Hip fractures in a city in Northern Norway over 15 years: time trends, seasonal variation and mortality

The Harstad Injury Prevention Study

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Abstract
Summary In this open population-based study from Northern Norway, there was no increase in hip fracture incidence in women and men from 1994 to 2008. Age-adjusted hip fracture rates was lower compared to reported rates from the Norwegian capital Oslo, indicating regional differences within the country.

Introduction The aim of the present population-based study was to describe age- and sex-specific incidence of hip fractures in a Northern Norwegian city, compare rates with the Norwegian capital Oslo, describe time trends in hip fracture incidence, place of injury, seasonal variation and compare mortality after hip fracture between women and men.

Methods Data on hip fractures from 1994 to 2008 in women and men aged 50 years and above were obtained from the Harstad Injury Registry.

Results There were altogether 603 hip fractures in Harstad between 1994 and 2008. The annual incidence rose exponentially from 5.8 to 349.2 per 10,000 in men, and from 8.7 to 582.2 per 10,000 in women from the age group 50–54 to 90+ years. The age-adjusted incidence rates were 101.0 and 37.4 in women and men, respectively, compared to 118.0 in women (p=0.005) and 44.0 in men (p=0.09) in Oslo.

The age-adjusted incidence rates did not increase between 1994–1996 and 2006–2008. The majority of hip fractures occurred indoors and seasonal variation was significant in fractures occurring outdoors only. After adjusting for age at hip fracture, mortality after fracture was higher in men than in women 3, 6 and 12 months (p≤0.002) after fracture.

Conclusions There are regional differences in hip fracture incidence that cannot be explained by a north–south gradient in Norway. Preventive strategies must be targeted to indoor areas throughout the year and to outdoor areas in winter.

Keywords Fracture registry · Hip fractures · Medical records · Validation

Introduction

Hip fractures in the aged constitute a major health problem with substantial morbidity [1], mortality [2, 3], and, as the ageing population increases, an increasing burden on the health care system [4]. Fracture risk varies markedly between countries [5]. In a study by Kanis et al. [6], comparing 10-year probability of hip fracture, all countries except Norway had lower risk than Sweden. Other countries categorized at very high risk (>75% of the risk of Sweden) were Iceland, Denmark and the US. At the age of 80, the estimated probability of sustaining a hip fracture the next 10 years is 8.6% and 17.7% in Norwegian men and women, respectively [7], and a report from the Norwegian capital Oslo calculated an overall annual fracture rate of 118.0 in women and 44.0 in men per 10,000 [8].

Several recent studies are reporting declining fracture incidence [9–14]. Although the Norwegian hip fracture rates remain the highest reported in the world, data from Oslo in 1996–1997 indicated no increasing incidence rates compared to the 1988–1989 [8]. Within Norway, considerable geographic differences have been reported, with
substantially lower rates in smaller cities and rural areas compared to Oslo [7, 15]. However, these are reports based on sporadic studies in few regions and in limited time periods [16, 17].

From 1985 to 2003, the Norwegian Institute of Public Health commissioned four Norwegian hospitals, representing 10% of the population, to run a national injury registry [18]. The registry collected a variety of data connected to the actual injury itself and the event leading to the injury. In the city of Harstad in Northern Norway, the registration continued and has been running for more than 23 years. Throughout the years of the National Injury Registry, the injury rates in Harstad closely resembled the rates of the national registry [18]. With reference to the recent reports suggesting stabilizing hip fracture incidence internationally as well as nationally, and regional differences within Norway, we have used the hip fracture data in the Harstad Injury Registry to:

1. Describe age- and sex-specific incidence of hip fractures in Harstad, Northern Norway and make comparison with rates from the Norwegian capital Oslo
2. Describe time trends in hip fracture incidence in Harstad from 1994 to 2008
3. Describe place of injury and seasonal variations in hip fracture incidence in Harstad
4. Compare 3-month, 6-month, and 1-year mortality after hip fracture between women and men in Harstad

