Injuries are not accidents!

An emergency-department population-based epidemiological study of injuries with special reference to trauma recidivism, hip fractures and geriatric falls

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To my family
# Table of contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table of contents</td>
<td>i</td>
</tr>
<tr>
<td>Skador är inte otyckal</td>
<td>iii</td>
</tr>
<tr>
<td>Abbreviations</td>
<td>vi</td>
</tr>
<tr>
<td>Aims</td>
<td>vi</td>
</tr>
<tr>
<td>Thesis-at-a-glance</td>
<td>vii</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Injury definition</td>
<td>1</td>
</tr>
<tr>
<td>Epidemiology</td>
<td>1</td>
</tr>
<tr>
<td>Injury pyramid</td>
<td>2</td>
</tr>
<tr>
<td>Measurements of injury burden</td>
<td>3</td>
</tr>
<tr>
<td>DALY</td>
<td>5</td>
</tr>
<tr>
<td>Fall injuries</td>
<td>5</td>
</tr>
<tr>
<td>“Low-energy injuries”</td>
<td>5</td>
</tr>
<tr>
<td>The Vision Zero in road traffic</td>
<td>6</td>
</tr>
<tr>
<td>Sport</td>
<td>6</td>
</tr>
<tr>
<td>Severity grading</td>
<td>6</td>
</tr>
<tr>
<td>Age</td>
<td>7</td>
</tr>
<tr>
<td>Trauma-recidivism</td>
<td>8</td>
</tr>
<tr>
<td>Prevention</td>
<td>8</td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>9</td>
</tr>
<tr>
<td>Fracture liaisons services</td>
<td>9</td>
</tr>
<tr>
<td>Materials and Methods</td>
<td>10</td>
</tr>
<tr>
<td>Umeå Injury Database</td>
<td>10</td>
</tr>
<tr>
<td>Inclusion</td>
<td>10</td>
</tr>
<tr>
<td>Registration procedure</td>
<td>11</td>
</tr>
<tr>
<td>AIS/ISS</td>
<td>11</td>
</tr>
<tr>
<td>Validation of the database</td>
<td>11</td>
</tr>
<tr>
<td>Statistics</td>
<td>11</td>
</tr>
<tr>
<td>Ethical aspects</td>
<td>12</td>
</tr>
<tr>
<td>Results</td>
<td>13</td>
</tr>
<tr>
<td>The Umeå injury database 1993—2014 in a demographic perspective</td>
<td>13</td>
</tr>
</tbody>
</table>
In a helicopter perspective, describe injury mechanisms, place, activity and severity in relation to sex/age

Trauma recidivism

What happens before and after a hip fracture?

Geriatric fall injuries

Discussion

Materials and Methods

Age

Injury mechanisms

Time and place

Type and localization of injury

Injury trends

Trauma recidivism

Hip fracture—the queen of all fractures

Geriatric falls

Osteoporosis

Accountability

Monitoring injuries

Injury prevention

Physical activity

Fall prevention examples

Adherence or compliance?

Where have all the fractures gone?

Sports injuries

Injury data base in memoriam

Strengths

Weaknesses

What should be done?

Conclusions

Acknowledgements

References
Skador är inte otur/olycka!

Skador är ett gigantiskt globalt folkhälsoproblem som enligt WHO dödar fler människor än tuberkulos, malaria och AIDS tillsammans. Skador drabbar individen med smärta/invaliditet, samhället med vårdkostnader och produktionsbortfall. Sverige har varit föregångare i trafiksäkerhetsarbetet, inom arbetslivets risker och inom barnsäkerhetsarbetet. År 2020 omkom 190 individer i trafiken, vilket är det lägsta antalet någonsin. Dödliga fall däremot, som senaste åren passerat över 1500 årligen, uppmärksammas betydligt mindre, kanske pga. att de ofta uppkommer i hemmet, drabbar äldre kvinnor och sannolikt också att de betraktas som ej möjliga att förebygga. Fallskador dödar fler än alla andra skador tillsammans och är nu det största trauma-problemet i rika länder.


Frakturer stod för en fjärrledel av alla skador, hälften hos äldre, och ansvarade för hela 75% av alla skade-relaterade vårddagarna. Men även mjukdelsskador var viktiga och utgjorde ungefär hälften av skadorna och en väsentlig del av vårddagarna på sjukhus.


Tidigare skador gav en måttlig riskökning för höftfraktur. Även här framkommer att fraktur är den vanligaste skadetypen som föregår en höftfraktur. 40% av alla som drabbar av en höftfraktur har haft en eller flera tidigare skador och de som drabbar av höftfraktur är mer skadebenägna än de som inte drabbar av höftfraktur. Flera tidigare skador ökar också risken för framtida höftfraktur. Vi fann att 12% av alla med höftfraktur drabbar av en ytterligare höftfraktur.

Förekomsten av höftfraktur ökar med en faktor på cirka 100 under livet—en exceptionell åldersfördelning, vilket troligen beror mer på falltendens och oförmåga att parera fall än enbart på benskörhet. Skadorna visar nämligen ett åldersrelaterat anatomiskt mönster där frakturerna i nedre extremiteten blir allt vanligare, och även centralt lokaliserade, närmare bålen. Även mjukdelsskador i ansikte/huvud ökar med åldern vilket också visar betydelsen av att kunna ta mot sig och dämpa rörelseenergin.
Abstract

Injury is a major public health problem. In rich countries fall injuries now kill more people than all other injury mechanisms together, because of global ageing and large-scale sustainable injury prevention programs for all other injury mechanisms but falls. Injuries from falls in the young are often trivial, but in old people falls may have devastating consequences.

We used the Umeå Injury Database, 1993 – 2014, 220,014 injury events attended to by the emergency department: e.g., type of injury, localization, mechanism, activity and severity. Logistic regression was used to evaluate injury trends, Cox regression for associations between injury type, severity and recidivism.

Fractures were responsible for ¼ of all injuries and for ¾ of trauma inpatient days. Fractures and contusions became more common with increasing age while sprains and wounds decreased with age. Injuries due to fall increased during the study period.

Recurrent injuries accounted for some 40%, mostly in young men and in old women. Prior fractures and sprains were strongest predictors for recurrent serious injuries.

The hip fracture incidence fell for the most important age/sex groups during the 22-year period, but the total number increased with 3.5%, due to an increasing elderly population. 40% of all hip fracture patients had sustained a previous injury. Multiple previous injuries also increase the risk of future hip fracture. No less than 12% hip fracture patients suffered a new one. With age, injury pattern changed, with more lower extremity fractures that also were more proximally located. Soft tissue injuries to the head/face also increased, also indicating that the ability to reduce and spread the impact of the kinetic energy is a key factor in geriatric trauma, in addition to tissue strength.

The most common, expensive and devastating injury mechanism, falls, are still outrageously neglected, especially concerning injury prevention, which has been so successful in reducing road traffic- and workplace-related deaths. Why? A common misconception is the primitive belief that fall injuries are fated and therefore inevitable. There are also few economic and legal drivers to prevent falls, especially recurrent ones. Another reason is that GDPR has prohibited the injury database. Statistics on fall injuries are necessary for targeting preventive interventions. Without spying, no clue. On-line feedback of official statistics should be used to monitor the results. There are no technical, just legal hurdles. The Swedish parliament has since 1997 flagged a zero vision for road traffic injuries; in 2015 the government also launched a more modest goal for a 50% reduction of falls in the elderly. So far, nothing has happened...
# Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS</td>
<td>Abbreviated Injury Scale</td>
</tr>
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<td>CI</td>
<td>Confidence interval</td>
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<td>DALY</td>
<td>Disability Adjusted Life Years</td>
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<td>ED</td>
<td>Emergency department</td>
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<td>EHLASS</td>
<td>European Home and Leisure Accident Surveillance System</td>
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<td>GDPR</td>
<td>General Data Protection Regulation,</td>
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<td>HR</td>
<td>Hazard Ratio</td>
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<td>IDB</td>
<td>Injury Data Base</td>
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<td>ICD</td>
<td>International Classification of Diseases</td>
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<td>ISS</td>
<td>Injury Severity Score</td>
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<td>MSB</td>
<td>Myndigheten för Samhällsskydd och Beredskap (Sv.) Swedish Contingencies Agency (Eng.)</td>
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<td>NISS</td>
<td>New Injury Severity Score</td>
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<td>OR</td>
<td>Odds Ratio</td>
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<td>PYLL</td>
<td>Potentially Years of Lost Life</td>
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<td>SoS</td>
<td>Socialstyrelsen (Sv), The Swedish National Board of Health and Welfare (Eng.)</td>
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<td>STRADA</td>
<td>Swedish Traffic Accident Data Acquisition</td>
</tr>
</tbody>
</table>

# Aims

- The Umeå injury database 1993—2014 in a demographic perspective
- In a helicopter perspective, describe injury mechanisms, place, activity and severity in for all age groups and trends in the adult population
- Trauma recidivism
- What happens before and after a hip fracture?
- Describe geriatric fall injuries, as an isolated injury mechanism
## Thesis-at-a-glance

