

ORIGINAL ARTICLE

Increased risk of fatal paediatric injuries in rural Northern Norway

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Background: Finnmark, Northern Norway, had a mortality rate for paediatric injury in 1998-2007 that was more than twice the national average. We investigated whether this rate had decreased in 2008-2015 after improvements in emergency care. We also compared the mortality rate to rates of non-fatal injury and trauma team activation both regionally and in Norway.

Methods: The study was based on 4 national registries. Mortality and injury rates were calculated per 100 000 persons per year. The study population was divided into age groups; 0-5, 6-10, 11-15 and 16-17 years.

Results: Between 1998-2007 and 2008-2015 there was an overall decrease in paediatric mortality rate due to external causes in Norway in total from 7.1 to 4.0. Despite this, in 2008-2015, the mortality rate remained 2.5 times higher in Finnmark than in Norway (9.7, RR = 2.5 CI 1.4-4.3, $P = 0.001$), similar to findings for 1998-2007. Finnmark had half the rate of non-fatal injuries in 1999-2007 (5052, RR = 0.6, 95% CI 0.6-0.7, $P < 0.001$) and in 2008-2015 (3893, RR = 0.5, 95% CI 0.5-0.6, $P < 0.001$) as in Norway. The rate of trauma team activation was similar in Finnmark and Norway.

Conclusions: The risk of injury-related death remained significantly higher, while the overall risk of non-fatal injury was significantly reduced for children in rural Northern Norway. Thus, injuries in this rural area seem to be less frequent but more severe. There is a need for detailed examination of each death to determine possible preventive measures.

1 | INTRODUCTION

Paediatric trauma is a leading cause of death globally and leads to the loss of many years of life.¹ Previous studies have shown associations between trauma outcomes and geographic location. Several studies have found higher mortality rates in rural areas and in areas in which there is a potential delay of treatment due to longer distances to healthcare providers.²⁻⁷ One study found that the risk of death was 3 times higher for injured patients who had transport times that were more than 1 hour to access full trauma treatment.⁸

Transport-related injury is the leading cause of death for those 17 years old and younger globally, and for those 16 years old and younger in Norway.^{1,4} The second most common cause of traumatic death for children below the age of 17 in Norway is self-harm.⁴ For decades, Finnmark—the Northern-most and most rural county of Norway—has had the highest injury mortality rate in Norway.⁶ A previous study found that the mortality rate for paediatric trauma in Finnmark from 1998 to 2007 was 3 times that of the national average in Norway.⁴

Many studies have suggested that prevention is the best way to decrease the number of years of life lost because of paediatric

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trauma-related deaths.^{5,6,9} In rural areas, most of the incidents with fatal outcomes involve pre-hospital deaths.^{4,6,10-12}

The Norwegian trauma system has developed since the previous study from 1998 to 2007. A national trauma plan was implemented in 2006¹³ and all Norwegian hospitals caring for severe injuries are now subjected to quality control and must fulfil a number of criteria concerning training, preparedness and facilities. The education of ambulance personnel has improved, and ambulance personnel are now authorised healthcare providers. Cars have improved, legislation concerning restraining devices have been enforced, even for public transport. Road safety has been focused amongst others by specific research into paediatric road traffic injuries.⁵ Thus, there is a hope that the high paediatric mortality rate in Northern Norway has decreased.

The aims of this study were to determine whether the mortality rate for paediatric injury decreased in Finnmark in 2008-2015 after advances in trauma care and road safety, and to compare the rate of mortality to rates of non-fatal injury and trauma team activation in Finnmark versus the rest of the country.

2 | METHODS

2.1 | Setting

The study compared statistics for Finnmark county to those in the rest of Norway (described as Norway where not specified). Norway, including Finnmark, has 19 counties, and Finnmark is the northernmost county and has the lowest population density (2.0/km²). This rural county is 48 000 km², which is comparable in size to Belgium. In 2015, there were 75 605 inhabitants in Finnmark, of whom 16 109 were under 18 years old.

