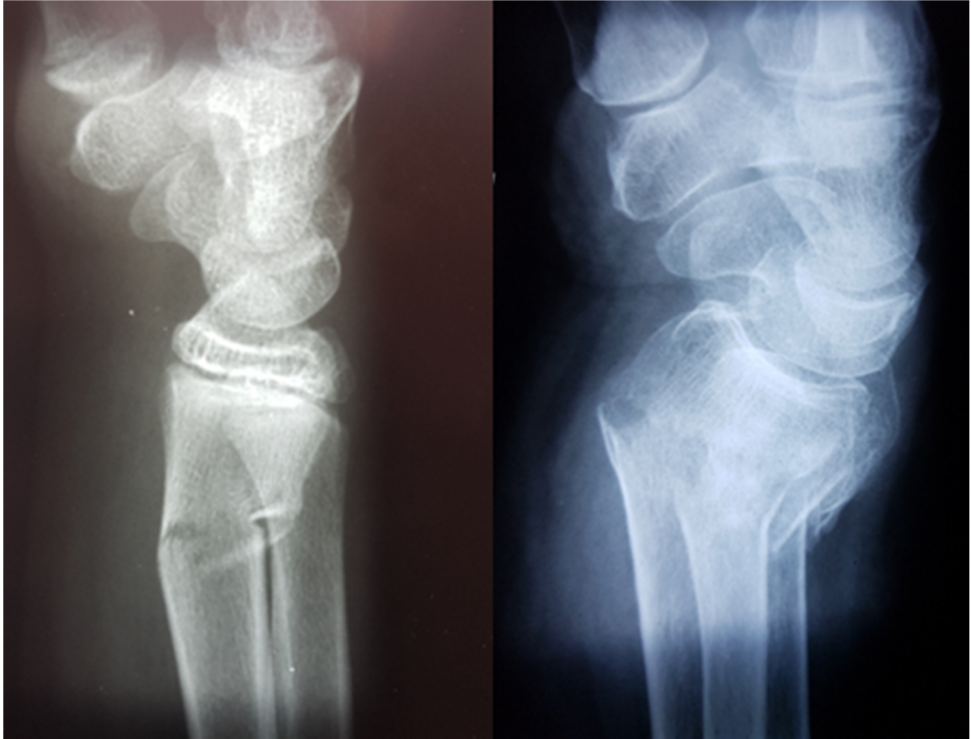


**Figure 3.**  
Example of factors affecting fracture risk.

To facilitate and simplify the estimation of fracture risk in a specific individual the on line Fracture Risk Assessment Tool (FRAX) has been developed (<https://www.sheffield.ac.uk/FRAX>). On the web page or app the patient or doctor can fill in answers to some simple questions regarding the patient and get an individual 5 or 10 year fracture risk estimate for the specific patient. The estimation is possible with or without a previous DXA examination.

### *The distal forearm fracture*

The most common fracture in both children and adults is the distal forearm fracture. It usually occurs after a fall from standing height. The fracture tends to be dorsally displaced (Colles' fracture), but is occasionally volarly displaced (Smith's fracture). It may be intra-articular or extra-articular. The left side is slightly more often affected than the right (O'Neill et al. 2001, Lofthus et al. 2008). Children tend to have incomplete fractures due to an immature bone and a thick periosteum. Most fractures in children results from playing or sports accidents (Landin 1983, Hedstrom et al. 2010). In adults most fractures results from low energy trauma in- or outdoors (Melton et al. 1998, Flinkkila et al. 2011).



**Figure 4:**  
Distal radius fracture with dorsal angulation in a child (to the left) and an adult (to the right).

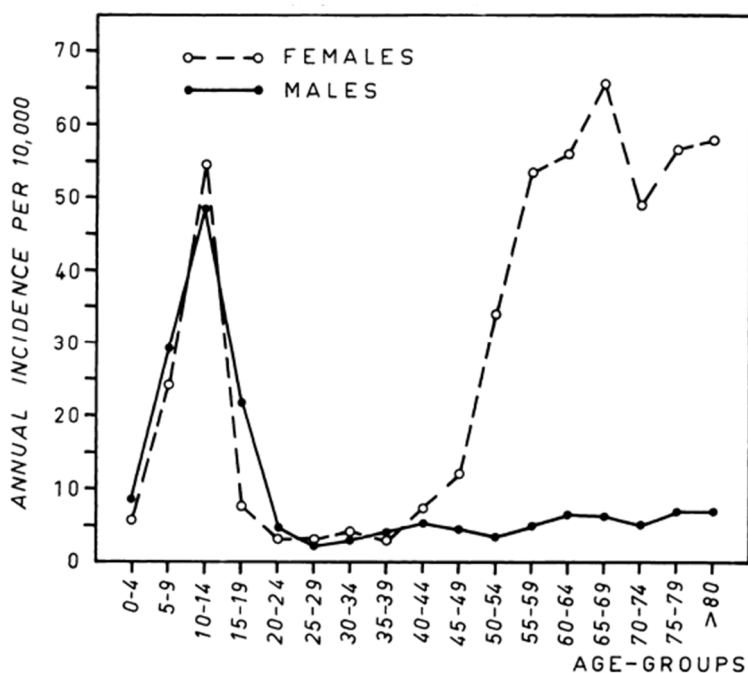
## Fracture epidemiology

The epidemiology of fractures is interesting in many respects. Fractures are a major reason for seeking medical help around the world causing both individual suffering and high societal costs. One of the cornerstones in attempts to deal with these issues is to understand the size and fundamentals of the problem. If you do not know where you are, you are unlikely to understand what you see.

Fracture rates differ between time periods, populations and geographical areas. Age, gender, lifestyle and health are some other important variables affecting the risk of sustaining a fracture.

## Time periods

In 1959 Buhr presented epidemiological data on fractures in the *Lancet* (Buhr et al. 1959). This became a starting shot for fracture epidemiology research in many places, even so in Malmö, Sweden, where Alffram (Alffram et al. 1962) described the epidemiology of forearm fractures in 1953–57. They concluded that the distal forearm fracture was about equally common in men and women until the age of 40, whereas after the age of 60 the female fracture incidence outnumbered the male by a factor of more than 7 (Figure 5).

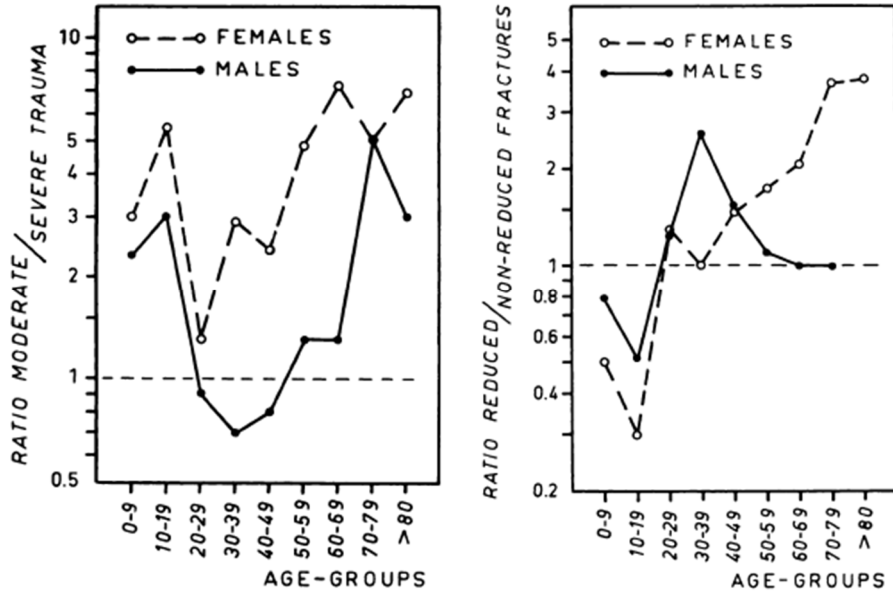


**Figure 5:**

The incidence of distal forearm fractures in Malmö, Sweden per  $10^4$  py by age and gender 1953–1957 as described by Alffram (Alffram et al. 1962).

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They also concluded that these fractures in women were more severe (i.e. needed to be manually reduced to a greater extent) despite that the severity of trauma decreased by age, suggesting fragility of especially metaphyseal bone as an explanation (Figure 6).



**Figure 6:** Severity of trauma and severity of fracture ratios in distal forearm fractures between men and women as described by Alffram 1962 (Alffram et al. 1962). Published with permission from the author, Per-Axel Alffram.

The incidence of distal forearm fractures increased both in children and in adults from the 1950s to the 1980s, but then seemed to plateau in both children and adults. The reasons for variations over time are unclear and probably reflect changes in many factors. The changes may partly be explained by so called cohort effects. The main reasons for an increasing or decreasing incidence in a study of present day may reflect changes in factors further back in time, in childhood or even during the prenatal period affecting only individuals born at a certain time.

## Population and Geography

Incidence might differ between adjacent geographical areas even if the populations seem to be similar. Some studies have for instance shown higher fracture incidence rates in rural than in urban areas (Sogaard et al. 2007, Hedstrom et al. 2014).

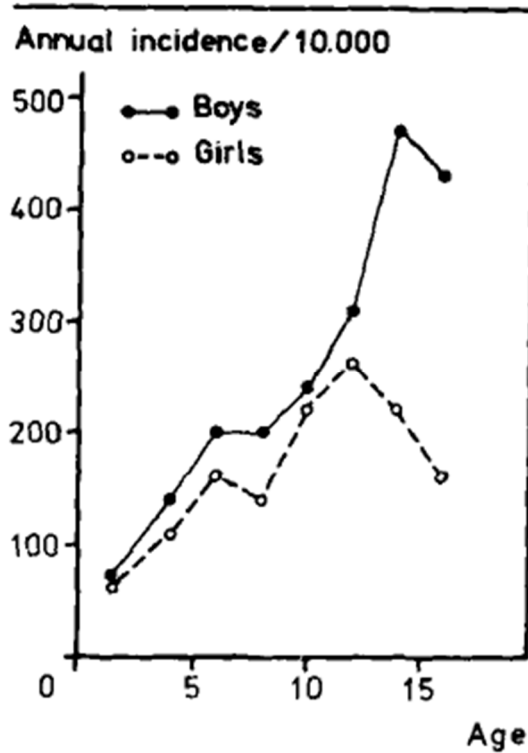
## **Age and gender**

Many factors may exert an influence on the fracture incidence in a population. As the risk of sustaining fractures changes with age, the age-profile of a population may affect incidence rates profoundly unless standardized for age. The incidence is higher in childhood and in the elderly, while young adults generally have a lower incidence. There are also differences between genders. Both men and women have high incidence rates during childhood and then rates decline to low levels in young adulthood (Landin 1983). After menopause, rates for women increase dramatically with age due to bone frailty, while rates in men increase just slightly with age (Rosengren et al. 2015).