<table>
<thead>
<tr>
<th>No.</th>
<th>Aim</th>
<th>Methods</th>
<th>Results and Interpretations</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Description. General overview all ages. Methology. Data repository.</td>
<td>Descriptive epidemiology. Trends and incidences</td>
<td>Yearly changes were small, but home and leisure injury, mainly falls, became even more dominating in trauma care, especially hospitalizations. Fall was the only injury mechanism where women dominated, surpassing men around menopausal age. Fall injuries were common in all ages, often trivial in the young and devastating in the old. “Minor injury” is now a big problem.</td>
</tr>
<tr>
<td>II</td>
<td>Adult injuries only.</td>
<td>Descriptive epidemiology. Trend analysis with Logistic regression</td>
<td>Fractures dominated with 75% of trauma hospital days. Fractures, contusions and concussion incidence increased with age while sprain decreased.</td>
</tr>
<tr>
<td>III</td>
<td>Predictive power of prior injuries for new ones.</td>
<td>Descriptive epidemiology. Associations analysis with Cox regression.</td>
<td>Prior injuries—fracture more than other injuries—have a moderate predictive power, that must be supplemented with other medical and administrative data to sharpen the predictive tools.</td>
</tr>
<tr>
<td>IV</td>
<td>What happens before and after the first hip fracture?</td>
<td>Descriptive epidemiology. Associations analysis with Cox regression.</td>
<td>Prior fractures and other injuries give a moderate risk increase for hip fracture. A second hip fracture occurred in 12%, more often than not the same fracture type, which may indicate a constitutional factor. There was a clustering of injuries around the index hip fracture.</td>
</tr>
<tr>
<td>V</td>
<td>Geriatric falls.</td>
<td>Descriptive epidemiology and graphic presentation.</td>
<td>With age, more injuries occurred in the lower extremity and also more proximally. Fractures comprised only 40% of fall injuries. Severity score was more associated with age than with injury type. Fall height was inversely associated with severity score since the proportion of “high energy” falls declined with increasing age while the severity score increased.</td>
</tr>
</tbody>
</table>

V Geriatric fall injuries. Manuscript. **Röding, F.** & al.
Introduction

INJURY IS A HUGE GLOBAL HEALTH PROBLEM. According to WHO 5 million people die every year due to injuries globally, which is almost twice as many as the death toll of malaria, tuberculosis and HIV combined.¹ (At the time of writing some 3 million people are estimated to have died with or from the Covid pandemic.) Within the EU, about 232,000 people die each year as a result of injuries, and more than 3 million wind up disabled.² The idea that injuries occur as a result of chance or bad luck, is the victim’s own fault, or an act of God, is still today a common and primitive misconception.³ This is one of the heaviest obstacles in injury prevention.

Injury definition
When studying diseases/disorders, epidemiological definitions are important. These are often not those used clinically, but more exact and in a way also more abstract. For example, diseases are defined in several different ways; it can be a lab analysis parameter like in diabetes when a fasting blood sugar level exceeding 7.0 mmol/l is considered diabetic, in other diseases such as rheumatoid arthritis a certain number of criteria must be met in the presumptive patient.

Injury requires firstly, tissue damage; and secondly, that this damage has been inflicted by some noxious agent, usually transfer of energy. Thus, a cerebral hemorrhage due to a ruptured blood vessel without an external cause is not considered an injury. Similarly, a rapid physical energy transfer in a car crash without any ensuing physical change is not an injury. On the other hand, the case of a foreign body, the external energy does not have to damage the tissue; or inhalation of irritants or something to block the airways does not have to cause any physical tissue damage in the short term. In frostbite and drowning, the cold and lack of oxygen cause the damage.

“Injuries are not accidents” is the theme of this thesis. But although injury, like many other natural phenomena, certainly has a stochastic element, it is not the result of bad luck or fate. If so, any attempt at injury prevention have been futile. What, then, is an accident? This noun was actually banned from the British Medical Journal.⁴ Usually the term is used for an unexpected event, intentional or unintentional, typically sudden in nature and associated with injury, loss, or harm.

Epidemiology
“Epi” means above, “demos” people, indicating that the focus is not on the individual patients—which is paramount to clinicians—but on populations. The daily toil in emergency departments and operation theatres sometimes makes it difficult to see the forest for of the trees. The causes of injuries are often more complex than in defined diseases, also involving sociocultural, economic and political aspects.

Epidemiology a concept can be traced as far back as 400 BC when Hippocrates suggested that both the environment and individual factors influenced disease outcomes. In more modern times, the anesthesiologist John Snow is considered as the father of field epidemiology. He investigated the cholera outbreak in London in 1854 and suggested that its source to be a well on Broad Street. He was mocked and ridiculed. But when he removed the pump handle, the epidemic subsided. Another pioneer was Florence Nightingale, the
lady with the lamp, mother of nursing, who was the first to systematically use statistics in medicine.

Epidemiology also studies the extent to which environment, lifestyle and genetic factors separately and in concert affect good as well as ill health. By looking at injuries through epidemiological lenses, it is possible to investigate the impact of underlying as well as environmental factors.

William Haddon was a pioneer in injury epidemiology. He studied road traffic injuries, a success story of engineering where focus is on results, not primarily on knowledge per se. In 1968, he described a method of analyzing injuries, a matrix that divides the injury process into three distinct phases: On an x-axis he put: before the injury, the injury itself, and after the injury Figure 1. As he worked with traffic safety, his original terms were unsurprisingly pre-crash, crash and post-crash. He also added a y-axis with the categories host, i.e., the victim; the vector (the causes the injury, a machine or a vehicle); and lastly, the environment. These phases aimed to distinguish areas where various efforts/interventions could be targeted to ameliorate the injury outcome for victims of traffic injury. The matrix has been widely used in safety work in general, such as for in catastrophic events like earthquakes, and also in medicine, but, alas, not very often by orthopedic surgeons; we tend to focus on surgery and rehabilitation i.e., “post-crash”.

Figure 1. Haddon’s matrix systematizes the circumstances of an injury. Runyan further developed this with a third dimension with political, economic and ethical issues: effectiveness, cost, freedom, equity, stigmatization, preferences, feasibility, among others. For example, motorcyclists sacrifice freedom to ride unrestricted when a helmet law is passed.

Injury pyramid
Another geometrical shape, a triangle, has also been used to illustrate injuries. The concept of the injury pyramid was first described by Heinrich in 1931 in a study on the prevention of injuries in industry. His idea was that by preventing minor “accidents” also the incidence of severe injuries would decrease, due to an increased awareness of risk Figure 2. Since then, the concept has been used and augmented, and is now often used as a model in describing the distribution of seriousness of injury.
Figure 2. Left, Heinrich triangle illustrates the proportion between severe and more trivial injuries against the background of prevention. Right, practical applications from LKAB, a mining company, of how minor adjustments can reduce overall risks.

Diagnosis codes (International Classification of Diseases, ICD) can be used to create injury pyramids for different trauma mechanisms, which yields an informative illustration of the burden of different injuries Figure 3.

Figure 3. The base of the pyramid shows the frequency of emergency room visits, the middle hospitalization, and the uppermost death. To the left injury mechanisms in all ages, from falls to firearms. The right-hand pyramids show all trauma diagnoses, but now by age groups.8, 9

An international comparison between the EU with 230,000 deaths per year and 32.5 million emergency room visits, and the US with 208,577 deaths and 37 million emergency room visits, discloses astoundingly similar mortality rates of 0.7% and 0.6%, respectively, in spite of quite different circumstances.

Measurements of injury burden
In Sweden the official figure for trauma deaths is about 5,000 per year, which is about 6% of the total mortality of 90,000 per year. Contrary to what most people think, most cases of fatal trauma occur in home and leisure settings, no less than 91%; road traffic deaths only comprise 8% and workplace deaths a mere 1%. Murder and manslaughter are still rare in Sweden. In 2019 comprising “only” 111 murders, three more than in 2018. However, ascribing death to trauma is largely a matter of definition. Like in Covid mortality statistics
most frail people die from the virus because of massive comorbidity. As anyone who has ever signed a death certificate knows, stating cause of death it is not rocket science.

![Pie chart showing trauma-related mortality in Sweden 2015-2017](image)

**Figure 4.** Trauma-related mortality in Sweden 2015-2017 is dominated by home- and leisure injuries.\(^\text{10}\) Source MSB.

There are some 70,000 fractures annually in Sweden. The trend is clear: the number of fatal falls and intoxications are increasing, traffic-related deaths subside.\(^\text{11}\) But orders of magnitudes more people are disabled by trauma than those succumbing.

Deaths due to drowning have been constant for the last years except for the year of the Estonia ferry catastrophe. Moreover, drowning deaths is yet another triumph of injury prevention: today it is 0.8 per 100,000 persons-years compared with 53.5 in 1861.\(^\text{12}\)

![Line graph showing trauma deaths in Sweden](image)

**Figure 5.** Trauma deaths in Sweden (Swedish contingencies agency, MSB).\(^\text{10}\) Note that the most common trauma death, falls, increases. Road traffic (yellow decreases). Intoxications (dashed blue) increases. The peak of drowning (dotted red), the Estonia sinking, amply illustrates the leitmotif of this thesis: injuries are not accidents. There were at least a dozen causes of the sinking of MS Estonia.
In Oklahoma, USA, a similar trend as in Sweden was found with a 4% increase in fall injuries between the years 2000 and 2014 that required hospitalization and at the same time a reduction in traffic injuries by 4%.