Materials and method

The municipality of Harstad, located 250 km north of the Arctic Circle, comprises with its 23,257 inhabitants (January 1, 2010), 0.5% of the Norwegian population. All injured persons, including hip fracture patients, entering the hospital emergency room are recorded in the Harstad Injury Registry. The local hospital, which is the only hospital in the area, has an X-ray department and access to orthopedic surgery, and all patients with hip fractures are treated locally with a minimal leakage to other hospitals. From 1985 to 1993, the registration of hip fractures was used for evaluation of an injury prevention program [18, 19]. Data from the period between 1985 and 1988 provided baseline information for a 5-year intensive community-based intervention program running between 1989 and 1993, which included removal of environmental hazards in homes, promotion of safe footwear used outdoors and reduction of slippery surfaces in traffic areas during winter. The results indicated a significant reduction of hip fracture rates related to falls indoors and in traffic areas in winter in men [18]. After 1993, the intervention program continued as an integrated part of the community health service and the present study encompasses the years from 1994 to 2008, after termination of the prevention study.

Registration of hip fractures

On admission in the hospital, the patient or someone accompanying him/her and the admitting doctor complete an injury registration form providing information concerning name, date of birth, sex, place of residence, activity during injury, time, place and type of injury as well as injury mechanism and body part injured. An open-ended question describes in free text the event leading to the injury. The admitting doctor registers the patient’s diagnosis to the injury registration form, usually based on the present clinical symptoms. The forms are collected and examined by a specially trained nurse who also assures that all incidents are registered by comparing with the admission list. She then enters the data into a common database. Hip fracture data from the Harstad Injury Registry are retrieved by a search combining body part and diagnosis.

Validation of the fracture registration

From the municipality of Harstad, altogether 639 hip fractures were recorded in the Harstad Injury Registry in persons aged 50 years and above during the 15 years from 1994 to 2008. In 2009, the medical records on every hip fracture event in the registry were retrieved for examination of X-ray description, operation and discharge report, the date and side of hip fracture. Patients with repeated entries, sequel from a previous fracture (e.g. caput necrosis, infection, failure of fixation materials), contusion of the hip without verified fracture, femur shaft or pelvic fractures and pathological fractures due to cancer metastasis were excluded from the analyses. Patients living outside the municipality were also excluded from the analyses. The validation procedures excluded 51 (8%) of 639 registered fractures. Searching the patient administrative system for the period between 2002 and 2008 identified additional 15 fractures, which are included in the incidence analyses (research questions 1 and 2) and the mortality analyses (research question 4), altogether 603 hip fractures in analyses. A complete dataset with 588 hip fractures and information concerning the fracture event was available for description of place of injury and seasonal variation (research question 3).

Statistical analyses

Age at fracture in women and men were compared using independent sample t-test. For each sex, we tested for time trends in age at fracture using linear regression.

Average incidence rates per 10,000 person years were calculated for each sex in 5-year age groups for the time
period 1994–2008. The age- and sex-specific fracture rates were compared with the corresponding rates reported from Oslo in 1996–1997 [8], where hip fracture data was collected for the whole population through patient administrative data of the hospitals of the city [8]. For each sex, an age-adjusted rate was calculated for two 3-year time periods: 1994–1996 and 2006–2008, using the age distribution in Oslo in January 1, 1997 as reference [8]. Assuming a Poisson distribution of the number of hip fractures, 95% confidence limits for the rates were calculated and the difference between incidence rates was tested. Dividing the data in (age) groups, we performed several tests simultaneously and should adjust for simultaneous testing. We have chosen to use the false discovery rate (FDR) which controls the expected proportion of incorrectly rejected null hypotheses (type I errors) and is less conservative and has a higher power than the more traditionally used Bonferroni correction [20].