The healthcare system and emergency medical services (EMS) in Norway are publicly funded and characterised by numerous smaller hospitals managing trauma patients, and long prehospital transports in rural areas. Four hospitals in Norway are defined as trauma centres, and contain facilities, personnel and preparedness similar to American College of Surgeons level I trauma centres (Oslo, Trondheim, Bergen and Tromsø), and 32 hospitals provide trauma care in addition throughout the country. All these hospitals have defined trauma team composition and requirements for training, response time and equipment. The EMS is based on 526 ground ambulances, 19 helicopters and 9 airplanes. Finnmark county has 2 acute care hospitals fulfilling the criteria, and ambulance response times are close to median values in Norway.¹⁴

All Norwegian hospitals have trauma team activation criteria. In the past, the criteria have varied somewhat between hospitals,¹⁵ but they have gradually converged towards a national standard. In 2015, common guidelines for trauma team activation were published in Norway.¹⁶ Every trauma team activation and every patient with injuries that had a New Injury Severity Score above 12 (irrespective of trauma team activation) are registered by the Norwegian National Trauma Registry.¹⁷

Editorial Comments

Despite a general decrease in trauma mortality nationally, the relative risk of fatal paediatric injuries may be higher in the northern region of Norway.

2.2 | Participants and data collection

This retrospective population-based study was based on national registries: The Norwegian National Cause of Death Registry (CODR), the Norwegian Patient Registry (NPR), the Norwegian National Trauma Registry (NTR) and Statistics Norway. Due to restrictions in ethical review board approval, the data from different registries were not merged at an individual level. Each registry delivered detailed statistics according to specifications in study plan and ethical review board approval.

The deaths of all Norwegian residents under the age of 18 years that occurred in 1998-2007 and in 2008-2015 were identified in the CODR, and the ICD-10 codes (International Classification of Diseases, 10th Revision) were determined. The codes ranged from V01 to Y89 ("External cause of morbidity and mortality"). Deaths due to medical conditions or iatrogenic causes were excluded (X20-X29, X40-X49, X50-X57, X60-X69, X85-X90, Y06, Y10-Y19, Y40-Y84 and Y88).

The population was categorised according to cause of death; transport injury (V01-V99), assault (X85-Y09, Y87.1), fall injury (W0), fire (X00-X09), self-harm (X60-X84, Y87.10) and other (V01-Y89), and place of death by institution type, as registered in the CODR.

To describe the number of injuries with non-fatal outcomes, all injuries registered in NPR for the 2 time periods, 1999-2007 and 2008-2015, with ICD-10 codes ranging from S00 to T78, were extracted and divided into 2 groups based on the geography: Finnmark Health Trust versus Norway, and by cause of injury. Only figures concerning inpatient care, independent of duration, were included, and all elective treatments were excluded. Each injury with the same main diagnosis was counted only once per patient per year in order to avoid counting patients with follow-up consultations more than once.

To compare the rates of suspected severe injuries based on the number of trauma team activations, this study included all trauma team activations in 2015 for Norwegian residents under the age of 18 years in Finnmark Health Trust vs the rest of Norway.

2.3 | Statistical analysis

For our comparison, both mortality and injury rates were calculated per 100 000 persons per year for the 2 populations based on the average number of inhabitants in the 2 areas and the number of deaths/injuries each year for the 2 time periods.

The population from both CODR and NPR was divided into 4 groups based on age, 0-5, 6-10, 11-15, and 16-17 years. By

categorising 4 groups according to age and merging them for the 2 time periods, we minimised the risk of identification of individuals when the total number of fatal injuries were especially low in Finnmark. This is required according to Norwegian regulations on patient confidentiality.

The trauma team activation rate was calculated as the number of activations per 100 000 inhabitants under 18 years old in the hospital catchment area for the index year 2015. PASW Statistics v.25 software (SPSS, Inc., Chicago, IL, USA) was used to perform the statistical analysis using χ^2 statistics, and statistical significance was set at $P < 0.05$.

2.4 | Ethics

The Regional Committee for Medical and Health Research Ethics for Northern Norway at the University Hospital of Northern Norway, Tromsø (ref. 2017/1374), approved the study.