**DALY**

Mortality is a well-defined measure that is often used in international and global comparisons. But death is just the tip of the pyramid Figure 2. There are many more minor than severe injuries that also affect quality of life, which is more difficult to estimate because of its subjective nature, depending on, e.g., the individual’s needs and expectations but also of many social and economic factors, not least social insurance systems. To describe this better, the WHO has developed DALY\(^{13}\), Disability Adjusted Life Years and YLD, Years Lived with Disability which combines estimations of lost years of life and disabled years of life. It is a theoretical estimation of a combination of years in relation to quality of life and a theoretical ideal health status. (The WHO hard-to-understand and utopian definition of health is a “complete state of wellbeing, not merely the absence of disease.)

Eurosafe reports that fall injuries are the causal mechanism that clearly dominates as a quantitative contributor to the injury burden in the EU. Calculations of PYLLs (potential years of life lost) discloses a loss of 9 years in death due to a fall, while a fatal traffic accident leads to 32 lost years. The Swedish Transport Administration (Trafikverket) values a human life at SEK 41 million in their economic calculations when planning road construction projects.

**Fall injuries**

Fall injuries are already now the most common injury mechanism, mainly due to the rising number of elderly citizens, and together with intoxication, still increases in Sweden. This increment will continue as the number of octogenarians in Sweden will double in the next decades.\(^{14}\)

**“Low-energy injuries”**

It is a common misconception that falls from standing height or lower are necessarily “low-energy”\(^{15}\). Actually, since the kinetic energy is proportional to the mass times the velocity squared, the kinetic energy can be considerable if the patient’s neuromuscular reflexes do not dampen the impact. Neuromuscular protective reflexes is the most important mechanism to prevent injuries, more important than tissue strength. Furthermore, bones are mechanically anisotropic, i.e., much stronger in the usual physiological directions. Even a normal hip can fracture after an unprotected lateral fall—the difference being that young people seldom do. One or two such cases are seen every year in any orthopedic department, usually occurring in young/middle-aged cyclists or skiers having suffered sideways falls.
The Vision Zero in road traffic
The Swedish Parliament has endorsed a zero vision for deaths on roads and at workplaces. And actually, between 2000 and 2018, the number of road traffic deaths decreased by 45% from an already low level. This was achieved by many different interventions, lower speed limits, safer cars, level crossings, roundabouts and 2-1 roads etc., not by isolated individual actions. However, if the government really had wanted to prioritize the zero vision, the goal could have been easily achieved by introducing a general speed limit of 5 km/h, i.e., normal walking speed.

Sport
Sport injuries contribute about 25% of all acute injuries and a considerable part of overuse injuries. Driving motorcycle and snowmobile are activities with the highest injury incidence followed closely by playing handball. Football is the sport with most injuries and responsible for almost half of the total injuries, but it is also the most common sport in Sweden.

In certain sports donning protective devices such as helmet and braces are common or mandatory. The usage of a helmet is well tolerated and reduces the risk of contracting serious head injuries except for the more common concussions. However, there are studies suggesting there are no clinical benefits to wearing knee supports: The protective effect on ligament injuries in American football is inconsistent and is accompanied by negative effects such as a higher risk for injuries of adjacent joints. On other hand, ankle braces have proved effective for secondary prevention. Braces are shown to be effective in decreasing the risk of snowboarding wrist injuries. Spine protections for motorcyclists, however, do not exert any convincing mitigating effect on the injury outcome. Hip protectors have been used in nursing homes and have a certain effect in patients with frailty and multimorbidity. The problem for people in community living seems to be adherence to the regime.

Severity grading
Abbreviated Injury Scale (AIS) was developed for statistical purposes. It is based on anatomical division: head, face, neck, thorax, abdomen, spine, upper extremity, lower extremity, and whole body. Severity is graded into 6 levels: AIS 1 is a mild injury and AIS 6 is fatal. An example of AIS 1 is a superficial wound and AIS 3 a femoral fracture. The system was further developed to better describe patients with multiple injuries and their mortality risk by including the three most severely injured regions. Each injury is given an AIS number.
that is squared to give a total sum, which is rated to the Injury Severity Score (ISS).\textsuperscript{89} This, in turn, has been criticized for only including one injury of each body region, leading to the possible inclusion of a less serious injury in another body region rather than another serious injury in the same body region. To overcome this limitation, a modified ISS, the New Injury Severity Score (NISS), was introduced: the sum of squares of the three most serious injuries, regardless of site. Further modifications have been introduced to improve predictability, for example, Wang et al developed the Exponential Injury Severity Score (EISS) by modifying the AIS system.\textsuperscript{19}

**Age**

In medical epidemiology, age is usually the strongest factor by far, and also concerning injury. Time is naturally described by a line or vector. For the individual at a given moment, age encapsulates many factors that can be illustrated by yet another geometrical shape, a circle surrounded by numerous factors that modify the subject’s vulnerability, and risk factors that have different centers of gravity for different injury mechanisms, constantly changing because of comorbidity and the external environment. In my opinion the most interesting one from a prophylactic point of view is opinion fall injuries in the elderly where endogenic, intrinsic factors dominate Figure 7.

*Figure 7. The complex situation of individual patient can also be described with a circle, illustrating the almost countless factors that influence not only the fall risk but also the consequences of injuries. But it is also important to realize that there is a constant change along the timeline, especially in old people in whom comorbidity and other adverse events are common.*
Trauma-recidivism

The concept of trauma recidivism was framed for urban young men in big US cities but has also been described elsewhere plagued by social problems and abuse. Injury-prone subjects have also been noted also in sports, e.g., those repeatedly suffering ankle sprains and anterior cruciate ligaments injuries. Risk-taking behavior affects more than the type of injury. Unfortunately, the literature is sparse for non-sport associated injuries. It has also been suggested that disability per se may convey trauma recidivism.

It is therefore easier to understand that comorbidity is a risk factor for injuries, especially so for psychiatric/neurological disorders. In younger people, ADHD (Attention-Deficit/Hyperactivity Disorder) is characterized by cognitive deficits and behavioral disturbances like incapacity to regulate body movements. In a meta-analysis ADHD was significantly associated with an increased risk of injuries by about 50% in children and adolescents. In approximately 65% of children symptoms persist into adulthood. In a cross-sectional study from Canada ADHD was overrepresented with a factor of 2.5 among adults with traumatic brain injury (concussion). Among epileptics, on the other hand, there is surprisingly only a moderate overall increase in injuries. In contrast, as the injury pyramids show, comorbidity has a huge impact in geriatric trauma.

Prevention

Traumatologists often have a tepid interest in injury prevention, in contrast to colleagues from other medical fields, e.g., infectious diseases, cardiology, and oncology. Specialists in infectious disease celebrate their grandest triumphs in plagues that never break out. In cardiology, long-term work in Denmark has halved the incidence of fatal myocardial infarction. According to the Swedish heart registry, the risk of death within a year of a heart attack has decreased from 25% to 15% between the years 1995 and 2010. The improvement has been achieved through many sustainable and widely applicable interventions, such as the Norsjö project which shows that public health effects are better served by many people doing a little than by a few doing a lot.

As previously mentioned, the load of most types of injuries have decreased significantly during recent decades, particularly work-related injuries and traffic injury mortality. Pediatric injuries have also decreased due to effective preventive work.

8
Figure 8. The pediatrician Ragnar Berfenstam started 1953 a loose network to decrease “accidents” in children. Here in clinical action in the mid 1950’s. He is probably the Swedish physician who has saved most human lives—also probably some of the readers’ or their parents’—not by treating individual patients but rather by networking and opinion building the foundations of public health work.

However, despite these achievements, efforts are now needed in areas of injury that up to now have received too little attention in view of their extent. Leisure-related injuries are so far not subject to any systematic preventive measures.

Osteoporosis
Traditionally, fragility fractures have largely been ascribed to frail bones, osteoporosis. Osteoporosis was not included in the present study since we had no links to measurements of bone mineral density. However, most people with “osteoporosis-related fractures” do not have osteoporosis but osteopenia. Yet there are indications that it would be favorable to infuse high-risk patients with zolendronate after surgery, before they leave the orthopedic ward.

Fracture liaisons services
Secondary prevention with fracture liaison services from Sweden and Australia have reported a 30% and 18% risk reduction for future fractures, respectively, among those who were included in the prevention program. The programs include osteoporosis screening in both studies, the Australian study also advice on lifestyle and diet. However, many different intervention programs seem to fail in real life, due to a low rate of adherence.
Materials and Methods

Umeå Injury Database

At the emergency department (ED) of Umeå University Hospital an injury registration procedure was established in 1985, IDB (Injury Database), including Umeå and surrounding municipalities. Since 1995 the records were digitized to annual databases using 10-digit unique personal identity numbers for references. We concatenated the databases and also added 1993-94 digitized from paper forms. The Umeå Injury Database has been part of the European Injury Database, held by Eurosafe on behalf of the EU31 and the Swedish Board of Health and Welfare32. Also, transportation injuries were registered in a separate database.33

Table 1. All studies were based on all patients registered in the Umeå area that came to the emergency department.

