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LOCOMOTOR DISEASES

Hip fractures in Norway 1999–2008: time trends in total incidence and second hip fracture rates. A NOREPOS study

Tone K. Omsland · Kristin Holvik · Haakon E. Meyer · Jacqueline R. Center · Nina Emaus · Grethe S. Tell · Berit Schei · Aage Tverdal · Clara G. Gjesdal · Guri Grimnes · Siri Forsmo · John A. Eisman · Anne Johanne Søgaard

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Abstract Declining incidences of hip fractures are reported from western countries. Norway has among the highest rates in the world. The aim of this study was to investigate trends in total hip fracture rates in Norway between 1999 and 2008 and risk of second hip fractures. All hospitalizations given a hip fracture diagnosis code (International Classification of Diseases (ICD) 9 or ICD 10) (cervical, trochanteric or subtrochanteric) in Norwegian hospitals were retrieved with accompanying surgical procedure codes and additional diagnoses. A total of 93,123 hip fractures were identified between 1999 and 2008 in persons ≥50 years. Annual incidences of hip fractures were calculated and tested for trends. Rates of first and second hip fractures (2006–2008) were compared. The age-standardized total incidence of hip fracture decreased by 13.4 % (95 % confidence interval (CI): 11.0–15.6) in women and 4.8 % (95 % CI: 0.7, 8.7) in men. Age-adjusted rates of second hip fractures did not change in the observation period. In those with a prior hip fracture, the age-standardized risk of a subsequent hip fracture was 2.5-fold (95 % CI: 2.5, 2.6) in women, and 4.6-fold (95 % CI: 4.5, 4.7) in men. Total hip fracture rates declined in both genders during 1999–2008, whereas rates of second hip fractures did not change.

Keywords Hip fracture · Incidence · Osteoporosis · Norway · Women · Men

NOREPOS (The NORwegian EPidemiologic Osteoporosis Studies) is a collaboration between epidemiologic osteoporosis studies, which are sub-studies within large population-based surveys in four districts of Norway (Tromsø, Nord-Trøndelag, Hordaland, Oslo). The NOREPOS Hip fracture Database includes all hospitalizations for hip fracture in Norway.

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T. K. Omsland (✉) · K. Holvik · H. E. Meyer · A. Tverdal · A. J. Søgaard
Division of Epidemiology, Norwegian Institute of Public Health, PO Box 4704 Nydalen, 0403 Oslo, Norway
e-mail: Tone.Kristin.Omsland@fhi.no

T. K. Omsland · K. Holvik · N. Emaus · G. S. Tell
Department of Public Health and Primary Health Care, University of Bergen, Bergen, Norway

H. E. Meyer
Department of Community Medicine, Institute of Health and Society, University of Oslo, Oslo, Norway

J. R. Center · J. A. Eisman
Osteoporosis and Bone Biology Program, Garvan Institute of Medical Research, Sydney, NSW, Australia

N. Emaus
Department of Health and Care Sciences, University of Tromsø, Tromsø, Norway

B. Schei
Department of Obstetrics and Gynecology, Faculty of Medicine, St. Olav's University Hospital, Trondheim, Norway

B. Schei · S. Forsmo
Department of Public Health and General Practice, Faculty of Medicine, Norwegian University of Science and Technology (NTNU), Trondheim, Norway

C. G. Gjesdal
Department of Rheumatology, Haukeland University Hospital, Bergen, Norway

Introduction

The risk of hip fracture varies significantly between countries, with the highest reported rates in the North of Europe and North America, and highest lifetime risk in the Scandinavian countries [1–3].

In a review from 2011 the scientific working group of the International Osteoporosis Foundation described that incidence rates of hip fractures in most western populations increased until the 1980s and have thereafter reached a plateau or decreased [3]. Studies in Europe, Australia, and North America now report declining hip fracture rates [3–10]. The latest overall trends in Norway, with some of the highest hip fracture rates in the world [11–14], have, however, not been described.