## **Fractures in children**

Fractures are common in children. Landin established a landmark in the knowledge of childhood fractures with his thesis on fracture patterns in Malmö children, Sweden during the years 1975 to 1979 (Landin 1983). Among other things, he concluded that the fracture incidence had doubled for both genders since the 1950s, and that the accumulated risk of sustaining a fracture before the age of 17 was 42% in boys and 28% in girls and that the distal forearm was the most common fracture site in both genders. These risk figures should, however be interpreted with some caution. All fractures were included in the estimation, i.e. more than one fracture may have been included for a specific individual and the cohort was not continuously followed from birth to age 16 years.

The overall fracture incidence in children is known to increase by age and peak fracture incidence occurs in the early teens for girls and a couple of years later for boys (Landin 1983). In both genders, the fracture incidence then decreases to low levels, more quickly in girls than boys (Figure 7).



**Figure 7:** The incidence of childhood ( $\leq 16$  years) fractures by age and gender as described by Landin in Malmö in 1983. Published with permission from the author, Lennart Landin.

Different fracture types are known to strike different ages in childhood, and the distribution between genders is also different, with higher rates in boys than in girls (Landin 1983).

The recent trend in fracture incidence in children is not clear as some studies report a decreasing incidence (Tiderius et al. 1999, Mayranpaa et al. 2010), others an increasing incidence (Lyons et al. 1999, Hedstrom et al. 2010) and some a stable fracture incidence (Cooper et al. 2004).

Even though the incidence of fractures is high in children a childhood fracture is rarely severe as the vast majority mend without complications and no other treatment than immobilization. Even in cases where surgery is needed the children tend to recover completely.

## **The distal forearm fracture**

The distal forearm fracture, also called distal radius fracture or wrist fracture, is the most common fracture in both children and adults. Usually it occurs after mild trauma such as a fall from standing. Like most fractures, it most often heals well without complications in children. In young adults it is quite unusual, as are most fractures, but with increasing age wrist fractures become more common again, especially in women after menopause.

In recent decades, a shift in treatment has occurred with an increasing proportion of patients undergoing surgery (Mellstrand-Navarro et al. 2014). The surgical technique has also changed from simple to more advanced methods (Wilcke et al. 2013, Mellstrand-Navarro et al. 2014). As a result, treatment costs have increased (SBU 2017).

### *Definition*

A fracture is usually considered a distal forearm fracture if it involves the metaphysis of the bone. The border between diaphysis and metaphysis is, however, not clearly defined and a few slightly different definitions have been proposed, especially in children (Schneidmuller et al. 2011, Joeris et al. 2017).

## **Treatment of distal forearm fractures**

### **Non-surgical**

Historically, and still, a simple plaster will do the job in most cases. About 75% of all distal forearm fractures are treated non-surgically (Mellstrand-Navarro et al. 2014) When a patient presents after a trauma with a fracture, it will be assessed by a physician and considered either displaced or non-displaced based on an X-ray examination.

A non-displaced fracture will be treated with a plaster for 4 to 5 weeks. A displaced fracture will normally be reduced before immobilization with a plaster. A displaced fracture that has been adequately reduced will be followed up after approximately 1 week and controlled with X-ray to rule out re-displacement.



## **Surgical**

If the fracture is not possible to reduce and the displacement of the fracture stays unacceptable, or a re-displacement has occurred at the control after a week, given the specific patient's demands, it is normally considered for surgery. There are quite a few techniques and combinations of techniques to surgically reduce and fix a distal forearm fracture.

### *External fixation*

With an external fixation the fracture is bridged with an external frame connected to pins attached to the proximal fragment in the radius and in a metacarpal bone in the hand. It is considered as a minimally invasive technique.

### *Percutaneous pinning*

Pinning is another minimally invasive technique where pins are used to stabilize the fracture after closed reduction. The pins are placed in the bone percutaneously, via small incisions in the skin.

### *Plating*

The most recently developed method is plating, which includes an open reduction of the fracture after which a plate is attached to the bone by screws. The plate is usually placed on the volar aspect of the distal radius and a combination of locking and non-locking screws is normally used. Depending on the fracture characteristics there are also plates for radial and dorsal use.

## **Economic aspects**

The last decade has seen a change in the treatment of distal forearm fractures in two ways: (i) A greater proportion of the patients is treated with surgery. (ii) The previously preferred surgical procedures external fixation and percutaneous pinning have almost been replaced by open surgery with plating (Wilcke et al. 2013, Mellstrand-Navarro et al. 2014). As surgery is a more expensive treatment than a non-surgical treatment, and as open surgical treatment with plating is more expensive than external fixation and pinning, this has led to higher costs. Has the outcome of distal forearm fractures been improved?

This subject has been debated recently and the answer is mainly no (SBU 2017). For this reason it would be valuable if surgeons could reach a consensus on how to treat this fracture type in a responsible way.

Much attention has been paid to fractures among children and elderly, but even though the majority of fractures strike those parts of the population, a distal forearm

fracture in working ages is probably more expensive due to costs for absence from work.

To be able to maintain a high healthcare standard, not only in fracture treatment, but in all health care facets it is necessary for those who prioritize between patient groups to know the expected needs in different areas. In this, up to date epidemiological data have an important role to play.

## Known clues to project the future

In the western world the demography is expected to change dramatically in the coming decades as life expectancy increases and birth rates are low (Christensen et al. 2009). In plain text this means that fewer and fewer tax payers will have to support the medical costs of more and more elderly.

In a report by Odén et al, the number of individuals  $\geq 50$  years with a high risk of sustaining an osteoporotic fracture was projected to double worldwide, from 157 million people in 2010 to 319 million people in 2040, due to demographic changes (Oden et al. 2015).



# Aims of the thesis

*The aims of this thesis were:*

- To describe the incidence, incidence age- and time-trends, and number of distal forearm fractures in the Skåne region in the south of Sweden.
- To describe the incidence, incidence age- and time-trends, and numbers of all fractures in children in the Skåne region in the south of Sweden.
- To describe childhood distal forearm fracture incidence time-trends in Malmö since the 1950s and also actual etiology of this fracture type in Malmö 2005/2006.
- To estimate future national distal forearm fracture numbers in adults in Sweden.



# Patients and methods

Papers I, II and IV in this thesis are based on register studies of the population in the Skåne region, the southernmost part of Sweden. The official database of Statistics Sweden was used to identify the study population and the Skåne Healthcare Register (SHR) was used to identify the individuals suffering from a fracture during the years 1999 – 2010.

Paper III is different as the study population includes only the population of Malmö (derived from Statistics Sweden), the largest city in the Skåne region. The study method was based on review of X-rays and medical records, which is the gold standard method for studying fracture epidemiology.

We used SAS system v 9.2, SPSS v 17.0 and Microsoft Excel 2010 for data management and statistical calculations. We considered a  $p < 0.05$  as a statistically significant difference.

## Statistics Sweden and population

Statistics Sweden is an official, mainly government-funded, authority that holds databases on multiple areas of the Swedish population including detailed regional census since 1968. The main task is to supply statistics for decision making, research and debate. General descriptive data are free of charge and easily accessed via the internet without any demands for registration (Statistics Sweden).

The Skåne region is the southernmost region in Sweden with both urban and rural areas. The population as a whole was 1.3 million in 2016, which constitutes 13% of the Swedish population. The largest city Malmö had approximately 320 000 citizens in 2016, making it the third largest city in Sweden (Statistics Sweden).

# Skåne Healthcare Register (SHR)

The Skåne Healthcare Register (SHR) is an in- and outpatient diagnosis register covering all public health care units. Accurate registration of individuals in the register is possible as each Swedish citizen has a unique 12-digit personal number which is registered in all contacts with the healthcare system. The personal number can then be linked to personal information such as sex, birthdate, contacts with healthcare and physicians and diagnosis.

For diagnosis the International Classification of Diseases (ICD) 10 code system has been used since 1996.

## **Validity**

The SHR started in 1998 and has been validated specifically for distal forearm fractures in adults with a sensitivity of 90% and a positive predictive value of 94%, compared to gold standard procedure, i.e. examination of X-rays and medical records (Rosengren et al. 2015). Information on the affected side (right and left) is not included in the register; bilateral fractures will thus only be registered as one fracture. Citizens of the Skåne region who incur a fracture and seek medical aid for it outside the Skåne region, for example during a holiday, will not be registered. It is however customary for follow-up of such injuries, to be referred to the home hospital. At such a follow-up visit the fracture will be registered.

## **Wash-out**

To minimize multiple registrations of the same fracture in papers I, II and IV we decided to use a washout of 365 days. If an individual was identified with a fracture that individual was excluded from the register (and the denominator) for that specific fracture type for 365 days. As the treatment in the vast majority of all fractures in children and distal forearm fractures in adults is finished by that time, any newly registered fracture after this period is likely to be a new fracture.

The register was started 1998, but this first year was used only as washout for 1999.

# Malmö Pediatric Fracture Register

## Identification of fracture cases

### *Earlier data from 1950–1994*

From beginning of the 20<sup>th</sup> century until 2001 referrals, reports and radiographs from the only emergency hospital in Malmö (Skåne University Hospital Malmö) have been saved and stored in an archive. The radiographs are archived according to year and diagnosis in chronological order. Thus all persons suffering from a specific fracture one year are stored in sequence in the archive, and thereby easy to identify.

This archive has previously been used to set up a database of pediatric fractures for the years 1950, 1955, 1960, 1965, 1970, 1975–79 (Landin 1983) and 1993–1994 (Tiderius et al. 1999). As no age and gender adjustments were included in the previous reports it is not known whether the reported changes were, fully, partly or not at all, due to demographic changes.

### *New data from 2005 to 2006*

When the hospital in 2001 changed from physical to digital X-ray films a new archive was set up. Unfortunately it was decided not to register diagnosis for each examined X-ray film, as had previously been done. Therefore the X-rays for each patient were found by the unique 12-digit personal number that all Swedish citizens have. To find cases for the years 2005 to 2006 the hospitals diagnosis registers were searched for visits including a fracture diagnosis. The medical records and X-rays were then reviewed to verify cases and to avoid multiple registrations.