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<tr>
<th>#</th>
<th>Title</th>
<th>Years</th>
<th>Age</th>
<th>Selection</th>
<th>N</th>
<th>% men</th>
<th>Research questions</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td>Trauma recidivism at an emergency department of a Swedish medical center</td>
<td>1999 - 2012 20-108 X=47</td>
<td>Adults</td>
<td>98,502</td>
<td>55%</td>
<td>Trauma recidivism</td>
<td>Descriptive epidemiology. Associations analysis with Cox regression.</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Geriatric falls</td>
<td>1993 - 2014 65-108 X=79</td>
<td>Fall injuries</td>
<td>27,402</td>
<td>33%</td>
<td>Injury panorama. Fall vs severity score</td>
<td>Descriptive epidemiology</td>
<td></td>
</tr>
</tbody>
</table>

Inclusion

All patients at the ED were registered in the database. The inclusion criteria being that the patient/relative thought that it was necessary. This to some extent explains that a number of individuals did not have an injury. Only residents in the catchment area were included. The IDB data forms contained about 70 items, e.g., sex, age, site of residence, place, time, and date of the injury; up to three diagnoses, abbreviated injury scale (AIS), free text
describing the injury event, and several data specifics of the injury event, for example, whether seat belts and head rests were used. Since the information gathered in the registry was captured with a high degree of resolution, it was necessary to aggregate the variables. E.g., injury type consists of 27 groups. We merged them into 10 main groups: fracture, contusion, wound, sprain, concussion, foreign body, thermo, strain, poisoning and other. Most of the injuries grouped into these injury categories were fairly homogenous. However, in the case of the variable 'wound', the spectrum of injury was relatively diverse and included simple open wounds engaging the skin and sometimes subcutaneous tissue as well as more severe injuries including muscle, nerve, vascular injuries, and traumatic amputations. Simple open wounds were 86% of the cases classified as a wound. To classify activities, we used the following categories: work, leisure, road traffic, and sports. The work category is based on the following sub-categories: employment, housework, and education.

Registration procedure
At the ED, patients were asked to fill out a questionnaire on the injury event, including a consent; if unable, relatives or proxies answered the questionnaire of the IDB. The forms were registered by trained coders, about 20 during the study period. The patients’ medical records, ambulance reports, and sometimes police reports were also checked. If information was still missing, the coders contacted the patient by telephone for additional information.

AIS/ISS
IDB used the abbreviated injury scale (AIS) to classify the severity of an injury. From year 2001, up to three injuries were registered per injury event for calculating an ISS value. The ISS is an anatomical scoring system that gives an overall score for patients with multiple injuries. For each body region injured, the AIS gives a number between 1 and 6. The three most injured body regions have their AIS number squared and summed up to give the ISS.

Validation of the database
The database was validated every year for missing cases by the hospital’s patient registry for inpatient cases and by billing information from the Emergency Department for out-patient cases. There were 2.3 % missing cases, most of whom had registered but could not wait for examination.

Statistics
In paper 2, 3 and 4, respectively, we calculated incidences in 10-year age groups, in paper 5, 5-year age groups, using the mid-year population data obtained from Statistics Sweden. We took, for example, the 1999 population data which is calculated 1999-12-31 and summed up with 2000-12-31 and then halved this sum for the year 2000. This was reported as events per 10,000 person-years with a 95% confidence interval. In paper 5 we presented the fracture incidence by 1,000 and 100 person-years. To compare averages, we used independent samples t-tests and to examine differences in proportions, Pearson’s chi square tests were used. To compare injury type, proportions before and after first hip fracture z-test was used.

For trend analysis we used logistic regression with time as a quantitative explanatory variable. Logistic regression is used when binary outcomes are considered: injury or not injury. The result is presented in odds which are the probability that something will happen divided with the probability that will not happen. Logistic regression was used in paper 2,3 and 4 to evaluate the trends for different injury types, hip fracture, injury mechanisms, and
activities the individual was engaged in at the time of the injury. The dependent variable was injury (injury = 1; non-injury = 0), and the continuous predictor variable was time (in years). We used 95% confidence interval for presentation of the odds ratios.

To analyze the association among independent variables (injury types, activity at the injury, number of previously injuries and age) and risk for recurrent injury and hip fracture, Cox regression analysis was used. In Cox regression method in paper 3 we used all other injury types as the reference and in paper 4 fracture was used as the reference. Age was adjusted for as a confounding factor and the rejection level was set at 5%.

**Ethical aspects**
The IDB has been used for numerous reports and scientific papers. The patients gave their permit when filling in the form. The data were handled anonymously on a group level and the data is kept in servers of the region Västerbotten. Ethical permits, Regional Ethics Committee Umeå. Registration numbers: 2013/148-3, 2014/48-31; 2013-61-31; 2016/447-31
Results

The Umeå injury database 1993—2014 in a demographic perspective

The catchment area constitutes of 6 municipalities Table 2. Between 1998 and 2014 the population of the study area increased by nearly 10%, which is entirely propelled by the regional center and its ability to attract students and other groups of people, originating from other parts of the country and abroad, interested in job opportunities in the expanding trade and industry (In 1991 university students were registered at the place of study). Umeå’s share of the population was 76% in 1998 and grew to 80% in 2014. The development of the surrounding municipalities is unfortunately rather gloomy since the population numbers drop at a significant pace. This is partly due to an ongoing urbanization process in society in general, and partly a skewed age distribution with numerous elderly people residing in these municipalities. This age-related imbalance is to a certain extent emanating from extensive net out-migration in the past when young people and middle-aged people had to move to jobs offered in thriving manufacturing industries in southern Sweden.  

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Umeå</td>
<td>103,517</td>
<td>119,613</td>
<td>15.5%</td>
</tr>
<tr>
<td>Vännäs</td>
<td>8,574</td>
<td>8,616</td>
<td>0.5%</td>
</tr>
<tr>
<td>Nordmaling</td>
<td>7,873</td>
<td>7,085</td>
<td>-10.0%</td>
</tr>
<tr>
<td>Robertsfors</td>
<td>7,439</td>
<td>6,724</td>
<td>-9.6%</td>
</tr>
<tr>
<td>Vindeln</td>
<td>6,245</td>
<td>5,383</td>
<td>-13.8%</td>
</tr>
<tr>
<td>Bjurholm</td>
<td>2,786</td>
<td>2,451</td>
<td>-12.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>136,434</strong></td>
<td><strong>149,872</strong></td>
<td><strong>9.8%</strong></td>
</tr>
</tbody>
</table>

Table 2. Demographic changes in the Umeå area.

Figure 9. Demographic development for Sweden, Umeå, and Robertsfors. Blue men, red women.
The different municipalities had different incidence rates for ED visits as well hospitalization.

<table>
<thead>
<tr>
<th>Residents in</th>
<th>n</th>
<th>Incidence 10,000 person years</th>
<th>n</th>
<th>Incidence 10,000 person years</th>
<th>% hospitalized</th>
<th>Distance from Umeå (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Umeå</td>
<td>175,821</td>
<td>765</td>
<td>27,768</td>
<td>121</td>
<td>16%</td>
<td>0</td>
</tr>
<tr>
<td>Vännäs</td>
<td>13,012</td>
<td>694</td>
<td>2,791</td>
<td>149</td>
<td>21%</td>
<td>32</td>
</tr>
<tr>
<td>Nordmaling</td>
<td>9,483</td>
<td>590</td>
<td>2,260</td>
<td>141</td>
<td>24%</td>
<td>51</td>
</tr>
<tr>
<td>Robertsfors</td>
<td>8,959</td>
<td>670</td>
<td>1,939</td>
<td>145</td>
<td>22%</td>
<td>60</td>
</tr>
<tr>
<td>Vindeln</td>
<td>6,153</td>
<td>365</td>
<td>1,653</td>
<td>98</td>
<td>27%</td>
<td>56</td>
</tr>
<tr>
<td>Bjurholm</td>
<td>7,511</td>
<td>424</td>
<td>673</td>
<td>114</td>
<td>27%</td>
<td>59</td>
</tr>
<tr>
<td>Unknown/missing value</td>
<td>4,065</td>
<td>1513</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>220,014</td>
<td>38,597</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Incidences of trauma ED visits and trauma hospitalizations of the municipalities.

Figure 10. Left: age distributions for the entire population. Middle: injuries that visited the ED. Right: hospitalizations to the. The nose of the Janus faces of Umeå illustrates that it is a university town. (Note that the x-axes have different scales).

The age pyramids of the population show a relatively even distribution between men and women. For all injuries the distribution was skewed. Men were responsible for the most ED visits from childhood to about 60 years of age. In the older age groups, women had most ED visits and hospitalizations.

Among children 0-2 year 13.4% were not diagnosed with an injury according to ICD or AIS, the proportion for 3-17 years was 3.5%. Among adults the percentages were 4.1% for those 18-64 years and 2.4% for those older than 65.
Figure 11. Injury mechanisms for 220,014 injury events in different age groups at the emergency department. Blue, traffic. Yellow falls. Red all other injuries. Left column, absolute numbers Right column, percentages. Upper row ED visits. Lower row the resulting trauma-related hospital days.