3 | RESULTS

3.1 | Mortality rate

Between 1998-2007 and 2008-2015, there was an overall decrease in the total number of paediatric deaths due to external causes. The paediatric mortality rate from traumatic injuries in Finnmark decreased from 17.0 per 100 000 persons per year in 1998-2007 ($n = 31$) to 9.7 in 2008-2015 ($n = 13$). The same tendency was seen for Norway: the mortality rate decreased from 6.9 per 100 000 persons per year in 1998-2007 ($n = 730$) to 4.0 in 2008-2015 ($n = 348$) (Table 1, Figure 1).

The mortality ratio between Finnmark and Norway showed a persistent, significant and elevated risk for children living in Finnmark that did not change between the 2 time periods. In 2008-2015, the mortality risk was 2.5 times higher in Finnmark than in Norway (RR = 2.5, 95% CI 1.4-4.3, $P = 0.001$), similar to findings for 1998-2007 (RR = 2.5, 95% CI 1.7-3.5, $P < 0.001$). The highest rate for death after traumatic injuries was seen in the age group 16-17 years,

TABLE 1 Mortality rate for Finnmark and Norway except Finnmark for the age group 0-17 years, and the ratio in relative risk, RR, between these populations in the time period 1998-2007 and 2008-2015

Fatal injuries per 100 000 per year					
	0-5 years	6-10 years	11-15 years	16-17 years	Total population
1998-2007					
Finnmark	11.3	11.3	22.3	38.7	17.0
Population at risk (n)	6179	5305	4929	1808	18 221
Norway	5.4	3.1	6.5	23.6	6.9
Population at risk (n)	349 912	301 999	288 906	109 741	1 050 558
Ratio F/N	2.1	3.6	3.4	1.6	2.5
2008-2015					
Finnmark	7.5	0.0	7.5	42.4	9.7
Population at risk (n)	5104	4538	5039	2076	16 757
Norway	2.2	1.3	3.8	15.8	4.0
Population at risk (n)	362 138	299 081	309 617	127 180	1 098 016
Ratio F/N	3.5	0.0	2.0	2.7	2.5

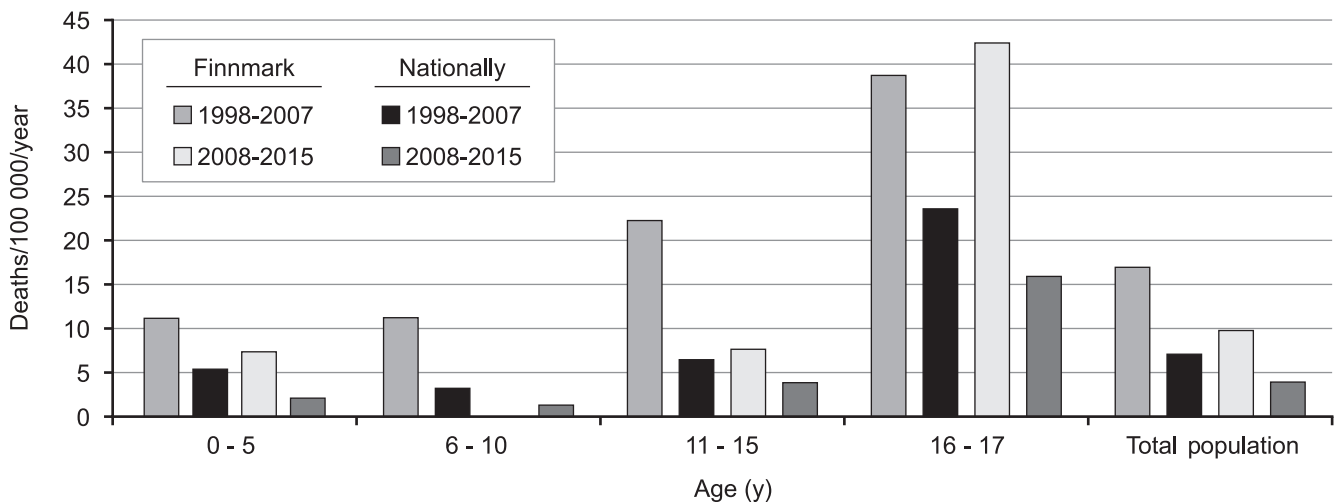


FIGURE 1 The paediatric mortality rate from traumatic injuries in Finnmark and Norway except Finnmark for 2 time periods

both in Finnmark and Norway. In Finnmark, the mortality rate for this age group increased slightly between the 2 time periods, but this difference was not statistically significant ($P > 0.05$).