## Validity

To validate the register for 2005 to 2006 we searched the digital in- and outpatient diagnosis register of the hospital for fractures in citizens 17 years between January 1 and February 28, 2005. A total of 103 fractures were identified. For the same period all digital X-rays for patients <17 years, irrespective of referral unit or reason for referral, were examined, and 103 fractures were identified. When the results were compared, 100 fractures were identified by both methods, while only three were uniquely identified by one of the methods, representing a misclassification rate of 3%.



## Washout

As the cases for this study were verified manually by examination of medical charts and X-ray examinations no washout was needed. Fractured side (left or right) was noted and a new fracture on the other side or a new fracture on the same side, during the examination period was thus registered as a new one.

## Ethics

The studies were approved by the Ethical Review Board at Lund University, reference number 2011/432 for papers I, II and IV and reference number 2010/191 for paper III. The studies were conducted in accordance with the Declaration of Helsinki. None of the authors have any competing interests.

## Funding

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## Paper I

For the period 1999 to 2010 we used the SHR to identify residents in Skåne region  $\leq 16$  years with a distal forearm fracture. The ICD 10 codes used were those for open and closed fractures of the distal radius and open and closed fractures of both distal radius and ulna (S52.50, S52.51, S52.60, S52.61). Washout was set at 365 days.

To estimate the persons at risk (for each gender and 1-year age class) during each individual year of observation we used the Statistics Sweden database on population. We used the average of the population at the start of each year (December 31 of the year before) and the end of the year (December 31 of the year of interest).

The denominator (population at risk) for the overall incidence estimations was estimated in person years (py) by adding the population at risk of each of the years under consideration (1999–2010). For estimation of temporal trends in incidence

rates, we tabulated data by year and used Poisson regression of annual crude as well as direct age-standardized incidence rates. We used the average annual population during the years examined as the standard population.

Differences in age-rate distribution between periods were examined by Poisson regression with incidence as dependent variable and time and period as factors with interaction. To allow for comparison with more distant time points we retrieved fracture data from previously published studies on children in Malmö (Alffram et al. 1962, Landin 1983, Tiderius et al. 1999). The fracture data in those studies were collected from manual review of medical records and/or X-ray films.

## Paper II

For the period 1999 to 2010 we used the SHR to identify all residents in Skåne region  $\geq 17$  years with a distal forearm fracture. The method used was exactly the same as in paper I with the following exceptions (i) No comparison with historical data was performed and (ii) To estimate the number of expected distal forearm fractures in the whole of Sweden in the coming decades we used Statistic Sweden's demographic forecast for the years 2017 to 2050 (Statistics Sweden). We then applied the overall incidence during our observation period (in one-year age classes) for Skåne region 1999–2010 to estimate future fracture numbers.

## Paper III

Historical distal forearm fracture data for children  $< 16$  years for the years was derived from the Malmö Pediatric Fracture Register (described in the section with the same name above) for the years 1950, 1955, 1960, 1965, 1970, 1975–1979 and 1993–1994.

As the hospital switched from physical to digital X-ray the historical method (Alffram et al. 1962, Landin 1983, Tiderius et al. 1999) to identify cases was no longer available from 2001. To ascertain fracture data for 2005 and 2006 the hospital's digital diagnosis records were searched for the ICD 10 codes for forearm fractures in general (S52) and for closed and open fractures of the distal radius and/or ulna specifically (S52.50, S52.51, S52.60 and S52.61).

For each identified potential fracture event the patient-specific digital X-rays were reviewed. A fracture was included in the study only if it was visually verified as a distal forearm fracture according to the historical inclusion criteria (Landin 1983, Tiderius et al. 1999). A distal forearm fracture was defined as a fracture of the radius

and/or the ulna located distal to the diaphysis. The point where the cortex attained a constant thickness defined the border between the diaphysis and the metaphyses. To avoid classification errors, all X-rays with fractures of the entire forearm (ICD S52) were also reviewed.

As many children suffering from a fracture are followed up, and sometimes with an X-ray, all visits for each patient were reviewed which made it possible to avoid multiple registration of the same fracture.

Medical charts, referrals and X-ray reports were used as information sources for fracture etiology (activity related to the fracture).

As in earlier reports (Landin 1983, Tiderius et al. 1999) multiple fractures on the same patient were registered as unique fractures and a re-fracture at the same site within a year as a new fracture. If an individual in Sweden suffers a fracture away from home, the hospital responsible for the initial treatment will usually refer the patient to the home hospital for follow-up, and therefore most residents initially treated elsewhere would be included.

For each verified fracture we registered patient age, gender, fracture date, fracture side and the activity leading to the fracture.

The previously reported distal forearm fracture data were grouped in 5 periods (1950/1955, 1960/1965, 1970/1975, 1976–1979, 1993–1994) and the new data from 2005–2006 as a separate period. Thereafter the total and gender-specific incidence rates of distal forearm fractures during each period were estimated. The results are presented as number of fractures, mean fracture incidences per 100 000 person-years (py) or as proportions (%) of all fractures. The population at risk (city residents <16 years) during each period was available through the official records of Statistics Sweden (Statistics Sweden). In order to estimate the age- and gender-standardized rates we utilized direct standardization to the average population at risk (in one-year classes) during the study period as reference. Differences in rates were estimated using rate ratios (RR) by Chi-square distribution including 95% confidence intervals (95% CI) to describe uncertainty.

## Paper IV

From 1999 to 2010 we used the SHR to ascertain all diagnosed fractures in children and adolescents  $\leq 20$  years residing in the region (3.548 million py) by using physician-set diagnostic codes according to the Swedish version of the International Classification of Diseases (ICD) 10 system. The included fractures and codes were: Pelvis (S32.1-32.5, S32.8), Vertebra (S12.0-S12.2, S12.7, S22.0, S22.1, S32.0, M485, Skull (S02.0-S02.4, S02.6-S02.9), Rib and sternum (S22.2-S22.4), Clavicle

(S42.0), Scapula (S42.1), Proximal humerus (S42.2), Humerus diaphysis (S42.3), Elbow (S42.4, S52.0, S52.1), Radius and ulna diaphysis (S52.2-52.4), Wrist (S52.5, S52.6, S52.8), Hand (S62.0-S62.7), Hip (S720-S72.2), Femur diaphysis (S72.3), Distal femur (S72.4), Patella (S82.0), Proximal tibia and fibula (S82.1) Tibia and fibula diaphysis (S82.2, S82.4), Ankle (S82.3, S82.5, S82.6, S82.8) and Foot (S92.0-S92.5, S92.7, S92.9).

From the complete data set we estimated sex-specific incidence rates per 100 000 py using the cumulative annual population  $\leq 20$  years, in one year age classes from Statistics Sweden as denominator (population at risk) (Statistics Sweden). For estimation of temporal trends, we tabulated data by year and used Poisson regression of annual direct age-standardized incidence rates (with the average population during the examined years as the standard population) and included 95% confidence intervals (95% CI) to describe uncertainty.

To estimate the total number of fractures in children and adolescents in the whole of Sweden in the coming decade, the overall 1-year age group specific incidence rate during the examination period from 1999 to 2010 from the Skåne region was applied to the demographic forecasts for Sweden for each of the years 2017–2030 derived from Statistics Sweden (Statistics Sweden).



# Summary of papers

## Paper I

### **Increasing wrist fracture rates in children may have major implications for future adult fracture burden – A registry study of 2.8 million patient years in Skåne region, Sweden 1999–2010**

**Introduction:** The aim of this study was (i) to describe the incidence and time trends of distal forearm fractures in children  $\leq 16$  years of age and (ii) to estimate the vector of fragility fracture risk in the future as childhood fractures are associated with lower peak bone mass (a determinant of osteoporosis in old age) and higher adult fracture risk.

**Results:** The distal forearm fracture rate during the period 1999-2010 was 63.4 per  $10^4$  py (75.0 for boys and 51.2 for girls). This was 50% higher compared with the 1950s. Also within the period 1999-2010 we found increasing rates for both boys (+2.0% (95% CI 1.5, 2.6)) and girls (+2.4% (1.7, 3.1)).

**Conclusion:** Distal forearm fracture rate in children is presently 50% higher than in the 1950s and seems to be increasing further. The reasons for this increase are not clear but may be associated with a more sedentary lifestyle or changes in risk behavior. If the higher fracture risk follows the children into old age, fragility fracture numbers may rocket as also an upturn in life-expectancy has also been suggested.

## Paper II

### **Epidemiology and Time Trends of Distal Forearm Fractures in Adults – A Study of 11.2 Million Person-years in the Skåne region, Sweden**

**Introduction:** The aim of this study was to describe recent epidemiology and time trends of distal forearm fractures in an adult population  $\geq 17$  years during the period 1999 to 2010. As fractures of the distal forearm in working ages present challenges

in terms of treatment, sick-leave and possible sequelae, special attention was paid to fractures in individuals from 17 to 64 years of age.

**Results:** There were a 30% higher annual numbers in 2010 compared with 1999 and an increase in the annual age-standardized incidence in both men, +0.7% per annum (95% CI 0.1, 1.4), and women, +0.9% (0.5, 1.3). This was mainly due to an increased annual incidence in working ages (17–64 years), +0.8% (+0.0, 1.5) for men and +2.1% (1.5, 2.8) for women.

**Conclusion:** There is an increase in incidence of distal forearm fractures in adults in the Skåne region, which seems to be driven mainly by an increase in working ages. This may present special challenges to the healthcare system with increased costs for society.

## Paper III

### **Time Trends in Childhood Distal Forearm Fracture Epidemiology during Six Decades in Sweden**

**Introduction:** The aim of the study was to describe the epidemiology of distal forearm fractures in children <16 years in Malmö, Sweden in 2005 and 2006. We also set out to conduct comparisons with historical figures from Malmö.

**Results:** By the use of medical records and digital X-ray films a total of 521 distal forearm fractures were identified during 2005 and 2006 representing a crude incidence of 56.4 per 10<sup>4</sup> py (71.9 for boys and 40.1 for girls). There were no evident changes when comparing the age-standardized incidence for 2005–2006 with those for 1993–1994, however a non-significant tendency of an increase in boys (RR 1.2 (0.98, 1.6)) and a non-significant tendency of a decrease in girls (RR 0.8 (0.6, 1.1)). However there was an increase in both crude (+46%) and age standardized (+44%) incidence totally and in boys and girls respectively when comparing data from 2005–2006 with data from 1950 and 1955.