Fall was the most common injury mechanism for all injuries, pronounced in young and old ages. Fall-injuries among elderly people was the reason for the most days in hospital. Men were more injury-prone from childhood until the age of 60, whereas women were more affected by fractures and all fall injuries from the age of 45 Figure 12.

Figure 13. Absolute numbers, (bars) and incidences (lines) of 220,014 injury events. Men blue, women red. All injuries (upper left); fall injuries (lower left); all fractures (upper right); and fall fractures (lower right). Left Y-axes denote absolute numbers. Right Y axes incidences per 100 person-years. Note the different scales of the Y-axes in the four graphs.
The most common activity at the injury event was leisure and the most common place where at home.
In a helicopter perspective, describe injury mechanisms, place, activity and severity in relation to sex/age

During 1999—2008, we found an annual increase of all injuries by 0.5%. The most common injury was a fracture and was responsible for 75% of all hospital days that were trauma related. Wound and contusions were also common. Contusions accounted for 8.5% of the hospital days.

Table 7. Injury numbers, categorized by injury type and mechanism, for ages 20 and above, during years 1999 to 2008

<table>
<thead>
<tr>
<th>INJURY TYPE</th>
<th>N(visits)</th>
<th>Proportion of ED visits</th>
<th>N(days)</th>
<th>Proportion of in-hospital days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture</td>
<td>17,109</td>
<td>25.1%</td>
<td>9,914</td>
<td>74.9%</td>
</tr>
<tr>
<td>Wound</td>
<td>15,523</td>
<td>22.8%</td>
<td>5,773</td>
<td>4.4%</td>
</tr>
<tr>
<td>Contusion</td>
<td>14,688</td>
<td>21.4%</td>
<td>11,112</td>
<td>8.5%</td>
</tr>
<tr>
<td>Sprain</td>
<td>12,425</td>
<td>18.2%</td>
<td>4,011</td>
<td>3.1%</td>
</tr>
<tr>
<td>Concussion</td>
<td>2,712</td>
<td>3.2%</td>
<td>2,247</td>
<td>1.7%</td>
</tr>
<tr>
<td>Other</td>
<td>6,304</td>
<td>9.2%</td>
<td>9,661</td>
<td>7.4%</td>
</tr>
</tbody>
</table>

Table 8. Numbers and proportion of Emergency Department visits and in-hospital days for major injury types.

The injury types had different age patterns. Fractures had a fairly equal level between 20 to 60 years and thereafter increased with increasing age. Contusions had a similar pattern whereas sprain decreased with older age. Wound showed a more biphasic distribution especially among men. In the younger age groups men were more injury prone, especially for wounds. In the older age groups, women were more affected. Injuries due to fall increased with age.
Figure 14. Incidence for women and men in 10-year-age groups (95% confidence interval), for five injury types and falls, 1999 to 2008 (A to F).

The most frequent activity when injuries occurred was during leisure time followed by work time. Leisure time injuries also increased during the study period. In this study the activity variable work included beyond employment work, also homework and education. Injuries that occurred during sports remained at the same level.

Trend analysis of fractures showed a significant increase in both men and women in the ages between 50 and 60, while other age group were at the same level. For contusions, there was an increase for almost all age groups.
**Trauma recidivism**

Thirty-six percent of all patients suffered recurrent injuries which accounted for 40% of all injuries, and were associated with more hospital days. Young men and elderly women were at the highest risk for trauma recidivism. At 20 to 24 years, men had a 2.4 (CI 95% 2.3–2.5) higher risk than women, a 90-year-old woman had almost a 10-fold higher risk for another moderate/severe injury than 20 years old one.

To widen the knowledge base for prevention we analyzed the risk (hazard) for a recurrent injury with moderate or severe outcome (ISS 4 or more), within 5 years from the first injury.

Fractures and sprains among men increased the HR for recurrent injury more than for other injury types while wounds as well as foreign bodies reduced the HR. “Foreign body lesions” mainly represents corneal lesions. Women exhibit similar patterns except that fractures do not increase the HR statistically significant in the older age group. Younger men had a significant higher HR for future injury if they had a concussion as first injury.

<table>
<thead>
<tr>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age group</strong></td>
<td><strong>20-65 year</strong></td>
</tr>
<tr>
<td></td>
<td>HR 95% CI</td>
</tr>
<tr>
<td><strong>Concussion</strong></td>
<td>1.41 (1.12-1.77)</td>
</tr>
<tr>
<td><strong>Contusion</strong></td>
<td>ns</td>
</tr>
<tr>
<td><strong>Fracture</strong></td>
<td>1.28 (1.15-1.42)</td>
</tr>
<tr>
<td><strong>Sprain</strong></td>
<td>1.13 (1.00-1.26)</td>
</tr>
<tr>
<td><strong>Wound</strong></td>
<td>0.89 (0.80-0.98)</td>
</tr>
<tr>
<td><strong>Poison</strong></td>
<td>ns</td>
</tr>
<tr>
<td><strong>Thermo</strong></td>
<td>ns</td>
</tr>
<tr>
<td><strong>Foreign body</strong></td>
<td>0.76 (0.59-0.98)</td>
</tr>
</tbody>
</table>

*ns = not significant*

**Table 9.** Hazard ratio for moderate/severe second injury in relation to first injury type. The analyses were divided by gender and age group and adjusted for age (in years) within each age group. The reference is all other injuries.
What happens before and after a hip fracture?
The hip fracture incidence decreased annually by some 2-3% but the total numbers increased with 3.5%. The age distribution was almost identical with the national register.

Figure 15. Hip fracture age distribution in the Swedish hip fracture register (left) Rikshöft 2019 (n=12,402). An almost identical distribution as the injury database (right). It is obvious that below 60, hip fractures are rare and more equal between the sexes. Hip fracture in young and middle age has different pathomechanisms—severe trauma and metabolic bone diseases—than in older age groups.

Figure 16. Number of events per month before (left) and after (right) the first hip fracture at zero, origo. The index hip fractures are not shown in the graph. Blue bars, all injuries. Red, subsequent hip fracture. Black, death.

Of course, there is a selection, since one cannot die before a hip fracture. But there is a clustering of events at origo. The wide age span, (>50) probably dilutes the results, since some 75% of hip fractures occur in people over 75. From a practical health care point of view, a window of a few years before and after would be more clarifying. These data suggest that prior injury in an unselected material, perhaps, only conveys a moderate risk increase. The death toll is striking and subsequent injuries are most frequent the first years.
Table 10. Fracture type for the subsequent hip fracture (contralateral/ipsilateral) It was more common that the second hip fracture was the same type.

Analyzing the association between prior injuries and hip fractures shows that fracture is the most important injury type. Among younger men the HR for contusion is 0.46 and 0.84 for elderly women, which is to be interpreted that a contusion is probably more predictive for future hip fracture in a elderly women than a young men. The number of earlier injuries have an effect on the HR for hip fracture in the younger age groups.

Table 11. Hazard ratio for hip fracture in relation to earlier injury type age and number of earlier injuries. The analyses were divided by gender and in two age group and adjusted for age (in years) and number of injuries within each age group (for the injury type table). The reference for the Cox regression is fracture.
The 1-year mortality was 28.2% among men and 17.9% for women. 12% of the patients suffered a subsequent hip fracture, in 17% on the same side. The average time to the subsequent hip fracture was 2.8 years for men and 3.6 years for women. The subsequent hip fractures were most often of the same type as the first one. Table 11

**Geriatric fall injuries**

Falls constituted about the same percentage of all injuries mechanism as chronological age. Estimated fall height decreased with age. Injuries became more common in the lower extremity and also more proximal with increasing age.

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th></th>
<th>Women</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=</td>
<td>%</td>
<td>n=</td>
<td>%</td>
</tr>
<tr>
<td>Fractures</td>
<td>3,821</td>
<td>27%</td>
<td>10,210</td>
<td>73%</td>
</tr>
<tr>
<td>Soft tissue injuries</td>
<td>5,090</td>
<td>39%</td>
<td>8,026</td>
<td>61%</td>
</tr>
<tr>
<td></td>
<td>8,911</td>
<td></td>
<td>18,236</td>
<td></td>
</tr>
</tbody>
</table>

**Table 13. Summary of Figure 17, anatomical distribution of fall injuries.**

![Figure 17](image)

*Figure 17. Incidences of the most common extremity fractures (81.8%) because of falls in different age groups per 100 person-years. Red women, blue men. Note that the scales are different, hip fracture is about ten times and wrist about 2-3 times the other ones.*

Most fracture types become more common with increasing age, except for ankle fractures. Hip fractures increased 40-fold from the age of 65 to 90 year and femur diaphysis fracture about 8 times, whilst wrist fracture incidences only increased slightly, which indicates that the bone strength is of minor importance and that other factors as neuromuscular reflexes are more important.
Figure 18. Ratios localization of extremity fractures in different age groups. There is a shift to localization in the lower extremity, about a doubling, towards a more proximal localization. However, in the upper extremity there was an increase in wrist fractures women in the 75-84-year group, not seen in any of the other fracture localization groups.

Table 12. The IDB has 7 classifications of falls. We arbitrarily dichotomized them into “high”: fall in stairs and estimated fall >1 m; and “low”:slipping, tripping, and <1 m.