3.2 | Place and mechanism of death

The majority of deaths occurred before the patient arrived at the hospital, both in Finnmark (77% for both time periods) and in the rest of the country (64% in 1998-2007 and 73% in 2008-2015). In Finnmark, transport injuries caused 68% ($n = 21$) of deaths, and self-harm caused 19% ($n = 6$) of deaths in 1998-2007, whereas 31% ($n = 4$) were caused by transport injuries and 31% ($n = 4$) by self-harm in 2008-2015. For Norway, in 1998-2007, 41% ($n = 302$) of deaths were caused by transport injuries and 20% ($n = 147$) by self-harm. For 2008-2015, transport injuries caused 33% ($n = 116$) of deaths and self-harm 26% ($n = 92$) (Table 2, Figure 2).

3.3 | Non-fatal injury rate

The rate of registered injuries with non-fatal outcomes increased in Finnmark from 3182 per 100 000 persons per year in 1999-2007 to 3893 per 100 000 persons per year in 2008-2015. The same trend was seen in Norway, where the injury rate increased from 5052 to 7245 per 100 000 persons per year (Figure 3). Finnmark had a

significantly lower relative risk of non-fatal paediatric injury than Norway for both time periods: 0.6 in 1999-2007 (RR = 0.6, 95% CI 0.6-0.7, $P < 0.001$) and 0.5 in 2008-2015 (RR = 0.5, 95% CI 0.5-0.6, $P < 0.001$).

3.4 | Rate of trauma team activations

In 2015, there were 111.7 trauma team activations per 100 000 persons under the age of 18 in Finnmark. In Norway, there were 111.3 alarms per 100 000 persons under the age of 18. Using 2015 as an index year, there was no significant difference in the ratio between Finnmark and Norway (RR = 1.0, 95% CI 0.6-1.6, $P > 0.05$).

4 | DISCUSSION

4.1 | Mortality

Despite a significant decrease in the number of trauma-related deaths in both Finnmark and Norway, the paediatric mortality rate in Finnmark in 2008-2015 remained 2.5 times higher than the national average (Finnmark excluded). The risk of paediatric trauma-related death was thus persistently higher in Finnmark than in Norway. This indicates that prevention has lowered the total number of deaths for both of the considered areas, yet the difference in paediatric

TABLE 2 Mechanism of death for Finnmark and Norway except Finnmark in the time period 1998-2007 and 2008-2015 for the age group 0-17 years, calculated as percentages (%) of the total number of events in each population

Mechanism of death, percentages (%) of the total number of events in each population						
	Transport injury	Fall injury	Fire	Self-harm	Assaults	Other
ICD-10	(V01-V99)	(W0)	(X00-X09)	(X60-X84, Y87.10)	(X85-Y09, Y87.1)	(V01-Y89)
1998-2007						
Finnmark	67.7	3.2	0.0	19.4	0.0	9.7
Norway	41.1	3.3	4.7	20.1	6.3	24.2
2008-2015						
Finnmark	30.8	7.7	15.3	30.8	7.7	7.7
Norway	33.3	3.2	2.6	26.4	14.4	20.1