**Conclusion:** There was an over 40% higher incidence in 2005–2006 compared to 1950s (1950 and 1955). Compared with 1993–1994 the incidence rates seem to have plateaued, although with tendencies for an increase in boys and a decrease in girls.

## Paper IV

### **Landscape of Fractures in Children and Adolescents - A register-based study of 3.5 million person-years in Sweden 1999–2010**

**Introduction:** Epidemiology data on childhood fractures are common but trends regarding recent decades are sparse. As childhood fractures are associated with lower Bone Mineral Density (BMD) and Peak Bone Mass (PBM) and a higher adult fracture risk it is important to have up-to-date data. We aimed to describe the landscape of fractures in children aged  $\leq 20$  years in the Skåne region, Sweden, for 1999 to 2010 and ascertained fractures through the SHR and acquired annual high-resolution population data from Statistics Sweden.

**Results:** We identified 71 525 fractures during 3.5 million py representing an overall fracture incidence rate of 205 per  $10^4$  py. We found 37% more fractures in 2010 compared to 1999. The overall age-adjusted incidence increased by 2.6% (CI 2.4, 2.8) per year.

**Conclusion:** The incidence of childhood fractures is increasing. As it is known that fractures in childhood are associated with increased risk of adult fractures, these findings are troublesome, especially since the proportion of elderly is expected to increase in the years to come.





# General discussion

No matter what study design is used to answer a scientific question, questions should be raised as to whether it is suitable or not. When it comes to fracture epidemiology the examination of X-rays and medical records is regarded as the gold standard method, as the validity by this method is usually very high. Even though register studies, which most of this thesis is built on, are subject to the risk of bias, they are usually robust as it is easy to include many cases. Thus, if done properly, they are most suitable for evaluation of relative changes such as temporal trends.

One out of four studies (study III) included in this thesis is based on gold standard data while the rest are register-based (studies I, II and IV). Both study I and III are reports on distal forearm fracture epidemiology among children in the south of Sweden. As the results from these studies differ there are reasons to try to find explanations. Is it possible that both of the studies reflect the reality?

## Children

### Child-adult border

The papers in this thesis all include different age limits. In paper I children are defined as  $\leq 16$  years, in paper III as  $\leq 15$  years and in paper IV as  $\leq 20$  years. The limit used in paper I was selected as earlier Malmö data used that limit and in concordance with this the limit for adults in paper II was set to  $\geq 17$  years. In paper III the aim was to use the same age span as in earlier Malmö data. After the process of fracture ascertainment, however, we identified a problem regarding the cases in the 16-year old children in 2005/2006, possibly also influencing the historical data. We therefore decided to include only children  $\leq 15$  years and thus also excluded the 16 year old cases from earlier data to make comparisons as accurate as possible. In study IV we set the limit to  $\leq 20$  as to complement an earlier study on the landscape of adult fractures that included the patients 20 years or older (Rosengren et al. 2015) while still enabling comparisons to most other studies examining fracture epidemiology in children. It would have been logical to use the same age limit in all studies, but it is however not obvious at what age that limit should be set.

## Distal forearm fractures

### *Comparison of methods in papers I and III*

Apart from the different fracture ascertainment methods, the most obvious methodological differences between the two studies were that paper I included the whole population  $\leq 16$  years of Skåne region during a 12-year period (1999 to 2010) while paper III included only the population  $\leq 15$  years of Malmö during a 2-year period (2005 and 2006).

In paper I only register data from Skåne Healthcare Register (SHR) were used. This register is based on data from health care providers and the hospital register used in paper III is also included in paper I. The SHR was searched for the ICD 10 codes for distal forearm fractures (S52.50/51 and S52.60/61). The validity of the data relies on codes set by many different doctors, not only orthopaedic specialists. This might be a problem, as every single incorrectly diagnosed fracture will lead to an incorrectly included or excluded case. To calculate incidence, official population data from Statistics Sweden were used. All cases that were not citizens of the Skåne region at the time of their fracture were excluded. Even though patients injured elsewhere are usually referred to follow-up at home, and then included, a few such cases could have been lost if not referred to a home hospital. To avoid multiple registrations we used a wash out period of 365 days. Any new fracture of the same type during this period will thus not be registered. On the other hand a complicated case with follow-up after more than a year will be counted as a new fracture. As the register does not include information on left and right, bilateral cases will be counted as only one fracture.

In paper III we used a gold standard method. The hospital records in Malmö were searched for the distal forearm fracture ICD 10 codes (S52.50/51 and S52.60/61) and once found the X-ray films and medical charts for these cases were reviewed and verified according to set criteria (see method paper III) by a single orthopaedic surgeon. To avoid classification errors, X-rays for every case with a fracture that involved either the distal forearm or the diaphysis were reviewed. All cases addresses were checked, so that only citizens living in Malmö were included. We also validated the case finding strategy and found a misclassification rate of only 3%. The incidence rates were then calculated with official population data from Statistics Sweden. A falsely high incidence, by this method, seems highly unlikely. As fractures usually are diagnosed and treated by orthopaedic surgeons the risk of missing cases seems low. Childhood fractures of the distal forearm are however common, and usually not severe. Many of those fractures are treated with just a plaster and the parents are told to remove it after a couple of weeks when the pain has vanished. Thus, there is a possibility that some cases have been diagnosed elsewhere and told that no follow-up was needed when returning home; though probably few, any such cases would have been lost in study III.

Another problem concerning both studies is how to decide what a distal forearm fracture is, especially in children. Hedström et al made a validation of fracture site recording in their material and found that 20% were incorrectly diagnosed (Hedstrom et al. 2010). In study I we may have missed a few distal forearm fractures diagnosed as fractures of the diaphysis and may also have included some fractures of the diaphysis classified as distal fractures. In study III the criteria for a distal forearm fracture are strict, which makes comparisons with earlier Malmö studies with the same criteria more reliable. However there are a few other, slightly different classification systems which may complicate comparison with reports from other centers (Schneidmuller et al. 2011, Joeris et al. 2017).

### *Comparison of results in papers I and III*

Both methods seem valid and still the incidence figures from Malmö are lower than those for the whole Skåne region. This is peculiar as fracture incidence is usually higher in urban than in rural areas (Hedstrom et al. 2014).

In an attempt to find explanations we decided to tabulate the data from the two studies and present results for as similar populations as possible. In table 2 the data are presented in the same age spans (0–15), the same time period (2005–2006), and age-standardized by the use of the same reference population. It is now obvious that the previously evident differences between the results in study I and III are less pronounced. When the Malmö population was age-standardized to the average population of Skåne region 2005 and 2006 the point estimate of the incidence difference in boys was were small, but remained large and statistically significant in girls. It thus seems as if the difference in total incidence rates between the two studies is driven mainly by a lower fracture incidence among the Malmö girls (Table 2, Figure 8).

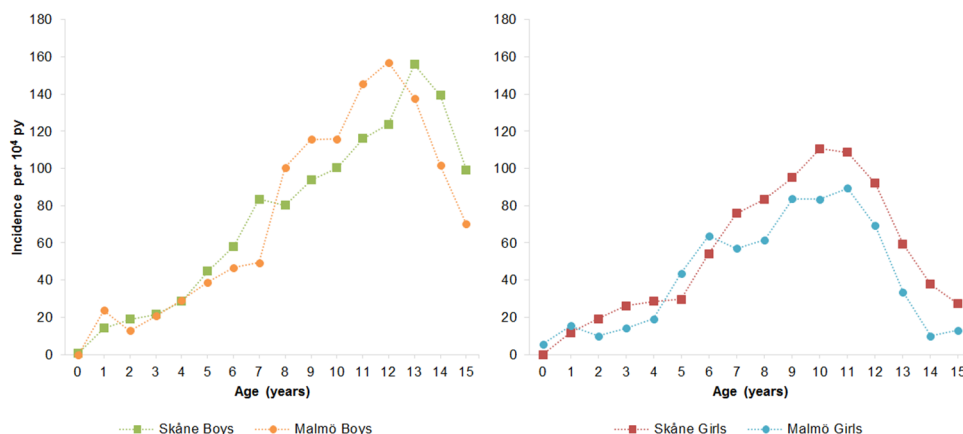
**Table 2:**

Comparison of distal forearm incidence rates per 10<sup>4</sup> in Malmö (paper III) and Skåne (paper I), with different age spans and years. Incidence Rate Ratios (IRR) between Skåne and Malmö figures presented with 95% CI in brackets).

	Location	Age	Year	Note	Incidence per 10 <sup>4</sup> py		
					Boys	Girls	All
1	Malmö	0-15	2005-2006	Crude	71.9	40.1	56.4
2	Malmö	0-15	2005-2006	Adjusted <sup>a</sup>	75.9	41.7	59.3
3	Skåne	0-16	1999-2010	Crude	75.0	51.2	63.4
4	Skåne	0-15	1999-2010	Crude	75.8	53.1	64.8
5	Skåne	0-15	2005-2006	Crude	77.1	54.1	65.9
IRR Skåne/Malmö (line 5 vs 1)					1.07 (0.95, 1.20)	1.35 (1.15, 1.58)*	1.17 (1.06, 1.28)*
IRR Skåne Malmö (line 5 vs 2)					1.02 (0.95, 1.09)	1.30 (1.19, 1.42)*	1.11 (1.05, 1.17)*

a) Age standardized to the Skåne population 2005-2006

\* Statistically significant

**Figure 8:**

Age standardized distal forearm fracture incidence rates per 10<sup>4</sup> py 0-15 years in boys and girls in Skåne and Malmö 2005 to 2006.

Apart from the possibility, that one or maybe both of the studies do not reflect reality, a more likely reason for at least some of the difference is different populations at risk. One aspect of populations at risk that has not been considered in these studies is ethnicity. This will be discussed later (see headline Gender).

When put into perspective the results of these studies have parallels with other centers. Hedström et al reported a total incidence for distal forearm fractures of 59.1 per 10<sup>4</sup> py and 74.0 and 43.0 per 10<sup>4</sup> py for boys and girls respectively for the years 2006 and 2007, thus similar to the results in study I regarding incidence in boys and totally. The incidence in girls however is closer to the results in study III. As the study performed by Hedström et al include individuals aged ≤19 years their reported

incidence would increase if the age span had been  $\leq 15$ , especially in girls as their peak in distal forearm fractures occur earlier than in boys. (Hedstrom et al. 2010). On the other hand by use of the gold standard method in the report by Mäyränpää et al from Finland (Mayranpaa et al. 2010), the total distal forearm fracture incidence rate in children  $\leq 15$  years was 49.6 per  $10^4$  (62.7 for boys and 36.1 for girls), thus lower than the results from our Malmö study (paper III). The differences might be a result of different populations at risk but other explanations cannot be ruled out.

