

Fatal injuries in rural and urban areas in northern Finland: a 5-year retrospective study

L. Raatiniemi^{1,2,3}, T. Steinvik^{4,*}, J. Liisanantti^{5,6,*}, P. Ohtonen^{6,7}, M. Martikainen¹, S. Alahuhta⁶, T. Dehli⁸, T. Wisborg^{3,4,9} and H. K. Bakke^{4,10}

¹Centre for Pre-Hospital Emergency Care, Oulu University Hospital, Oulu, Finland

²Department of Anesthesia and Intensive Care, Lapland Central Hospital, Rovaniemi, Finland

³Department of Anesthesiology and Intensive Care, Hammerfest Hospital, Finnmark Health Trust, Hammerfest, Norway

⁴Anesthesia and Critical Care Research Group, University of Tromsø, Tromsø, Norway

⁵Division of Intensive Care Medicine, Oulu University Hospital, Oulu, Finland

⁶Medical Research Center, University of Oulu and Oulu University Hospital, Oulu, Finland

⁷Division of Operative Care, Oulu University Hospital, Oulu, Finland

⁸Department of Gastroenterological Surgery, University Hospital North Norway, Tromsø, Norway

⁹Norwegian National Advisory Unit on Trauma, Oslo University Hospital, Oslo, Norway

¹⁰Mo i Rana Hospital, Helgeland Hospital Trust, Mo i Rana, Norway

Correspondence

L. Raatiniemi, Centre for Pre-Hospital Emergency Care, PL 20, 90029 OYS Oulu, Finland
E-mail: lasse.raatiniemi@gmail.com

*Equal contribution.

Conflicts of interest

The authors have no conflict of interest.

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Background: Finland has the fourth highest injury mortality rate in the European Union. To better understand the causes of the high injury rate, and prevent these fatal injuries, studies are needed. Therefore, we set out to complete an analysis of the epidemiology of fatal trauma, and any contributory role for alcohol, long suspected to promote fatal injuries. As a study area, we chose the four northernmost counties of Finland; their mix of remote rural areas and urban centres allowed us to correlate mortality rates with 'rurality'.

Methods: The Causes of Death Register was consulted to identify deaths from external causes over a 5-year time period. Data were retrieved from death certificates, autopsy reports and medical records. The municipalities studied were classified as either rural or urban.

Results: Of 2915 deaths categorized as occurring from external causes during our study period, 1959 were eligible for inclusion in our study. The annual crude mortality rate was 54 per 100,000 inhabitants; this rate was higher in rural vs. urban municipalities (65 vs. 45 per 100,000 inhabitants/year). Additionally, a greater number of pre-hospital deaths from accidental high-energy trauma occurred in rural areas (78 vs. 69%). 42% of all pre-hospital deaths occurred under the influence of alcohol.

Conclusion: The crude mortality rate for fatal injuries was high overall as compared to other studies, and elevated in rural areas, where pre-hospital deaths were more common. Almost half of pre-hospital deaths occurred under the influence of alcohol.

Editorial comment: what this article tells us

In this retrospective study, the authors analysed almost 2000 trauma deaths over a 5-year period in a well-defined region. They found that 63% died prehospitally and that the incidence of fatal injuries was higher in rural areas.

Accidents and intentional injuries are the leading cause of death for young people worldwide.^{1,2} In addition to years of life-lost, 9% of all hospital admissions resulted from injuries within the European Union; a region where post-trauma disabilities are major public health burdens for member states.^{1,2}

The association between higher mortality caused by injuries,^{3,4} and remote rural areas, can be attributed to multiple factors. These include; the spectrum of injuries that occur, delayed accident reporting, and lengthier response and transportation times for emergency medical services (EMS).^{5,6} A depressed socioeconomic status, compounded with elevated risk behaviours, may also contribute to rural mortality rates.^{7,8} In particular, alcohol use has been shown to increase the risk of injury and death,⁹ although the precise contributory factors are poorly defined.

Despite Finland's comparatively high injury mortality rate (the fourth highest in the European Union¹), there are relatively little data for trauma mortality, and pre-hospital trauma deaths, in rural vs. urban areas. Internationally, rural areas have been shown to have a higher mortality rate, with a different pattern of injury demographics. However, data to show conclusively whether or not this pattern is repeated in Finland, and especially in its more remote areas, are lacking. To make up for this shortfall, and to improve trauma care, injury prevention and emergency medical service planning, we sought to investigate the distribution, and characteristics, of fatal injuries across a rural-urban context.

