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

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Background: Death after injury with low energy has gained increasing focus lately, and seems to constitute a significant amount of trauma-related death. The aim of this study was to describe the epidemiology of deaths from low-energy trauma in a rural Norwegian cohort.
Methods: All deaths from external causes in Finnmark County, Norway, from 1995 to 2004 were identified retrospectively through the Norwegian Cause of Death Registry. Deaths caused by hanging, drowning, suffocation, poisoning, and electrocution were excluded. Trauma was categorised as high energy or low energy based on mechanism of injury. All low-energy trauma deaths were then reviewed.
Results: There were 262 cases of trauma death during the period. Low-energy trauma counted for 43% of the trauma deaths, with an annual crude death rate of 13 per 100,000 inhab-
itants. Low falls accounted for 99% of the injuries. Fractures were sustained in 89% of cases and head injuries in 11%. Ninety per cent of patients had pre-existing medical conditions, and the median age was 82 years. Death was caused by a medical condition in 85% of cases. Fifty-two per cent of the patients died after discharge from the hospital.
Conclusion: In this cohort, low-energy trauma was a significant contributor to trauma related death, especially among elderly and patients with pre-existing medical conditions.

TRAUMA is a leading cause of death worldwide.[1]

Most studies on trauma death concentrate on high-energy (HE) injuries. While HE trauma includes important contributors to mortality such as road traffic accidents and violence, this approach neglects a substantial share of trauma deaths. A new concept in trauma epidemiology seems to be emerging: fatal trauma caused by low-energy (LE) injuries. Evans et al. recently reported LE trauma to be responsible for 41% of all trauma deaths and with an epidemiology distinct from HE trauma,[2] including greater age, a large proportion of late deaths, and exclusively caused by low falls.

Worldwide, the general population is ageing and geriatric conditions like LE trauma are likely to have an increasing impact on the health-care system.[3–5]

Finnmark County is a sparsely populated county in the very north of the Scandinavian Peninsula with a high rate of death from external causes, and we have previously reported on its HE trauma deaths.[6]

In light of the above, we wanted to investigate also the LE trauma deaths in the region.

Prior studies on or including LE trauma have often been limited to falls as the mode of injury,[7–10] included only in-hospital deaths or 30-day mortality,[2,7,10–13] or have excluded femoral neck fractures altogether.[6,9,10] However, the definitions of LE fatal trauma are not uniform. The aim of this study was to describe the epidemiology of deaths after LE trauma.

Materials and methods

Study area

The study comprised the population of Finnmark County, the northernmost county of Norway. The county had 76,629 inhabitants at the beginning of the study period and covers an area of 48,617 km^2.[14]*

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*Statistics Norway, Table 07459. http://statbank.ssb.no/statistikkbanken/?PLanguage=1 [Accessed November 2012]

The population is served by two local hospitals in addition to the University Hospital of Northern Norway (UNN), the latter being located outside of the county. Both local hospitals offer general and orthopaedic surgery and intensive care. UNN offers all medical specialties and is the referral centre for local hospitals in northern Norway including the county of Finnmark.

Patients

All deaths in which an external factor [International Classification of Diseases 10th revision (ICD 10) code V01 to Y98][15] was a direct or contributing cause in the county and occurring from 1 January 1995 to 31 December 2004 were acquired from the Norwegian Cause of Death Registry. We excluded all deaths from hanging, drowning, suffocation, poisoning, and electrocution in which there was no associated anatomical injury. All cases of HE trauma were excluded (HE trauma was defined as falls > 3 m, motor vehicle-related traffic injuries, major burns, gunshot, stab wounds,[2] and homicide by blunt violence). For all the included cases, we reviewed the hospital records; for the cases occurring at the scene of accident, ambulance records and police and autopsy reports were reviewed. Injury type and cause, time of injury, admission, discharge and death, place of death, cause of death, pre-existing medical conditions (PMCs), treatment given, complications, and demographic data were registered in a standard form. It was not possible to discern between contributing and direct causes of death.

In order to describe the full extent of fatalities, time from injury to death was not an exclusion criterion. As long as trauma was registered, as a direct, underlying, or contributing cause in the Cause of Death registration, the patient was included.

For those patients who died after being discharged, time and place of death were based on the information from the Cause of Death Registry. For all patients, cause of death was based on the information from the registry. General practitioner and nursing home records were not reviewed. General population characteristics were obtained from Statistics Norway.

