UNIVERSITY OF TROMSØ UIT

Death after trauma in the rural High North

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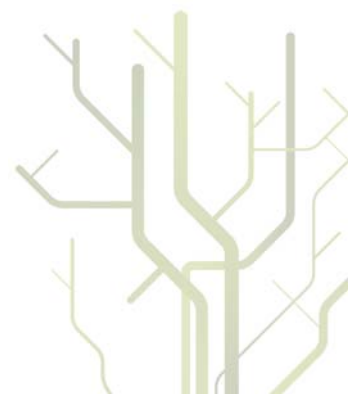
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Preface and acknowledgements

As with many things in life I stumbled into research more or less by coincidence. When I was at the beginning of my second year of medical school some of my friends had joined, or were thinking of joining, the research line program and I did too. I can't remember why, I certainly had no ambition of doing a PhD. And why on the theme of trauma? Possibly because that was one of the few things that seemed comprehensible at that time in my education. Car crashes; people get hurt. Or I, being a male in my early twenties, may have been attracted by the prospect of action; speed, sirens, helicopters (a thoroughly misguided notion if that was the case, I may add). I guess it can be put down this: It seemed like a good idea at the time.

I am certain the lack of clinical experience has coloured the reasoning and preconceptions in my work, but I don't believe it has been detrimental to my interest in the field. Research work has been a great way to attain knowledge, and the scientific mindset useful in every other part of my medical education. Through the research line I have found good friends and attained at least a glimpse of insight into a broad spectre of research fields.

Hopefully my work can be of some use for others as well. While most of us will never be anywhere close to the elite league of Nobel prize winners and the likes, there is much to be said for just being part of that big collective effort of improving one's chosen field, that research is (though a Nobel prize – any prize really - *would* of course be nice).

I owe thanks to many people for their contribution to this thesis, and to my research work thus far. Firstly I'd like to thank my main supervisor, Professor Torben Wisborg. This thesis is testimony to his skills considering that I did not have a PhD in mind in the first place. I look very much forward to our continued cooperation in the future. My thanks to assistant supervisor Professor Mads Gilbert for his enthusiasm and encouragement, and to all of my co-authors for their substantial and much appreciated contributions. Kristian Bartnes and Ellen Blix are kindly thanked for revision of the manuscript.

I also want to thank the founders of the research line and its administration. The work they do to recruit medical students into research and the support of their students is invaluable and much appreciated. My fellow research line students as well, for great discussions, and just as important: heaps of fun.

Friends and family are thanked for interest and support. In particular I need to mention my parents, my parents in law, and my Besten (grandfather).

I have learned that the position as last author in an academic paper is a place of honour; therefore it is fitting that the last persons to thank should be my wife Erle, and daughter Tinde. My daughter has, as far as research goes, frankly been more of a disturbance than anything; I'll thank her anyway because she brings so much joy into my life. Erle, thank you for your support and backup. I apologise for having to say "so far"; I'll try not to swear so much in the future (or possibly invest in a better computer).

Håkon Kvåle Bakke

List of papers

This thesis is based on the following papers; they will be referred to by their Roman numerals in the text:

I.   Håkon Kvåle Bakke, Torben Wisborg. Rural high north: a high rate of fatal injury and prehospital death. World J Surg. 2011 Jul;35(7):1615-20

II.   Håkon Kvåle Bakke, Ingrid Schrøder Hansen, Anette Bakkane Bendixen, Inge Morild, Peer K. Lilleng, Torben Wisborg. Fatal injury as a function of rurality-a tale of two Norwegian counties. Scand J Trauma Resusc Emerg Med. 2013 Mar 2;21:14

III.   Håkon Kvåle Bakke, Trond Dehli, Torben Wisborg. Fatal injury caused by low-energy trauma – a 10-year rural cohort. Submitted

IV.   Tomas Dybos Tannvik, Håkon Kvåle Bakke, Torben Wisborg. A systematic literature review on first aid provided by laypeople to trauma victims. Acta Anaesthesiol Scand. 2012 Nov;56(10):1222-7

Abbreviations and definitions

AIS – Abbreviated Injury Scale
ARIA – Accessibility/Remoteness Index of Australia
EMS – Emergency Medical Services
GP – General Practitioner
HE – High Energy
ICU – Intensive Care Unit
ISS – Injury Severity Score
LE – Low Energy
LIMC – Low and Middle Income Countries
NISS – New Injury Severity Score
PMC – Pre-existing Medical Condition
RTA – Road Traffic Accident
RTC- Randomised Controlled Trial
SSB – Statistisk Sentralbyrå (Statistics Norway)

Summary

The work of this thesis was initiated because Finnmark County had a mortality rate from external causes well above national average for several decades.

The aims of the thesis were to 1) investigate possible reasons for Finnmark's' elevated death rate from external causes, 2) identify challenges that a trauma system in Scandinavia must be tailored to meet, and 3) find access points to limit the burden of injury in Finnmark.

The thesis consists of four papers. The first paper gives an epidemiological description of the deaths from trauma in Finnmark for a ten-year period, and explores changes over time. In the second article the epidemiology of trauma death in Finnmark is compared to Hordaland County. The third paper describes the deaths from low energy trauma in Finnmark County for the ten-year period. The fourth paper is a review of the literature on first aid to trauma victims by bystanders.

We have found an urban-rural continuum where mortality, and share of prehospital death increases with rurality. For RTAs the rate of accidents with personal injury was distributed inversely to mortality along the continuum. The most common modes of injury were fractures in elderly, suicide, and road traffic accidents. There is a potential for injury mortality reduction in first aid from laypeople, but literature in that field is very sparse. Low energy trauma constitutes a considerable and underestimated share of deaths from trauma, and the victims are older and with higher pre-injury morbidity than victims of high energy trauma. The overall mortality from external causes in Finnmark has declined from the early 90's to the mid-2000, but the epidemiological pattern of injury is otherwise unchanged.

Finnmark's high rate of death from external causes is probably tied to the county's rural nature and the multi-faceted disadvantage of rurality. A trauma system in Scandinavia will have to meet the challenge of mortality rates increasing with rurality, and the majority of deaths occurring in the prehospital phase. 3) Finnmark does not seem to differ greatly from other areas in one singular area, and access points will mostly be the same as other rural areas.

Background

Trauma

"An injury is a bodily lesion at the organic level, resulting from acute exposure to energy (mechanical, thermal, electrical, chemical, or radiant) in amounts that exceed the threshold of physiologic tolerance. In some cases (e.g., in drowning, strangulation, or freezing), the injury results from an insufficiency of a vital element."

Krug et.al The Global Burden of Injury [1]

Trauma is the oldest disease there is. As injury can occur to inanimate objects, the disease as such precedes life itself. On a less abstract and far more interesting and important level, trauma remains a major cause of death and disability around the world. Internationally it accounts for an estimated 10 to 16 % of the total burden of disease [1-4]. It is a leading cause of death among young people with significant loss of life-years [3, 5]. For every death there are several major and minor injuries, placing an extensive burden on the health care systems [6]. Road traffic accidents represent the leading cause, closely followed by self-inflicted injuries [3].

 The burden of trauma is by far greatest in low- and middle-income countries (LIMC) where 90 % of deaths from injury in the world occur. From news media coverage one could be led to believe that this was a result of war, but injuries are predominantly unintentional, and war injuries constitute only a portion of intentional trauma deaths [4, 7-9]. The global burden of injuries is expected to increase for the coming decades [4]. Trauma causes loss, pain and suffering in individuals, families and impacts life in local communities and nations.

The burden of injury is by far greatest in the poor areas of the world, but it is not dismissible in the high-income western society. In Norway there were 2607 deaths from injuries and poisoning in 2011 [10], and just as there exists differences between countries, there are differences in trauma mortality within Norway. Finnmark County had a mortality rate from external causes well above national average from 1970 to 1995 [11]. This was the reason for the investigations of this thesis, in the hopes that we might find the means to alleviate the situation.

Urban rural differences in trauma

In everyday speech, and media coverage of trauma, one is often left with the impression that trauma happens by chance or coincidence. On the contrary, neither trauma incidence, nor mortality is evenly distributed.

Like other diseases, trauma has its risk factors and pathogenesis. Gender, age, socioeconomic status, occupation, and location will all affect the probability of being injured or killed. Identifying targeting points at which to direct measures has been found an effective approach in several studies [4, 12, 13].

Rural areas have higher trauma death rates compared to urban areas [14-21]. Particularly road traffic accidents (RTA), fires, occupational injuries, machinery, drowning and self-harm are modes of accident that are reported to be higher in rural areas [14, 15, 17, 19, 20, 22-24]. Urban areas, on the other hand, are reported to have higher rates of fall and assault/homicide [14, 15, 17, 19, 20, 22]. There are some discrepancies to this picture though; suicide and drowning have both also been reported to be more common in urban areas in some studies. Rural areas are also reported to have higher hospitalisation rates and the patients to have increased disability on discharge [19, 20, 24, 25]. The reasons can, as far as they have been established – or suggested - be grouped into factors that affect a) how often accidents occurs, b) how bad the consequences of the accidents are, that is whether injury occurs and the initial injury severity c) the access to and quality of health care (hereunder rehabilitation) which in turn affects the final outcome and severity of injury. Some of the suggested factors are just that; suggested, whereas other are backed up with more substantial evidence.

In the first group, contributing to how often injuries occur, are factors such as employment in high-risk professions. Agriculture, fishery, and mining are examples, and are more common in rural areas [15, 17, 19, 23, 24]. Conditions of the road system, and high density of firearms are other factors [19, 23, 26-28]. The extensive use of motor vehicles both because of distances, but also for recreation is yet another [29-31].

Contributing to higher injury severity are attitudes towards the use of seat belts, helmets, and other safety-equipment [26, 32]. Rural roads may have higher speed limits leading to collisions occurring at higher speeds. In urban areas there may be more intersections leading to a larger share of front-to-side accidents opposed to head on collisions in rural areas [18, 19, 29]. Also the rural car park may be older and hence less crash-secure [15].

A single factor can affect both the to rate of accident, and the injury severity. A culture of high-risk behaviour will affect both, likewise may the condition of the road system. Factors may also be entwined. Employment and behaviour for example, are linked to socioeconomic

status [33]. It has been shown that socioeconomic status adversely affects trauma mortality, and injury incidence [34], though the effect on the latter is not as consistent as the former [35]. Also the association varies between injury type, and age group, and it is greater for more severe injury [36-39]. Socioeconomic status is indeed reported to be a better predictor for injury mortality than a rural locale by itself [33].

The last group of factors contributing to a higher mortality rate from injury are those affecting access to health care, and its quality. Long distances in rural areas lead to longer response and transport times. Together with low population density they may also result in longer time from injury to discovery of the patient. The time intervals are also determined by the development level and deployment of the emergency medical service (EMS) [40]. Long response times from the EMS have been reported to have adverse effect on survival [22, 26, 41-43]. The reported high share of deaths occurring in the prehospital phase are also most often held to be the result of the above. However, this could also be the result of higher injury severity in rural accidents, and the role of EMS-times remains a point of dispute [44, 45]. Other studies have found no association between long EMS-times and poor outcomes [17, 21, 45, 46]. This may be because time only is a critical factor for some patients, and to study setting and methods differing between studies [21].