### *Incidence trends*

The results from the SHR (paper I) showed an annually increasing incidence from 1999 to 2010, totally as well as for boys and girls. This is again in line with the findings of Hedström et al from the north of Sweden (Hedstrom et al. 2010).

In paper III, however, when comparing the results from 2005 and 2006 with 1993 and 1994 no significant differences in fracture incidence were apparent. Mäyränpää et al on the other hand found a higher incidence of distal forearm fractures in Helsinki when comparing the result from 2005 with historical rates from 1983 (Mayranpaa et al. 2010). As their calculations, however, were not age-standardized, differences may be explained by a different age distribution between the periods.

### *Comparison with Malmö historical data*

In both paper I and paper III comparisons were made with older Malmö data and results were similar. We found a 50% higher rate in distal forearm fracture incidence in Skåne region 1999–2010 compared with Malmö in the 1950s. Correspondingly we found a 44% higher incidence in the Malmö population 2005 and 2006 compared with Malmö data from the 1950s.

As we have found differences in incidence rates between Malmö (2005 and 2006) and Skåne region (1999–2010) data, questions could be raised whether it is suitable or not to compare the Skåne region data with historical Malmö data. The population in Malmö today is however not the same as in Malmö in the 1950s as it has become multicultural. In fact it is possible that the composition of the Skåne region population 1999–2010 resembles the Malmö population of the 1950s better than the Malmö population 2005 and 2006 as the proportion immigrants is much smaller in Skåne region than in Malmö (Table 5). Nevertheless, the findings should be interpreted with care.

## All fractures

### *Fracture numbers and incidence*

In the studies included in this thesis, the fracture numbers are generally higher than historically. The total number of childhood fractures in the Skåne region population ( $\leq 20$  years) increased by 37% from 4732 to 6500 between 1999 and 2010. This is in concordance with a register-based report from northern Sweden where Hedström et al found an increase of 59%, from 499 fractures in 1993 and 788 fractures in 2007 (Hedstrom et al. 2010). They also found a total incidence rate of 201 per  $10^4$  py for children  $\leq 19$  years for the period 1993–2007. Our result for children  $\leq 20$  years was 205 per  $10^4$  py. This strengthens our findings as it is a report from the same country during almost the same period. It is arguable however, whether the populations of northern Sweden and southern Sweden are similar or not, and also how much the winter conditions in the north of Sweden affect the incidence rates. Hedström et al did indeed report a peak in incidence rates in February and March and that skiing accidents accounted for between 30 and 42% of these. The rest of the year the seasonal variations in fracture numbers were similar to those reported by other authors with peaks in the spring/summer and summer/autumn periods and also with low numbers in December (Landin 1983, Tiderius et al. 1999, Lyons et al. 2000).

In contrast to the incidence figures in paper IV, Lempesis et al, in a gold standard study from Malmö, Sweden, reported a total fracture incidence rate of 183 per  $10^4$  py for children  $\leq 15$  years for the years 2005 and 2006, which is slightly lower than ours (Lempesis et al. 2017). We tabulated the data from their study and harmonized the results with ours, by age-standardizing the figures to the average population in Skåne region 2005 and 2006. Furthermore, skull, rib and sternal fractures were excluded in the Skåne material before comparison, as the study by Lempesis did not include these fractures. Interestingly the same pattern as in distal forearm fractures was then revealed. The statistically significant difference in overall fracture incidence rate ratio (IRR) between the studies seems to be driven mainly by differences in girls, as rates were similar in boys (Table 3, Figure 9).

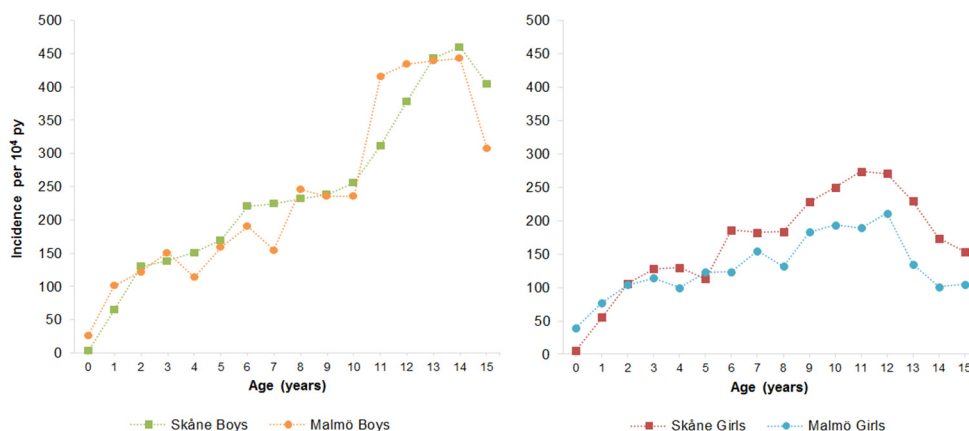
**Table 3:**

Comparison of overall fracture incidence rates in Malmö (paper I) and Skåne, with different age spans and years. Skull, rib and sternum fractures excluded from the Skåne data. IRR between Skåne and Malmö figures presented (95% CI in brackets) (Lempesis et al. 2017).

	Location	Age	Year	Note	Incidence per 10 <sup>4</sup> py		
					Boys	Girls	All
1	Malmö	0-15	2005-2006	Crude	235.9	127.6	183.2
2	Malmö	0-15	2005-2006	Adjusted <sup>a</sup>	246.9	131.0	190.9
3	Skåne	0-15	1999-2010	Crude	236.9	164.8	201.8
4	Skåne	0-15	2005-2006	Crude	240.7	169.7	210.8
IRR Skåne/Malmö (line 4 vs 1)					1.02 (0.96, 1.09)	1.33 (1.22, 1.45)*	1.15 (1.09, 1.21)*
IRR Skåne/Malmö (line 4 vs 2)					0.97 (0.94, 1.01)	1.30 (1.23, 1.36)*	1.11 (1.08, 1.14)*

a) Age-standardized to the Skåne population 2005–2006.

\* Statistically significant

**Figure 9:**

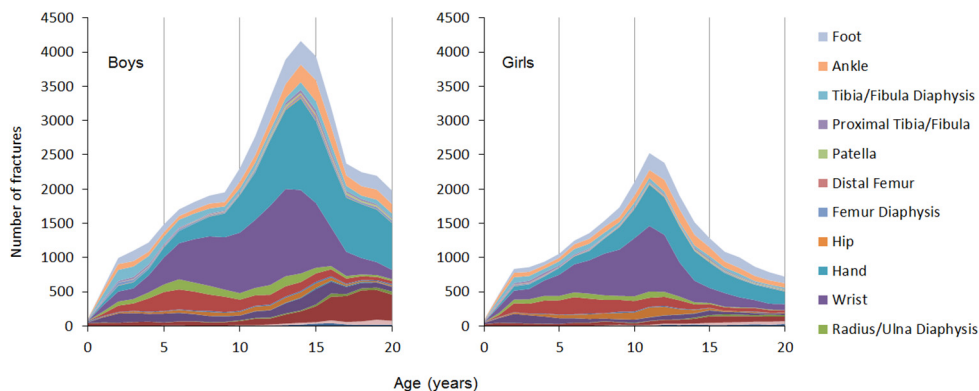
Over all age-standardized fracture incidence rates per 10<sup>4</sup> py 0-15 years in boys and girls in Skåne (paper IV) and Malmö 2005 - 2006 (Lempesis et al. 2017). Skull, rib and sternum fractures excluded from the Skåne data.

However in a northern European perspective, Mäyränpää et al, using a gold standard method, in a study of overall fracture epidemiology, with all types of fractures included, from a single large center in Helsinki, reported a lower total incidence rate of 163 per 10<sup>4</sup> py for children ≤15 years (Mayranpaa et al. 2010). Even though the setting is northern European, differences in population at risk might differ and affect the result, but an actual difference cannot be ruled out.



## Fracture location

The most common fracture sites in children were the distal forearm, followed by fractures of the hand in both genders. This is well in line with the findings by Landin some decades ago but also with the more recent findings by Hedström et al (Landin 1983, Hedstrom et al. 2010). The only fracture that was more common in girls than boys was the proximal humerus fracture (boys/girls IRR 0.8).



**Figure 10:**  
Number of fractures by age in boys and girls in Skåne region 1999 - 2010.

## Age trends of different fracture types

In detail data on age distribution of different fracture types has been presented in Paper IV.

## Fracture origin

The origin of fractures in terms of trauma mechanism has previously been reported in several studies, and found to be fairly similar between studies, with sports and playing accidents as the main responsible activities preceding a fracture (Landin 1983, Tiderius et al. 1999, Lyons et al. 2000, Rennie et al. 2007, Hedstrom et al. 2010) When we examined the etiology of distal forearm fractures in Malmö (paper III the main activities preceding the fractures were sports (41%) and playing (32%). Results and comparison with historical Malmö data also requires scrutiny as the proportion of missing data gradually decreased from a level over 50% in 1950/1955 to 25% in 2005/2006. It seems, however, that the proportion of traffic- and home accidents resulting in distal forearm fracture cases has gradually decreased and that the levels of these in 2005/2006 are lower than in all previously examined periods.

## **Incidence time trends**

Reports on incidence time trends in pediatric fractures have been scarce in the recent few decades (Hedstrom et al. 2010, Mayranpaa et al. 2010, Lempesis et al. 2017). One of these, Hedström et al (Hedstrom et al. 2010) is register-based while the two others have used a gold standard method to ascertain fractures. In addition, when it comes to time trends Hedström et al report similar results as the register-based studies (papers I, II and IV) in this thesis. The gold standard method-based study by Lempesis et al found stable incidence trends between 2005 – 2006 and 1993 – 1994 in Malmö, Sweden while Mäyränpää et al found decreasing fracture incidence trends between 1983 and 2005 in a gold standard method based study in Helsinki, Finland (Mayranpaa et al. 2010, Lempesis et al. 2017). However, Mäyränpää et al did not present age-standardized data.

The report published on total fracture data in Malmö children by Lempesis et al concluded that there was a decrease in incidence rates for girls but not in boys between 1993 – 1994 and 2005 – 2006 (Lempesis et al. 2017). Mäyränpää et al, reported a decreasing incidence in both boys and girls in Helsinki, Finland between 1983 and 2005 (Mayranpaa et al. 2010).