We aimed to study the incidence of fatal injuries, and the proportion of pre-hospital deaths that occurs in northern Finland (primary outcome measures). To provide a geographic context, we addressed the urban-rural distribution of trauma mortality, together with the proportion of pre-hospital deaths that occurs while under the influence of alcohol (secondary outcome measures).

Methods**Study design and cohort**

The study was a cohort study based on data from the Finnish Cause of Death Registry.

Data were collated for all deaths between 1 January 2007, and 31 December 2011, for which an external cause of injury (V00-Y89),¹⁰ was recorded (as per the tenth revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10)). These data were obtained from the Finnish Causes of Death Register (FCDR), provided by Statistics Finland. FCDR data are held for the resident Finnish population; data for foreigners, and non-residents, were not available. In Finland, the full medico-legal procedures are engaged when a death is unexpected, or when it's cause could have been the result of a crime, accident, suicide, poisoning, occupational disease or medical treatment.¹¹ All fatalities that occurred within the study area were included (Fig. 1), except for poisonings, deaths resulting from medical intervention, and deaths in excess of 90 days post-injury (ICD-10 X44-49, X69, X85, Y40-46, Y70-89).

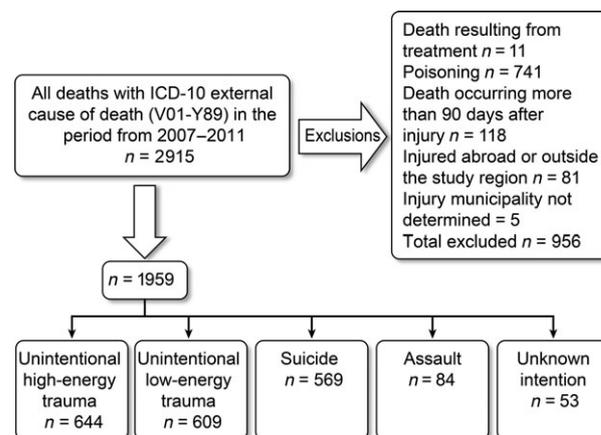


Fig. 1. Flow chart of the inclusion and exclusion criteria.

Study area

Our study area included Lapland, Kainuu, and the Northern and Central Ostrobothnia counties. Collectively, these regions comprised 728,847 inhabitants, living in a geographic area spanning 154,688 km²; 56% of this population were defined as urban, with 44% living in rural municipalities (Fig. 2). The university hospital in Oulu is the area's central trauma centre, which has 70 to 100 trauma team activations annually. Four central hospitals are equipped with trauma teams and specialist emergency surgical care facilities. Emergency Medical Services (EMS) comprises first responders, basic, and advanced level ambulances. During the study period, one anaesthesiologist-manned, and one paramedic-manned, helicopter serviced the study area. Inter-hospital transfers of trauma patients were mainly carried out by road; direct transit to a trauma centre was recommended for patients with multiple injuries, whenever possible.

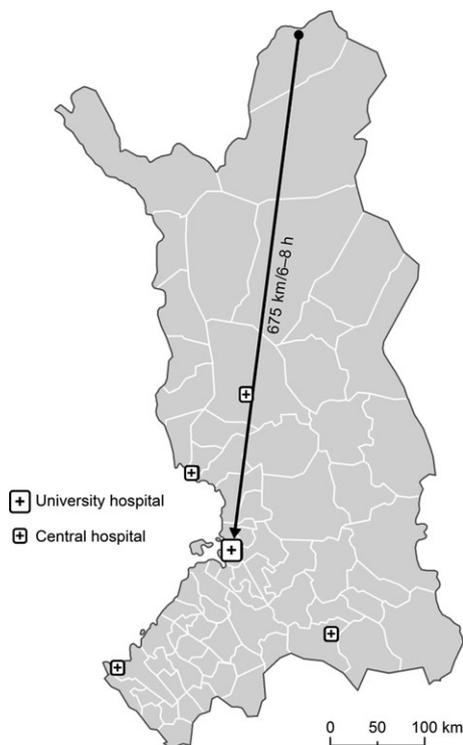


Fig. 2. Study area. Distance in kilometres (km), and estimated driving time in hours, from the most remote rural municipality to the trauma centre.