In addition to less easy access to health care in rural areas, it is believed that the quality of rural health services may be suboptimal [15, 18, 47-49]. Rural pre- and intrahospital personnel see fewer trauma cases than their colleagues in urban areas and are therefore less experienced in managing major trauma [15]. Smaller local hospitals often have neither the equipment nor specialist staff, such as for example neurosurgeons, needed for more advanced treatment [50, 51]. Definitive care in local hospitals has been associated with worse outcomes in trauma [50, 52]. Likewise has the centralisation to and designation of trauma centres been associated with better outcomes. While patient volume has been believed to play part, evidence is inconclusive.
Some of the studies on volume have compared centres with trauma systems in place to local hospitals that are not part of a trauma system, or improvement in mortality after implementation of trauma systems. In such case both centralisation of patient volume and better guidelines and routines may be the cause of improvement. Also volume effect may only be applicable to certain subsets of trauma patients [21, 43, 53-56]. Local hospitals are regarded to have an important role in areas with long transport times to large trauma centres, as part of an inclusive trauma system [57-60]. Though volume has not conclusively been shown to

affect outcome in trauma such studies have largely been conducted in the United States where local hospitals are larger than most Norwegian hospitals, and volume has been shown to matter on surgeon level [51]. Trauma systems will be further elaborated upon in the following section.

Training of personnel in the handling of trauma can also, to some extent, make up for a lack of experience [61-63]. It has also been suggested that rural populations are older than urban [20]. While this does not directly affect the quality of care received, older patients are physiologically more vulnerable to the impact of injury and as such also more difficult to treat [64, 65].

Rural areas are of course diverse, and it is not given that all the factors are applicable in any rural area. For example are penetrating injuries generally constituting a larger share of the injuries in studies from the in the United States compared to Europe [66-72], and such differences will also affect the pattern of rural areas. Indeed not every study has found an urban-rural difference in overall mortality [17] at all. Differences among countries and between studies are one of the reasons why it is interesting and important to repeat studies on urban-rural differences.

Trauma systems
The systematic approach to the treatment of trauma, like so much of trauma care, has its origins in combat medicine [21]. The development of trauma systems in the civilian setting has been an ongoing process since the sixties [73]. A trauma system is at its core a formalisation of the treatment of the trauma victim within a geographical area. Systems range from exclusively focusing on the treatment immediately after the injury until the threat to life is over, on to include rehabilitation and further to encompass community teaching and prevention programs [55, 74, 75]. A system can revolve around a single, centralised trauma centre in a region, taking care of all victims of injury (exclusive). It can also involve all hospitals and health care resources in an area and specify roles for each of them, providing treatment and transfer protocols [55, 74-76]. The development has been gradual and has been moving from the exclusive to the more inclusive system, lifting trauma from a strictly surgical disease to a multidisciplinary matter and all the way into the public health domain [74, 76].

The effect of trauma system implementation has been repeatedly investigated and is associated with lower injury mortality and better outcomes from trauma [73, 76, 77]. An important part of trauma systems

is self-evaluation through trauma registries and research to ensure that they become as effective as they can be. The latter is also of importance to find access points of prevention, arguably the best way to handle injuries all together (as far as it can be done).

Norway lacks a formalised trauma system, but is in the process of developing and implementing one [51, 75, 78]. The report preceding the implementation has recommended a four-tiered system (pre-hospital level, acute care hospitals, trauma centres, and rehabilitation), and a national trauma registry [51]. The report pointed out several weaknesses in the present care of injured patients. The most relevant to the contents of this thesis were the lack of requirements to and variations in training and level of education in pre- and intra- hospital personnel handling trauma patients. These weaknesses were believed to be worse in the areas with the longest transport times [51, 78]. Studies from northern Norway have also discovered shortcomings in intrahospital transfers, and use of emergency surgical procedures by local hospitals in the current system [79, 80].

To achieve best possible results a trauma system should be designed to meet specific needs of its catchment area. For example, an area that has a high rate of gunshot wounds needs to be trained at handling penetrating trauma. Or a small area with a very centralised population may only need one trauma hospital and not as much focus on advanced pre-hospital medicine compared to a large area with a scattered populace that may need to focus more on the chain of survival prior to trauma centre arrival [75].

Prior study on trauma mortality in Finnmark
Because Finnmark had a consistently above average trauma mortality rate, my supervisor Torben Wisborg conducted a study on the epidemiology of trauma in Finnmark [81]. The study investigated the years 1991 through 1995 in the western part of Finnmark and was published in 2003. The victims were shown to die at the scene of injury in 85 % of the cases, and for the most part found dead. Time from injury to death could be established for 104 of the 130 patients and 72 % died within an hour from injury (a fate they probably shared with the majority of the unestablished cases). The main causes of death were Road Traffic Accidents (30 %), Suicide (29 %) and Drowning (21 %). The overall mortality rate was 77 per 100 000 inhabitants.

After this study was conducted trauma care in Norway and Finnmark saw several improvements: Ambulance services became responsibility of the hospitals, and requirements to personnel and equipment were improved. Standards for guiding laypeople at the scene were implemented in the emergency dispatch centres. Trauma care in the hospitals were standardised and team training through the BEST-program instituted. A national suicide prevention program was launched, and local psychiatric services strengthened [61, 82-86].

Despite the changes Finnmark seemed to retain a high death rate, and thus it was of interest to attempt a new and more thorough analysis of trauma deaths. As such, this work formed the basis of the first article of the current thesis, it consequently had heavy influence on the methodology of study I and II.

Low energy trauma

The great majority of injuries encountered by the health care system are minor injuries where there is no threat to life or of serious sequelae, and where the multidisciplinary rapid response of a trauma system is not needed [87]. Whether an accident will lead to serious injury or not is linked to the mechanism, or cause, of injury. Falling several stories before hitting the ground will most likely lead to more severe injuries than falling from ground level. Likewise it is more serious to collide at 90 than at 30 km/h, and being shot is more serious than being hit by a fist. Mechanism alone is sufficient to precipitate trauma team activation even if the patient is apparently unhurt [88].

Low energy trauma is used in orthopaedic literature to denote fractures from trauma that is not caused by road traffic accidents, falls from height, or similar high-energy mechanisms [89-91]. The concept is emerging in the literature of epidemiology of trauma [92]. These injuries are often excluded from studies on trauma because of mechanism, low ISS, or lack of trauma team activation [70, 79, 93, 94]. The rationale is understandable from the need to limit the research projects, in addition to the fact that minor injuries are less urgent, and not in the need of the multidisciplinary approach in the emergency phase as major trauma. However, to appreciate the total burden of injury on a society and health care system it is necessary to include these injuries when studying the epidemiology of trauma [87].

It is worth noting that low-energy trauma may well lead to death, and has been reported to constitute 41 % of total trauma mortality [92]. Death from low-energy trauma is mainly seen in the elderly with serious comorbidity, and with the ageing of the general population may constitute

an increasing problem for the health care system in the foreseeable future [95-97].

Aims

General aim of the thesis
The general aims of this thesis were 1) to investigate possible reasons for Finnmark's' elevated death rate from external causes, 2) highlight challenges that a trauma system in Scandinavia must be tailored to meet, and 3) find access points to limit the burden of injury in Finnmark.

I. Rural High North: A high rate of fatal injury and prehospital death
As described, my supervisor Torben Wisborg did a study describing the fatal injuries in western Finnmark during the early nineties [81]. Through the nineties there was developments of trauma care in the region. We wanted to do an updated description of the fatal injuries in Finnmark and assess whether the changes in trauma care had made an impact.

Originally we also aimed to determine whether the fatalities were preventable, an approach to improve trauma care in the health system. The aim had to be abandoned, which will be elaborated upon in the methods section.

II. Fatal injury as a function of rurality – A tale of two Norwegian counties
In order to explore where Finnmark differed in a Norwegian setting, we intended to do the same approach as used in article I in another Norwegian county and then compare the two. Upon discovering Finnmark's typical rural injury pattern compared to international literature in our work with article I, we also aimed to explore the impact of rurality on Finnmark's injury epidemiology.

III. Fatal injury caused by low-energy trauma – a 10-year rural cohort
During the course of our investigation of fatal injuries in Finnmark we became aware that low energy trauma constitute a substantial share of trauma deaths. These injuries are commonly excluded from trauma studies and indeed also in our own. As the basis of our other studies was Finnmark's high death from *external causes,* it seemed pertinent to investigate these deaths as well. The aim of the study was thus to describe the epidemiology of deaths from low energy trauma.

IV. A systematic literature review on first aid provided by laypeople to trauma victims

This study followed the finding from study I, that most deaths occurred prior to the arrival of health care personnel. May there be a role to play for the layperson in the provision of care to the trauma victim? We aimed to review the existing literature on first aid provided by laypeople.

Methodological considerations

Introduction
The methods used are described in each paper. In this section follows some elaborations concerning the methods. I will also discuss the reasons for choosing the methods we did, and some consequences and weaknesses of the methods chosen.

Study areas

Finnmark County
Finnmark is the largest and least populated county in Norway with an area of 48 617 km^2 and a population of 73 787 as of 1st January 2012 [98, 99]. The climate is mainly subarctic, and the county subject to harsh weather conditions through both low temperatures and high winds [100]. Seventy four percent of the population is settled in towns and villages. The largest settlements are Alta (14 439), Hammerfest (8 843), and Kirkenes (7 637) (when the nearby settlements of Hesseng and Bjørnevatn are counted as part of Kirkenes, and Rypefjord part of Hammerfest) [100].
The economy is based on natural resources, and a comparatively high share (7 %) of the working population is employed in the primary industries (mostly fishery). The average gross income for men is the lowest in the country, where it for women is close to the national average [101]. Life expectancy is 81.6 years for women and 76.3 for men; this is lowest in Norway where national life expectancy is 83.5 years for women and 79.0 years for men [102].

Indigenous people and minority population
The Sami are the indigenous people of Norway, Sweden, Finland and the Kola Peninsula. It is uncertain when the Sami first settlements in Norway were established, but the earliest written account is from Tacitus' *Germania,* 98 AD. From the middle of the 19th century the Sami of Norway were subjected to systematic oppression and forced assimilation into Norwegian society by the government, a policy that remained into the 1960s [103]. Today Sami are entitled to special protection and rights. It is known that the majority of the Sami reside in Finnmark, and a 1972 estimate based on surveys was that the Sami accounted for 20 % of Finnmark's population at that time [104]. Official statistics regarding the Sami populace is rather based on geographic areas that receive grants for business development through the Sami national assembly [105].

Kvens are descendants from Finnish immigrants and a significant minority population in Finnmark. Like the Sami they were subjected to

oppression forced assimilation from the Norwegian authorities and people.

Health care system
All of Finnmark's municipalities have at least one ambulance stationed on 24-hour call, except the municipalities Kvalsund (covered by Hammerfest) and Nesseby (covered by Tana and Vadsø). The ambulance is manned by personnel at least one of who must be a certified emergency medical technician (ambulansefagarbeider)[106]. Each municipality also have a general practitioner (GP) and local emergency room available, sometimes in collaboration with a neighbouring municipality (Hammerfest/Kvalsund, Gamvik/Lebesby, and Nesseby/Tana) (personal communication by B Øygard, County Governor's office, 27 November 2012). The GP work in close co-operation with the ambulance crew in emergencies. The County is served by two local hospitals situated in Hammerfest and Kirkenes. Both offer 24-hour general and orthopaedic surgery, diagnostic imaging, and intensive care. The emergency medical dispatch centre (Akuttmedisinsk kommunikasjonssentral) located in Kirkenes dispatches and co-ordinates EMS resources and provides first-aid guidance to laypeople on the scene of accident. Helicopter EMS are provided by a Norwegian Air Force search-and –rescue helicopter stationed at Banak (Lakselv), and an air ambulance helicopter stationed in Tromsø, both manned by paramedic and anaesthesiologist. The University Hospital of Northern Norway (UNN) is the trauma referral centre for Finnmark County and is located in Tromsø some 120 kilometres southwest of Finnmark County. Table 1 gives the population size for Finnmark's municipalities, the approximate driving time from the municipality centres to the local hospital, and flight times (fixed wing) to Tromsø for the municipalities with an airport. From table 1 we can make out that approximately 72 % of the population resides more than an hour away from hospital by car, and 50 % more than two hours. The helicopters have a one-way flight time of 30 minutes from the County border to Tromsø, and they have scramble times of 15-20 min. Fixed wing aircrafts are stationed in Kirkenes and Alta. Flight times in table 1 are given for one way, and do not include the 20 minute scramble time (personal communication by LMS Hansen, Flight coordinator, the flight coordination central, University Hospital of Northern Norway). In addition to flight and scramble times comes on-scene time, transport to and from airport as well as loading/unloading of patient. Thus we see that as good as any patient injured in the county is at the *very* least one hour away from the trauma centre under optimal conditions and EMS response.