However, to be able to create a trend line at least three measure points are needed; if there are just two only comparison is possible. As fracture incidence is a fluctuating continuum, more measure points mean more robust results, and more cases per measure point also tend to make the amplitudes of the fluctuations less prominent. By means of time trend analysis, studies based on very large register data may thus be more robust, given that any selection bias is constant during the examined period.

## **Gender**

It is well established that girls have a lower fracture incidence than boys (Landin 1983). The highest risk during childhood is reached during the time when entering puberty, thus the peak incidence for boys comes a couple of years later than in girls. Different fractures, however, have different age distribution. As the most common fracture types (i.e. distal forearm and hand fractures) peak at those ages the less common fracture types are not visible in overall incidence rate by age curves.

As mentioned earlier, we have found that there seems to be a difference in fracture incidence in girls between Malmö and the rest of Skåne region, regarding both distal forearm fractures and total fracture incidence. Meanwhile, we found similar fracture incidence rates in Malmö and Skåne boys. Why is this?

One possible explanation might be ethnicity. Malmö is known to have a large proportion of immigrants. According to Statistics Sweden the proportion of children in Malmö of foreign origin is 100% higher than in Skåne region as a whole (Table 5) (Statistics Sweden).

**Table 5 :**

Number of children ≤15 years in Malmö and Skåne and number of children of foreign origin year 2005 to 2006. Proportion of foreign children in % (Statistics Sweden).

	Malmö			Skåne		
	Boys	Girls	All	Boys	Girls	All
Number of children	47431	44908	92339	221518	209931	431449
Of foreign origin	20241	18863	39104	44520	42238	86758
Proportion of foreign origin*	43%	42%	42%	20%	20%	20%

\*Foreign is defined as born abroad or born in Sweden with two parents born abroad.

During the recent few decades Malmö has become one of the most multicultural cities in Sweden, with immigrants from many countries. It is difficult to find reliable data on exact proportions of different ethnicities but the Arabic-speaking proportion is regarded as large and influencing the culture in the city. This might also influence the fracture incidence in girls. In a report from Saudi Arabia, Al-Jasser et al reported on pediatric hand fractures and found that boys suffered from 80% of the fractures and girls only 20%. Fractures due to sports accidents were common in boys, but no girls were injured in that way and the authors concluded that girls tend to spend their time at home (Al-Jasser et al. 2015). There are also Swedish studies on the extent to which boys and girls of different origins participate in sports activities. In a study from 2010, Riksidrottsförbundet reports that 54% of boys and 47% of girls of Swedish origin (same definitions as in table 5) participated in sport activities outside school while the figures for boys and girls of foreign origin were 52% and 31%, respectively (Riksidrottsförbundet 2010).

Even if it is likely that these circumstances in part explain the lower fracture incidence of girls in Malmö compared to the rest of Skåne region, it is probably not the only explanation.

## Possible explanations for incidence time trends

The development of the skeleton and a high peak bone mass (PBM) is a complex process to a large extent determined by hereditary factors (Heaney et al. 2000). What affects the road to a strong skeleton, apart from those refractory components set by conception, probably starts right there; in the uterus. Buttazzoni et al, for example, found that pre-term children that were small for gestational age are at risk of low adult bone mass (Buttazzoni et al. 2016), and Parviainen et al concluded that maternal smoking during pregnancy resulted in a higher fracture risk of offspring during childhood than children where the mother did not smoke (Parviainen et al. 2017). Furthermore, a less physically active lifestyle is possibly one of the factors involved.



**Picture 1:**  
Physically extremely inactive children.

Daily physical activity has been shown to increase the PBM (Karlsson et al. 2008) and also to be associated with reduced fracture risk in children (Fritz et al. 2016). At first, this seems a bit contradictory as less physical activity reasonably decreases the risk to fall, and thus the risk of sustaining a fracture. On the other hand, children tend to play and to be active at some point or another and those with a good balance and good bone quality are then less likely to fall, and if they fall, less likely get a fracture.

Body mass index (BMI) might also influence fracture rates in children and overweight children generally have a more sedentary life style (Valerio et al. 2012).

# Adults

## Incidence and time-trends of distal forearm fractures

Incidence rates of distal forearm fractures in adults have been reported from several locations in the last few decades (Table 6). As these figures are derived from different settings and cannot easily be age-standardized for comparison, interpretations must be made with caution. With respect to this the reports from northern Skåne region and Stockholm, both in Sweden, are the most suitable for comparison with our results. Brogren et al conducted a gold standard study in the north of Skåne region during 2001 and thus their study population is included in ours, which at least partly can explain why their results are similar to ours (Brogren et al. 2007). On the other hand Wilcke et al found a somehow lower incidence in a register study from Stockholm, Sweden, during 2004 to 2010. Yet their study method, which will be discussed in more detail below, may have resulted in an underestimation of incidence rates.

**Table 6:**

Reported incidence (crude) of distal forearm fractures for adult men and women per 10<sup>4</sup> py since 1999 (Brogren et al. 2007, Flinkkila et al. 2011, Sigurdardottir et al. 2011, Tsai et al. 2011, Wilcke et al. 2013, Bentohami et al. 2014, Court-Brown et al. 2014, Abrahamsen et al. 2015).

Location	Year	Age	Incidence	
			Men	Women
Skåne, Sweden	1999-2010	≥ 17 years	150	399
Edinburgh, UK	2010-2011	≥ 35 years	130	440
Denmark	2010	≥ 20 years	153	530
Stockholm, Sweden	2004-2010	≥ 18 years	140	360
Oulu, Finland	2008	≥ 16 years	147	363
Taiwan	2007	≥ 20 years	100	189
Reykjavik, Iceland	2004	≥ 16 years	170	370
Northern Skåne, Sweden	2001	≥ 19 years	120	390
Taiwan	2000	≥ 20 years	81	123

The recent trend, according to our results, regarding distal forearm fractures in adults ≥17 years is that it is also increasing. During the period 1999 to 2010 the age-standardized incidence increased by 0.7% (CI 0.1, 1.4) annually. Interestingly, analysis of sub-groups also found significantly increasing trends in both men and women in working ages 17–64 years, but no apparent changes in elderly (Table 7).

**Table 7:**

Average annual change in distal forearm incidence in different age groups in Skåne, Sweden 1999–2010.

Age stratum (years)	Annual percent change (95% CI)	
	Men	Women
≥17	+0.7 (0.1, 1.4)*	+0.9 (0.5, 1.3 )*
17-64	+0.8 (+0.0, 1.5)*	+2.1 (1.5, 2.8)*
≥65	+0.5 (-0.7, 1.8)	+0.1 (-0.3, 0.6)

\* Statistically significant.

These trends are not easily set in an international perspective. The only studies known to us with a similar study design during recent years are Swedish (Wilcke et al. 2013, Mellstrand-Navarro et al. 2014). Wilcke et al, in a register study from Stockholm, Sweden, reported a decreasing incidence in both men and women between the years 2004 and 2010. Mellstrand-Navarro et al, also in a registry study, reported stable incidence rates in the whole of the Swedish population between 2005 and 2010. Their results should be interpreted with care as their methods will underestimate incidence rates.

Wilcke et al counted only one fracture per individual, giving a decreasing population at risk during the following examined years without any corresponding decrease in the denominator in incidence estimates. Furthermore no adjustment for lower risks was made in those who remained eligible (Wilcke et al. 2013).

Mellstrand-Navarro et al recorded fractures from 1987 to 2010 in the Swedish population as a whole. The study period was set from January 1, 2005, to December 31, 2010, but all patients recorded with a fracture prior to 2005 were excluded with no exclusion of these individuals in the denominator. Also, no adjustment for lower risks was made in those still eligible.

## Possible explanations

The explanations for the increasing incidence of distal forearm fractures in adults in this thesis are not clear. Like incidence changes in children, they are multifactorial.

## **Age Period Cohort effects**

Age Period and Cohort effects (APC effects) are factors or circumstances that may affect the incidence or prevalence of diseases and conditions including fractures.

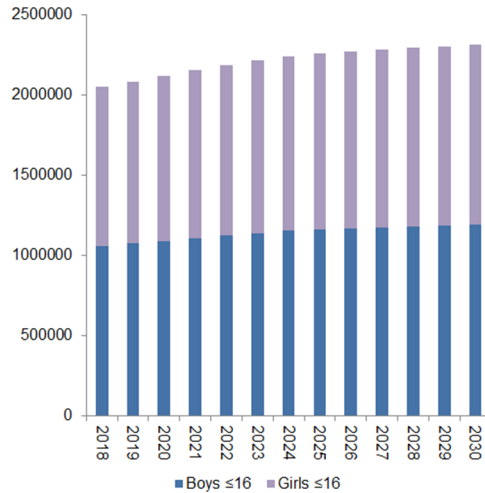
Age is, as mentioned earlier, an important and well-known factor influencing fracture incidence but the period when you live may also be important. Birth cohort effects influence only individuals born during a certain time. For example children born during certain years will reach school age six to seven years later and if schools then had less physical education, these children may reach a lower PBM and thus have higher fracture risks later in life than children born earlier that were offered more physical education. Period effects are circumstances affecting all citizens in a population living during a certain period irrespective of age and birth year.

## **Projections**

Projections of future fracture numbers are always difficult and the results need to be interpreted with care. The most accurate would have been to make a projection of only the Skåne region as the fracture incidence in Skåne region not necessarily reflects the incidence in the rest of the country. Unfortunately, Statistics Sweden does not provide such regional projections why we choose to calculate on a national basis. That being said there are circumstances pointing in the direction of both higher fracture numbers and higher age-specific incidence in the adult population in the coming years.

### **Projection of fracture numbers**

The Swedish population is estimated to increase in decades to come. According to Statistics Sweden the younger part of the Swedish population ( $\leq 20$  years) will increase until 2030 (Statistics Sweden) (Figure 11). The number of children in the near future is however precarious to gauge as it will include individuals not yet born and future immigration is also difficult to appraise. For this reason we have avoided to make a projection on the number of childhood fractures in a more far future.