Registries and definitions

In Norway, all deaths are recorded in the Cause of Death Registry. Recorded data include the date of death, home municipality of the patient, place of death by municipality and institution type, and the immediate, underlying, and contributing causes of death. The information is linked to the unique personal security number of the patient. The registry bases the cause of death primarily on the death certificate issued by the physician viewing the body unless an autopsy is performed.

PMCs were defined as any significant medical condition that was present before the injury occurred and registered in the patient's hospital record. Complications were defined as any new medical or surgical condition diagnosed between injury and death. Place of death was grouped as scene of injury, hospital, nursing home, or home. Patients were counted as dying at home only if they died there after being discharged from the hospital. All time intervals were measured in days.

Statistical analysis

Analysis was carried out by the use of PASW (SPSS) statistics version 19 (SPSS Inc., Chicago, IL, USA). For comparison of the major subgroups, the Mann–Whitney U-test was used for continuous variables, and the chi-square test or Fisher's exact test was used for categorical variables with Holm–Bonferroni correction for multiple comparisons. A value for $P < 0.05$ was considered significant.

Ethics

This study was approved by 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), the Norwegian Director of Public Prosecutions (Ra 07–526 IFO/mw 639.2), and the Regional Committee for Medical and Health Research Ethics (200702984-3/IAY/400, and 2010/1703).

Results

There were 112 deaths from LE trauma during the study period; for 14 (12.5%) of these, no record of an injury was found in the patient's hospital records, and they were excluded from further analysis. Figure 1 shows the exclusion/inclusion process. Thus, LE trauma constituted 43% (112/262) of all trauma deaths for the 10-year period in Finnmark County and 25% (112/453) of all deaths from external causes, with a crude death rate of 13 deaths per 100,000 inhabitants per year. Table 1 gives the age-stratified death rates.

Table 2 shows patient characteristics. The patients had a median age of 82 [interquartile range (IQR) 79–89], and 64% (63/98) were female. PMCs were registered in the records of 90% (88/98) of patients.
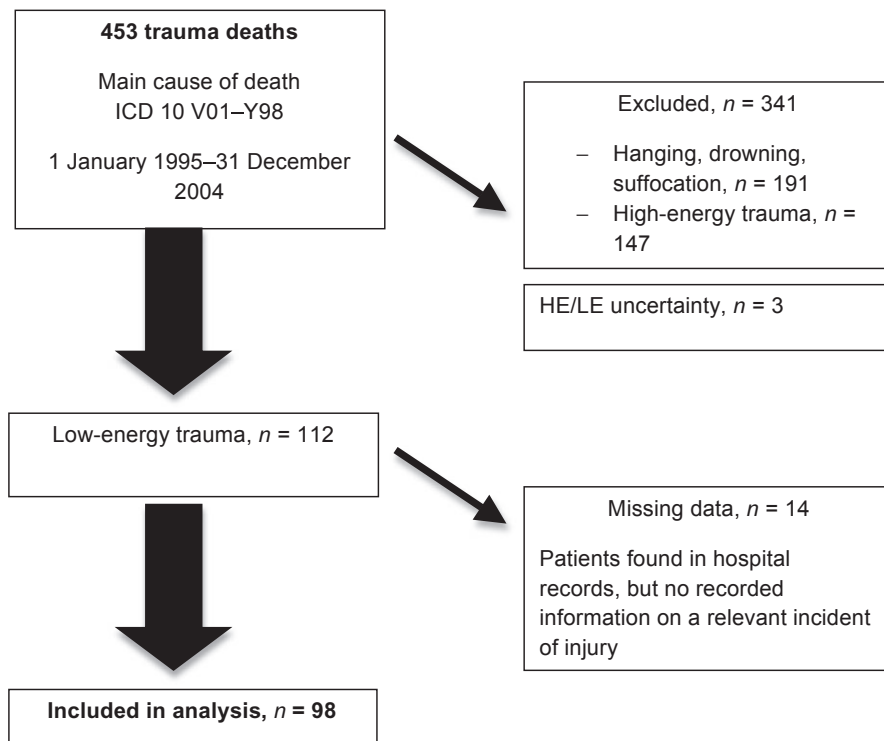
453 trauma deaths

Main cause of death
ICD 10 V01–Y98

1 January 1995–31 December 2004

Excluded, *n* = 341

– Hanging, drowning, suffocation, *n* = 191
– High-energy trauma, *n* = 147

HE/LE uncertainty, *n* = 3

Low-energy trauma, *n* = 112

Missing data, *n* = 14

Patients found in hospital records, but no recorded information on a relevant incident of injury

Included in analysis, *n* = 98

Fig. 1. Flow chart of the inclusion and exclusion process.