Table 1 Transport times in Finnmark

Municipality	Population	Time to local hospital by car [107]	Flight time to Tromsø (fixed wing)
Alta [b]	19 282 (26 %)	2 h 0 min	30 min
Berlevåg	1 015 (1%)	4 h 0 min	1 h 0 min
Båtsfjord	2 089 (3%)	3 h 30 m	1 h 0 min
Deatnu Tana	2 896 (4%)	2 h 0 min	-
Gamvik	1 008 (1%)	5 h 30 m	55 min
Guovagedaidnu Kautokeino	2 927 (4%)	4 h 0 min	-
Hammerfest [a]	9 934 (13%)	0	35 min
Hasvik	995 (1%)	Island	25 min
Kárásjohka Karasjok	2 763 (4%)	3 h 0 min	-
Kvalsund *	1 010 (1%)	30 min	-
Lebesby	1 356 (2%)	5 h 40 min	-
Loppa	1 087 (1%)	3 h 50 min	-
Måsøy	1 243 (2%)	2 h 30 min	-
Nordkapp	3 228 (4%)	2 h 40 min	45 min
Porsanger Porsángu Porsanki	3 946 (5%)	2 h 0 min	40 min
Sør-Varanger [a, b]	9 860 (13%)	0	1 h 0 min
Unjárga Nesseby*	901 (1%)	1 h 40 min	-
Vadsø	6 125 (8%)	2 h 20 min	1 h 0 min
Vardø	2 122 (3%)	3 h 20 min	1 h 5 min

a Local hospital
b Aircraft (fixed wing) stationed
- • ambulance not stationed in municipality
- - no airport

Figure 1. Finnmark

By: Eilert Sundt 2013

Circles denote 30 min fly-time for helicopter

Ambulansefly

Ambulansehelikopter

Redningshelikopter

Sykehus

Bilambulanse
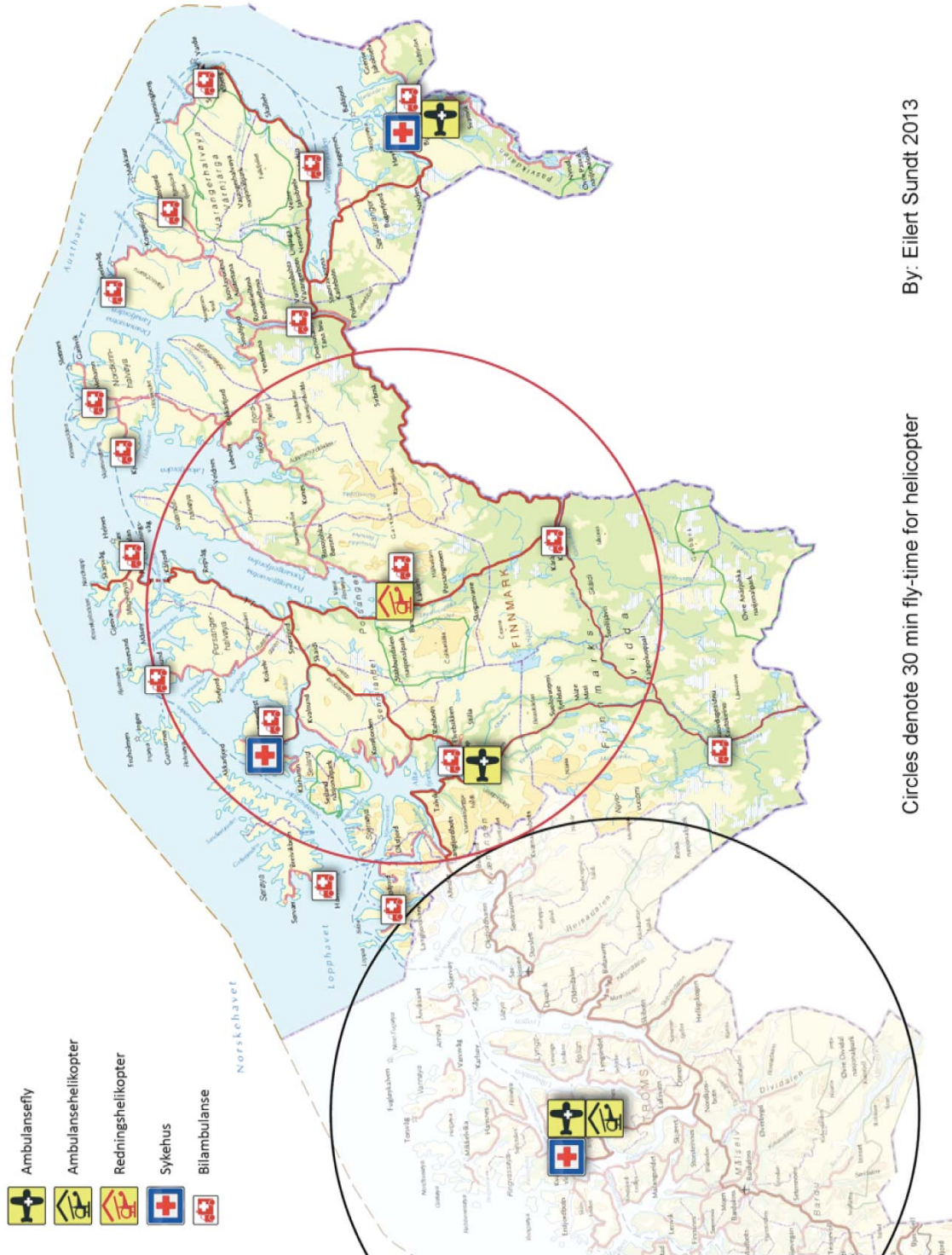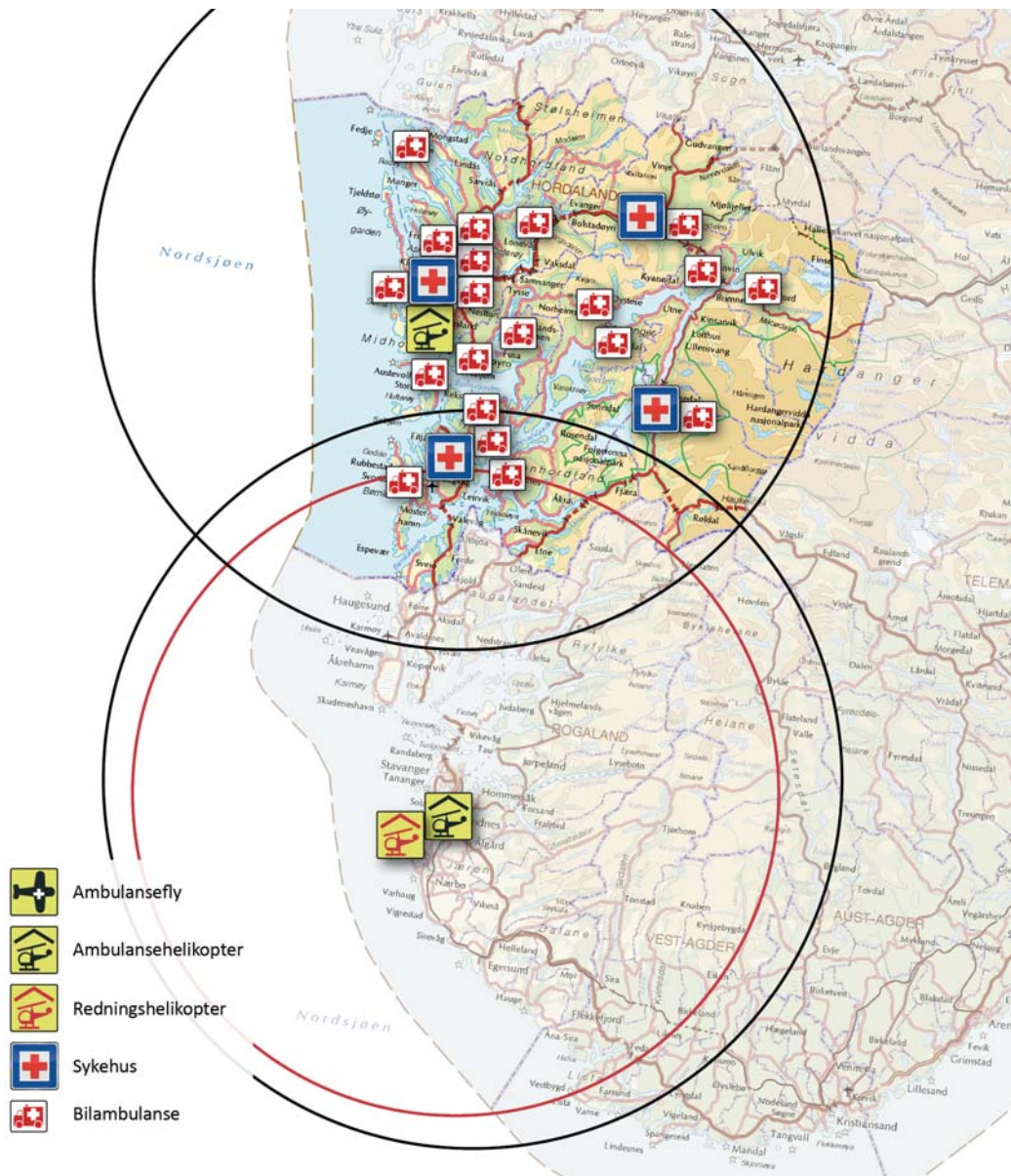
Figure 2. Hordaland   By: Eilert Sundt 2013
Circles denote 30 min fly-time for helicopter

Hordaland County

The main area of focus in this thesis is Finnmark County, but in article II we used Hordaland County for comparison, and to explore the contribution of rurality to Finnmark's death rate. Therefore a short presentation of Hordaland County is given.

Hordaland is a county in the western part of Norway. Approximately a third of Finnmark's size it covers an area of 15 440 km^2. The county has 490 570 inhabitants, half of whom reside in the municipality of Bergen, Norway's second largest city [98]. Other major settlements include Askøy, Leirvik, Knarrevik/Strauma, Osøyro, Voss and Odda. The region is one of the main industrial areas in Norway owing to the availability of hydropower, and 16 % of the work force outside of Bergen is employed in industry. Fishery and agriculture are also of importance and accounts for 5 % of the employment [108].