A number of studies report that sustaining an osteoporotic fracture increases the risk of a subsequent fracture [15]. The risk of subsequent hip fractures is less studied, but available data suggest at least a doubled risk of a second hip fracture compared to the risk of a first [16–19]. Although many studies report declining hip fracture incidences [4–9], only one study has to our knowledge studied whether the decline also applies to second hip fractures [17].

The aims of this population study in women and men 50 years and more were to

(1) Examine whether total and age-specific hip fracture rates have changed in Norway between 1999 and 2008,
(2) Compare overall rates of first and second hip fractures in both genders,
(3) Investigate whether the incidence rate of second hip fractures has changed over time.

Materials and methods

Data collection

Data on hip fractures treated in Norwegian hospitals from 1 January 1994 to 31 December 2008 were retrieved from computerized discharge diagnoses through a system developed by the Norwegian Knowledge Centre for the Health Services. The unique 11-digit personal identification number assigned to every permanent resident in Norway was used. Information about each inpatient with a hip fracture diagnosis was extracted from the hospitals' patient administration systems (PAS) at 48 hospitals/health trusts treating hip fracture patients in Norway. The discharge diagnoses used to classify a hip fracture were according to the International Classification of Diseases, Ninth Revision (ICD-9): 820–820.9 and Tenth Revision (ICD-10): S72.0–S72.2. Thus, cervical, trochanteric and subtrochanteric hip fractures were obtained. Information on secondary diagnoses, surgical procedures, name of hospital, date of admission and discharge was included for each hospital stay where a hip fracture diagnosis code had been given. Age at discharge was calculated.

Data pertaining to a total of 168,118 hospitalizations with hip fracture diagnosis (main or secondary) were obtained. A total of 931 hospitalizations (0.55 %) were excluded due to missing date of admission (n = 10) or invalid/missing personal identification number (n = 921) mainly due to hip fracture in non-Norwegian residents.

Definition of fractures and quality assurance

We identified 139,913 new hip fractures in 126,026 subjects between 1994 and 2008. A thorough quality assurance was performed to exclude hospital stays that represented transfers between hospitals and readmissions. Additional diagnosis codes and surgical procedure codes were used to classify each record as either *incident* hip fracture or *not incident* hip fracture.

The *incident* hip fractures (1) had surgical procedure codes characteristic for a primary hip fracture surgery (including surgical procedure code indicating hemiarthroplasty occurring without any accompanying reoperation codes) (89 %), or (2) were the individual's first or only admission but without surgical procedure codes (5 %), or (3) hospitalizations with information suggesting an *incident* hip fracture but with additional codes for rehabilitation or complications (6 %).

A patient's second hospitalization with a hip fracture diagnosis code was defined as a second hip fracture if the fracture occurred more than 3 weeks after the first and fulfilled criteria as an *incident* hip fracture (see description above). A total of 13,887 subjects thus had two hip fractures. We excluded 27,274 hospitalizations representing hip fractures that were *not incident* (records with surgical procedure codes and/or diagnosis codes suggesting reoperation or typical diagnosis codes for rehospitalization (rehabilitation or complications) or admissions occurring less than 3 weeks apart). A more detailed description of the

C. G. Gjesdal
Section of Rheumatology, Institute of Medicine, University of Bergen, Bergen, Norway

G. Grimnes
Division of Internal Medicine, University Hospital of North Norway, Tromsø, Norway

G. Grimnes
Tromsø Endocrine Research Group, Department of Clinical Medicine, University of Tromsø, Tromsø, Norway

quality assurance, the classification and validation of the NOREPOS Hip Fracture Database (NORHip), is published online (Online Resource 1).

Additional data sources

Background population demographics on 1 January 1994–2009 were obtained online from Statistics Norway [20]. Mid-year population was calculated as the mean of the population on 1 January at two subsequent years. Dates of death and emigration were obtained from the National Population Register.

Validation

The data on hip fractures were further validated at an individual level in Oslo and Tromsø, where careful hip fracture registrations already had been done in connection to local health studies [21, 22]. The combined Cohen's kappa for comparison of the NORHip fractures with local fracture registries was 0.95.