<table>
<thead>
<tr>
<th>Kind of fall</th>
<th>65-69</th>
<th>70-74</th>
<th>75-79</th>
<th>80-84</th>
<th>85-89</th>
<th>95-94</th>
<th>95+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall same level, slipping</td>
<td>1373</td>
<td>32%</td>
<td>1217</td>
<td>27%</td>
<td>1013</td>
<td>19%</td>
<td>756</td>
</tr>
<tr>
<td>Fall same level, tripping</td>
<td>1196</td>
<td>28%</td>
<td>1440</td>
<td>32%</td>
<td>1890</td>
<td>36%</td>
<td>2159</td>
</tr>
<tr>
<td>Fall in stairs</td>
<td>369</td>
<td>9%</td>
<td>343</td>
<td>8%</td>
<td>373</td>
<td>7%</td>
<td>335</td>
</tr>
<tr>
<td>Fall &lt; 1 m</td>
<td>342</td>
<td>8%</td>
<td>364</td>
<td>8%</td>
<td>386</td>
<td>7%</td>
<td>436</td>
</tr>
<tr>
<td>Fall &gt; 1 m</td>
<td>199</td>
<td>5%</td>
<td>126</td>
<td>3%</td>
<td>145</td>
<td>2%</td>
<td>45</td>
</tr>
<tr>
<td>Other specified fall</td>
<td>206</td>
<td>5%</td>
<td>220</td>
<td>5%</td>
<td>226</td>
<td>4%</td>
<td>272</td>
</tr>
<tr>
<td>Unspecified fall</td>
<td>648</td>
<td>15%</td>
<td>760</td>
<td>17%</td>
<td>1302</td>
<td>25%</td>
<td>1686</td>
</tr>
</tbody>
</table>

Table 12. The IDB has 7 classifications of falls. We arbitrarily dichotomized them into “high”: fall in stairs and estimated fall >1 m; and “low”:slipping, tripping, and <1 m.

Figure 19. Percentage of falls that were classified as “high energy” in all age groups (n=95,196).
**Figure 17** Injury distribution after falls in different age groups. “Soft tissue injuries” were operationally defined as all other injuries than fractures.

### Anatomic %-distribution of fractures after falls in different age groups

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>65-74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75-84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>85+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table and diagram illustrate the percentage distribution of fractures across different age groups, with specific details not clearly visible due to the image resolution.
Anatomic %-distribution of soft tissue injury after falls in different age groups

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>65-74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75-84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>85+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- Blue: Percentage of Men
- Red: Percentage of Women

Note: Specific percentages are not provided in the image.
Discussion

I AM SOMEWHAT EMBARRASSED that during a 23-year long career as an orthopedic surgeon I have rarely thought that it would be possible to reduce the load of injuries at a macro level. For individual patients? Well, of course: slippery floors and snow clearing off roofs, etc, but in a busy ED, there is seldom time to spot the forest for the trees.

Materials and Methods

The inclusion criteria for this injury database were that the patient or their proxy thought it was necessary to visit the emergency department (ED), and also that the patient was registered as an inhabitant of the Umeå area. Most injuries, though, were trivial, and especially in infants a definite trauma diagnosis was often not made. The Swedish social insurance system ensures that the hospital fees are low for adults, for children free. But there are of course other than medical factors that steer demand and supply. Health care is indeed an elastic commodity with an almost infinite demand. The association between geographical distance to the ED and the injury incidence indicate that availability has an effect. 36

It is also human to think that a sudden and unexpected pain that usually happen during physical activity, is caused by injury, e.g., acute low back pain and muscle/ tendon ruptures due to degenerative diseases. Insurance-wise it is also more beneficial for the patient to receive a trauma diagnosis than a disease/disorder label. In addition, luckily, we have a deficient memory for physical pain, and injury events are by definition acute, so reconstruction of events is not always straightforward, even for lucid persons.

The injury database (IDB) also includes intoxication and self-inflicted injuries that along with falls are increasing. There were also a number of more or less specific “over-use injuries” that are not included in this analysis. Traumatic brain injury was difficult to analyze in the IDB for several reasons: the categorization criteria for cerebral concussion was changed during the study period; the most common entity chronic subdural hematoma is often not possible to link to a specific injury event. Furthermore, diagnostic imaging and the improved treatment of stroke has changed much; previously some strokes were considered as fall injuries, and vice versa. 37

Age

In medical epidemiology age is almost always the strongest factor, not least because age integrates many if not most other medical factors. We found different age-depending patterns for the major injury types. Fractures and contusions became more common with age in spite of a more sedentary life style in the elderly. The striking changes in distribution pattern is previously described for fractures but as far as I know not for a single injury mechanism nor for soft tissue injuries.

Injury mechanisms

The IDB has a pragmatic and wide definition of injury, but some 90% was caused by mechanical energy, the main focus of this study. Falls dominated, comprising 43%. As previously mentioned, in rich countries falls kill more people than all other injury mechanisms combined. It is a common misconception is that all falls from standing height or even less are necessarily “low-energy injuries”. It deserves to be repeated: Kinetic energy is proportional to mass times velocity squared, and if one cannot par and dampen the fall, the
impact can become considerable and break any bone. Evolution cannot afford to over-
dimension tissue strength, that would result in heavy and cumbersome bones, that would
have been negative for survival of the fastest on Africa’s savannas some million years ago.38

During the project my attention was increasingly focused on fall injuries in elderly people,
the by far most common problem, not least because other injury mechanisms are already
more well investigated. We found a striking association: with increasing age the proportion
of “high-energy” falls (>1m) decreased and the severity of injury increased. This supports the
importance of having intact protective neuromuscular reflexes to dampen the impact of a
fall, an ability that deteriorates with age.39

**Time and place**

Most injuries in our study occurred during leisure time and at home. In affluent countries, as
mentioned, these injuries kill and maim more people than all other injury mechanisms
together. In Sweden about 91% of all trauma deaths happened at home or during leisure
time.10, 40 But why are home and leisure injuries so neglected in terms of prevention?

One explanation is that other injury mechanisms have been subjected to persistent injury
control and prevention, because of laws and economic incentives. Another one, is that they
happen in everyday activities, in the bathroom or kitchen, and therefore are trivialized,
irrespective of their often calamitous consequences. An individual is responsible for her own
safety at home; at work and in transportation or commercial settings someone else may be
blamed.

Besides humanitarian aspects, money has thus been a strong incentive for injury prevention
in industry and transportation. The efficacy of these projects has been impressive. It is easier
to claim responsibility from, e.g., employers and insurance companies when an otherwise
healthy person suffers an injury, than a multi sick elderly person. Statistically, the most
dangerous place to be is in a hospital or institution.41 Unsurprisingly, in our material 4% of all
hip fractures occurred in hospitals and 29% in nursing homes, which is almost the same
figures as for Sweden as a whole, according to the Swedish Registry for hip fractures.83

This sorry state of affairs has been shown many times before, but few seem to bother,
perhaps because many believe that it is inevitable. It is indeed a pity that most
hospitals/institutions cannot give reliable figures of adverse events, e.g., falls, and use this
knowledge as a tool for statistical process-steering like most other industries, e.g.,
production and transport.10 Health care largely relies on unreliable point prevalence
measurements and yesteryears’ information.

**Type and localization of injury**

Orthopedic injuries predominated, and extremity injuries accounted for some 60%.
Fractures were the most common injury, most radiologically confirmed, and surely the
fracture diagnoses were more reliable than “soft tissue injuries” (the term we used to
describe non-fracture injuries), where an exact anatomic diagnosis it is seldom necessary for
treatment. One of the most reliable trauma diagnoses is hip fracture—beloved by
epidemiologists—, since almost all patients are so incapacitated that they seek health care,
and almost all undergo surgery and therefore wind up in diverse databases. The shift of
injury type and localization—more localized proximally in the lower extremity—, again,
underlines the importance of neuromuscular protective reflexes.
Injury trends
Figures were remarkably constant during the study period, bar fall injuries and intoxications. One explanation of the slight annual increase in the total injury incidence could, as mentioned, be the availability and perhaps a continuous urbanization, less distance to the ED increases the number of visits; the increased proportion of mild injuries also speaks in the same direction. Also, perhaps, a more active lifestyle, as suggested in a Swedish study where the oldest cohorts were reported to have become more physically active, and the younger more sedentary. Another study, the Västerbotten Intervention Program, found that already active middle-aged people became more physically active, thereby increasing their injury risk.

Trauma recidivism
We found a surprisingly high rate of recurrent trauma (40%), higher than in most previous studies, perhaps because we included all injuries, not just severe ones like in the most US studies. There was also just one ED in the area, and we had a long follow-up observation.

But, how far into the future should one look? A couple of years might be reasonable. This seems largely dependent on the purpose of the prognoses, and not least on the patients’ age. In political and economic planning some 4-5 years are often used as a foreseeable time perspective. Cox analyses compensate somewhat for time intervals.

Regression analysis showed that fracture and sprain were the injury types that most often preceded a new injury with an ISS of 4 or more. Also, more severe injuries conveyed an increased risk of new ones. One interpretation may be that fractures leads to more disability which per se increase injury risk. But, trauma recidivism is probably more often due to other factors, as behavior observed in hockey players with cerebral concussions and other injuries.