Health care system

Local hospitals are located in Stord, Voss and Odda. The southernmost municipalities are partially served by the local hospital in Haugesund, in Rogaland municipality. All offer 24-hour general and orthopaedic surgery, but only limited intensive care. Tertiary trauma centre for the region is primarily Haukeland University Hospital in Bergen, but trauma patients in the southernmost municipalities may also be routed to Stavanger University Hospital unless there is head injury present. Haukeland University Hospital also functions as local hospital for the inhabitants of Bergen and adjacent municipalities. The location of ambulance bases is shown in figure 2. Like in Finnmark two personnel man the ambulances with the same minimum requirement as to qualifications, and work closely in co-operation with local on-call general practitioner. The use and structure of emergency medical dispatch centres (Akuttmedisinsk kommunikasjonssentral) is likewise similar. While the distances are shorter and the climate milder, Hordaland have numerous inhabited islands, deep fjords and relatively high mountains, affecting pre-hospital transport. Populations size for Hordaland's municipalities, and the approximate driving time from the municipality centres to the closest hospital are given in table 2. In Hordaland fixed-wing aircraft are not used for trauma patient transport. Helicopter flight times to Stord and Voss are approximately 20 minutes, and to Odda 30 minutes (personal communication by G Brattebø, section Head, Emergency medical Section, Haukeland University Hospital, 27 November 2012). With scramble times of 15 minutes we gather that a not unsubstantial share of the inhabitants of Hordaland are likely to be more than one hour away from a trauma centre if injured. However, half of Hordaland's inhabitants

reside in Bergen, and of those not residing in Bergen near half reside in one of the adjacent municipalities.

Table 2 Transport times in Hordaland

Municipality	Population	Time to local hospital by car [107]
Askøy	26210 (5.6%)	16 min
Austevoll	4792 (1.0%)	30 min [b]
Austrheim	2776 (0.6%)	1 h
Bergen [a]	263762 (56.8%)	0
Bømlo	11503 (2.5%)	27 min
Eidsfjord	957 (0.2%)	1 h 5 min
Etne*	3963 (0.9%)	56 min
Fedje*	576 (0.1%)	1 h 10 min [b]
Fitjar*	2944 (0.6%)	28 min
Fjell	22720 (4.9%)	17 min
Fusa	3811 (0.8%)	47 min [b]
Granvin	923 (0.2%)	30 min
Jondal	1050 (0.2%)	1 h 15 min
Kvam	8522 (1.8%)	1 h 10 min
Kvinnherad	13318 (2.9%)	52 min [b]
Lindås	14668 (3.2%)	26 min
Masfjorden*	1683 (0.4%)	1 h 10 min
Meland*	7036 (1.5%)	28 min
Modalen*	370 (0.1%)	1 h 12 min
Odda [a]	6946 (1.5%)	0
Os	17726 (3.8%)	30 min
Osterøy	7521 (1.6%)	28 min [b]
Radøy*	4952 (1.1%)	47 min
Samnanger*	2417 (0.5%)	45 min
Stord [a]	17957 (3.9%)	0
Sund	6409 (1.4%)	37 min
Sveio	5228 (1.1%)	19 min
Tysnes	2766 (0.6%)	29 min [b]
Ullensvang*	3417 (0.7%)	40 min
Ulvik*	1112 (0.2%)	45 min
Vaksdal	4138 (0.9%)	36 min
Voss [a]	13978 (3.0%)	0
Øygarden*	4419 (1.0%)	44 min

a Hospital
b including ferry on route
* ambulance not stationed in municipality

Paper I-III

Definition of trauma

The definition of trauma in literature is not uniform. Some studies limit themselves to the strictly mechanical and exclude thermal injuries, electrical injuries, chemical injuries, hanging, drowning, strangulation, hypothermia, and poisonings all together; others will include some or more of them [23, 70, 81, 92, 109]. The different classifications are understandable, as the definitive treatment will vary between them. On the other hand they will be covered by the same emergency medical services, and with a common level of urgency. From a public health view there are similarities in approaches to prevention, and they all are categorised in the same chapter, "external causes", in ICD-10 (V01-Y98) [1, 110]. In the discussion I will use the term external cause when referring to the entire category (including poisonings).

```
Table 3 – Study I inclusion and exclusion criteriae

Inclusion
- Cause of death ICD-10 V01-Y98

- Occurred in Finnmark County
January 1, 1995 to December 31, 2004

Exclusion
- Simple fracture after fall from ground level
  in persons > 64 years of age
- Poisoning as sole cause of death
```

For studies I and II we followed the definition Wisborg et.al had used previously to be able to make a meaningful comparison to that study [81]. The definition was a broad one, and included all deaths from external cause (based on the ICD-10 classification system), except from poisonings. In addition fall from own height in elderly were excluded, as discussed in the introduction. The use of a broad definition was desirable as it was a high rate of death from *all external causes* that precipitated the investigation.

That fishery was a major way of living and reports of high suicide rates in the county also counted for the inclusion of drownings and hangings respectively. Falls from own height and poisonings could, and should for the above reasons, have been included as subgroups in studies I and II.

Falls from own height were eventually investigated thoroughly in study III.

```
┌─────────────────────────────────────────────────────┐
│ Table 4 – Study II inclusion and exclusion criteriae │
│                                                       │
│ Inclusion                                             │
│ - Cause of death ICD-10 V01-Y98                       │
│                                                       │
│ - Occurred in Finnmark County                         │
│ January 1, 2000 to December 31, 2004                  │
│                 OR                                    │
│ - Occurred in Hordaland County                        │
│ January 1, 2003 to December 31, 2004                  │
│                                                       │
│                                                       │
│ Exclusion                                             │
│ - Simple fracture after fall from ground level        │
│   in persons > 64 years of age                        │
│ - Poisoning as sole cause of death                    │
│                                                       │
└─────────────────────────────────────────────────────┘
```

Definition of low energy trauma

Low energy (LE) trauma is a quite recent concept in the epidemiology of trauma mortality, and consequently lacks a common definition. We were inspired to investigate the deaths from LE trauma by the article "Epidemiology of Traumatic Deaths: Comprehensive Population-Based Assessment "(Evans et. al) [92] and consequently decided to use the same inclusion and exclusion criteria to be able to make a meaningful comparison. Evans had included all deaths from trauma and excluded electrocution, drowning, hanging asphyxiation, strangling, and poisoning. The remaining deaths were categorized as low energy or high energy, where high energy (HE) trauma was defined as follows:

"HE trauma included falls of > 3 meters, road and traffic-related injuries, industrial injuries, major burns, and trauma related to gunshot and stab wounds" [92]. Hence the definition of low energy trauma was solely based on exclusion. There were also doubt as to the categorization of deaths from blunt violence, Evans had no such deaths but would have categorized them as low energy (personal communications from Z Balogh, Department of Traumatology, Division of Surgery, John Hunter Hospital, 12 October 2012).

In our study, we categorised assault by blunt object as HE trauma. This was because the deaths in our material were the result of repeated blows to the head, and the setting in which it was inflicted would have

more in common with a stab wound contrary to a single blow (for example in a scruff in a taxi queue). Also, while a single blow is more akin to a low fall than a car at high speed in the amount of energy delivered, the repetition result in a greater total amount of energy transferred than through a low fall. The use of the term "energy" is on the whole imprecise, through another example: A stab wound from a knife may be inflicted at lower speed and will have a lower mass than a body falling from 1 meter. The kinetic energy transferred is hence to be considered "low". That stab wounds are considered high energy is rather due to the damage inflicted by penetration rather than the energy transferred. For future studies the term LE trauma needs to be better defined (and perhaps renamed)

Table 5 – Study III inclusion and exclusion criteriae

Inclusion
- Cause of death ICD-10 V01-Y98

- Occurred in Finnmark County
January 1, 1995 to December 31, 2004

Exclusion

- Electrocution	- Gunshot wounds
- Asphyxiation	- Fall > 3 m
- Hanging	- RTA
- Drowning	- Industrial injury
- Strangling	- Major burns
- Poisoning	- Stab wounds
- Assault	

Cause of death

The main inclusion criterium for studies I, II, and III was that the patient must be registered in the Norwegian Cause of Death Registry with external cause of death (ICD-10 code V01-Y98). External cause of death corresponds to what I previously have referred to as *mode of injury*, that is to say road traffic accident, hanging, fall, and so forth. The Cause of Death Registry also contain information concerning the immediate and contributing causes of death, that is to say; what sort of injury or injuries were sustained in the accident, and caused or contributed to the outcome. In studies I and II immediate and contributing causes of death were not used, whereas we in study III included this information. I will therefore discuss the Cause of Death Registry's methods, and the background for our inclusion or omission of cause of death in our studies.

The Cause of Death Registry

The Norwegian Cause of Death Registry includes all persons who at the time of their death resided in Norway according to the National Population Register [111]. Physicians in Norway are required by law to fill in a death certificate in any death they encounter as part of work [112]. The physician asserts the immediate cause of death (for example myocardial infarction), the underlying cause (for example coronary artery disease), and intermediate causes or significantly contributing causes if any, as far as can be established. Medical terminology and plain language is used (not ICD-coding). The death certificate is sent to the probation court for administrative purposes, through to the Municipality Head Physician for quality control before delivered to the Cause of Death Registry [111, 113].

Autopsy is performed if the doctor who calls the corpse desires (provided that the deceased's family consent). The physician is required to report the event to the police authority if the death is an unnatural death [114], that is, caused by accident, violence, or drug abuse, is unexpected, related to medical treatment, occurs in prison or custody, or the body is found dead. In such case it is the police who decides whether an autopsy should be performed (though the physician may still opt to request an autopsy if the police do not). The results of autopsies are sent to the Cause of Death registry. For more than 90 % of all deaths in Norway, an autopsy is not performed. For deaths in hospitals, and for unnatural deaths the share is higher, but there is great geographical variation [70, 81, 115-117].

The Cause of Death Registry collect information from death certificates and autopsies and perform ICD-coding of the resulting diagnoses according to the WHO's principles [110, 111]. The registry also obtains information from the Cancer Registry of Norway when

applicable. The Cause of Death Registry cooperates with a medical consultant who aids in interpreting the contents of death certificates and autopsy reports. When there are inaccuracies, or the certificate is incomplete the head physician of the municipality where the death occurred, is contacted on a standard form to resolve the issue. The Cause of Death Registry is linked to the National Population Register in order to catch deaths that are registered in the latter but not the former. In such event the Municipality Head Physician is contacted [111].

Death certificates
The Cause of Death Registry's reliance on death certificate is problematic as information in death certificates have been shown to be quite unreliable. A Danish Study showed that diagnoses on death certificates had low reproducibility and considerable discrepancy between issuing physicians [118]. Autopsy based studies on hospital deaths showed incorrect content in 20 - 27 % of death certificates [119], that autopsy resulted in change in underlying cause of death in 61 % of deaths and in considerable change in 32% [115]. Particularly heart disease increased and cancer decreased, moreover the share of changed diagnoses was greatest among the oldest and youngest patients. A review of English language literature on discrepancy between clinical and autopsy diagnosis found disparity in cause of death in 25 % to 63 % of cases (based on 5 studies) [120].

Studies I and II
In studies I and II we did not include cause of death (e.g. exsanguination, CNS-injury, etc.), only the accident that caused the injury (inclusion criterium). In these studies deaths from falls from own height in persons above 64 years of age and poisonings were excluded. Considering the methods by which the Cause of Death Registry works it is likely that a near full catch of death occurring in the areas under study was achieved. While there are problems concerning the reliability of the information in death certificates, it is likely that the external cause is rather easily discerned in most cases, and caught immediately, or through the system quality control mechanisms. The obvious exceptions are persons who are not registered as residents of Norway such as tourists or foreign workers. The latter leave some uncertainty of the reliability of findings concerning work accidents, where numbers are small.

We chose not to include the information on immediate cause of death (what injuries caused the death) from the Cause of Death Registry in article I and II. In studies on trauma it is of interest whether deaths are caused by injuries to the Central Nervous System (CNS), haemorrhage, or organ failure. The distinction matters because the approach to treatment and improvement of it differs [121, 122]. Because of the low

autopsy rate in our material (40%), and that it in most cases would be impossible for the physician to discern between death from CNS injury and internal exsanguination, the information would be entirely unreliable and useless. Arguably the cause of death could have been given for those cases where an autopsy had been performed. However, autopsies in violence and accidents are predominantly required by the police and paid for by the local police district, and therefore seldom prioritised in accidents. This in turn would entail a considerable bias if we reported cause of death from only that share of the material [117, 123].