Statistical methods

Total number of fractures and time trends

Age-, gender- and year specific *total* incidence rates were calculated by defining the mid-year population of Norway aged ≥50 years as the population at risk. Mean age at fracture for the study population was calculated for all hip fractures combined, and linear regression analysis was used to test whether mean age at fracture changed over the 10 years.

The main analyses were performed on the complete dataset for the period 1999–2008, due to incomplete data from four hospitals prior to 1999. Sub-analyses of trends in hip fracture rates during the whole period (1994–2008) were also done excluding these four hospitals.

Age-standardization was done by the direct method using the mean age distribution 1999–2008 in women and men in Norway in 5-year age-groups as standard population. Age-adjusted linear regression was used to test whether the total number of fractures changed over time, whereas age-adjusted Poisson regression analyses were employed to test for time trends in total hip fracture rates and the trends in sub groups of age. The age stratified analyzes of time trends were adjusted for age in 1-year age groups.

First and second hip fractures

Data from the three final years (2006–2008) were used to calculate overall incidences of first and second hip fractures. These years were chosen because the individuals' fracture status *before* 1994 was unknown and a proportion of the hip fractures registered from 1994 onwards could be the individuals' second hip fracture.

Person-years for second hip fracture rates were calculated as time from first fracture to the end of study (maximum 3 years), but for comparability with first hip fracture rates (calculated with mid-year populations of Norway), subjects who died were assigned half a year in the year they died. An age-standardized incidence rate ratio (IRR) of second hip fractures was calculated, using those who had sustained a first hip fracture (2006–2008) as standard population (in 5-year age groups).

Finally, rates of second hip fractures occurring *within* 1 *year* were calculated to study trends over time (1999–2007), and person-years were calculated as sum of days from the first hip fracture to exit at 1 year or censoring (second hip fracture, death, or emigration). Time trends in risk of second hip fractures within 1 year were tested in Poisson regression analysis adjusted for age. In an alternative analysis, the mid-year population of Norway ≥50 years was defined as the population at risk.

PASW Statistics 17 and STATA 12 were used to analyze the data.

Ethics

The study and the linkages of data were approved by the Regional Committee for Medical and Health Research Ethics and the Norwegian Data Inspectorate, the Directorate of Health, and Statistics Norway.

Results

Time trends

During 1999–2008, a total of 93,123 hip fractures occurred in subjects aged ≥50 years, and a total of 71 % of the hip fracture patients were women.

In women, the age-standardized total hip fracture incidence per 10,000 person-years was 91 in 1999 and 80 in 2008, whereas the corresponding figures in men were 41 and 38 (Table 1). Age-adjusted IRR (per 10 years in regression analyses) was 0.87 (95 % confidence interval (CI): 0.84, 0.89) in women, and 0.95 (95 % CI: 0.91, 0.99) in men. In other words, the overall 10-year decrease was 13.4 % in women and 4.8 % in men. The results were unaltered if we included only hospital admissions with accompanying surgical procedure codes (data not shown).

Despite the decline in age-standardized incidence, the absolute number of hip fractures in women did not change

Table 1 Total annual number of hip fractures by year with crude and standardized rates per 10,000 for women and men aged 50 years and more

	Number of fractures[a]	Population[b]	Crude[c] rate	Standardized[d] rate	95 % CI	
Women						
1999	6,752	739,638	91	91	89	93
2000	6,599	747,521	88	89	86	91
2001	6,786	755,060	90	90	88	92
2002	6,680	761,613	88	87	85	90
2003	6,774	769,694	88	88	86	90
2004	6,790	779,128	87	87	85	89
2005	6,599	789,171	84	84	82	86
2006	6,658	799,555	83	83	81	85
2007	6,764	810,503	83	84	82	86
2008	6,521	821,206	79	80	78	81
Men						
1999	2,561	626,707	41	41	39	42
2000	2,465	637,261	39	39	37	40
2001	2,595	647,577	40	40	38	42
2002	2,492	657,223	38	38	36	39
2003	2,596	668,232	39	39	38	41
2004	2,604	680,070	38	39	37	40
2005	2,587	692,451	37	38	36	39
2006	2,774	705,926	39	39	38	41
2007	2,752	720,209	38	38	37	39
2008	2,775	734,266	38	38	36	39