Potential time trends in incidence rates over the study period were analyzed using linear regression. Place of injury for each sex was compared using Chi-square testing. Seasonal variation in the number of hip fractures was analyzed by Cosinor analyses with month of the year as analytical units. A Cosinor analysis is essentially a regression where the independent variable represents a sine and a cosine transform of a time factor: $y_t = a_0 + a_1 \cos \frac{2\pi t}{T} + a_2 \sin \frac{2\pi t}{T}$, where $t$ is the time step (month) and $T$ the total time period (12 months).

To test for significance of seasonality, we tested whether the model was statistically significant.

Mortality was analyzed by survival analysis using Cox’s proportional hazard rate including censoring. The follow-up time for one person was from the day the fracture occurred to death or the censoring date in January 1, 2009. The analyses were performed using the Statistical Package for Social Sciences version 15.0 (SPSS, Chicago, IL, USA), Microsoft Office Excel version 2007 and the statistical program R, version 2.11.0 (The R Foundation for Statistical Computing).

**Results**

Fracture incidence and time trends

Of the 603 fractures, 73% (95% CI: 69.5, 76.5) occurred in women providing a female: male ratio of 2.7. The mean age at fracture in this population (aged 50 years and above) was 80.0 years (95% CI: 79.1, 80.9) in women and 76.7 years (95% CI: 75.1, 78.3) in men ($p<0.001$). The median age at hip fracture was 81.7 and 79.3 years in women and men, respectively. Age at fracture did not change during the 15 years, neither in women ($p=0.43$) nor in men ($p=0.26$). The incidence of hip fractures rose exponentially with increasing age from 5.8 to 349.2 per 10,000 in men, and from 8.7 to 582.2 per 10,000 in women (Table 1 and

| Age groups (years) | Number of hip fractures | Person years in total | Incidence per 10,000 (SD) | 95% CI       |
|--------------------|-------------------------|-----------------------|---------------------------|-------------|
| **Men**            |                         |                       |                           |             |
| 50–54              | 7                       | 12,060                | 5.8 (2.2)                 | 1.5, 10.1   |
| 55–59              | 6                       | 10,095                | 5.9 (2.4)                 | 1.2, 10.7   |
| 60–64              | 6                       | 7,740                 | 7.8 (3.2)                 | 1.5, 14.0   |
| 65–69              | 20                      | 6,360                 | 31.4 (7.0)                | 17.7, 45.2  |
| 70–74              | 20                      | 5,595                 | 35.7 (8.0)                | 20.1, 51.4  |
| 75–79              | 27                      | 4,545                 | 59.4 (11.4)               | 37.0, 81.8  |
| 80–84              | 37                      | 2,970                 | 124.6 (20.5)              | 84.4, 164.7 |
| 85–89              | 28                      | 1,050                 | 266.7 (50.4)              | 167.9, 365.4|
| 90+                | 11                      | 315                   | 349.2 (105.3)             | 142.8, 555.6|
| **Women**          |                         |                       |                           |             |
| 50–54              | 10                      | 11,520                | 8.7 (2.7)                 | 3.3, 14.1   |
| 55–59              | 13                      | 9,810                 | 13.3 (3.7)                | 6.0, 20.5   |
| 60–64              | 11                      | 7,980                 | 13.8 (4.2)                | 5.6, 21.9   |
| 65–69              | 22                      | 6,990                 | 31.5 (6.7)                | 18.3, 44.6  |
| 70–74              | 41                      | 6,750                 | 60.7 (9.5)                | 42.2, 79.3  |
| 75–79              | 74                      | 6,075                 | 121.8 (14.2)              | 94.1, 149.6 |
| 80–84              | 127                     | 4,620                 | 274.9 (24.4)              | 227.1, 322.7|
| 85–89              | 81                      | 2,460                 | 329.3 (36.6)              | 257.6, 401.0|
| 90+                | 62                      | 1,065                 | 582.2 (73.9)              | 437.2, 727.1|
Fig. 1). The incidence rates differed significantly between the two sexes only in the age groups 75–79 ($p=0.01$) and 80–84 ($p=0.005$).