The practically most important prognosis is fracture prediction in the elderly. FRAX®, uses a 10-year perspective, which seems a little bit long for the oldest old that have the highest risk. Shorter time spans are more appropriate, perhaps a couple of years, especially if we can embark on comprehensive injury prevention programs, when efficiency and efficacy have to be monitored. For the elderly, the risk of other life-changing medical and social events is perhaps too substantial for a decade-long perspective. (Compare with weather prognoses that in spite of an enormous data input and supercomputers can rarely accurately predict more than 5-10 days.)

Statistics Sweden estimates an average remaining life span of 7 years that for an 83-year-old person (about the mean age for hip fracture patients), but hip fracture patients are frailer and often die sooner, especially males. Our results for the one-year hip fracture mortality were 28% for men and 18% for women, but impairment and quality of life are perhaps more important aspects. Despite vigorous efforts hip fracture mortality has remained remarkably constant during the last decades supporting the notion that it is not only the fracture that kills and impairs, but the patients’ general conditions are equally if not even more important, and this should be included in prognostic tools.

Hip fracture—the queen of all fractures
Unlike all other fractures, hip fracture has an age distribution, increasing exponentially 40-fold from middle age to senescence, like many cancer diagnoses. The incidence of hip
fractures has decreased from the end of the 1990’s in most rich countries. The hip fracture incidence in our material from 1993-2014 decreased by a few percent annually, mainly for women, in harmony with previous studies.

Why? Improved general health? Osteoporosis treatment? The increased incidence of hip prosthesis surgery? The non-smoking generations? In the 1980’s about 30% of adult Swedes smoked, today 9%. Unfortunately, the IDB does not contain information of tobacco abuse habits. (On the other hand, smokers have a 5–7-year shorter life span, and they often die rapidly, so they may have less time to sustain hip fractures?)

At the same time absolute numbers increase: In our material a 3.5% increase in absolute numbers, and this will continue. The morbidity and mortality are still staggering, at par with metastazing cancer and stroke.

Risk factors for hip fractures are several: as age, female gender, Parkinson disease, low weight, smoking status and earlier fracture. Earlier fracture higher the risk with about 2 times. Our finding is that fracture is the injury type with highest association with future hip fracture, but other injury types as sprain and contusion also have an effect, although less. This finding support including all injuries in selecting patients for hip prevention programs.

No less than 38 % of hip fracture patients sustained new injuries, mostly of them within the first years. Subsequent hip fractures occurred in 12% of patients. Interestingly, no less than 17% of the recurrent hip fractures was on the same side, (hip prosthesis complications were excluded). Admittedly, the distinction between late fracture complications and acute fractures is not crystal clear. However, the subsequent fracture type in the second fracture was more often the same as the first one, which perhaps may indicate inherent constitutional factors.

Geriatric falls
The hip fracture paper led us to study the common denominator from a mechanistic perspective, the root of the evil, i.e., the fall. Since falls are common in all ages, but seldom lead to grave consequences in younger people, we excluded subjects below the tender age of 65. Most studies have wider age spans, which dilutes the results, and it is also common to include all injury mechanisms. By including falls only, we obtained a more homogenous population from a biomechanical perspective. Other reasons for a narrower focus are that some 75% of hip fractures occur in people >75 years of age with a mean >83.

Falls are the only injury mechanism where women predominate. Otherwise, men are generally more injury prone, e.g., road traffic “accidents”, assault and contact sports, because of various factors including aggressiveness and recklessness. There are several possible explanations both from sex (nature) and gender (nurture) perspectives. In a 2005 paper, Fausto-Sterling discusses “The bare bones of sex”, but considering the current political interest in feminism and women’s health, there is curiously little written about this except for bone metabolic aspects (one might wonder why?) Fragility fractures are, after all, one of the biggest women’s health problems, affecting about half of all women during their lifetime, compared with a quarter of all men.

The incidence curves for men and women for all injuries cross over some 10-15 years later than fall injuries/fall fractures. Figure 13. Nature or nurture? Men generally have bigger bones. Mechanically, bigger structures are stronger than smaller ones. E.g., the strength of
a cylinder is proportional to the diameter to the power of three. Moreover, bone mineral density (BMD) is calcium density (g/cm²), and is fairly similar in both sexes, and it is important to remember that BMD is age-wise compared with that of young healthy women. Unfortunately, we did not have links between IDB and BMD.

**Osteoporosis**
No one who has ever operated on patient with a fracture in shrimp-shell-thin bone can deny the importance of osteoporosis, a condition that is probably both overtreated and undertreated. However, bone specific drugs can improve BMD with a few percent per year. And only about 40% of hip fracture patients do have osteoporosis. Recently, studies have shown that zoledronate, a bisphosphonate given intravenously once a year, also has effect on patients with osteopenia. It might therefore be a good idea to give high risk patients with fragility fractures, a zoledronate infusion just after surgery; the risk for delayed fracture healing seems to be low. But one can start with those who get prosthesis as fracture repair, since bisphosphonates also seem to decrease the risk for prosthesis loosening. Moreover, zoledronate can be given without DXA, which is necessary before peroral medications. One shot, one kill. Also, parathyroid hormone and biological drugs, i.e., denosumab, an antibody that suppresses osteoclasts, should perhaps be given more liberally. However, this is not as straight-forward as a single infusion before discharge from hospital.

**Accountability**
We also have the judicial aspect of accountability. As an illustration, when an assistant nurse sprained her knee in a nursing home in Skellefteå, the police carried out an investigation to whether a violation of the Work Environment Act had been committed. Luckily, it had not. Clearly, the cops would have had an even more difficult task to investigate the nurse’s patients’ fall injuries. It would be difficult to find and convict the culprit straw that broke the camel’s back. But at a macro level—just as we have been doing for over half a century for road traffic and workplaces—it is possible to get hold of reliable data that can be converted into useful information, and above all, to track changes and trends. Otherwise, how can we discern the effects of interventions?

**Monitoring injuries**
It is therefore unfortunate that the Swedish Board of Health and Welfare (SoS) has discontinued IDB, allegedly because of GDPR. To achieve reliable IDB information on the national level, it has been estimated that some 15 % of all ED-visits is required. Currently it is 0%. And it would take many years to set up new organizations for registrations, if it is possible at all. In the meantime, one should rather structure and use the health care data that are registered so redundantly in health care databases and the medical records. For every trauma event or hospitalization many ICD codes and administrative data are registered and these can be used for injury surveillance and converted to useful information.

Traffic injuries are decreasing in most rich countries because of sustainable long-term projects. In Sweden STRADA (Swedish Traffic Accident Data Acquisition)33, that was coupled to IDB, has had a leading role, but today STRADA is not registered for various judicial reasons, just like IDB. Road safety work in Sweden has been a success story: road traffic deaths are now at an unusually low level, even compared with other rich countries, and about one fourth compared with countries like Eritrea and Thailand. There are of course several explanations of this positive development, e.g., level roads and separate areas for vehicles and people, speed limits, drunk driving checks and safer cars, to mention a few.
Other necessary measures were massive information campaigns. About 1.8 times more money has been invested in prevention each year than the traffic injuries cost. Corresponding investments to reduce the risk of fall injuries are estimated to be a seventh. In Umeå cyclists were those worst off, but some of them apparently consider themselves immortal.

**Injury prevention**

Tomorrow’s injury panorama in rich countries will certainly be even more geriatric than today. Trauma teams have key roles in secondary prevention in identifying high-risk patients. The ED is not designed to follow up chronic conditions. Primary prevention on a societal level is a public health issue. But the ED and orthopedic departments are strategically placed. We could spot and track our regular customers, *e.g.*, frequent fallers. Airlines have bonus programs for frequent flyers, to lure their customers back. We should keep track of our loyal and faithful customers and offer them gold cards with fast tracks and upgrades—but perhaps not free drinks — and register their mileage to minimize the number their ED visits.

Fall injuries have become increasingly burdensome for health care, while other causes of injuries have decreased in rich countries. There are already many excellent initiatives, *e.g.*, fracture liaison services, osteoporosis clinics, fall clinics, physical therapy to improve balance and strength, nutrition, general medical conditions, along with technical devices, as electronic surveillance exoskeleton and hip protectors, to name a few. 56–64

But since the causes of injuries in general, and geriatric injuries in particular are so diverse, with almost innumerable risk factors, it is difficult to build guidelines on the basis of evidence with randomized controlled trials (RCT), the holy grail of modern medicine.

For one thing, there is almost always a component of injury involved, with so many extrinsic factors, and it would be difficult to convince an ethics committee to approve an RCT on safety risks, *e.g.*, unsafe cars, slippery floors and poor illumination. (We also have the Hawthorne effect, *i.e.*, when we know that we are observed, we change our behavior).

For another, there is very rarely, if ever, just one intrinsic factor. Multimorbidity and polypharmacy are the rule rather than the exception in senior citizens45, 66, and simple casual relationships between them are rare indeed. In addition, we have real and important qualitative issues like judgement and recklessness that also are modifiable, variable and difficult to define in algorithms. We found that prior injury had an effect on the risk for new ones, but that effect is modest, *per se* probably less than many other factors not recorded in the IDB. Age and sex were here used as proxies.