Table 1

Age-specific trauma-related death rates.

Age group	Persons at risk	Number of deaths	Deaths/ 100,000/year
0–59	619,151	5	< 1
60–64	31,932	1	3.1
65–69	29,042	3	10.3
70–74	26,258	5	19.0
75–79	20,566	13	63.2
80–84	13,386	20	149.4
85–89	6708	27	402.5
90–94	2074	18	867.9
95+	389	5	1354.4

Table 2

Patient characteristics, *n* = 98.

Pre-injury housing situation	Home	38%	*n* = 37
	Assisted-living residency	2%	*n* = 2
	Nursing home	57%	*n* = 56
	Missing	3%	*n* = 3
Pre-existing medical conditions (PMCs). None to seven PMCs per patient	None	10%	*n* = 10
	Cardiovascular	53%	*n* = 53
	Dementia/senility	36%	*n* = 35
	Pulmonary disease	19%	*n* = 18
	Prev. Stroke/TIA	15%	*n* = 15
	Diabetes	9%	*n* = 9
	Infection (ongoing)	7%	*n* = 7
	Renal failure	6%	*n* = 6
	Malignancy	5%	*n* = 5
	Anaemia	5%	*n* = 5
	Osteoporosis	5%	*n* = 5
	Other	5%	*n* = 5

Twenty-six per cent (25/98) of patients had one registered PMC, 24% (25/98) had two, and 11% (11/98) had three registered PMCs. The remaining 28% (27/98) had more than three PMCs. Figure 2 shows the mechanism and type of injury.

Admission length ranged from 1 to 137 days [median 5 days, (IQR) 3–8] for the patients living to discharge. For the patients who died in hospital admission length ranged 0 to 46 days [median 4 days, (IQR) 2–10]. Ninety per cent (66/73) of hip fractures were surgically treated. Thirty-two per cent (21/66) of these were operated on the day of injury, 35% (23/66) the day after the injury, and altogether 80% (53/66) were operated within 48 h from injury.

Complications were registered in 60 of the 94 patients who did not die on the scene (Table 3). Any condition that occurred after the first admission to the hospital was counted, including those conditions that occurred after discharge and that led to readmission.

Only 8 of 98 patients were autopsied. Therefore, causes of death were based upon data from the Norwegian Cause of Death Registry, where a distinction between immediate and contributing causes was not

Injury type

Mechanism of injury

Fall 99% (n = 97)
RTA 1% (n = 1)

Fractures 87 %

Head injuries 13 %

Shoulder/upper arm 3 % Other/several 6 %
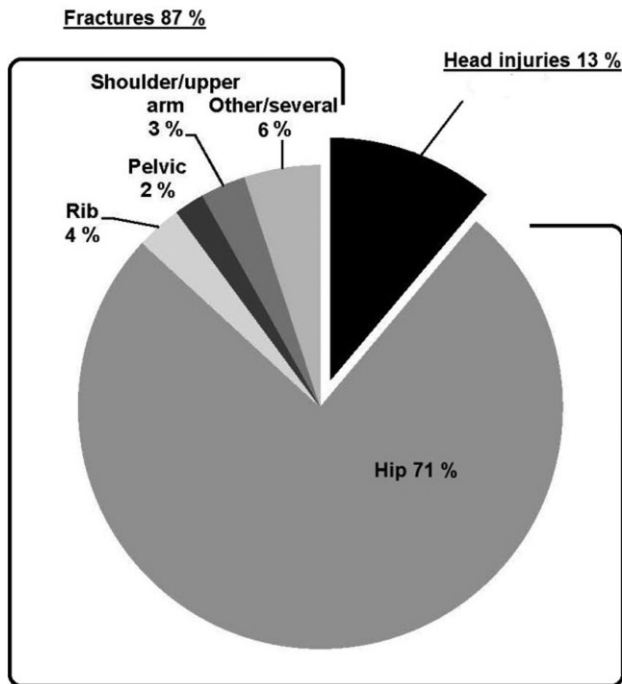
Pelvic 2 %

Rib 4 %

Hip 71 %

Fig. 2. Injury type and mechanism of injury. (RTA = road traffic accident).