Variables studied

Intention, date of death, injury mechanism and dominating injury data were obtained from the death certificates. Data for time elapsed from injury to death, and the municipality where the injury occurred, were collated from death certificates and if needed, from forensic medical reports, ambulance charts, and other medical records or Database of Road and Off-road Accidents, investigated by Finnish road accident investigation teams (Finnish Motor Insurers' Centre, Traffic Safety Committee of Insurance Companies). The lead researcher (LR), estimated the time period between injury and death, in cases where these data were missing. The place of death (home, institution, pre-hospital, during primary admission or later) was retrieved from death certificates. Data regarding the influence of alcohol were obtained from the FCDR.

Geographic definitions

Previous studies have defined rural areas, or the degree to which an area is deemed to be rural (i.e. rurality), according to a number of different criteria. However, given that the 'urban to rural' transition represents a continuum, it is not surprising that there is no consensus among researchers as to how to assign individual regions.^{4,12} We chose to use the municipality classification as categorized by Statistics Finland, as this was the most locally relevant reference.¹³ This classification defines a municipality as urban if at least 90% of its population lives in urban settlements, with the largest settlement comprising at least 15,000 inhabitants. A semi-urban designation was reserved for municipalities with at least 60% of their population settled in urban areas, with the largest settlement comprising at least 4000 individuals. To be classed as rural two criteria could be met. Either, a maximum of 60% of the population was settled in urban areas, the largest being less than 15,000 inhabitants, or, at least 60% lived in urban settlements, with the largest urban settlement less than 4000 inhabitants. In this study, rural and semi-urban municipalities were grouped together.

Data relating to the proportion of pre-hospital deaths, the place of injury, the time elapsed

between injury and death, and injury mechanisms, were collated for the municipality in which the injury occurred. Deaths resulting from unintentional injuries were categorized as high- or low-energy (HE and LE respectively). LE trauma included falls from a height equivalent to, or less than the person's recorded height;¹⁴ all other trauma deaths were regarded as HE. Where the height of a fall was not provided, the definition of LE or HE was assigned according to details provided in the death certificate. For example, a fall on stairs was classified as HE trauma. While these definitions are similar to those used in the literature,^{15,16} we also classified deaths from drowning, and burning, as HE trauma (ICD-10 W16, W68-69, W71, V90.0, V90.3, V90.8, V90.9, X71, X00-09). Deaths resulting from carbon monoxide intoxication, or other toxic fume inhalation due to fire, were classified as 'fire', and not as poisoning (ICD-10 X46-47). The victim was classified as 'under the influence of alcohol' if the cause-of-death registry had recorded a diagnosis of acute alcohol intoxication (ICD-10 F10.0, X45); toxicological screenings are routinely obtained during an autopsy. Only pre-hospital deaths were included in our data set to assess the influence of alcohol, as these variables are unreliably recorded for those hospitalized.

Statistics and analysis

Statistical analyses were carried out using SPSS for Windows (IBM SPSS Statistics for Windows, Version 22.0, Armonk, NY, USA). The Kruskal–Wallis test was used to compare continuous data. Data were expressed as medians, with an interquartile range (IQR). The crude mortality rates are expressed per 100,000 inhabitants, within the 95% confidence interval (95% CI). The crude mortality rate per 100,000 inhabitants per year, was calculated for each type of municipality (rural or urban), based on the victims' municipality of residence. The year 2010 was used as the index year for population size and municipality structure. When calculating the annual crude mortality rate per 100,000 inhabitants, the mean number of deaths within the 5-year period in each municipality type was used. The study period of 5 years was chosen to avoid

bias resulting from changes in trauma care, while capturing sufficient events to enable comparison of the rural, and urban groups and sub-groups.

Ethics

The study was approved by: Statistics Finland (TK53-1151-13); our Regional Ethics Committee (98/2013); all five hospital districts in northern Finland; the National Institute for Health and Welfare (THL/3/5.05.00/2014); Finnish Motor Insurers' Centre, Traffic Safety Committee of Insurance Companies; the Regional Administrative Agency for Northern Finland (PSAVI/2791/03.02.01/2014), and the Provincial Archives of Oulu.

Results

A total of 2915 deaths with an ICD-10 of external causation (V00–Y89) occurred during the study period. Of these, 1959 patients met the inclusion criteria for our study (Fig. 1). A total of 33% (644/1959) of deaths resulted from HE trauma, 31% (609/1959) from LE trauma, 29% (569/1959) from suicide, 4% (84/1959) from assault and a further 3% with intention unknown 53/1959. All injury types are illustrated in Fig. 3.

An autopsy was performed in 90% (1759/1959) of all deaths, and for 100% of the pre-hospital deaths. Data were missing for the geographic location where the fatal injuries occurred, or for the time period from injury to death, in 7% of death certificates (144/1959). For these cases, medical records, forensic medical reports or data from road traffic accident investigations were consulted.