Table 2 displays the incidence rates in Harstad compared with reported rates from four studies from other parts of Norway. Compared to Oslo, the age-specific rates in Harstad were lower than those reported from Oslo in 1996–1997 (Fig. 1, Table 2). The crude incidence rate was 77.0 in women and 31.9 in men per 10,000 in Harstad. Using the age distribution of the Oslo population 01.01.1997 as the reference, the age adjusted incidence rates in Harstad were 101.0 and 37.4 per 10,000 in women and men, respectively, compared to 118.0 per 10,000 in women ($p=0.005$) and 44.0 per 10,000 in men ($p=0.09$) in Oslo [8]. Using the same reference, the age adjusted incidence rates in Harstad were 150.0 and 71.0 per 10,000 in women and men above the age of 65 years, respectively. The corresponding figures for Oslo were 192.0 per 10,000 in women ($p<0.001$) and 85.5 per 10,000 in men ($p=0.07$) [8].

Fig. 2 displays the age-adjusted incidence of hip fractures in women and men in Harstad during 1994–2008 for three different age groups. There were indications of an increase in the incidence in men aged 65–79, but adjusting for multiple testing, the trend was no longer significant. The age-adjusted incidence rates for women were 97.3 and 105.2 per 10,000 in 1994–1996 and 2006–2008, respectively ($p=0.55$). The corresponding incidence rates for men were 32.5 and 46.3 per 10,000, respectively ($p=0.12$).

**Discussion**

The main finding from this study with 15 years of population-based data is that the age-adjusted hip fracture incidence rates of women above 50 years are significantly lower in Harstad, Northern Norway, than in Oslo. The incidence rates in Harstad are comparable to the rates reported from two other cities, a city in the central [17] and south eastern parts of Norway [16], in women, but higher than the rates in the more rural area in mid-Norway [15] (Table 2). Our results confirm that there is a great variation in hip fracture rates between different regions in Norway [7], as there is for distal forearm fractures [21]. Furthermore, the age-adjusted rates from Harstad are lower than both winter and summer rates in Oslo [8] and also lower than earlier reported rates from Copenhagen and Gothenburg, but they are higher than reported rates from the US [5].

International variations in hip fracture risk have displayed a north–south gradient [6] which has been linked to the importance of sunlight exposure [22]. A study using national data from France showed substantial heterogeneity of hip fracture risk within the country, with higher hip fracture risk in the Southern France [23]. Other studies reporting regional differences in hip fracture rates within
countries explain the differences by an urban–rural gradient [24]. In a study from Australia, the age-adjusted incidence of hip fracture was 32% lower in rural compared to urban residents aged 60 years and above, 26% lower in women [25]. In comparison, the age-adjusted rates in women aged 65 years and above were 21% lower in Harstad than in the more urbanized capitol Oslo [8]. Unfortunately, with the registry data available, we do not have explanation for the indicated urban–rural difference, but another Norwegian study reported higher bone mineral density levels in rural versus urban dwellers at the hip [26], one factor which may explain differences in fracture risk. In a study by Ringsberg et al. [27], urban subjects had significantly poorer balance compared with their rural counterparts, a difference which increased with increasing age, affected gait performance and risk of falls. With an extensive prevention program running in Harstad between 1988 and 1993 [18, 19] and part of this program still integrated in the community health service, this may also explain the differences in fracture rates between Harstad and Oslo.

It could furthermore be expected that the extensive prevention program might have resulted in lower fracture rates especially in the first years after 1994. However, comparison of the two periods, 1994–1996 and 2006–2008, indicated no significant change in the age-adjusted incidence rates in any of the sexes during the time of the study. Interestingly, this stability of age-adjusted incidence rates is