One common mistake is to focus preventive programs on fractures only, as the Swedish board of Health and Welfare (SoS) does in the recent guidelines that almost entirely pinpoints osteoporosis.67 Of course, tissue strength is important as mentioned, but it is difficult to find valid arguments to exclude most of the other possible causes for injuries, if the goal is to prevent fractures rather than to increase the Swedish BMD.

Compare, *e.g.*, with drowning deaths (water is usually a necessary component) and road traffic deaths (better and safer cars is not a panacea). True, there are many successful local initiatives (if it works, don’t fix it), but no comprehensive national coordination, like for road traffic and work place injuries. There are many examples of local and short-term national
projects, and also successful long-term safety projects for children, employees, and motorists. Not so much for frequent fallers, perhaps because they are mostly old women?

Of course, as for other public health problems, local resources and solutions differ much between affluent suburbs and underprivileged, sparsely populated areas.

Programs like the Norwegian “Trygge eldre”87 (Safe seniors) and the Swedish “Balansera mera”88 (Balance more) certainly have a temporary effect. But to be sustainable they must have long-term support and also definable goals, that are constantly followed-up.

SoS has, alas, not only discontinued IDB but also other fall projects. MSB (the Swedish Contingency Agency) has criticized the authorities’ neglect of fall injuries10,11,40,68,69, but in 2010’s also MSB and the National Institute of Public Health, along with SoS, for unknown reasons excluded falls from the agenda. At present, some 9-10 governmental authorities share the irresponsibility for the most common and dangerous injury mechanism.

Physical activity
There is a plethora of physical exercise studies with somewhat diverging results.60,70-75 For obvious reasons there are no long-term large-scale RCT’s that give a five-star grade evidence that physical activity is good for your health, but there seems to be few reasons to set up one. In contrast, there are many RCT’s and observational studies indicating that activity and physiotherapy may decrease fall/fracture risk. However, most physical work-outs are a small fraction of a day’s physical activity. And as Ragnar Berfenstam, who worked with pediatric injuries, wrote: children’s playgrounds must not be designed to be safe and dull, as the kids then will find funnier and more dangerous venues for their activities...

Our somewhat increased risk for fractures in middle age, may perhaps be ascribed to the physical fitness trend. However, most of these sports-related fractures are quite trivial. A finding also identified in a study on postmenopausal women from the USA, where increased physical activity gave a lower risk of future hip fracture while high activity increased the risk of wrist fractures: even a low level of physical activity exerted a risk reduction on hip fracture. This suggests the need to find activities that lead to better balance and strength and at the same time not increasing the risk of injury. More is not always better.

Fall prevention examples
Comprehensive, multi professional approaches seems to be more efficient than monotherapies, but in real life the implementation and project administration are often more important than the methods used. Also, it is impossible to dissect the effects of the many components in a complex multilevel intervention. There are many practical down-to-earth examples of beneficial effects of fall prophylaxis among the elderly: so-called fixer services, e.g., lamp changing, curtain installation, and activating group activities like dancing or organized walking tours, that are difficult to fit in RCT’s.

Trauma teams have a key role, since advice to patients are more effective when given immediately after an injury—a golden pedagogic opportunity—and reinforced at each and every revisit.

Adherence or compliance?
One difficulty with comparing and assessing comprehensive programs to change people’s behavior is, as mentioned, that the method is one thing, the implementation quite another
one. In pharmacological studies compliance was previously used as a term for how patients followed the doctor’s prescriptions. (Most people don’t.) Now adherence is considered more politically correct. Either way, the clinical reality is usually far from RCT’s detailed protocols.

**Where have all the fractures gone?**
At the time of writing, the covid pandemic ravages the world. One perhaps not so surprising spin-off is that the incidence of fracture has decreased in both young and old people, along with many other diagnoses, e.g., myocardial infarction. A higher activity level is indeed associated to injury risk, as shown by a study of high-intensity training at a nursing home for demented people, where the authors found an increased risk for injuries among Alzheimer patients.

**Sports injuries**
Sport is a reliable supplier of injuries, in this material 18%. Most sports injuries are trivial, but knee injuries, especially in soccer girls, are an increasing problem, that can be prevented by simple and unexpensive means—proprioceptive training, giving information to coaches, parents, and players, *i.e.*, about the same procedure as for geriatric injuries.

**Injury data base in memoriam**
The IDB was a far-sighted major public health project that initially had a strong political and financial support. It gave a lasting imprint on injury panorama, mostly in road traffic injuries but also regarding dangerous products. However, the result of successful injury prevention is that—nothing happens! And after a while security is taken for granted, and adverse events are seen as singular stochastic events. Perhaps as a result of the fragmented organization of Swedish health care with many small health care organizations, which isn’t the case with other rich countries, such as the other Scandinavian countries, it was difficult to rig a nationwide data collection. The same problem, as mentioned, is also found among the public authorities, where there are government offices for most risk modalities, *e.g.*, radiation, electricity, air, water, and fire, but not for the most common ones, home and leisure injuries. Department of Falls?

**Strengths**
- IDB provides information for a complete population in a well-defined, stable geographic area
- Only one hospital in the area
- A dedicated and stable IDB staff
- No major reorganizations of emergency care during the study period
- Hospitalizations validated with patient registrations
- Yearly logical controls
- Describing text for all injury events
- Detailed categorization, some 70 variables
- High coverage, over 95%
- Registration and coding performed by only approximately 20 people during the study period
- Registration routines to paper forms started already 1985
- Large scientific production
- Homogenous population.
Weaknesses

- Homogenous population, limited generalizability in a national/international perspective
- A few casualties dead prior to admission were not registered
- IDB code changes in 1998
- AIS codes changed 2005 affecting, *e.g.*, knee injuries and cerebral concussions
- IDB discontinued 2014
- Selection bias, since we do not have access to injuries prior to 1993
- IDB got insufficient national coverage, mostly in mid-sized cities in Sweden

Sustainability

- National health care organization
- Low support from central governmental organizations.

True, life is lethal, but apart from humanitarian aspects, it would be highly profitable to try to prevent injuries in those most in need, the old and frail. In a society with subsidized health care, the tax payers will have to pay the hospital bills anyhow—alternatively the insurance companies. And since we now have few direct economic incentives, it would seem rewarding and reasonable if the health care organizations financed and organized a systematic injury prevention. We also need legislation like in the UK.

This cannot be done without a continuous monitoring of injuries, not necessarily all injuries, stratified random samples of the most important ones may do. Today, there is a rampant overdocumentation of data in health care that are never fed back or used. Decontamination of redundancy might make room for the important information.

**What should be done?**

We need a broader perspective of all injuries for preventive work. A one-dimensional strategy just addressing one risk factor will fail. **AIDA**, awareness, information, decision, and action, is a well-tried acronym in opinion formation, propaganda and advertising. Today, we are still somewhere between A and I, closer to the A than the I. Actually, we do have the information\(^{79-86}\), but we don’t use it. We should use the high-quality data in health care databases, national quality registers, and patient records, and transform data to information at the macro level. It must become easier to link databases. Today’s obsolete IT laws must be rewritten. It is dangerous not to have seamless information transfer between hospitals and nursing homes.

For individual patients, we must use the patient record databases to calculate risks and track frequent fallers. This can also be used by the health care providers for economic analysis and patient safety work. We also need more powerful analyzes to transform complex multi-factorial data into useful information, *e.g.*, neural networks, Bayesian statistics, and artificial intelligence.

Fall int! (Northern Swedish vernacular for don’t fall!)
Conclusions

The Umeå injury database 1993—2014 in a demographic perspective
- Fall injuries were common in all ages, often trivial in the young and devastating in the old
- Fall injuries among elderly was overall responsible for most trauma hospital days
- Geographic proximity to the emergency department was associated with increased trauma health care consumption
- Infants often did not get a clear-cut trauma diagnosis.

From a helicopter perspective, to describe injury mechanisms, place, activity and severity in for all age groups and trends in the adult population
- Fracture was the most common adult injury
- Fractures accounts for the largest proportion trauma hospital days
- Soft tissue injuries are common and account for a significant proportion of trauma care burden
- Fall injuries increased among middle-aged adults, which implies a need for fall prevention

Trauma recidivism
- Trauma recidivism was common in young men and old women
- Fracture and sprain had a stronger predictive power for severe recurrent injury than wounds, and can be useful as tools in secondary injury prevention.

What happens before and after a hip fracture?
- Hip fracture incidence decreased annually with 2-3% but increased in absolute number 3% during the study period
- Hip fracture has a unique age incidence curve increasing about 40-fold after middle age to senescence
- Injuries have a moderate predictive power for hip fracture
- Ten percent of the hip fracture patients got a new hip fracture on the other side, 2% on the same side
- In both cases, more often than not, at the same localization as the first one; this may indicate a constitutional factor.

Describe geriatric fall injuries, as an isolated injury mechanism
- After middle age, fall constituted about the same percentage of all injuries as chronologic age
- Fractures comprised only about half of all fall injuries
- With increasing age, fractures and other injuries became more common in the lower extremity, where they also became more proximally located
- The proportion of “high energy” falls declined with increasing age while the severity score for the injuries increased.
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