Table 3

Complications after injury, n = 94.

Number of complications

(0–6 complications per patient)	None	36%	n = 34
	1 complication	20%	n = 19
	2 complications	19%	n = 18
	≥ 3 complications	24%	n = 23

Complications

(41 patients had more than one complication)	Infection	40%	n = 38
	Heart failure	13%	n = 12
	Myocardial infarction	11%	n = 10
	Significant anaemia	10%	n = 9
	Renal failure	10%	n = 9
	GI bleed	9%	n = 8
	Sustained arrhythmia	5%	n = 5
	Sustained hypotension	5%	n = 5
	Stroke/TIA	4%	n = 4
	Fall and fracture	4%	n = 4
	DVT/lung embolus	3%	n = 3
	Other	6%	n = 6

Table 4

Place and cause of death.

Place of death			(n = 98)
	On scene	4%	n = 4
	In hospital	44%	n = 43
	Nursing home	50%	n = 49
	Home	2%	n = 2

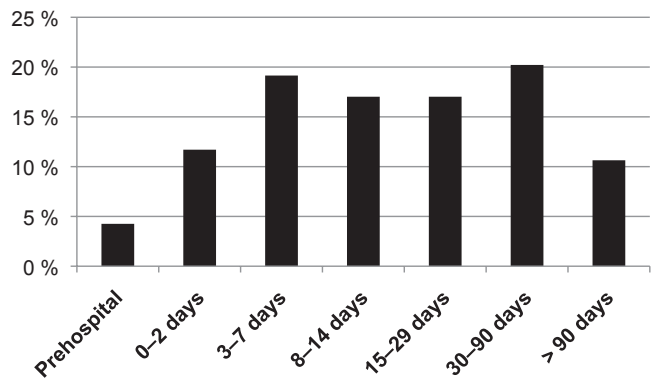| Cause of death			
Immediate and contributing (more than one per patient), the injury itself not included	Cardiovascular/stroke	46%	n = 45
	Infection	39%	n = 38
	Dementia/senility	16%	n = 16
	Renal failure	9%	n = 9
	Pulmonary disease	8%	n = 8
	Malignancy	5%	n = 5
	Liver failure	3%	n = 3
	Other causes	21%	n = 21
	No explanatory cause except injury	15%	n = 15
	Head injury	*7%*	*n = 7*
	Fractures	*8%*	*n = 8*

Fig. 3. Time from injury to death.

possible. Table 4 gives the places and causes of death. A poor prognosis was noted in 5 of the 51 patients dying subsequent to discharge.

Time from injury to death could be established for 94 of 98 patients (Fig. 3). Median time from injury to death was 14 days (IQR 5–46) and spanned from 0 to 2277 days. Sixty-six per cent (65/98) died within 30 days of the injury and 90% (84/98) within 90 days of the injury.

We compared the two major subgroups of injury, head injuries, and fractures. Two patients were excluded from this analysis. For both patients, suffocation or similar circumstances contributed to death. There was no difference in gender distribution (P = 0.336) or time from injury to death (P = 0.073). For age, there was no difference (P = 0.315) between the groups. Head injuries (12/96) had a median age

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of 80 (IQR 57–89), ranging from 40 to 93 years. Fractures (84/96) had a median age of 85 (IQR 80–90) ranging from 64 to 101 years. Patients with head injury died more often on the scene ($P = 0.014$).

Discussion

This study found that LE trauma accounted for 43% of total trauma deaths during a 10-year period in a rural area. It primarily affected the population above 75 years of age. Fifty-two per cent of the patients died subsequent to hospital discharge. Ninety per cent of the patients had PMCs. Death was caused by a medical condition, such as cardiovascular disease or infection, in at least 85% of the cases.

An important finding in this study is the high share of deaths occurring after discharge from hospital. This finding indicates that studies on falls and LE trauma underestimate the true impact these injuries have on mortality when they are limited to mortality at discharge. This is likely the reason for the higher LE death rate in our study [13 per 100,000 inhabitants per year, 95% confidence interval (CI) 10.6–15.9] compared with that of Evans et al. (8.1 per 100,000, 95% CI 6.7–10.7).[2] A skewed account of injury type might be another effect of omitting post-hospital deaths: Evans et al. report that 26% of their patients had head injuries whereas in our material, the share was only 11%. Ultimately, we may be neglecting a possibly important area of care for these patients.