Incidence of fatal injuries

The crude incidence of fatal injuries was 54 (95% CI 51–56) deaths per 100,000/year (Table 1). Males comprised 73% (1430/1959) of all fatalities. The median age was 58 years (IQR 43–79), reducing to 47 (30–59) for suicides, and 43 (28–55) in the 'death by assault' category. The highest median age of 82 years (69–88) was recorded for LE trauma.

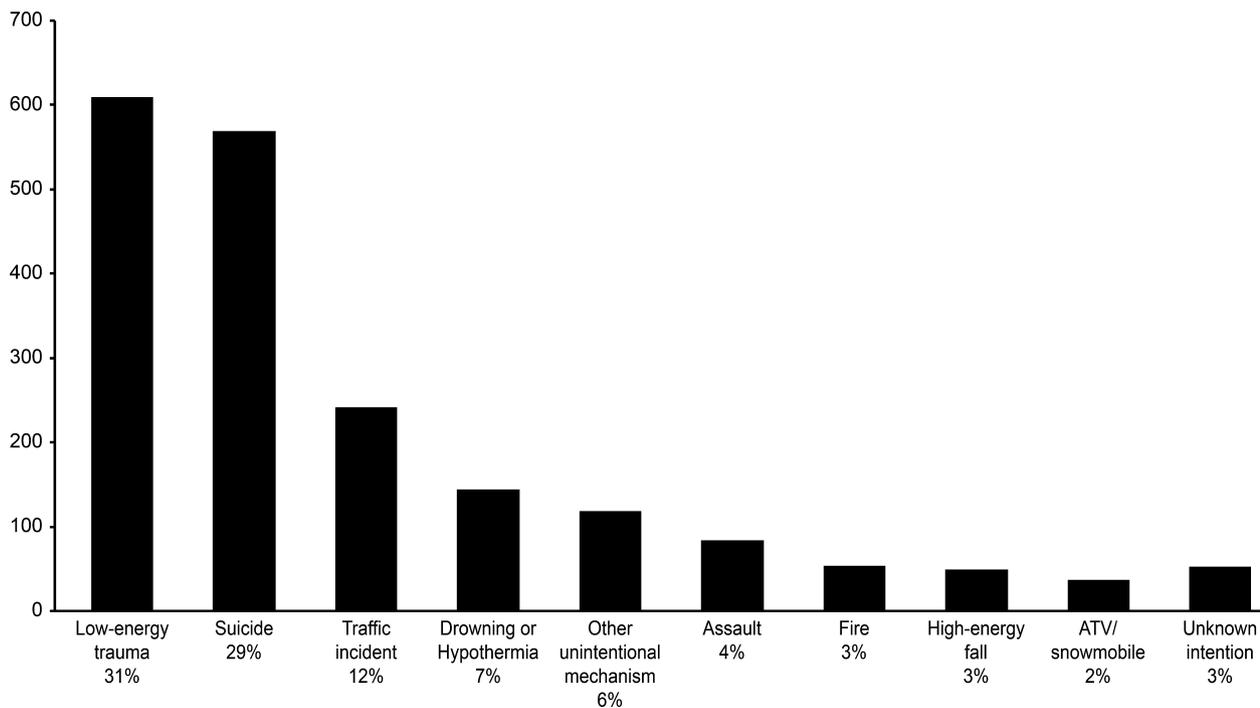


Fig. 3. Mechanism of injury. Total number and percentages of fatal external trauma cases for each category. ATV, all-terrain vehicle

Table 1 Crude mortality rate per 100,000 inhabitants per year, with 95% confidence intervals.

Trauma categories	Study area	Rural	Urban
All deaths	53.8 (51.4–56.2)	65.2 (56.6–74.7)	44.9 (42.0–47.9)
Unintentional high-energy trauma	17.7 (16.3–19.1)	22.8 (17.7–28.5)	13.7 (12.2–15.4)
Unintentional low-energy trauma	16.7 (15.4–18.1)	21.2 (16.3–26.8)	13.3 (11.7–15.0)
Suicides	15.6 (14.4–17.0)	16.9 (12.6–22.0)	14.6 (13.0–16.4)
Assaults	2.3 (1.8–2.9)	2.6 (1.1–5.0)	2.1 (1.5–2.8)
Unknown intention	1.5 (1.1–1.9)	1.8 (0.6–3.9)	1.2 (0.7–1.7)

Proportion of pre-hospital deaths

The majority (63%, 1241/1959) of deaths occurred pre-hospital, with just over half (53% (1046/1959) within the first hour of injury. In LE trauma, 53% (323/609) of the deaths occurred later than one week after injury. Estimates for time elapsed from injury to death

could not be estimated in 4% (72/1959) of cases.

