Injury, Int. J. Care Injured 45 (2014) 23–30

Contents lists available at SciVerse ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Epidemiology of trauma: A population-based study of geographical risk factors for injury deaths in the working-age population of Norway

Thomas Kristiansen [a,b,c,*], Hans Morten Lossius [a,d], Marius Rehn [a,d,e], Petter Kristensen [f,g], Hans Magne Gravseth [f], Jo Røislien [a,h], Kjetil Søreide [i,j]

[a] Department of Research and Development, The Norwegian Air Ambulance Foundation, PO Box 94, N-1441 Drøbak, Norway
[b] University of Oslo, Faculty Division Oslo University Hospital, Kirkeveien 166, N-0450 Oslo, Norway
[c] Diakonhjemmet Hospital, Department of Anaesthesiology, PO Box 23 Vinderen, N-0319 Oslo, Norway
[d] Field of Prehospital Critical Care, Network of Medical Sciences, University of Stavanger, Kjell Arholmsgate 41, N-4036 Stavanger, Norway
[e] Akershus University Hospital, Sykehusveien 25, N-1474 Nordbyhagen, Norway
[f] National Institute of Occupational Health, PO Box 8149 Dep., N-0033 Oslo, Norway
[g] Institute of Health and Society, University of Oslo, PO Box 1130 Blindern, N-0318 Oslo, Norway
[h] Department of Biostatistics, University of Oslo, PO Box 1122 Blindern, N-0318 Oslo, Norway
[i] Stavanger University Hospital, Department of Surgery, PO Box 8199, N-4068 Stavanger, Norway
[j] University of Stavanger, Institute of Health and Medicine, Rennebergstien 30, N-4021 Stavanger, Norway

ARTICLE INFO

Article history:
Accepted 6 July 2013

Keywords:
Trauma
Injury
Population-based
Epidemiology
Rural health
Norway

ABSTRACT

Introduction: Trauma is a major global cause of morbidity and mortality. Population-based studies identifying high-risk populations and regions may facilitate primary prevention and the development of optimal trauma systems. This study describes the epidemiology of adult trauma deaths in Norway and identifies high-risk areas by assessing different geographical measures of rurality.

Methods: All trauma-related deaths in Norway from 1998 to 2007 among individuals aged 16–66 years were identified by accessing national registries. Mortality data were analysed by linkage to population and geographical data at municipal, county and national levels. Three measures of rurality (centrality, population density and settlement density) were compared based on their association with trauma mortality rates.

Results: The study included 8466 deaths, of which 78% were males. The national annual trauma mortality rate was 28.7 per 100,000. Population density was the best predictor of high-risk areas, and there was a consistent inverse relationship between mortality rates and population density. The most rural areas had 52% higher trauma mortality rates compared to the most urban areas. This difference was largely due to deaths following transport-related injury. Seventy-eight per cent of all deaths occurred in the prehospital phase. Rural areas and death following self-harm had higher proportion of prehospital deaths.

Conclusion: Rural areas, as defined by population density, are at a higher risk of deaths following traumatic injuries and have higher proportions of prehospital deaths and deaths following transport-related injuries. The heterogeneous characteristics of trauma populations with respect to geography and mode of injury should be recognised in the planning of preventive strategies and in the organisation of trauma care.

Introduction

Trauma is a leading global cause of death and disability [1]. Traumatic injuries largely affect young people, which increases the societal burden of trauma [2]. Primary prevention has reduced mortality from trauma through the identification of effective protective measures and the reduction in the incidence of traumatic events [3]. The organisation of trauma systems [4,5] has become a major secondary preventive effort to reduce the impact of traumatic injuries in many regions [6–11].

Population-based studies report higher trauma mortality rates in rural compared with urban areas [12–15], with a majority of deaths occurring in the prehospital phase [16–19]. Despite this, the majority of trauma research has focused on hospital management

* Corresponding author at: Norwegian Air Ambulance Foundation, PO Box 94, 1441 Drøbak, Norway. Tel.: +47 64 90 44 44; fax: +47 64 90 44 45.
E-mail addresses: thomas.kristiansen@norskluftambulanse.no, thomas.kristiansen@snla.no (T. Kristiansen).

0020–1383/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.injury.2013.07.007

within urban trauma systems. The benefit for rural areas of the centralisation of trauma management is debated [18,20–22], and studies indicate that rural populations are less likely to reach centralised services [16,23].

Although a national trauma system has yet to be implemented in Norway, there is a tendency to centralise trauma care [24,25], increasing the distances to definite care for rural areas. Optimal initial stabilisation by the emergency medical service (EMS) and local hospitals and efficient interhospital transfers are suggested resources for rural trauma care [16,26,27]. Targeted primary prevention and optimisation of trauma systems necessitate an increased understanding of etiological, demographical and geographical risk factors [3,28,29]. To identify high-risk areas, validated measures of rurality are needed. Several operational definitions of rurality exist in trauma research. A Norwegian study identified large urban-rural differences in paediatric trauma mortality using both municipal centrality and population density as measures of rurality [30].