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Table 2  Age- and sex-specific annual hip fracture incidence per 10,000 in different regions in Norway

| Age groups (years) | Harstad, Northern Norway (Emaus 2010) | Oslo, Norway (Lofthus 2001) | South Eastern Norway (Bjørgul 2007) | Mid-Norway (Grønskag 2009) |
|--------------------|---------------------------------------|-------------------------------|--------------------------------------|---------------------------|
| Men                |                                       |                               |                                      |                           |
| 50–54              | 5.8 (1.5, 10.1)                       | 3.9 (0.8, 7.0)                | 4.2 (1.8, 6.5)                      |                           |
| 55–59              | 5.9 (1.2, 10.7)                       | 8.0 (2.5, 13.5)               | 3.0 (1.8, 6.5)                      |                           |
| 60–64              | 7.8 (1.5, 14.0)                       | 13.7 (5.6, 21.7)              | 12.5 (7.3, 17.8)                   |                           |
| 65–69              | 31.4 (17.7, 45.2)                     | 25.0 (14.3, 35.7)             | 15.7 (9.6, 21.9)                   |                           |
| 70–74              | 35.7 (20.1, 51.4)                     | 54.6 (38.7, 70.6)             | 38.9 (29.0, 48.8)                  |                           |
| 75–79              | 59.4 (37.0, 81.8)                     | 78.5 (57.2, 99.9)             | 79.1 (63.7, 94.4)                  |                           |
| 80–84              | 124.6 (84.4, 164.7)                   | 166.4 (126.3, 206.6)          | 141.1 (114.3, 167.9)               |                           |
| 85–89              | 266.7 (167.9, 365.4)                  | 246.8 (173.1, 320.6)          | 265.2 (210.2, 320.1)               |                           |
| 90+                | 349.2 (142.8, 555.6)                  | 429.8 (264.6, 594.9)          | 325.7 (218.0, 433.3)               |                           |
| Women              |                                       |                               |                                      |                           |
| 50–54              | 8.7 (3.3, 14.1)                       | 5.3 (1.6, 9.0)                | 3.9 (1.6, 6.2)                     |                           |
| 55–59              | 13.3 (6.0, 20.5)                      | 11.4 (5.0, 17.9)              | 9.9 (5.9, 13.9)                    |                           |
| 60–64              | 13.8 (5.6, 21.9)                      | 16.1 (7.9, 24.2)              | 13.7 (8.4, 18.9)                   |                           |
| 65–69              | 31.5 (18.3, 44.6)                     | 40.5 (28.2, 52.7)             | 32.2 (23.9, 40.6)                  | 21.1 (11.6, 38.1)        |
| 70–74              | 60.7 (42.2, 79.3)                     | 77.1 (61.2, 92.9)             | 68.5 (56.6, 80.4)                  | 53.3 (43.0, 66.0)        |
| 75–79              | 121.8 (94.1, 149.6)                   | 142.5 (120.9, 164.1)          | 137.3 (120.3, 154.4)               | 95.1 (81.6, 110.7)       |
| 80–84              | 274.9 (227.1, 322.7)                  | 282.6 (247.9, 317.4)          | 236.6 (211.5, 261.6)               | 170.2 (149.0, 194.4)     |
| 85–89              | 329.3 (257.6, 401.0)                  | 475.5 (417.8, 533.2)          | 366.8 (326.2, 407.5)               | 307.4 (267.1, 358.9)     |
| 90+                | 582.2 (437.2, 727.1)                  | 618.0 (523.7, 712.3)          | 396.3 (331.3, 461.3)               | 496.7 (412.4, 598.2)     |

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Table 3  Place of injury where hip fractures are occurring, in Harstad, Northern Norway

| Place of injury     | Percent (N)    | Age, years (SD) |
|---------------------|----------------|-----------------|
| At home indoors     | 38% (225)      | 80.4 (8.8)      |
| At home outdoors    | 9% (54)        | 75.8 (10.2)     |
| Transport area outdoors | 17.5% (103) | 72.8 (11.1)     |
| Nursing home        | 24% (140)      | 84.2 (6.4)      |
| Hospital            | 1.5% (9)       | 81.7 (4.0)      |
| Not reported        | 10% (57)       | 75.7 (11.0)     |