Study III

In study III we included information on the immediate and contributing causes of death, in addition to the underlying cause (*mode of injury*) that defined the material. The autopsy rate was considerably lower than for studies I and II and almost all data on cause of death are based on death certificates only. This information was as such encumbered by all the sources of error discussed above: untrustworthy and not suited to draw any specific conclusions from. We still chose to include causes of death to give a general description of what sort of patient group we had found, because the inclusion of the causes of death illustrates that these patients differ greatly from patients dying from HE trauma. The weakness of these data could probably have been more emphasised and discussed in the article.

More concerning is the reliability of the inclusion criteria, the underlying cause of death (*mode of injury).* The patients were included if they were registered in the Cause of Death Registry with cause of death V01 – Y98 (external causes). HE trauma, poisoning, hanging, drowning, suffocation and hangings were excluded, which left a material almost exclusively consisting of patients with low falls as cause of death. The association between the accident and death is far more uncertain in the LE deaths because of the relatively long time period between injury and death. Also the patients are old and multi-morbid and at risk of death regardless of injury. From Alfsen's study on reliability of death certificates we see that of 37 patients where fall and fracture was set as underlying cause of death after autopsy 18 patients originally had not this listed as a cause of death in their death certificate, and as many patients who had fall and fracture set as cause of death on the certificate had this removed after autopsy [115]. The unreliability is supported by a British study [124]. Therefore it is likely that some of the patients included in the study did not in fact die from their injury. Likewise there is probably a portion of patients who died from fall and fracture that did not have this recorded on their death certificates and thus is not included.

Preventable deaths

In assessing trauma care the preventability of the deaths is a much used quality indicator [125, 126]. It is used to determine where measures to reduce trauma mortality are to be taken. If almost every death in an area is from injuries that are incompatible with life, little will be gained from improvements in the health care system. At the onset of study I our intention was to assess the preventability of the deaths in our material, though in the end we were not able to do so. As mentioned in the introduction one of the proposed explanations for urban rural differences in trauma is lower quality of rural trauma care, thus an assessment would have been of value in investigating Finnmark's comparatively high mortality rate. I will therefore briefly cover the matter of preventability assessment; how it is done, and why we could not do it.

To measure preventability there are two main approaches: the use of a scoring system, or the use of a peer review panel. With scoring systems one grades the severity of anatomical injury, the patients' physiological parameters, or the two together (along with for example age). Physiological parameters are used because they account for that an injury may be more damaging than anatomical severity suggests, for example if a minor wound is allowed to keep bleeding. After scoring the patient's injuries, the score is used in prognostic models to determine whether each death was expected [127, 128]. The share of observed compared to expected deaths, is used to evaluate a health care system correcting for the severity of trauma, but cannot point out where or what sort of errors occur [71].

In panel review, also called peer review, the patient record for each death is presented to a panel of physicians who determine whether the death was preventable, if any errors in care occurred, and whether they contributed to the patients demise. There is considerable variation between studies in the composition of the panel, criteria for preventability, and the amount of clinical information reviewed for each case [126]. The use of panel review has been criticised for weak reliability and reproducibility, but it seemingly depends on the exact method and criteria used for the panel to reach a conclusion. It is found no worse than the use of the ISS-scoring system, and in a recent systematic review panel review was found a valid and reliable quality indicator [125, 126, 128, 129]. The method has the advantage that it can identify specific aspects of care that are in need of improvement [47, 71].

We intended to apply the panel review method, possibly backed up by TRISS-scoring (a scoring system based on anatomy, physiology, age, and blunt/penetrating mode of trauma). However, during data collection it became apparent that patient records often were incomplete. This was partly because of transition from paper to electronic records, and relocation of archives, leading to misplacement of records. Particularly pre-hospital information was scant, and most deaths occurred prehospitally. The latter could have been amended through the use of autopsy reports [130], but the autopsy rate was very low because police districts have to pay expenses tied to the procedure, and is seldom prioritised in accidents. Because reliability of panel review is very much depending on completeness of information given to the panel, we abandoned this approach concentrating instead on the epidemiological aspect [126].

ISS
Injury Severity Score is a scoring system of anatomical injury. Injuries in different body regions (six) are severity scored from 1 (minor) to 6 (lethal) according to the Abbreviated Injury Score (AIS) and the highest injury score from the three most severely injured regions are squared and added up to the ISS [131].
The score can be used to predict preventability as discussed in the previous section, but also serves the purpose of defining the study population's injury severity for comparison to other studies. Direct comparison may be obstructed by the existence of several slightly different versions of the AIS, and poor inter-rater reliability when doing AIS. Also there exists a slightly different version of the ISS, the New Injury Severity Score (NISS) [132-135]. Injury Severity Scoring still gives a reader a general description of the study population.
As discussed injury severity scoring was impossible for the material in studies I and II. In study III almost every patient succumbed subsequent to hospitalisation, and in theory information regarding injury should be present in the patient records, possibly at a level of detail so that ISS can be done. However the possibility was quite frankly forgotten after the approach was abandoned for the studies earlier in the research process. It is probable that the information in the patient records is sparse. When information is lacking it is customary to do conservative scoring of the injuries, that is, to grade the injury as non-severe as possible. This is probably a problem in a large share of the patients and injury severity scoring of the material will be inaccurate.

Considering that the main type of injury in the material is fractures in elderly after low energy trauma, it is doubtful whether ISS will add anything to the general description of the study population.

Measuring rurality

"Definition of **rural**
adjective
in, relating to, or characteristic of the countryside rather than the town"
<div align="right">Oxford Dictionaries [136]</div>

The American College of Surgeons' Committee on Trauma defines rural as: "an area where geography, population density, weather, distance or availability of professional or institutional resources combine to isolate the trauma victim in an environment where access to definitive care is limited."[137] We see that the committee covers limitations in access to health care, but not the cultural or socioeconomic aspects of rurality, though they are certainly correlated. Because there is no common definition of rural, a number of different ones are in use. They are typically based on population density, or a population cut-off value within an area (such as a municipality) [17, 18, 20, 22, 42, 138]. Others are based on exclusion as they, more or less arbitrarily define an urban area and consider everything else rural [19, 30, 139]. Such measures of rurality are practical as population data are often easily available. Because health care services are for a large part centralized they also to some extent reflects the access to public services. However, there are some studies that have employed more specific measures of access to public services such as the Accessibility/Remoteness Index of Australia (ARIA) [14, 23]. Kristiansen et.al used several approaches on a material and found that mortality rates at municipality level increased both by population density, settlement density, and centrality (reflected access to public services as well as population density), but that the latter approach gave the best goodness of fit in exploring urban-rural differences of (paediatric) trauma [16].

In study II we explored the impact of rurality on injury epidemiology in Finnmark. We defined the entire county of Finnmark as rural as there was no trauma centre in the county and no large towns, and as such in line with studies from the United States where settlements of 50 000 or 25 000 were used as cut-off points [18, 22, 42]. Hordaland County was correspondingly divided into an urban and a rural area .The urban area of Hordaland was the municipality of Bergen housing Haukeland University

Hospital, and 235 423 people at the beginning of the study period. The remainder of Hordaland was considered rural, and not dissimilar to Finnmark in that the areas consisted of several small towns with local hospitals and a number of municipalities with smaller settlements. The rural area of Hordaland was of course geographically smaller and with a larger population than Finnmark. The municipalities Askøy and Fjell, adjacent to Bergen and with a high population density, could arguably have been considered urban. Particularly when one considers the driving times in table 2 the categorisation of these municipalities as rural is debatable. In retrospect it seems that a less arbitrary approach would have been better for exploring the issue, the methods applied by Kristiansen et.al an obvious choice and certainly achievable, perhaps with some minor modifications [16]. However, this study was published after the completion of our study.

Multiple comparisons
In the studies I to III we made a large number of different comparisons. In article I our primary aim was to investigate changes in trauma epidemiology across three time periods. Though the most important was the hard endpoint mortality we compared many different parameters both for changes over time, but also explored the material assessing for example seasonal variations in various subgroups. In article II we used part of the same material in a comparison to a material from Hordaland. In article III the material consisted mainly of cases excluded from the first two studies, but *part* of the cases were also investigated in studies I and II (see inclusion criteria: head injuries after fall from own height were included in both study I, II and III).

In studies I and II we did no statistical corrections for multiple comparisons.
The results were interpreted as an entity with little emphasis on any single result, and statistical significant findings viewed in light of existing literature in the field. Even so, any single finding should be viewed with caution [140].
Overall mortality rate should perhaps have been stated as primary endpoint in both studies. Also the weaknesses of multiple comparisons could have been emphasised further.

In study III we performed a Holm-Bonferroni correction for the multiple comparisons made between patients who sustained head injuries and those that sustained fractures. We chose to make corrections in this study, as the comparisons were not part of a greater context to be interpreted in

as the comparisons in studies I and II. Holm-Bonferroni correction is a less conservative variant of the Bonferroni correction that is based on the assumption that test statistics have a tendency of obtaining greater *p*-values when the corresponding hypothesis is not true [141]. When *n* comparisons are made the p-values are sequenced after value and the lowest one is held to a significance level of 0.05/*n,* the next to 0.05/*(n-1),* thereafter 0.05/*(n-2)* etc. [141]. We set *n* as the number of comparisons made in study III. However this does not take into account that study III share material with studies I and II, and the comparisons made in those studies. While the comparisons were not a major part of the study, as with studies I and II the results should be interpreted with caution.

Indigenous people

Indigenous people are reported to have a higher burden of injury compared to the majority population [142-145]. Sami constitute a considerable percentage of the populace of Finnmark, and the association between ethnicity and trauma mortality would have been of interest. However, studies from the neighbouring Finland and Sweden have found no difference between Sami and the non-Sami living in the same area [146, 147]. Because there exist no registry of the Sami population previous studies have based their cohorts on language competency along with parents' and grandparents' ethnicity and language competency, and area of residence [146-148]. Considering the workload needed to establish the parameter and the findings from Finland and Sweden, we decided not to investigate the matter.

Paper IV

Definition of laypeople

"Definition of **layman**
 noun (*plural **laymen**, **laywomen**, **laypersons**, or **laypeople***)
2 a person without professional or specialized knowledge in a particular subject: *the book seems well suited to the interested layman*"

Oxford Dictionaries [136]

In study IV we included any study that investigated first aid conducted by laypeople in prehospital trauma. Studies on professionals and persons with extensive first aid training such as military medics, or voluntary ambulance service personnel were excluded. When does a layman cease to be a layman? The transition to "specialized" is clearly gradual. A

military medic is a well-trained layman, a consultant physician a very well trained layman. The distinction may be made in the expectations tied to the role you inhabit, and the equipment you have access to. In some of the included studies a portion of the first aiders were health-care personnel who happened to pass by the scene of accident. In such case the person is not acting in his or her professional role and (likely) do not have access to any equipment. Bystander first aid (or first aid from passersby) would probably be a more appropriate wording. Some would say that bystander denotes someone passive ("standing"). However, I would say the word implies "bystander to the accident", and says nothing of their subsequent actions or lack thereof.

The inclusion of the study by Murad et.al on villagers in a mine-festered area, trained and equipped to be first responders, is debatable [149]. The villagers were subject to substantial training and summoned in the event of injuries, and as such neither quite laypeople nor bystanders. On the other hand, the described mortality reduction shows that first responder groups may be effective (at least in areas with a high share of penetrating trauma).