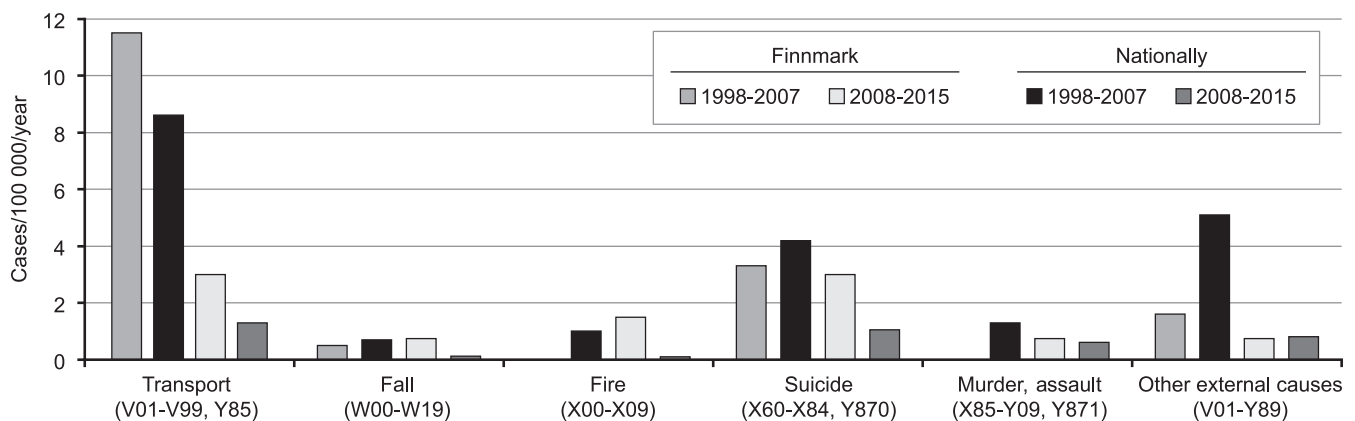


FIGURE 2 Incidence of fatal paediatric injuries in Finnmark and Norway except Finnmark by mechanism for 2 time periods (other external causes are all included cases except the specified causes)

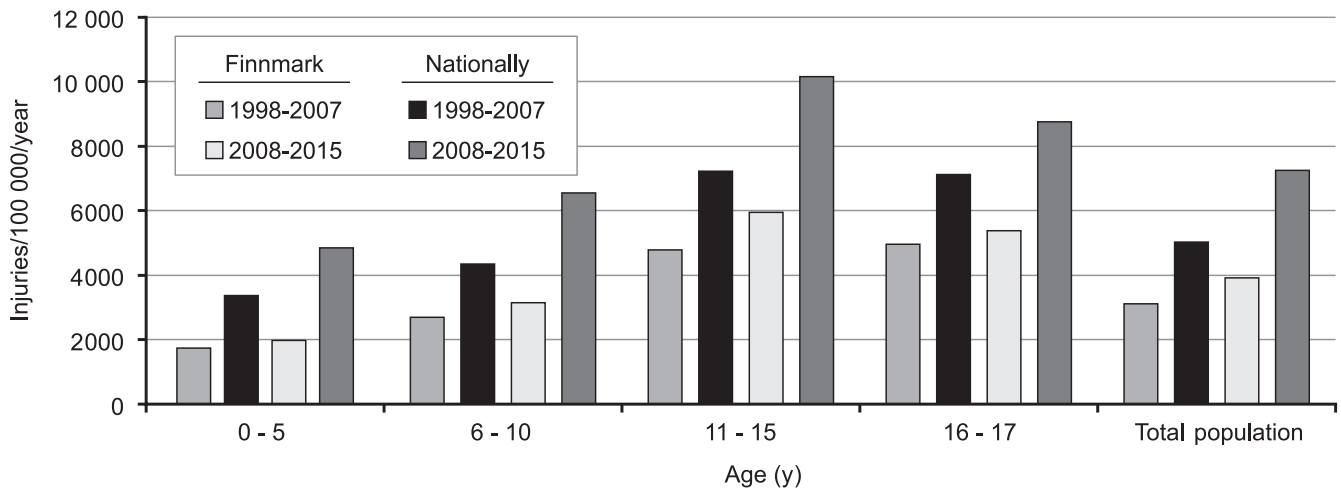


FIGURE 3 The rate of non-fatal paediatric injuries in Finnmark and Norway except Finnmark for 2 time periods

mortality between Finnmark and Norway persists. This corresponds with the findings by Kristiansen (2012)⁴ for the age group 0-15 years, and findings for Finnmark irrespective of the age groups.¹⁰

The greatest reduction in the number of cases with fatal outcomes was found for transport injuries. This is in accordance with findings in a recent (2014) Norwegian study that reported that better use of safety equipment in cars was a preventive factor with great potential for reducing the number of trauma-related deaths,² resulting in a reduced number of transport deaths of children under the age of 18.¹⁸

Similar to transport injuries, the number of self-harm incidents with fatal outcomes decreased in 2008-2015, but to a lesser extent. Therefore, as a cause of fatal injury, self-harm accounted for a higher percentage of deaths in 2008-2015 than in 1998-2007. This is due to the decrease in transport deaths and to the decreased overall number of trauma-related deaths.