For HE trauma, 74% (479/644) of deaths occurred pre-hospital. 1% (7/644) of deaths occurred in transit (to the hospital), and 3% (21/644) in the emergency room. Most LE deaths occurred during hospital admission (33%, 200/609), or after discharge (51%, 309/609). Death occurred in a pre-hospital setting in 95% (542/569) of suicides and 90% (76/84) of assaults.

Rural and urban differences

The annual crude incidence of fatal injuries per 100,000 was higher in rural areas (Table 1); fatal injuries in these areas were 1.5-fold higher than in urban areas. Even when unintentional and intentional deaths were segregated, rural municipalities still maintained a higher crude mortality rate. A higher crude mortality rate for unintentional fatalities, taking into account all injury mechanisms, was also apparent in rural areas. The frequency of autopsy was slightly lower in rural areas, at 88% vs. 92% for the urban municipalities. The median age was lowest in urban municipalities (compared to rural)

for all fatalities (58 vs. 61 years), and for suicides (42 vs. 51). For unintentional trauma and assaults, the median age did not differ between rural and urban municipalities. Pre-hospital deaths resulting from HE trauma were more common in rural than urban municipalities (78% vs. 69%). There were no significant differences in the rates of LE trauma, suicide or assault between urban and rural municipalities.

Of all the fatalities together, 47% (923/1959) occurred in the population residing in urban areas. However, only 45% of the fatal injuries occurred in urban areas. In the fatalities resulting from road traffic incidents, 46% (79/173) occurred in inhabitants of the urban areas but only 38% (66/173) the injuries were sustained in urban areas.

The influence of alcohol in pre-hospital deaths

Forty-two per cent (515/1241) of pre-hospital deaths occurred under the influence of alcohol, with no difference between the urban and rural groups. The influence of alcohol was documented in 41% (198/479) of HE traumas, 48% (48/100) of LE traumas, 37% (200/542) of suicides and 50% (38/76) of assaults.

Place of fatal injury

Fatal injuries in HE traumas commonly occurred on roads (34%, 221/644), and in residential areas (33%, 214/644). Fatal LE traumas were most common in residential areas 52% (314/609), or hospitals and nursing homes 37% (225/609). Suicides and assaults occurred most often in residential areas at 68% (388/569), and 74% (62/84) respectively.

Discussion

The main finding in this study was the 1.5-fold greater crude mortality rate from fatal injuries found in rural municipalities compared to urban, with 63% of these deaths occurring outside of the hospital. Another major finding was the implication of alcohol use in nearly half of all pre-hospital deaths.

Ours is not the first report to document higher injury mortality rates in rural areas.^{3-5,12,17} For

example, one study documented a mortality rate that was almost doubled for a rural vs. urban Norwegian working-age population;¹² a result broadly consistent with ours. As a whole, sparsely populated northern Finland has been shown to have a higher mortality rate than densely populated, southern Finland (72/100,000/year vs. 39/100,000/year).¹⁸

The overall incidence of pre-hospital deaths was higher in our study than previously reported by Søreide et al., in which 52% of trauma deaths occurred outside of the hospital in an urban population.¹⁹ An Australian study of rural areas also reported that the risk of pre-hospital death was twofold greater in rural vs. urban areas.¹⁷ In the present study, the proportion of pre-hospital deaths from unintentional HE trauma was markedly higher in rural areas, exceeding that found by Evans et al. when studying a mixed urban-rural population (66% vs. 74% in our study).¹⁶ However, their different inclusion criteria, and definitions of trauma, prevents a direct comparison of the data sets. Our findings are, however, comparable to several other studies performed in rural areas.^{3,12}

The circumstances that lead to fatal trauma differ markedly between rural and urban areas. For example, more severe traffic incidents are reported in rural areas,²⁰ with additional dangers from higher risk occupations, such as agricultural activity,⁵ or risky behaviours. In rural areas, traffic incidents are more often high speed accidents, which may explain the higher incidence of fatal injuries. Also, the use of a safety belt and the age of the vehicle are other important factors suggested for a higher rural incidence.²⁰ Despite this, traffic accidents alone cannot explain the overall difference between the urban and rural incidence of fatal injury in our study. Remote rural areas of northern Finland provide plenty of opportunity for snowmobile and all-terrain vehicle accidents that can be exacerbated by failure to wear protective gear. Additionally, a lower socioeconomic status in rural areas may impact the mortality rate.⁷