Ethics

The studies were approved by the Regional Committee for Medical and Health Research Ethics (200702984-3/IAY/400 and 2010/1703), the Norwegian Directorate for Health and Social Affairs (07/4817), the Norwegian Data Inspectorate (07/01595-3/clu), the Privacy Ombudsman for Research (17430/2/LT), and the Norwegian Director of Public Prosecutions (Ra 07-526 IFO/mw 639.2)

Results

Summary paper I

We aimed to do an updated description of the fatal injuries in Finnmark and assess whether changes in trauma care had made an impact.

In 2003 Wisborg et al. described the epidemiology of injury in the western part of Finnmark after the County had experienced several decades with injury rates well above average. In the nineties trauma care was improved in the region with upgrading of equipment and training of pre- and intra-hospital personnel. All deaths from external cause occurring in Finnmark for the years 1995-2004 were identified retrospectively from the Cause of Death Registry. Poisonings and fractures after fall from own height in elderly were excluded. Police and autopsy reports, ambulance and hospital records were reviewed for each case. To investigate changes over time the material from Wisborg's previous study was included and the time periods 1991-1995, 1996-1999, and 2000-2004 compared.

We found a decline in the overall mortality rate from external causes from 1990 to 2004. There was no difference between the time periods regarding mechanism of injury, place of death, nor time from injury to death. Also when we excluded suicide, drownings, and fires (all typically beyond the aid of the trauma system) there was no difference between time periods. For the 10 year period 1995-2004 there were 453 deaths from external cause in Finnmark, 61 per 100 000 inhabitants per year, while the rest of the country had a yearly rate of 54 per 100 000. Three hundred twenty seven were eligible for inclusion and hospital, autopsy or police records were found for 266. Eighty-three percent were male, and median age was 41.5 years. The leading causes of death were suicide (33 %), RTA (21%), drowning (12%), and ATV-accidents (8 %). Eighty six percent died in the prehospital phase, and 72 % prior to arrival of health care personnel. Time from injury to death was established for 181 of the 266 (68 %). Of these 52 % died within 1 hour from injury, 4 % died between 1 and 4 hours post injury, and 12 % died more than one hour from injury. For the 32 % for whom time from injury to death could not be established, most would likely have died within 1 hour from injury based on mechanism of injury and information from police and autopsy reports. In forty percent of the cases there was evidence that the deceased had been under influence of drugs or alcohol per autopsy or blood tests. Total mortality varied according to neither season nor month. Suicide varied with month; most suicides occurred in the months of May (17 %), December (16 %), and September (13 %). No other cause-of-death group

displayed seasonal or monthly variation. Forty-two percent of deaths occurred on Saturdays and Sundays. When inclusion criteria was modified to those of Trunkey et.al, and Søreide et.al, excluding drownings, hangings who typically die on-scene, Finnmark still had a high share of deaths prehospitally and in the 1-hour time category [70, 150]. The study concluded that changes in mortality rate could not be linked to improvements in trauma care, that Finnmark displayed a typical rural pattern compared to international literature and that the key to improvement of the injury morality rate lay in targeted prevention.

Summary paper II
We aimed to find where Finnmark differed in the epidemiological pattern of injury compared to another Norwegian county, and we aimed to explore the effect of rurality on Finnmark's epidemiological pattern of injury.
The material from Finnmark in study I was compared to a material from Hordaland, acquired by the exact same method as in study I. The years 2003 and 2004 in Hordaland were compared to the years 2000 to 2004 in Finnmark. The county of Hordaland was divided into a rural and an urban area (rural Hordaland and urban Hordaland) as described in the methods chapter. Data from Statistics Norway for the years 2001 to 2009 were also analyzed. The findings are summarised in table 3. The broad picture was that Finnmark had the typical rural traits described in study I, and as expected differed from Urban Hordaland in these, whereas Rural Hordaland seemed to fall inn somewhere between the two. Finnmark had a higher total mortality rate, as well as higher rates of snowmobile and machinery related deaths compared to both the other areas. In the data from Statistics Norway Finnmark also had a higher rate of suicide than both the other two counties. From the same data we also see that Finnmark have lower rate of Road Traffic Accidents with personal injury, but more deaths per RTA than the other counties. Rural Hordaland did not differ from urban Hordaland in rate of RTA with injury, but had significantly higher mortality per RTA than urban Hordaland. Time from injury to death could be determined with certainty for 97 % of the Hordaland cases but only 66 % of the patients in Finnmark. All fatalities where time from injury to death could not bee established were found dead and had most likely died within the first hour of injury. It is in other words quite certain that Finnmark in reality have a higher share of injury related death within the first hour than both the other areas.
The study concluded that there exists an urban-rural continuum in Norway where the most rural citizens are the most disadvantaged in trauma care. The difference in share of prehospital deaths may signify

that there is room for improvement through layperson first aid, and that this should be explored further.

Table 3 – Summary of paper II comparison between study areas

	Finnmark	Rural Hordaland	Urban Hordaland
Trauma mortality rate	33.1	23.7	18.8
Age (median)	40	50.5	46
Male gender	80%	75%	76%
Time from injury to death <1 hour [a]	78 %	80 %	71 %
Prehospital deaths	85%	82%	72%
Mode of injury rates			
Suicide	9.8	8.2	8.7
RTA	7.6	6.3	1.7
Fall	2.4	3.6	4.4
Drowning	3.5	2.7	1.1
Homicide	1.9	1.0	1.1
Fire	2.2	1.2	0.2
Snowmobile	2.7	0	0
Machinery	1.1	0	0
Other	1.9	0.7	1.9
Work	6.1	3.4	0
Statistics Norway			
Suicide	14.6	8.9	10.5
Fall	9.9	10.9	12.6
RTA per 100,000	206	245	269
Death per 100 RTA	3.5	2.4 *	0.64

■ = Significantly higher value

■ = In between value.
    If marked by asterisk: significantly different from both other areas.
    If not marked: not significantly different from any.

■ = Significantly lower value

a = Based on 81/122 patients in Finnmark, 86/89 in urban, and 95/98 in
    rural Hordaland.

Rates as deaths per 100,000 inhabitants unless otherwise stated

Summary paper III

We aimed to give an epidemiological description of deaths caused by low-energy trauma.

As for study I all deaths from external causes occurring in Finnmark County from 1995-2004 were obtained from the Cause of Death Registry. Poisonings, hanging, drowning, suffocation, and electrocution were excluded. HE trauma was also excluded as discussed in the methods section. Hospital and autopsy reports were reviewed.

The 112 LE trauma deaths in the period accounted for 25 % of all deaths from external causes, and 43 % of all trauma deaths. The crude death rate was 13/100 000 inhabitants. Stratified by age the death rate rose sharply from 75 years of age with 63 deaths per 100 000 and continued rising with increasing age, culminating at 1354 deaths per 100 000 among the persons over 95 years of age. Median age was 82 years and 64 % were female. Pre-existing medical conditions (PMC) were registered in 90 % of patients. Twenty-six percent of patients had one registered PMC, 24 % had two, 11% had three, and 28 % had more than three PMCs. The most common PMCs were cardiovascular disease (53 %), dementia/senility (36 %), pulmonary disease (19 %), and previous stroke or TIA (15%). Almost every injury (99 %) was a result of a fall, while there was 1 (1 %) death from a road traffic accident. Head injuries were seen in 13 % of the patients, and fractures in 87 %. Prior to injury 38 % resided at home, 2 % in assisted-living residencies and 57 % in nursing homes. Place of death was on the scene of accident in 4 % of cases, in hospital for 44 %, in a nursing home in 50 %, and at home for a mere 2 % of the cases. Median time from injury to death was 14 days, 60 % of the patients died within 30 days, and 90 % within 90 days of injury. Seventy-four percent of patients were operated upon, and 13 % were operated more than once. Complications were recorded in 64 % of patients treated in hospital, 43 % experienced more than one complication. The most common complication was infection accounting for 40%, followed by heart failure (13 %), myocardial infarction (11 %), anaemia (10 %), and renal failure (10 %). Causes of death were recorded from the Cause of Death registry, it was not possible to discern between immediate and contributing causes of death, and there was therefore more than one cause per patient. Fifteen percent had no other recorded cause of death than the injury itself. Cardiovascular disease (stroke included) was given as cause of death in 46 % of cases, thereafter followed infection (16 %), dementia/senility in (16 %) renal failure (9 %) pulmonary disease (8 %), malignancy (5 %), liver failure (3 %). Other causes constituted 21 %.

The patients with head injury and fractures were compared. There was no difference in age or gender distribution, or time from injury to death.

There was a difference in place of death, with head injuries succumbing more often on scene of injury

The study concluded that patients dying form low energy trauma are old and multi-morbid. Low energy trauma constituted a considerable share of trauma deaths, but that the true impact are likely underestimated in studies that limit themselves to in hospital or 30-day mortality. This limits knowledge of patient development and care after hospital discharge.

Summary paper IV

We aimed to review the existing literature on first aid provided by laypeople.

A systematic search was done in the databases, Embase, Medline, Pubmed, and Google Scholar, for trauma and first aid in a prehospital setting. Any language, journal, date, and study type was included. We excluded animal studies, non-traumatic cardiac arrest, first aid by medical professionals or trained personnel, intrahospital procedures, isolated ocular or dental trauma, minor burns, and near drowning. Frequency of first aid, quality of first aid, and impact on outcome were set as outcome measures.

The search and exclusion process yielded 10 articles eligible for review. Two of these were conducted on the same material and therefore considered as one article. Three studies were surveys, two were autopsy-based preventable-death studies, two were simulation based RTCs, one was a cohort trial, and one an observational study. The studies included between 75 and 2932 victims, only two studies had more than 500.

Five studies gave the share of accidents where victims received bystander first aid, which ranged from 10.7 % to 65 %. One study assessed the presence of bystanders, and there were bystanders present at 59 % of accidents. Three studies specified what measures were initiated. Airway check was performed in 11.5% of cases, head-tilt and jaw-thrust in 26.9%, and breathing check in 59.6% of cases (one simulation based study). Recovery position was performed in 63.5-73 % of cases and prevention of hypothermia in 42-44.2% of cases (one simulation based, and one real-life study). Bleeding control was performed in 22-60 % of cases (two simulation based, and one real-life study).

Adequacy of the first aid was measured by two studies. Use of recovery position was performed incorrectly in 1-11% and control of hypothermia in 0-13 % of cases depending on the bystander's level of training (one real-life study). Bleeding control was performed incorrectly in 83.7 % in a simulation-based study, but only in 4-9 % in the real-life study.

One controlled study investigated the impact of first aid by trained

layperson first responders on mortality compared to patients who did not receive first responder aid. The study, which was conducted in a mine-festered area of Iraq, found a 5.8 % reduction in mortality. Two autopsy-based studies from Australia and Sweden, estimated a 1.8 - 4.5 % reduction in mortality had appropriate first aid been carried out.

The study concluded that there is very limited evidence on first aid provided by laypeople to trauma victims, but that there seem to be a not inconsiderable potential mortality reduction if first aid is provided. It seems that layperson first aid may be an area for improvement.

Results not included in the articles

In urban Hordaland 53 % of accidents occurred under the influence of drugs or alcohol, in rural Hordaland the share was 39 %. These results were not compared to the findings in Finnmark because of the uncertainty tied to whether the remainder of patients tested negative or were not screened at all.

Urban Hordaland, approximately adapted to the inclusion and exclusion criteria of Søreide et al [70] and Trunkey [150], thereby excluding hangings, and drownings who usually die on the scene of accident, had 54 % of deaths occurring prehospitally, 54 % within 1 hour, 10 % from 1 to 4 hours, and 37 % after more than 4 hours, and a crude mortality rate of 8.7 per 100 000 inhabitants.