The NOREPOS Hip Fracture Database 1999–2008

CI confidence interval, *NOREPOS* NORwegian EPidemiologic Osteoporosis Studies

[a] Total number of fractures in subjects ≥50 years

[b] Calculated mid-year population aged ≥50 years

[c] Crude hip fracture rates per 10,000 person-years

[d] Age-standardized rates per 10,000 person-years. Standard population was mean age distribution 1999–2008 in 5-year age-groups

significantly ($P = 0.329$), whereas in men the absolute total number increased by an average of 31 fractures per year ($P = 0.002$) (Fig. 1). This was explained by the mid-year population aged ≥50 years increasing by 11 % in women, and by 17 % in men in this 10-year period.

Due to incomplete data the true incidence rates between 1994 and 1999 are unknown. In a sub-analysis excluding hospitals with incomplete data during these first years (105,337 hip fractures in analysis), the total decline during 1994–2008 was 17.9 % (95 % CI: 15.9, 19.9) in women, whereas no significant change in the hip fracture rate was found in men ($P = 0.47$). This represents a similar decline during 1994–1998 and 1999–2008 in women, but no decline in men during the early period.

Age-specific time trends in total hip fracture rates

Mean age at fracture (all hip fractures combined) was 81.8 years in women and 78.8 years in men ($P_{gender\ difference} < 0.001$). During 1999–2008, mean age at fracture increased by 0.9 (95 % CI: 0.6, 1.1) years in women, whereas mean age did not change significantly in men.

Age-adjusted hip fracture rates in women declined significantly in all age-groups ≥70 years ($P < 0.05$), but not in those below 70 years during 1999 and 2008 (Fig. 2). Age-adjusted hip fracture rates in men aged 75–79 years ($P < 0.001$) and 80–84 years ($P < 0.001$) declined significantly, whereas the rates in the other age-groups did not change. Total number of hip fractures in 5-year age-groups are presented in Supplementary Table.

Incidences of first and second fracture

In 2006–2008, about 15 % of the total hip fractures in women and 10 % in men constituted a second hip fracture. The crude overall rate of first hip fracture during 2006–2008 was 70 (95 % CI: 69, 71) per 10,000 person-years in women and 35 (95 % CI: 34, 35) in men. In women who had suffered a first hip fracture, the age-standardized IRR of a second hip fracture was 2.5 (95 % CI: 2.5, 2.6), and the corresponding IRR in men was 4.6 (95 % CI: 4.5, 4.7).

The total number of subjects who sustained a new hip fracture within 1 year after the first one did not change over time either in women ($P = 0.94$) or in men ($P = 0.78$). Similarly, the age-adjusted incidences of second fractures within 1 year did not change significantly over the observed time period (Table 2). Alternative calculation of the corresponding rates based on observation time in the mid-year population of Norway ≥50 years, gave similar results (data not shown).

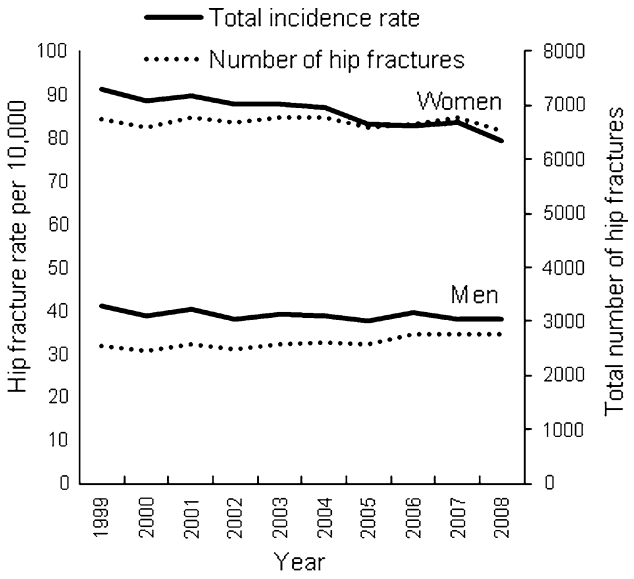

Fig. 1 Annual age standardized total incidence rates per 10,000 person years and total number of hip fractures in Norwegian women and men. Rates are standardized to the mean age distribution in 5-year age-groups. The NOREPOS Hip Fracture Database 1999–2008