For both Finnmark and Norway, the highest mortality rate related to trauma was seen for 16- to 17-year olds, same age group as seen in the previous studies.¹¹ This was caused by transport injuries and to self-harm, which were the most common causes. Preventive efforts that target this population will likely save life years.

Most trauma-related deaths are pronounced prehospital, most often before the arrival of healthcare personnel. This reduces the possible impact of experience in the hospital trauma teams, which however all adhere to similar national standards concerning composition, training and certification. Ambulance personnel training, authorisation and criteria for pronouncement of death are all similar throughout Norway. Unless injuries are incompatible with life, only physicians pronounce a patient dead in the prehospital setting, but general practitioners take part in most emergency ambulance calls throughout Finnmark. For the rest of Norway (ie, excluding Finnmark), there was an increase in the number of deaths pronounced outside hospitals from 64% to 73% in the 2 time periods. This might be due to the relative increase in deaths due to self-harm and suicide.

4.2 | Injuries

Regarding non-fatal injury ratios, the relationship between Finnmark and Norway was, paradoxically, reversed. Specifically, there were two and a half times as many deaths in Finnmark as in Norway but half as many non-fatal injuries. This may suggest that unintended events occur less often, but are more severe. The combination of long distances to hospitals in Finnmark plus possibly more severe primary injuries may increase the number of trauma-related deaths.

4.3 | Rural trauma

The more severe injuries, that is, those that fulfilled trauma team activation criteria, were equally common throughout the country. This raises the question: Why are fatal injuries so much more prevalent in Finnmark? A previous study in Norway¹⁰ reported the same relationship between rural areas and the high risk of death versus the number of non-fatal injuries. However, our data are not in accordance with the recent findings in Ohio, USA.^{7,19} Studies in Ohio found that the rate of injuries was highest in the most rural areas, while severe injuries were seen predominantly in urban or semi-urban areas. The standardised mortality rate was somewhat more scattered but had a tendency to be the highest in urban areas.^{7,19} A systematic review of paediatric injury in the US and Canada reported similar findings concerning injuries.²⁰

4.4 | Limitations

This study collected no further information about injury severity, travel distance to a hospital, time of day, involvement of drugs or autopsy results. The study did not include patients with injuries that were treated only by a general practitioner in an emergency room outside of a hospital setting. Even though long distances in rural areas may increase the number of non-fatal injuries treated locally, and thus not admitted to hospital, we find the difference in relative risk for non-fatal injuries to be of a size precluding local treatment to be the only explanation of the observed difference.

The number of fatal injuries that was used to calculate the mortality rates was fortunately low, especially in Finnmark; however, the long time period (10 years) and the consistency of the results with those in the previous time period and the previous study⁴ make these findings trustworthy. The findings in Finnmark compared to Norway only allow us to draw conclusions for Finnmark; that is, these findings cannot necessarily be generalised to other rural areas in Norway. Ideally, a new study should assess rural/urban differences in Norway at a national level.

5 | CONCLUSION

This study found a significantly increased risk of trauma-related deaths for children under the age of 18 years in Finnmark compared with Norway despite a significantly lower rate of non-fatal injuries in this geographical area.

The majority of deaths were declared outside of the hospital, and the most common causes of traumatic death were transport injuries and self-harm. These data confirmed the high rate of injury-related paediatric mortality reported previously in Finnmark. Indeed, despite a reduction in the absolute figures for both Norway and Finnmark, the risk of death for children in Finnmark remains significantly increased compared to Norway. There is an urgent need for assessment of other rural areas in Norway and for in-depth studies of individual fatal injuries throughout the whole treatment chain, to determine possible areas that can be targeted with preventive efforts.

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CONFLICTS OF INTEREST

No conflicts to report from any of the authors.

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