Rural Hordaland, when applying those same exclusion criteria, had 77 % of deaths occurring prehospitally, 71 % within one hour, 5 % from 1 to 4 hours, and 20 % after more than 4 hours. Rural Hordaland had a crude mortality rate of 13.6 deaths per 100 000 inhabitants.

For Low energy trauma, the crude mortality rate showed a tendency towards increase (p = 0.063) by linear regression. Thus it was not accountable for the observed decline in mortality rate from external causes.

When regarding articles I and III as one, the major causes of death were; fractures after low falls in elderly (24 %), suicide (24 %), and RTA (15 %). This is based on the cases found, and does not include 43 poisonings where an unknown share were suicide.

Discussion

This thesis, that is; the articles herein, started off with an intention to determine the reasons behind a decade-long elevation of injury-mortality in Finnmark compared to the national average in Norway. Whether we succeeded in answering the original research question is a matter I will reflect upon at the end of the discussion. (Though, given the complexity of urban-rural differences and causes of trauma mortality, briefly outlined at the beginning of the thesis, the intention to *determine* the issue in retrospect strikes me as more than a little ambitious.)

We have found that the overall mortality from external causes in Finnmark has declined from the early 90's to the mid-2000, but the epidemiological pattern of injury is otherwise unchanged. There exists an urban-rural continuum where mortality, and share of prehospital death increases with rurality. For RTAs the rate of accidents with personal injury was distributed inversely to mortality along the continuum. Most deaths occurred prehospitally in both urban and rural areas. The major causes of death were fractures in elderly, suicide, and RTAs. There is a potential for injury mortality reduction in first aid from laypeople, but literature in that field is very sparse. LE trauma constitutes a considerable and underestimated share of deaths from trauma. The patients succumbing to LE trauma are older and with higher pre-injury morbidity than victims of HE trauma.

Injury prevention

The share of patients dying on scene was higher in rural areas with 85 % succumbing prehospitally in Finnmark, but also in urban Hordaland the share was quite high at 72%. The potential for mortality reduction in improvement of trauma care is therefore most likely somewhat limited. Focus should first and foremost be on prevention. (This is a rather uncontroversial conclusion, as also those patients that can be saved by improvements in trauma care probably would prefer not to be injured at all.) These studies suggest that greatest impact on mortality lies in targeting the major mode-of-injury subgroups: suicide, RTAs, drowings, and snowmobile accidents (in areas where these are in widespread use).

Suicides constitute the largest group of patients in these studies; it is also a group of patients where the trauma system has little to offer when the injury has occurred. Suicide prevention is much studied, and a multitude of prevention programs and strategies have been developed. Many such

programs are multifaceted and it is difficult to establish exactly what interventions have effect. Training of general practitioners to recognise and treat depression and suicidality has been found effective, also restricting access to means of suicide, and improving access to care for people at risk. Persons with psychiatric conditions are especially at risk, comprising 90 % of all suicides [4, 151, 152]. Despite the above psychiatric specialist services are being built down and responsibility for treatment and prevention transferred to municipality level. According to a recent report from SINTEF [153], many municipalities have developed competent psychiatric services, but the demand created by the transfer of care, and a growing population, outweighs their capacity. Thus there are little resources left for prevention. Also psychiatric services will need to compete with other municipal tasks, and may not be prioritised [153].

Research on prevention of road traffic accidents is abundant. Measures as diverse as increased police patrols, speed bumps, reduced speed limit zones, speed cameras, graduated driving license, the use of retroreflectors, use of motorcycle helmet, and road improvements such as median barriers are all found effective in reducing incidence of, or morbidity and mortality from, RTAs [154-161]. Also alcohol ignition interlocks have been found effective in reducing recidive of drunken driving [162], this of particular interest regarding that at least 40 % of the deaths occurred under influence of drugs or alcohol.

Safety for fishermen has increased through improvement and implementation of safety equipment, though there is still room for improvement. Particularly it may be useful to target the embarkment/disembarkment accidents in port, which often occur under influence [163-165].

There is little research on snowmobile accidents, but it is reasonable to believe that some of the measures found effective in reducing road traffic mortality can be adapted to target snowmobile users. However, legislation on helmet use, mandatory driving tuition, and improved trails have been reported not to have had effect, and that the snowmobile related injury rate is rising in Finnmark [166]. It is worth noting that in our material only one of the snowmobile related deaths occurred at work, this in line with a study from Finnmark concerning snowmobile injuries who also found that most injuries occurred outside marked trails, and at night [166]. Thus it seems that it is appropriate to direct prevention efforts particularly at recreational drivers.

Almost none of the patients suffering low energy trauma died prior to hospital admission. They were as such accessible for treatment interventions, and there may be potential for mortality reduction through improvements of these, but the patient group is old, multi-morbid and hence difficult to treat [167, 168]. Therefore prevention is highly warranted for these injuries as well. Withdrawal of certain medicines, sprinkling of sand and use of spikes on ice, improvement of home safety (e.g. removing rugs), supervised exercise, and mulitfactorial intervention are found effective in preventing fall injuries on individual levels, likewise multifactorial population-based interventions [169-171].

Prevention measures may face difficulties even when found effective. They can be difficult to implement in a non-study situation without follow-up of the implemented measures. Programs may be expensive, and therefore not prioritised or implemented. Preventive measures that are effective are also prone to entail smaller or greater (governmental) constraints on personal freedom. Measures such as alcohol ignition interlocks, cars with built-in speed limitations, and legal requirements for safety belts all intrude on the individual's freedom to some extent. Medical expenses when someone is injured are on the other hand covered by the state and it is therefore, some will say, in its right to impose preventive measures on the population. Personal freedom can also be regarded as freedom *from* as much as freedom *to*, someone's right *to* drive drunk is not compatible with some other's right to freedom *from* being killed by a drunken driver, and it is the governments mandate to regulate such issues [172]. The balancing of the above is in the end a matter for politics.

It is important to keep in mind that injury is not only a matter of life or death, but also of health or disability. In our study we have only covered death from injury, but they can be regarded as the mere tip of the iceberg of injuries' full impact on society. For every death there are several more patients who are severely injured but survived with permanent disability, and for every permanently disabled there are even more with major but passing disability and so forth, depicted graphically as an injury pyramid (Fig. 3) [173]. The modes of injury with the highest mortality rates are not necessarily the ones that cause most disability, and perhaps not where preventive efforts should be directed. Thus, better to prioritise among preventability measures, one should make burden of injury estimates that cover both minor and major injury, as well as death, as stated by Polinder et. al [87].
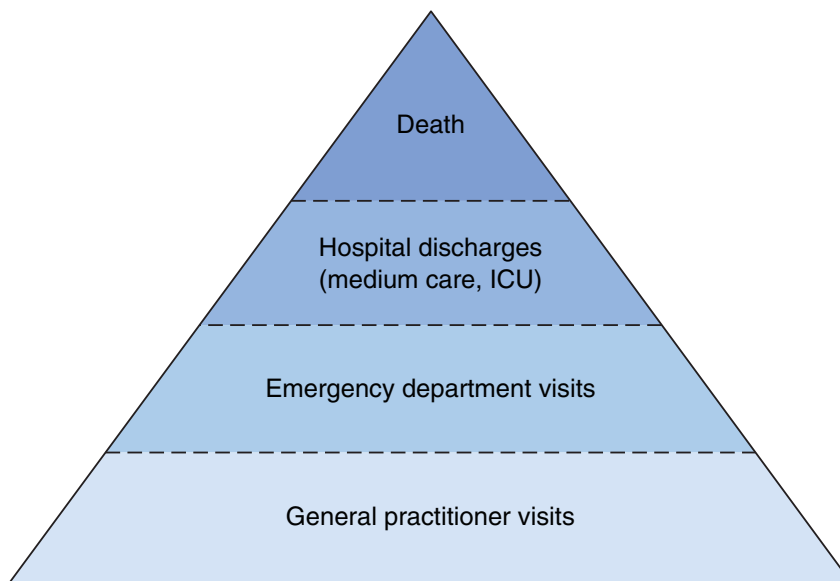
Figure 3. The injury surveillance pyramid
ICU = Intensive Care Unit
From Polinder et. al *Epidemiological burden of minor, major and fatal trauma in a national injury pyramid* (kindly with permission) *[87].*

Trauma system implementation
One of the aims of this thesis was to discern conditions a trauma system must be adapted to when implemented. As addressed in the previous section prevention is paramount. The registration of injuries and research on trauma is an important part of a trauma system [74, 75] and it is important that prevention receives due attention. Trauma registries can be used to measure effect of prevention programmes in various fields, but also to identify such things as RTA "hot spots" where local prevention measures can be directed. Also personnel employed in the trauma system should be involved in advocating preventive measures in their local community.

The higher death rate in rural areas signifies that these areas require particular attention when designing the trauma system. As the results from study II on discrepancy between injury and death rates from RTAs in rural areas show, the rural trauma victim is disadvantaged, and higher death rates in rural areas are not solely the result of higher injury incidence. The disadvantage may be because of poorer quality of health care, longer distances to definitive care, or the two combined.

Our studies do not answer which is the case in our study areas; merely that an urban rural gradient exist. (Though the intended method of preventability assessment could have given some indication.) Also distance and low volume are intertwined in that hospitals located places a long way from trauma centres, are mostly small and with long prehospital times in the surrounding areas. Though the effect of long distances and low treatment volumes on injury mortality is disputed, it seems pertinent that one should try to address both possibilities when implementing the trauma system.

There is some evidence for training as a means to counter the disadvantages of low volume, and the need of training needs to be emphasised in the system, for example through requirements imposed on small volume hospitals [61, 63]. Management support to smaller hospitals from trauma centres through telephone or video may be helpful. With long transport times, prehospital care is all the more important, and attention to training and education of ambulance personnel in rural areas may be due. One of the reports addressing the implementation of a trauma system in Norway also pointed out that the general practitioner on call in the municipalities is a resource that can be better utilised through better training and cooperation with the ambulance service [51]. This is of particular interests where helicopter flight times are long. The effect of long distances can perhaps be mediated through optimisation of ground ambulance allocations, as well as implementation and adherence to treatment and transfer protocols from local hospitals to trauma centre [79, 80].

Our findings do not support any one particular of the described measures, merely that rural areas are in need of extra attention, when implementing a trauma system. After implementation our studies can, together with statistics from Statistics Norway (SSB), provide a baseline to determine whether the system is effective.

Our results indicate that improvements in care will have limited potential for effect on mortality, and that a trauma system should be highly involved in research and prevention. A trauma system may, on the other hand, achieve a better mortality reduction than previous more isolated improvements to trauma care. Also, as with prevention, it is necessary to bear in mind that improvement in trauma care likely has effect on other endpoints than mortality such as disability and morbidity, or cost effectiveness [174, 175]. The exclusion of these endpoints is a severe limitation in our studies ability to address the aim of trauma system adaption requirements. Future studies should try to establish the trauma

system's impact on these, and how it can be adapted to improve them. For future studies it may also be of interest to cooperate with neighbouring countries, as Finland and Sweden share the challenges of large rural areas, to establish whether there are lessons to be learned from each other and investigate the potential for cooperation

Bystander first aid

The bystander is the ignored link in the trauma chain of survival. While bystander first aid is considered essential in improving outcome in cardiac arrest and has been subject to a considerable amount of research, little is known of her actions in trauma [176-179]. What research there is support that there may be a potential for reducing trauma mortality through layperson first aid. Considering that more deaths occur prehospitally in rural areas the bystander may be of particular importance here. Maybe the establishment of first responder groups in remote locations can be beneficial, or increasing the knowledge of first aid in the entire population. Before there is any point in implementing such measures there is much to be established. How often do trauma victims receive first aid per date? How often are bystanders present at all? Will training improve the chances of an individual performing the required actions in the face of injury? So while our findings are exiting it is long before this will have implications for the rural trauma system, apart from that trauma research should seek to address the matter.