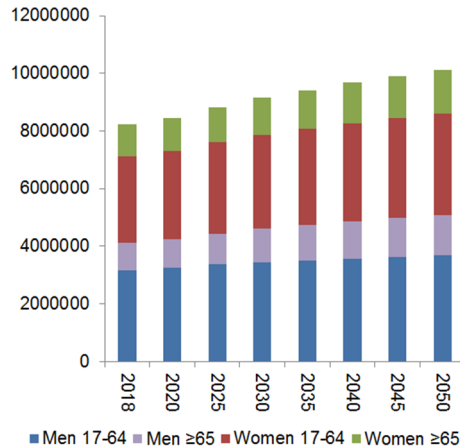


**Figure 11:**  
Projected number of children in Sweden 2018 to 2030.

Applying the overall incidence in children  $\leq 16$  years in Skåne region 1999 to 2010 on Statistics Sweden’s projection of the population of children ( $\leq 16$  years) 2018 to 2030 and assuming that the incidence will remain stable, the total number of fractures among children will increase from 42 000 to 48 000 an increase by 14%. During the same period the population  $\leq 16$  years is estimated to increase by 13%.

More interesting is the projection of the adult population as an increasing proportion of elderly will increase also the fracture numbers given that the age-specific incidence of fractures does not decrease dramatically (Figure 12). If the proportion of elderly increases, the tax paying proportion of the population will decrease, and likely the relative resources for health care will fall off.





**Figure 12:**  
Projected number of adults in Sweden 2018 to 2050 in different age groups.

In paper II we applied the mean age specific distal forearm fracture incidence in one year age classes from the adult Skåne population 1999–2010 to the projection of the Swedish population provided by Statistics Sweden. Given stable incidence rates throughout the period 2017 to 2050 we estimated the actual fracture numbers to increase from 22 800 in 2017 to 31 000 in 2050 an increase by 38% even though the increase in population is estimated at only 25%. The calculated difference is due solely to the changes in age structure with more and more elderly.

The corresponding result for the age group 17-64 years was an increase by 20% (10 400 in 2017 to 12 500 in 2050) and for the age group  $\geq 65$  years was an increase by 52% (12 200 in 2017 and 18 600 in 2050) (Figure 1 and 2 in paper II).

Life expectancy in the developed world has increased dramatically over the recent century, very much due to decreasing infant and child mortality and the introduction of antibiotics. Even though we all will face death eventually, the mortality rates in old age have also been decreasing successively and so far there are no signs of a break in this pattern (Christensen et al. 2009). Over 50% of the children born today are expected to experience their 100<sup>th</sup> birthday (Christensen et al. 2009).

## Forecast of incidence

Changes in incidence rates are more difficult to foresee as both historical and future factors will have to be put into the equation and none of these are fully known. Some clues may however indicate a direction. The most interesting one may be the increasing fracture incidence rates we found in children in the Skåne region (Paper I and IV). Even though recent reports on trends in childhood fracture incidence are quite scarce, the most reliable one by Hedström et al is in concordance with our results (Hedstrom et al. 2010).

Childhood fractures have been shown to be associated with an increased risk for fragility fractures later in life (Amin et al. 2013) and also appear to be associated with low bone mineral density in young adulthood (Ferrari et al. 2006, Buttazzoni et al. 2013, Farr et al. 2014). In addition, a distal forearm fracture has been found to be an indicator of osteoporosis (Cummings et al. 1985) and subsequent fractures (Kanis et al. 2004) in the elderly. Thus, whatever the explanations for increasing fracture incidence in children and young adults in this thesis, the results might influence the future incidence rates and number of fractures.

## Clinical and economic implications

In addition to the expected demographic changes and possible upturn in incidence in the adult population there are more circumstances that may increase the economic burden of fractures.

Regarding distal forearm fractures the tendencies in recent decades have been more aggressive treatment with a higher proportion of the patients having surgery and also with more expensive procedures (Wilcke et al. 2013, Mellstrand-Navarro et al. 2014). This is quite extraordinary as there is very little evidence that surgery is better than treatment in plaster, or that volar plating is better than external fixation or percutaneous pinning for the vast majority of patients (SBU 2017).

Mellstrand-Navarro et al reported that 27% of the distal forearm fracture cases  $\geq 18$  years in Sweden in 2010 was treated surgically and that the rate in 2005 was 23% (Mellstrand-Navarro et al. 2014). Wilcke et al reported that 70% of the surgically treated cases  $\geq 18$  years in 2010 in Stockholm, Sweden were treated with open reduction and plating, while external fixation was used in 16% of the cases (Wilcke et al. 2013). In the report from SBU the costs for intervention with a plaster was expected at 1 210 Swedish crowns (SEK), external fixation at 11 575 SEK and plating at 14 970 SEK. Note that these costs are just intervention costs which include material, costs for surgery and staff. (SBU 2017). Given the information above the

national costs in Sweden for the three most common treatment options in adults  $\geq 18$  years, plaster, volar plating and external fixation may be expected at 97 million SEK 2018, and 129 million SEK in 2050 if applied to the projection of distal forearm fractures presented above. Note that not all surgical procedures are defined, and thus that 14% of those treated surgically (mainly with pinning) are not included in the cost projection Table 8). Naturally, a projection like this is dependent on several assumptions and must, like all attempts to look in to the future, be interpreted with suspicion.

**Table 8.**

Estimation of future distal forearm fractures (N) in adults  $\geq 18$  years in Sweden, numbers treated with plaster and surgery. Estimation of numbers treated with the two most common surgical methods plating and external fixation (X-fix), costs per treatment (only intervention) and total treatment costs in million SEK. The total treatment cost estimation do not include cases surgically treated with other methods than plating and X-fix (14%).

Year	N	Numbers treated				Cost per treatment ( million SEK)			
		Plaster	Surgery	Plating	X-Fix	Plaster	Plating	X-fix	Total cost
2018	22900	16700	6200	4300	1100	20	65	12	97
2020	23500	17200	6300	4400	1100	21	66	12	99
2030	26500	19400	7200	5000	1200	23	75	14	112
2040	28700	21000	7800	5400	1300	25	81	15	121
2050	30500	22300	8200	5800	1400	27	86	16	129

## Strengths and limitations

### Papers I, II and IV

The strengths of the studies in papers I, II and IV are the large and geographically well-defined population in Skåne region between 1999 and 2010.

On the other hand, the gold standard when studying fracture epidemiology is examinations of X-rays and medical records as validity is usually very high. As every X-ray in this method is examined there are no intermediaries of the information, which minimizes the risk of both false positive and false negative diagnosis. In addition, background information on every case is often possible to ascertain. This method, however, is time-consuming as every case has to be reviewed manually and the number of cases is therefore seldom high. A register study makes selection bias, random or systematic, possible. Previous validations of the SHR have shown high accuracy regarding distal forearm fractures in adults (Rosengren et al. 2015). Even though our case finding strategy seems valid, it is always difficult to estimate absolute numbers from registers. Relative changes, such as time trends, are however often more easily examined and the results more robust.

### *Paper I*

The results in paper I are similar to those reported by Hedström et al in a study from the north of Sweden during the years 2006 and 2007 (Hedstrom et al. 2010). As they ascertained fractures through the gold-standard method with examinations of X-rays and medical records, comparisons with our results must be made with care. The concordance of rates between the studies, however, strengthens the usefulness of such comparisons.

In contrast, Wilcke et al, in a register study from Stockholm, Sweden, reported a lower incidence of distal forearm fractures in children  $\leq 17$  years than we found and also a decreasing incidence during the examined period between 2004 and 2010 (Wilcke et al. 2013). Their results should however be interpreted with caution as they counted only one fracture per individual, giving a decreasing population at risk over the following examined years without any corresponding decrease in the denominator. Furthermore, no adjustment for lower risks was made in those who remained eligible.

### *Paper II*

Our results are very similar to those of Brogren et al, who , used a gold-standard ascertainment method while reporting incidence rates of distal forearm fractures in adults  $\geq 19$  years in the northern part of the Skåne region in 2001 (Brogren et al. 2007). As their study population is actually included in ours, comparisons may be more relevant than the comparison between paper I and data presented by Hedström et al (Hedstrom et al. 2010).

A Finnish study by Flinkkilä et al, using a gold standard fracture ascertainment method also reported similar figures for adults  $\geq 16$  years in the city of Oulo in 2008 (Flinkkila et al. 2011).

On the other hand, in contrast to our results, Wilcke et al reported lower incidence in adults  $\geq 18$  years and decreasing incidence in elderly  $\geq 65$  years) but as mentioned before the differences might be a result of their different (compared to ours) study method (Wilcke et al. 2013).

### *Paper IV*

Again, our incidence rates for all fractures in children from 1999 to 2010 are very close to those reported by Hedström et al in Umeå (Hedstrom et al. 2010). Their total incidence for children  $\leq 19$  years was 201 per  $10^4$  from 1993 to 2007 while ours for children  $\leq 20$  years was 205 per  $10^4$  for the years 1999 to 2010.

On the other hand, a gold standard fracture ascertainment study by Mäyränpää et al from a northern European setting in Finland in 2005 reported a total fracture incidence of 163 per  $10^4$  for children  $\leq 15$  years (Mayranpaa et al. 2010). These figures are considerably lower than those found in our study as well as those

reported by Hedström et al (Hedstrom et al. 2010). This is interesting as they include only younger patients. The incidence would probably be even lower if they had also included patients between 16 and 20 years of age as the fracture incidence is known to decrease considerably in the late teens.

### **Paper III**

We used historical gold standard data from the 20<sup>th</sup> century and also ascertained new data for 2005 and 2006. The latter were collected cases from hospital registers and these were then verified with digital X-rays and medical reports. This new method depends on diagnosis codes set by other physicians and is presumably less reliable than the historical data. To validate the method, we searched the diagnosis registers for fracture cases of any kind in children  $\leq 16$  years from January 1, to February 1, 2005 and thereby identified 103 fractures. Likewise we also searched the digital X-ray system and all radiographs performed on this age group at the hospital were reviewed. Again 103 fractures were found. Both systems identified 100 of the fractures and each method also found 3 fractures not identified with the other method, a misclassification rate of 3%. In the late 1980s Jónsson et al expected a loss of 10% of patients when studying fracture epidemiology through the X-ray archive and medical records in Malmö and gave treatment outside Malmö (7%) or treatment at private care units within Malmö (3%) as explanations (Jonsson et al. 1994).