Discussion

The present study, including more than 93,000 hip fractures sustained between 1999 and 2008 in Norway, shows a significant decline in total incidence rates of 13.4 % in women and 4.8 % in men. In contrast, the corresponding incidence rates of second hip fractures did not decrease significantly. A hip fracture was associated with a 2.5-fold increased risk of a subsequent hip fracture in women and a 4.6-fold increased risk in men.

Time trends

Studies from many western countries report declining hip fracture rates over the past one or two decades [3–9]. Reported declines have generally been more pronounced in women than in men [3]. Results from our nationwide study are similar to data from Finland where national age-adjusted hip fracture rates for people aged ≥50 years declined by 20 % in women and 6 % in men from 1997 to the end of 2004 [4]. On the other hand, in a Danish nationwide study including subjects 60 years and older, the incidence of hip fractures from 1997 to the end of 2006 decreased by 20 % in both genders [7]. Thus, this represented a substantially larger decline in men than in our study. Similar to our study, the data were person identifiable and included total hip fracture incidences.

A study from Canada of subjects >55 years showed that hip fracture rates from 1985 to 2005 declined by 32 % in women and 25 % in men [5], but this study included all

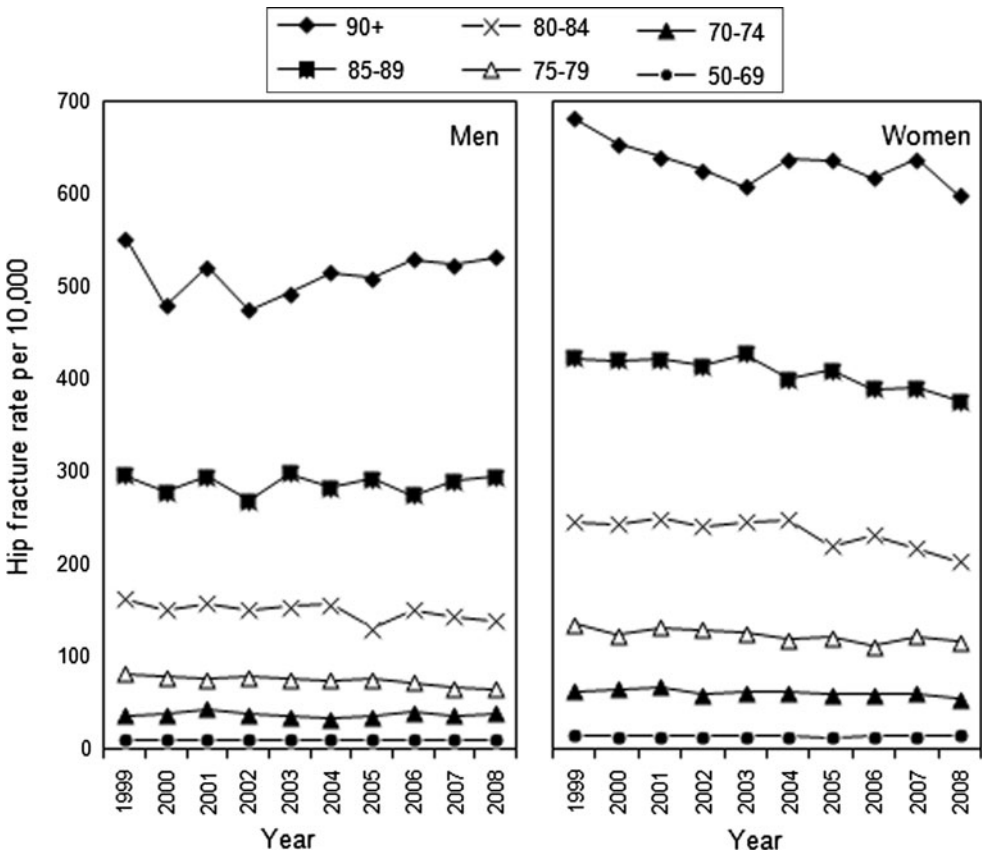

Fig. 2 Annual hip fracture incidence rates per 10,000 person years in women and men in Norway by age-groups. The NOREPOS Hip Fracture Database 1999–2008