Low energy trauma – a case for the trauma system?

Patients suffering low energy trauma are not generally met by trauma team on admittance in hospitals [88]. The patients have relatively straightforward issues, mostly with a single injury and no ABC compromise. There is strictly no need for the haste and broad approach as for the multi-trauma patient in the acute phase. The patient is at risk for death because of her age and comorbidities and not the trauma in itself. A multidisciplinary approach is probably warranted with geriatric or internal medicine services for optimising the patient for operation, and close follow up postoperatively, physiotherapy and mobilisation both in hospital and nursing home, and perhaps also close follow up from general practitioner in nursing home [180, 181]. This approach however is likely only indicated for high-risk patients who comprise only a fraction of all LE injuries [182, 183]. Thus LE injuries are not, in general, to be treated by the trauma system. Researched upon is another matter, LE trauma consist for the most part of patients commonly excluded from trauma studies. Though different in treatment, from a public health perspective LE trauma should be included alongside both minor and major trauma as

discussed in the prevention section. Also the trauma research approach may provide a different viewpoint and a useful supplement to orthopaedic and geriatric research in the field. On the other hand, our study highlights some of the difficulties identifying the exact patient population and what in fact causes their demise. Therefore LE trauma should not necessarily be part of trauma registries, but perhaps investigated through other approaches.

As mentioned, also here the main focus should be prevention. However, because the patient group is large, there is in addition a need to identify which comorbidites put patients at risk and make algorithms that help identify patients eligible for extra follow up [182, 183]. In order to address the issue of low energy trauma there is a need to properly define the patient group, as discussed in the methods section, because there exist no common definition, and the categorisation is currently based on exclusion.

What about Finnmark?

As I began this chapter I pointed out that the reason we began our studies in the first place was to discern the reasons for Finnmark's high mortality rate. We did find a fall in total mortality from external causes, but we could not discern any one reason for the decline. The overall epidemiological pattern remained unchanged and we could not detect a decline in any mode of injury subgroup. If either inhospital or prehospital care had improved substantially one would expect a shift in the place of death for the patient. Perhaps there were improvements in several areas at once. Our study was conducted after several improvements were made to the trauma system, the car park became increasingly more secure, and psychiatric services were improved. However, some of the improvements made to the trauma system and psychiatric services was done relatively late in the study period and one would expect there to take several years before an effect would be apparent.

So why was the mortality rate high in the first place? We found most mode-of-injury categories to be elevated compared to urban Hordaland. The county was more in line with rural Hordaland in this respect, but had higher rates of death from snowmobile accidents and machinery. Compared to national data Finnmark had a high suicide and homicide and low fall rate, but not sufficiently to be detected in comparison to Hordaland. Thus there does not seem to be one single mode of injury that accounts for Finnmark's high mortality rate. Mortality rate did not vary according to season or month indicating that polar nights or midnight sun do not have any marked impact in this respect. The share of persons

dying under influence of drugs and alcohol was seemingly in line with the other study areas, though the share represents a lower bound and is most likely higher than recorded. Based on data from neighbouring countries it seems that Sami are at same risk of injury as the majority population in the same area [146, 147]. We have also found that the elevated rate is not only due to an elevated injury incidence but that a disadvantage to treatment, caused by poorer care or long distances, contributes.

Elevated mortality rate, and epidemiological pattern seem to follow an urban-rural continuum, a finding supported by other studies. This continuum serves as the most likely explanation: Finnmark is one of the most rural (measured by centrality, and population density) of the Norwegian counties with all that entails (as discussed in the background)[16]. Long distances, and jobs that are more hazardous and comparatively low paid. This and a small population give a society with low socioeconomic status. The low population density leads to long distances to local hospitals, and the hospitals are thus themselves small and with limited resources and availability of specialities. The disadvantage of rurality is complex and its factors intertwined, and we do not know exactly which of the factors at play are contributing most to Finnmark's elevated mortality rate.

Validity

The epidemiological pattern found in Finnmark and rural Hordaland conforms to the 'typical rural' pattern found in international literature, and described in the background section. Though our methods differ somewhat it seems our results for urban Hordaland are roughly comparable to a study from the Stavanger region [70] in age, time and place of death, and mortality rate. Likewise our findings from Hordaland combined are comparable to a different study from the same county [184]. The urban-rural continuum is supported by the findings of Kristiansen el al. investigating paediatric trauma mortality in Norway [16]. Because our methods used in this regard were suboptimal, as discussed, our finding could conceivably have been an artefact created by the inclusion of the municipalities of Askøy and Fjell (both arguably more urban than rural) in rural Hordaland. That the continuum is supported by Kristiansen and international studies is thus reassuring, and indicates that the finding is transferrable [14]. Both the counties investigated are situated on the coast, and drowning as third leading cause of death is likely not applicable to landlocked counties that are more sparse in something to drown in. Deaths from snowmobile accidents were seen in neither urban nor rural Hordaland. Snowmobiles are little used in

the Western part of Norway, but we may assume that the findings from Finnmark are applicable to other areas where their use are prevalent, such as the other counties of Northern Norway, Trøndelag, and Hedemark County [185].

The incidence of femoral neck fractures have been reported to be lower in Finnmark compared to other areas of Norway, and death from low energy therefore is probably more frequent in other parts of the country [186, 187]. In international literature however, Scandinavia is held to have a comparatively high incidence of femoral neck fractures, and our findings perhaps more in line with other western counties [188, 189]. Though that assumption does not take into account the possibility of variation in care of these patients.

The findings from study IV concerning laypeople first aid in trauma are too sparse and divergent to say much concerning validity of the results. The share of cardiac arrest victims who receive bystander first aid is known to vary greatly between studies [190], and from our findings this is likely also true for first aid in trauma. The potential mortality reduction estimated from the two autopsy based studies [191, 192] was lower than the measured mortality reduction in the controlled trial [149]. One would expect it to be the other way around because of errors in the first aid given, and some victims potentially saved not receiving help at all for various reasons. The autopsy-based studies were only concerned with deaths that could have been prevented by provision of a free airway and bleeding control, and not measures such as hypothermia prevention that also are thought to be potentially life-saving. Nonetheless, the controlled trial was conducted in a mine-festered area, and its result therefore not applicable to areas where blunt trauma predominates (such as the autopsy based studies from Sweden and Australia).

Reliability
Can we trust our findings? Would they be the same were we to conduct the same study again (provided nothing had changed in trauma care)? Studies I-III are based on a retrospective material, and reports and records that are not written with research in mind. In studies I and II we found no information on 20% of cases included on basis of the cause of death registry in either police registries or health system records. This means that our findings are probably not quite accurate, and in particular results concerning smaller subgroups. Also, for many of the cases found information was not complete, and for the most part we elected not to investigate categories that were largely incomplete or encumbered with

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great inaccuracy such as cause of death, pre-existing medical conditions, injury survivability, and EMS response times. Exceptions were made for time from injury to death, which is closely tied to place of death, on the ground that the missing information could be made up for by place of death and injury mechanism. The share of deaths that occurred under the influence of alcohol and drugs was recorded and addressed in study I. This was based on autopsy reports or blood screens performed on victims not subject to autopsies. However for the 60 % not reported to have been under influence it was not possible to know whether this was because they were tested but not under influence or not tested at all.
The share reported is therefore a lower boundary. The share dying under influence reported for rural Hordaland is in line with the finding from another study from Hordaland by Hansen et al [184].
Findings from study I and II should thus, on the whole, be reasonably reliable given the retrospective material.

Study III is more vulnerable to the unreliability of retrospective studies. Pre-existing medical conditions, pre-injury housing conditions, and complications are based on hospital records. Whether they are complete depends on the patient's memory and comprehension of her own medical history, the physician's meticulousness and skills brining forth and recording the history, and the hospital's completeness of the patients record (diagnoses from other hospitals are not necessarily available). Recorded diagnoses may be more or less tentative and verified. In addition there is the matter of death certificate reliability that was discussed in the methods section.

By the sound of it study III is not very reliable at all, and given the above description of its reliability one will surely wonder whether there was any point in conducting the study at all. The study illustrates that low energy trauma constitute a considerable share of trauma deaths, though the estimate may be somewhat small, as mentioned in the methods section. We have found the LE patient population to be old and multi-morbid. While some of the patients included probably did not die from their hip fracture (though it may have contributed) and some who did die from hip fracture likely were left out it is reasonable to assume that age and presence of comorbidity are comparable in these groups. This is supported in existing literature on LE trauma and hip fractures, and probably also is a major reason for the difficulty in determining the exact cause of death in these patients without performing an autopsy [92, 97, 182, 183, 193, 194]. Lastly we found that half the patients succumbed after discharge from hospitals, primarily in nursing homes. I think we are safe to assume that most physicians manage to record the place of death fairly accurately on the death certificate.

Thus we see that while there is a fair amount of uncertainty concerning the details, the broad picture described in the article is rather reliable. Furthermore the study highlights some of the major difficulties tied to studying low energy trauma.

Conclusions

The general aims of this thesis were 1) to investigate possible reasons for Finnmark's' elevated death rate from external causes, 2) highlight challenges in Scandinavia that a trauma system must be tailored to meet, and 3) find access points to limit the burden of injury in Finnmark.

We have found that 1) Finnmark's high rate of death from external causes is probably tied to the county's rural nature and the multi-faceted disadvantage of rurality. The elevated death rate seems to be declining, and approach the national mean. 2) A trauma system in Scandinavia will have to meet the challenge of mortality rates increasing with rurality, and the majority of deaths occurring in the prehospital phase. 3) Finnmark does not seem to differ greatly from other areas in one singular area, and access points will likely be the same as elsewhere, though targeting snowmobile accidents may be warranted. There may be a potential in bystander first aid, though improvements in trauma care will likely have limited effect on trauma mortality.

Suggested measures

A trauma system in Norway should pay particular attention to rural areas, where both long distances and low treatment volumes should be sought addressed. The trauma system should have emphasis on research and prevention to reduce total injury mortality low energy trauma and psychiatry should be included in these efforts. Patients with simple fractures and serious comorbidity should receive extra attention in orthopaedic wards with medical, preferably geriatric, support. In nursing homes awareness of the patient group should be raised.

Implication for further research

Future research should include non-lethal injuries. Preventive measures should be prioritised. To learn from each other's practices and to assess the possibilities for cooperation, future epidemiological rural studies should encompass neighbouring countries. The potential for improvements in nursing home care for low energy patients should be assessed. There is a potential for mortality reduction in injury through

bystander first aid, though the research in the field is scant, and the first link of trauma care is in need of attention.

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Paper I

Håkon Kvåle Bakke, Torben Wisborg.

Rural high north: a high rate of fatal injury and prehospital death.

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Paper II

Håkon Kvåle Bakke, Ingrid Schrøder Hansen, Anette Bakkane Bendixen, Inge Morild, Peer K. Lilleng, Torben Wisborg.

Fatal injury as a function of rurality-a tale of two Norwegian counties.

Paper III

Håkon Kvåle Bakke, Trond Dehli, Torben Wisborg.

Fatal injury caused by low-energy trauma – a 10-year rural cohort.

Submitted

Paper IV

Tomas Dybos Tannvik, Håkon Kvåle Bakke, Torben Wisborg.

A systematic literature review on first aid provided by laypeople to trauma victims.