Not surprisingly, rural areas generally have poorer access to trauma care than urban areas,^{5,6} with longer EMS transit times generally, which can be lengthened further by delayed discovery or reporting of an accident. It has been suggested that 3.6% of road traffic fatalities could be pre-

vented with an eCall system. However, that finding, applied to our data set, would have impacted less than 1% of all fatalities.²¹ Trauma mortality has been reported to increase in proportion with the length of EMS response time^{17,22–24} and duration of hospitalization,²⁵ although the data are controversial.²⁶ Ultimately, the impact of transport time on mortality may be marginal, and model-dependent.²⁷ This study cannot determine the underlying causes for the higher injury incidence in the rural areas. Several of the aforementioned causes, or a combination, could be at play, and is an area of interest for future studies. We found that a share of urban residents fell victim to injury in rural areas and thus contributed to the higher incidence of trauma death in rural areas. This share was not sufficient to explain the entire difference.

Agreeing with previous data, suicides accounted for a significant share of overall trauma deaths (29%), with a high pre-hospital death rate (> 90%), with no difference between the rural or urban setting.^{3,12} For suicides in particular, the role played by emergency services is diminished as most of these intentional injuries are designed to lead to immediate death, or death shortly thereafter. A major impact could therefore be achieved by any programs aimed at suicide prevention.²⁸

In 42% of the pre-hospital deaths in this study, the influence of alcohol was recorded in patient records. The association between trauma mortality and alcohol has been frequently made.^{29,30} A striking example is the increased number of fatal, alcohol-related, traumatic brain injuries caused by falls, since the cutback of alcohol tax in 2004.³¹ Clearly, the argument that reducing alcohol consumption would help to prevent injury-related deaths, is a compelling one.

A strong point of this study is the high number of autopsies performed, which increases the robustness of our data, and conclusions drawn. These data should be valuable for future studies regarding the prevention of death in certain patient subgroups. Specifically, correlates could be derived for whether fatal injuries could have been prevented by first aid providers, faster access to EMS, specific interventions on hospitalization, or more appropriately targeted pre-hospital therapy. The majority of patients in our study died within the first hour of their injury,

which may be the result of non-survivable injuries. The study was not designed to demonstrate whether any deaths could have been prevented by faster access to EMS. However, the proportion of deaths judged to have been preventable has varied from 7 to 15% in different studies, indicating how early recognition of severely injured patients, and appropriate therapeutic interventions are important components in pre-hospital trauma care.^{32,33}

Our data showed that deaths from LE trauma comprised a substantial proportion of the total trauma deaths in this study, with patients tending to be older, and more susceptible to death during hospitalization. These data agree with other reports showing the susceptibility of this patient group to comorbidities and medical complications.¹⁵ However, in our study, a larger proportion of these deaths occurred pre-hospital.^{15,16} This finding may be due to different definitions of LE trauma, or the influence of alcohol in 48% of these trauma deaths. Moreover, the use of alcohol may delay injury detection and/or treatment compliance.

Limitations

The present retrospective study has some limitations. This study is restricted to fatal cases, as we did not have data on non-fatal injuries. It is therefore not possible to draw any conclusions as to prognosis after injuries. We did not complete Injury Severity Scoring (ISS),³⁴ and, in some cases, we had incomplete data for the place where the injury occurred, or chronology of events, that is, time of injury, time of death. Where possible, missing information was collected from forensic or medical records by a single investigator (L.R.), to minimize error. We should also acknowledge that considerable geographic and demographic heterogeneity exists within our definitions of rural vs. urban areas, as does socioeconomic status, and the variable quality in EMS provision. That said, the population density of a municipality correlated well with injury mortality.^{12,27}

This is the first study to describe fatal injuries and pre-hospital deaths in the context of rural and urban areas within northern Finland. We feel that the high autopsy rate supports the reliability of our data, together with our practice of

categorizing the municipality where each death occurred, rather than the place of residence.

Conclusions

We found a high crude mortality rate and number of pre-hospital deaths due to injury, which increased in rural areas. While the influence of alcohol was prevalent in fatal injuries, it was not a contributor to the increased rural mortality rate. Strikingly, suicides accounted for one third of all deaths in this study.

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