There is a scarcity of population-based trauma research, and epidemiological studies based on hospital data may underestimate the true contribution of fatal trauma [19,31]. Differences in mortality rates and proportions of prehospital deaths in different regions should be thoroughly described to ensure that both the EMS and hospital trauma resources are scaled in accordance with the needs of each geographic area, while validated measures for rural trauma may serve as generalisable tools to identify high-risk areas.

The aim of this study is to describe the national epidemiology and urban-rural distribution of fatal trauma. We analyse trauma mortality rates and the proportion of prehospital deaths in rural versus urban areas and explore which geographical measure best identifies the increased risk associated with rural trauma.

The study was approved by the Regional Committee for Medical Research Ethics (Ref. No. 2010/125) and informed consent from was not considered appropriate or necessary due the anonymous nature of the data and the results. The study is in compliance with the Declaration of Helsinki of the World Medical Association [32].

Materials and methods

Data collection and study participants

This study is based on data from the Cause of Death Registry, Statistics Norway [33], which maintains consecutively collected data on all national deaths. Registry data sources include medical death certificates, police reports and autopsy reports. Data quality is ensured by follow-up inquiries on incomplete death certificates and by linkage to other central health registries, Statistics Norway's transport accident registry and the population registry of the Norwegian Tax Administration [34]. Information on deaths from external causes (ICD-10 codes V01 to Y89) in a ten-year period (1998-2007) was extracted. Deaths due to medical or iatrogenic causes (ICD-10 codes: X20 to X29, X40 to X49, X50 to X57, X60 to X69, X85 to X90, Y06, Y10 to Y19, Y40 to Y84, and Y88) were excluded.

A related article on paediatric (0-15 years of age) trauma epidemiology has previously been published [30]. The standard age of retirement in Norway is 67 years. We aimed to study trauma mortality in the adult working-age population and thus included deaths in individuals aged 16–66 years of age.

Index year and setting

The number of municipalities was reduced during the study period, necessitating a reference municipality-structure for database construction and aggregated analysis. The year 2002 was chosen as an index year central to the study period (1998-2007) and served as a fixed year for descriptive purposes. Variables regarding municipal characteristics and populations were thus based on data from 2002.

In 2002, the population of Norway was 4.52 million, 2.95 million of whom were between 16 and 66 years of age. During the study period, there was a 0.62% annual population growth, and the mean total population during the period was 4.54 million (95% confidence interval (CI): 4.48, 4.60). The Statistics Norway's StatBank [35] was used to ensure that the index year was the most representative year, and within the 95% CI of the mean, for the entire study period; this was also ensured for rural and urban populations when they were assessed separately.

Norway was divided into 19 counties and 434 municipalities, and the population density was 14.0 inhabitants per square kilometre (inh/km^2), in the index year. The county population density ranged from 1.5 to 1129.5 inh/km^2 [36].

Norwegian EMS is publically funded and consists of paramedic-manned ground ambulances and nationwide coverage of an anaesthesiologist-manned helicopter ambulance service (HEMS) [25,37]. In 2002, 51 hospitals were receiving trauma patients, and the majority had multidisciplinary trauma teams in their emergency departments (ED) [38,39]; however, there was no formal designation of trauma centres [25].

Variables and definitions

The *mode of injury* was divided into four categories based on ICD-10 codes: transport (V01-V99), falls (W00- W19), self-harm (X70-X84), and assault (X91-Y09).

Data regarding place of death is collected from the death certificate and categorised in the Cause of Death Registry according to type of location. *In-hospital deaths* are defined as deaths that occurred within hospitals or other health care institutions. Deaths that occurred outside hospitals or during transport to a hospital are considered *prehospital deaths.* The database does not contain geographical data locating the site of injury. Using place of death to locate events, introduces bias in cases where deaths occur after or during transport from the site of injury; e.g., overestimating risk for areas surrounding acute care hospitals. Place of residency was therefore used to locate the events of the study.

Three different geographical measures of municipal rurality were extracted from the Norwegian Social Science Data Services (NSD) data base [36]: *centrality, population density, and settlement density*.

Centrality describes the number of inhabitants in towns or other geographically bounded areas within, or in the proximity of, a municipality. The variable is based on the municipality classification standard defined by Statistics Norway for the index year [40]. The variable was aggregated to four levels. The *most rural* category includes municipalities without, or with more than 45 min by road to, areas with more than 5000 inh. The *Rural* municipalities include, or are within 45 min by road to, areas with 5-15,000 inh. *Central* municipalities include, or are within 60 min by road to, areas with 15-50,000 inh, and the *most central* municipalities include, or are within 75 min by road to, areas of more than 50,000 inh and/or towns with a regionalised role for public services.

Population density was defined as the number of inhabitants per square kilometre based on the index year population from the NSD database [36]. The variable was categorised according to quartiles of population density when weighted by the total population as follows: *most rural*: $<$18.2 inh/km^2, *rural*: 18.2–76.9 inh/km^2, *central*: 77.0–442.7 inh/km^2, and *most central*: $>$442.7 inh/km^2. Population density was categorised according to population quartiles to compare groups of equal proportions of the total population.

Settlement density is based on Statistics Norway's municipality classification standard for the index year and describes the