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Fig. 2  Incidence of hip fractures in three different age groups in women and men in Harstad, Northern Norway, from 1994 to 2008, adjusted using the age distribution of the Oslo population in January 1, 1997 as the reference.
in accordance with data from Oslo [8] and reports from several other countries including Finland, Denmark, Norway, Switzerland, Canada, US and Australia [10, 12–15, 28]. There are studies reporting increasing numbers of hip fracture rates in women and men in Germany and Austria [29, 30], in men in Switzerland [28], in the oldest age groups in Swedish [31] and Swiss [32] women. Conflicting results are also reported within countries where, for example, a recent paper from the Australian Capital Territory reported significant declining hip fracture rates after 2001 in women [13], while other data from Australia indicate no change in incidence [33]. The Australian report suggests that the declining hip fracture rates may be explained by increased use of anti-osteoporotic treatments [13]. In the Danish study reporting declining hip fracture rates from 1997 to 2006, it is noted that the decrease is too large to be explained by the extent of anti-osteoporotic medication and therefore must be explained by other factors [11].

As reported from several other studies, both within Norway [17] and from other countries like UK [34] and the US [35], there was a significant seasonal variation in the occurrence of hip fractures in our study. In a study comparing and observing seasonal variation of hip fractures in Scotland, Hong Kong and New Zealand [36] as well as in Taiwan [37], it was claimed evidence against a major influence of conditions underfoot causing extra falls and increased risk of fracture during winter [36]. In our study, we had information about place of injury in 90% of all cases; 64% occurred indoors with no significant seasonal variation. For the fractures happening outdoors, there was a significant seasonal variation, which can be connected to falls on ice or slippery surfaces. Unfortunately, the data from the Harstad Injury Registry do not provide enough information for exact studies of the mechanisms leading to falls and fracture indoors.

The mean age at hip fracture in persons above 50 years in Harstad, were not different from the mean age at hip fracture in Oslo, which was 82.1 years in women and 76.6 years in men [8]. A lower mean age at fracture in men, compared to women, are also reported by others [26]. With 73% of the hip fractures occurring in women, the gender distribution of hip fractures in Harstad did not differ in comparison with Oslo (78%) or other comparable studies [12, 14]. Increased mortality risk up to 10 years has been reported for hip fractures [38], although mortality is highest in the first year [3, 38]. A sex difference in mortality after hip fracture has also been indicated, with higher rates in men compared with women [2, 3, 38, 39]. In our study, mortality was higher in men than in women 3 months after fracture and persisted at 6 and 12 months after adjustment for age of hip fracture. This is in accordance with other Norwegian data showing higher mortality in men throughout the first year after hip fracture [40], and with a recent meta-analyses showing that, although the sex difference in mortality persists, the difference is greatest in the first 3 months after hip fracture, with reported relative all-cause mortality hazard of 5.75 (95% CI, 4.94–6.67) in women and 7.95 (CI, 6.13–10.30) in men [41].

One of the strengths of this study is the possibility to study the incidence of hip fractures in a well-defined municipality over a long time period and the accessibility of a well-established injury registry, which also provides the opportunity for quality assessment of the hip fracture registration. Furthermore, the injury registry provided valuable information on date and place of fracture and through the medical records we got access to mortality data. There are, however, several limitations in our dataset. Given the location of Harstad, north of the Arctic Circle, it would have been interesting to study the impact of vitamin D status on fracture risk and on the seasonal variation [42], but neither biological data nor lifestyle information was available. Because of the lack of data we cannot explore if time trends and urban–rural differences can be explained by other important factors like smoking [43] and body mass index [44].

In conclusion, the present study supports previous reports concerning significant regional differences in hip fracture incidence within Norway, which cannot be explained by a north–south gradient. A majority of hip fractures happen indoors, suggesting the need of developing effective prevention strategies towards falls and fractures at home in the elderly. Although fewer hip fractures happen outdoors, they are mostly due to falls on slippery surfaces indicating that securing outdoor areas during winter must be included in prevention of hip fractures in the elderly.

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Conflicts of interest None.
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