Table 2 Annual total numbers and incidences rates per 10,000 of second hip fractures in Norwegian women and men

Year	No. of second hip fractures within 1 year[a]	Total number of person-years[b]	Crude rate[c] of second hip fractures per 10,000
Women			
1999	257	5,050	509
2000	243	4,917	494
2001	255	4,993	511
2002	259	4,866	532
2003	233	4,966	469
2004	255	4,977	512
2005	234	4,716	496
2006	253	4,749	533
2007	264	4,815	548
			$P_{trend} = 0.54$
Men			
1999	88	1,743	505
2000	83	1,671	497
2001	87	1,759	495
2002	67	1,685	398
2003	85	1,747	487
2004	86	1,793	480
2005	98	1,739	563
2006	78	1,858	420
2007	87	1,869	466
			$P_{trend} = 0.63$

The NOREPOS Hip Fracture Database 1999–2008

NOREPOS NORwegian EPidemiologic Osteoporosis Studies

[a] Number of subjects sustaining a second hip fracture within 1 year after the first hip fracture

[b] Person-years were calculated as sum of days from the first hip fracture to exit at 1 year or censoring (second hip fracture, death, or emigration)

[c] Time trends were tested in Poisson regression analyses adjusted for age

hospitalizations with a hip fracture diagnosis code and is not directly comparable to our study as we have excluded rehospitalizations of previous hip fractures (based on ICD-codes and surgery procedure codes). The authors of a US study of subjects aged ≥65 years included hospitalizations for hip fracture (sustained more than 180 days apart) in the Medicare population, and reported that hip fracture rates declined by 25 % in women and 19 % in men from 1995 to 2005 [6]. Another US study from California reported that hip fracture rates declined by 15 % in both women and men between 1997 and 2006 [10]. Between 2002 and 2008 hip fracture hospitalizations in France declined by 8 % in women, whereas the rates in men increased by 4 % [8]. Rates of hospitalizations for hip fracture in the Netherlands between 1994 and 2008 decreased by 0.64 % per year in women and did not change in men [9]. Hip fracture incidences in women and men in Austria increased between 1989 and 2005 and decreased between 2006 and 2008 [23]. Despite differences in data extraction, most figures indicate a similar declining trend in hip fractures as in the present study (1.4 %/year) in women and a smaller decline in men (0.5 %/year).

Men had a lower mean age at fracture compared to women, and this difference is not least due to a higher mortality in men who might not survive long enough to get hip fractures. The total number of hip fractures did not change in women and increased significantly in men. In other words, despite declining incidences, the burden to health care is increasing as a result of an aging population.

Possible explanatory factors for the declining rates

The reasons for the declining hip fracture rates and why rates have declined more in women than in men are not known. One possible explanation is that elderly subjects are becoming healthier with improved functional ability, better strength and balance and fewer falls, perhaps as a result of better nutrition, and more physical activity [3]. During these 10 years, mean life expectancy in subjects ≥50 years in Norway increased by 1.0 year in women and 1.1 years in men [20].

Mean body weight has increased in Norway, as in other Western countries, during the last decades and could have contributed to decreased fracture rates [24, 25]. A longitudinal study from the county of Nord-Trøndelag in Norway showed that body weight increased by approximately 4.5 kg from 1984–1986 to 1995–1997 in both genders [26], and a recent report concluded that mean body mass index in Nord-Trøndelag between 1995–1997 and 2006–2008 increased by 0.7 kg/m^2 in women (from 26.2 to 26.9) and

1 kg/m^2 in men (from 26.5 to 27.5) [27]. In middle aged men this trend started in the 1960s, whereas body mass index in middle aged women decreased until the late 1970s and have increased thereafter [25].