The use of 30-day mortality when studying (HE) trauma is common, and gives a reasonable estimate of deaths due to the injury.[16] Because deaths from later complications after the injury are not included, the 30 days as a cut-off might underestimate the true impact of LE trauma. Cohort studies have shown an increased mortality for over a year in patients who have suffered femoral neck fractures compared with their peers,[17,18] and in this study, a third of the patients died 30 days or longer after the fracture. With increased time between injury and death, there will be an increasing uncertainty as to whether post-injury disorders are caused by the injury or would have occurred regardless of the injury, especially for elderly and multi-morbid patients. To assess long-term effects of LE trauma, a cohort design may thus be better suited, at least if the fall is the cause of deterioration and not merely a symptom of an already failing health.

Age and PMCs have been found to be important factors determining outcome in trauma patients,[7–10,13,19–22] which is in accordance with the high age and high share of comorbidities in this study. Through age stratification, we see that incidence of trauma-related death rises quickly from age 75 years onward. This increase is consistent with the trend described in a Swedish study on hip fractures by Bergström et al.[23] and projects that LE trauma impact on mortality is apt to comprise an increasing share of trauma mortality in the coming years as the general population is ageing.[3–5,23]

Hip fractures formed the largest group of deaths, and for these patients, time from injury to operation is of importance for length of stay and perhaps for prognosis.[24] We found that 80% of patients were operated within the recommended 48-h limit. However, because of age and comorbidity, delay of operations may have been necessary to optimise patient health status for surgery.

LE trauma comprises a large share of trauma deaths, but death is the outcome for only a small share of trauma patients.[25] Therefore, it is necessary to identify in some way those patients who can be targeted for extra care. This study suggests that attention should be directed to patients older than age 70–75 years. Also in this group, most patients will be in relatively good health; however, so for targeting to be more specific, the PMCs associated with an adverse outcome need to be identified.[21,22]

In the care for LE trauma patients, a multidisciplinary approach may be of help and should be explored further.[26,27] Although research is limited, orthogeriatric wards have been found promising.[27,28] Full-scale orthogeriatric wards may not be feasible in smaller hospitals such as in this study, but perhaps designated beds and staff, where orthopaedic and internal medicine consultants have joint responsibility for patient care. Transfer to a higher level of care for selected patients may also be an option.

The above measures have been described for hospitalised patients. We found that half the patients died in nursing care facilities and that few were discharged with a poor prognosis. These findings suggest that the care LE trauma patients receive in nursing homes deserves further attention.

Because of the high mortality caused by LE injuries to old and multi-morbid patients who are inherently difficult to treat,[24,29] there is a need for a high focus on prevention. Measures have been directed both at institutionalised patients as well as those who live at home, and some have been found to be effective, although further research is warranted.[27,30,31] In our study, close to 40% lived at home, indicating that both approaches may have an effect on death rate should measures be effective, though

measures directed at institutions may be easier to implement.

This study has several limitations, some inherent to LE trauma studies, including the lack of a common definition of LE trauma; studies to date either concentrate on low falls or exclusion of HE trauma. As discussed, the matter of causality is uncertain when time from injury to death increases and cannot be established except by studies using a case–control design. Thus, our study could have contained patients who did not in fact die from LE trauma, and it might have left out some patients who did. Other limitations are specific to the study itself: The study is retrospective and based on the hospital records of each patient, yielding some uncertainty about the reliability of diagnoses given, housing situation, and actual prognosis at discharge. The lack of data from nursing homes and primary care leaves the period between discharge and death relatively obscure. The very low autopsy rate and resulting reliance on information from death certificates leaves considerable doubt as to the accuracy of the causes of death. Injury Severity Scoring (ISS)[32] was not performed, and the inability to distinguish between immediate and contributing causes of death is also a problem. Still, the material covers a complete county through 10 years, and does raise important questions despite these weaknesses.

In conclusion, LE trauma make up a substantial share of trauma deaths, and is underestimated when based on survival at discharge. The epidemiology is distinct from HE trauma, with rapidly increasing mortality from 75 years onwards, and the patients are highly comorbid. The major goal for future studies will be to identify which patients are at increased risk and appropriate interventions.

Acknowledgements

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