# General conclusions

- The number of distal forearm fractures increased by 18% in children  $\leq 16$  years and 30% in adults  $\geq 17$  between 1999 and 2010.
- The age-standardized incidence of distal forearm fractures in Skåne region has increased the recent decades in both children and adults. An increase was evident in both boys and girls  $\leq 16$  years. The increase in adults  $\geq 17$  years was driven mainly by an increase in working ages (17-64) years, while the incidence in the elderly part  $\geq 65$  years seemed stable.
- The current incidence rates in children in Skåne region and Malmö, Sweden are over 40% higher compared with rates in Malmö, Sweden in the 1950s.
- The etiology of distal forearm fractures in Malmö 2005/2006 was similar with other reports and the most common activities leading to a distal forearm fracture was sports and playing. The proportion of traffic and home accidents leading to a fracture seem to have decreased since the 1950s.
- The total amount of fractures in children  $\leq 20$  years increased by 37% between 1999 and 2010 and we also found an increase in overall age-standardized incidence rates over the examined period. Increases in fracture numbers and incidence rates were evident in both boys and girls.
- Due to expected demographic changes in the coming decades, with an increasing population, but more importantly, a greater proportion elderly, fracture numbers may rocket. Given stable incidence rates, the number of distal forearm fractures in adults is projected to increase by 38% until year 2050, while the population is projected to increase by only 25%.



# Future perspectives

A pallet of actions is suggested to achieve further understanding regarding fracture incidence, particularly in children:

Systematic gathering of information on underlying factors leading to fractures such as general level of physical activity, activity directly prior to a fracture, grade of trauma, BMI and BMD.

Monitoring of trends in behaviors, activities and milieus associated to trauma risk.

Future surveillance of the children followed in these studies from 1999 and 2010 (birth cohort 1982-2010), to find out whether they bring the tendency for sustaining fractures with them into older age or not, and to specifically monitor if this higher fracture risk is limited to those who in fact suffered from a childhood fracture or applies to all children of this birth cohort. Likewise, an update of incidence of distal forearm fractures among children in Malmö is eligible, and such a project has already been started.

With the expected demographic changes with a higher proportion of elderly the decades ahead, an increasing number of fractures are likely to appear in the years to come.

As the tendency to treat distal forearm fractures with surgery is increasing, and the treatment of choice in the recent decade has changed from external fixation to the more expensive volar plating, the economic burden to society may be even more troublesome. It would be valuable if the orthopaedic community could reach a consensus on how to treat this injury in a responsible way.





# Sammanfattning på svenska

## Introduktion

En stor mängd människor drabbas varje år av en fraktur. Även om vem som helst kan drabbas är det vanligen ett barn eller en äldre kvinna och i båda fallen är det högst sannolikhet att det är handleden som brutits. Det totala antalet frakturer hos barn kan uppskattas till ungefär 42000 per år i Sverige varav cirka 25% utgörs av handledsfrakturer. Det totala antalet handledsfrakturer om man inkluderar även den vuxna befolkningen uppgår till cirka 35000 i Sverige varje år.

Frakturer orsakar förstås mycket lidande men behandlingen kostar också samhället mycket pengar. Barns frakturer är ofta lättbehandlade och läker som regel utan några kvarstående men, även i de fall operation behövs. Handledsfrakturer hos vuxna behandlas oftast med bara ett gips men det senaste decenniet har en tendens mot ökad kirurgisk behandling skett. Dessutom opereras fler med en dyrare metod, utan att behandlingsresultaten kunnat visas vara bättre än tidigare.

I en tid när brist på resurser är ett ständigt problem är det viktigt att ha tillgång till färsk siffror på förekomsten av olika resurskrävande skador och sjukdomar. Detta för att kunna prioritera var pengarna ska satsas och för att kunna hitta problem som eventuellt kan förebyggas.

## Metod

I den här avhandlingen beskrivs frakturepidemiologin (dvs förekomsten av frakturer) hos barn i Skåne mellan åren 1999 och 2010. Speciell uppmärksamhet har ägnats åt den vanligaste frakturtypen, handledsfrakturen, som undersökts hos både barn och vuxna. Undersökningarna har gjorts genom två olika metoder. Studie 1, 2 och 4 är så kallade registerstudier och studie 3 är gjord genom granskning av röntgenbilder och sjukhusjournaler.

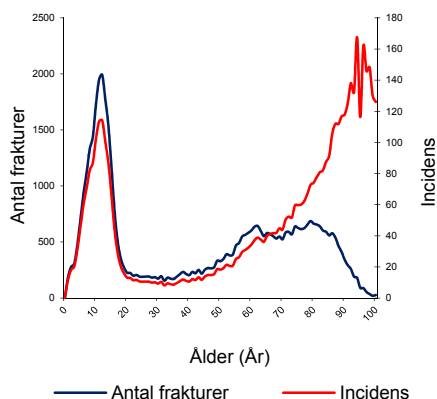
I registerstudierna har vi haft tillgång till diagnoser som satts på sjukhus och vårdcentraler mellan 1999 och 2010 och på så vis fått fram hur många frakturer som drabbat befolkningen varje år. Fördelen med en sådan studie är att man kan undersöka en stor befolkning, nackdelen i första hand att man inte har kontroll på

om den som har gett en patient en diagnos har satt den korrekt. Om många diagnoser satts fel blir också resultatet av undersökningen fel.

Studie 3, som är annorlunda, är en så kallad gold standard undersökning. Om man vill ha så tillförlitlig data som möjligt angående förekomsten av frakturer i en befolkning är det så här man ska göra. För barn med handledsfraktur i Malmö under 2005 och 2006 har röntgenbilder och journaler tagits fram och granskats. På så vis blir resultatet väldigt tillförlitligt. Nackdelen är att det tar väldigt lång tid jämfört med en registerstudie. Förekomsten av frakturer i befolkningen brukar beskrivas som incidens. För att räkna ut incidensen delar man med antalet inträffade frakturer med antalet individer i den befolkning man studerar.

## Resultat

Incidensen av handledsfrakturer hos barn i Skåne är hög och den har ökat successivt från 1999 till 2010. Jämfört med siffror från Malmö på 1950-talet så var incidensen för handledsfrakturer drygt 40 % högre i Malmö 2005-2006 och ca 50 % högre i Skåne 1999-2010. Idrottsrelaterade olyckor (41% av fallen) var den vanligaste orsaken till handledsfraktur hos Malmöbarnen 2005/2006. Näst vanligast var olyckor i samband med lek (32%).



**Figur 13.**  
Totalt antal handledsfrakturer och incidens av handledsfrakturer per 10 000 invånare, i olika åldrar, i Skåne 1999-2010.

Studie 2 visar att incidensen av handledsfrakturer hos vuxna (17 år eller äldre) också är hög och att den ökar. Dock verkar den inte ha ändrat sig hos individer som fyllt 65 år. Förändringen i incidens hos den vuxna befolkningen orsakas alltså främst av en incidensökning hos den arbetande delen av befolkningen (17-64 år). Det totala antalet handledsfrakturer fördelat på ålder hos barn och vuxna samt incidensen fördelat på ålder, under perioden 1999-2010 kan ses i figur 13. Om den incidens som gällde för åren 1999 till 2010 håller sig stabil fram till 2050 kommer antalet handledsfrakturer hos vuxna  $\geq 17$  år att öka med över 35% fram till år 2050 på grund av en förändrad åldersfördelning i befolkningen med ett ökat antal äldre.

Den totala frakturincidensen bland barn i Skåne har ökat successivt från 1999 till 2010. Pojkar får fler frakturer än flickor och ungefär 50 % av alla barnfrakturer drabbar hand eller handled.

## **Diskussion**

Vad den ökande incidensen beror på är svårt att sja om och det är inte alls undersökt i de här studierna. Faktorer som kost, övervikt och grad av fysisk aktivitet är exempel på sådant som kan ha betydelse.

Barn som drabbas av frakturer har ökad risk för fler framtida frakturer, även som äldre. Eftersom prognosen för framtiden dessutom är att den äldsta delen av befolkningen kommer att växa successivt fram till 2050 finns risk för att antalet frakturfall kommer att öka dramatiskt. Vad gäller handledsfrakturer så har man dessutom konstaterat att en större andel av de som drabbas blir opererade och dessutom opereras med dyrare metoder än tidigare. Kostnaderna kommer med stor sannolikhet att öka kraftigt. Eftersom den skattebetalande delen av befolkningen relativt sett blir mindre kommer bördan att betala för ett ökat antal frakturer också att bli tyngre.

Viktigt för framtiden blir att ta reda på varför frakturincidensen ökar och att nå konsensus kring hur vi ska behandla och förebygga handledsfrakturer. Det är också viktigt att följa upp med nya frakturepidemiologiska studier eftersom epidemiologiska data är en färskvara.

Vi har presenterat epidemiologiska data rörande frakturincidens hos barn under perioden 1999 till 2010 och jämfört med historiska data från Malmö sedan 1950-talet och ser att den totala frakturincidensen ökat kraftigt. Den har också ökat under den undersökta perioden 1999 till 2010. Vi har lagt speciellt fokus på den vanligaste frakturtypen, handledsfraktur, där vi undersökt hela den skånska befolkningen. Med utgångspunkt i vårt material kan vi konstatera att incidensen för handledsfrakturer har ökat i befolkningen som helhet samt i subgrupperna barn och vuxna i arbetsför ålder, men att inga skillnader hittats hos gruppen 65 år och äldre. Eftersom

befolkningsstrukturen förväntas förändras de kommande decennierna med en allt större andel äldre tyder mycket på kraftigt ökat frakturantal fram till år 2050.

Förhoppningen är att det här arbetet kan hjälpa politiker och tjänstemän sysselsätta inom hälso- och sjukvården att beräkna kostnader och prioritera var resurser ska läggas. Förhoppningsvis kan det också inspirera till forskning kring orsaker till incidensförändringarna och hur frakturer ska kunna förebyggas. För att säkerställa att våra gemensamma resurser används på bästa sätt är det också av största vikt att ortopedsamfundet når konsensus kring hur våra vanligaste frakturer ska behandlas på ett så bra sätt som möjligt, både ur patientens och sjukvårdens perspektiv.

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Fractures have always troubled humanity. In modern time, treatment options have rocketed and most people can return to a normal life after healing, but historically a fracture was a substantial threat to be disabled for life, and to life itself. Despite the land winnings made, the burden of fractures today, is in many perspectives still major.

During childhood and old age, fracture rates are high, and the most common fracture type in both children and adults is the distal forearm fracture (also known as wrist fracture). The studies in this thesis aimed to describe the epidemiology of fractures among children, and the epidemiology of distal forearm fractures in both children and adults in the Skåne region in southern Sweden in 1999-2010, and in the city of Malmö in children in 2005-2006.

The fracture incidence rates increased gradually during the examined years, both regarding total fractures in children and distal forearm fractures in children and adults. As the demography in Sweden is expected to change towards a larger proportion elderly more fractures may occur. The findings are also troublesome as childhood fractures have been associated with a higher risk to sustain fractures in adult life.

The reasons behind the increasing trends are not clear and further research is needed in order to develop prevention programs.