Another explanation for the decrease in hip fracture rates is antiosteoporotic medications (bisphosphonates, hormone therapy) [3, 14, 28, 29]. Abrahamsen et al. [7] however, claim that use of osteoporosis treatment cannot explain the substantial decline in hip fracture rates in Denmark, as the decrease in hip fracture rates was too large to be explained by the extent of osteoporosis medication. The proportion of daily male smokers in Norway (aged 16–74 years) decreased from 52 % in the 1973 to 21 % in 2008. The proportion of daily female smokers was stable at ~30 % until 2000 and decreased to 21 % in 2008 [30]. As smoking is risk factor for fractures [31], the decline in daily smokers may explain some of the decrease in hip fracture rates.

Risk of second hip fracture

In the present study, the age-standardized risk of a second hip fracture was 2.5 times higher in women and 4.6 times higher in men compared to the risk of a first hip fracture. These results are in line with other studies showing at least a 2-fold increased risk of second hip fractures compared to a first hip fracture [16–19]. Cases who have sustained a first hip fracture are more likely be characterized by risk factors that increase fracture risk than the general population (such as low BMD, smoking and physical inactivity) and the increased risk of second fracture compared to the risk of the first hip fracture is probably reflecting this. On the other hand, mortality is also higher in hip fracture patients, and some of the patients that sustained a first hip fracture die before they can sustain a second hip fracture.

The present study also demonstrated no significant decline in incidences of second hip fractures, whereas Melton et al. [17] reported a decline in incidences of second hip fractures between 1997 and 2006 in the population of Olmsted County, Minnesota. Whereas Melton et al. had information regarding whether the hip fracture was "first ever" or not, we used information from a database where fracture status before 1994 was unknown. Although data from 1999 and onwards were used, treating the years 1994 to 1998 as a "wash out period", some misclassification of individuals' first and second hip fractures is possible. Consequently, when calculating incidences of second hip fractures in the NOREPOS database person time might be inclined as caption of misclassified fractures is more likely early in the period. However, calculating rates using person time for the mid-year population of Norway aged ≥50 years, lead to the same conclusions. Further specifically-designed studies to investigate time trends in incidences of second hip fractures are needed.

Strengths and limitations

All hip fractures in Norway are treated in public hospitals, and fractures from all hospitals in Norway treating this patient group could be collected. Patients, who died before reaching the hospital and patients treated in hospitals abroad, unless they came for a control examination when back in Norway, could have been missed. Individual level data enabled studies of subjects with fracture, not merely admissions. Both surgical procedure codes and ICD codes were used to exclude admissions due to rehospitalization for previous fractures.

The good quality of the data was confirmed by merging the NORHip database with local hip fracture registries. However, a limitation is that a maximum of two fractures were counted per person. Persons may sustain more than two hip fractures, but we considered the potential error associated with counting more than two hip fractures per person to be larger than that related to miscoding of rehospitalizations. The statistical power for second hip fracture was less than for first hip fracture due to fewer end points. Moreover, to be able to study time trends in incidence of second hip fracture, analyzes were restricted to hip fractures occurring within 1 year, which is a simplification. Subsequent fracture risk is, however, highest immediately after an initial fracture [32].

Conclusion

These comprehensive national data from Norway suggest declining total hip fracture rates, more in women than in men. This is similar to reports from other western countries. However, although the incidence has decreased, the absolute number of hip fractures is still high in both women and men. As life expectancy is still increasing, the absolute number of older persons at risk of hip fracture is also expected to increase. The incidences of second hip fractures were similar in men and women and were not declining. The problem of osteoporosis is therefore likely to be a large and growing burden to society in the foreseeable future. Despite decreasing fracture rates, finding strategies for prevention and treatment of osteoporosis is still highly relevant. Monitoring time trends in hip fracture rates is important for exploring and understanding new ways of preventing hip fractures. Hence, further studies investigating reasons for the declining rates are warranted to explain the high hip fracture incidence in Norway and to identify possible modifiable factors.

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Conflict of interest The authors declare that they have no conflict of interest.

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