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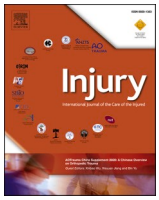

Trends in incidence, health care use and costs for subtrochanteric femur fractures in the Netherlands 2000–2019

Miliaan L. Zeelenberg [a], Esther M.M. Van Lieshout [a,*], Suzanne Polinder [b], Martien J. M. Panneman [c], Michael H.J. Verhofstad [a], Dennis Den Hartog [a]

[a] Trauma Research Unit Department of Surgery, Erasmus MC, University Medical Center Rotterdam, Rotterdam, the Netherlands
[b] Department of Public Health, Erasmus MC, University Medical Center Rotterdam, Rotterdam, the Netherlands
[c] Consumer Safety Institute, Amsterdam, the Netherlands

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ABSTRACT

Objective: This study aimed to provide population based trends in incidence rate, hospital length of stay (HLOS), trauma mechanism, and costs for healthcare and lost productivity of subtrochanteric femur fractures in the Netherlands.

Methods: Data on patients with subtrochanteric femur fractures sustained between January 1, 2000 and December 31, 2019 were extracted from the National Medical Registration of the Dutch Hospital Database. Incidence rates, HLOS, health care and productivity costs were calculated in sex- and age-specific groups.

Results: A total of 14,399 patients sustained a subtrochanteric fracture in the 20-year study period. Incidence rates in the entire population dropped by 15.5 % from 4.5 to 3.8 per 100,000 person years (py). This decline was larger in women (6.4 to 5.2 per 100,000 py, -19.8 %) than in men (2.6 to 2.5 per 100,000 py, -4.0 %). HLOS declined by 62.5 % from a mean of 21.6 days in 2000–2004 to 8.1 days in 2015–2019. Subtrochanteric fractures were associated with total annual costs of €15.5 M, of which 91 % (€14.1 M) were health care costs and €1.3 M were costs due to lost productivity. Mean healthcare costs per case were lower in men (€16,394) than in women (€23,154).

Conclusion: The incidence rates and HLOS of subtrochanteric fractures in the Netherlands have decreased in the 2000–2019 study period and subtrochanteric fractures are associated with a relatively small total annual cost of €15.5 M. Increasing incidence rates and a bimodal age distribution, described in previous studies from other European countries, were not found in the Dutch population.

Introduction

Hip fractures are the most common fracture to cause hospital admission in the Netherlands, with over 20,000 fractures each year [1,2]. Hip fractures are generally classified into three categories: femoral neck, trochanteric, and subtrochanteric fractures [3]. The first two, or typical hip fractures; they are the most common, are mostly seen in the elderly population, and are generally associated with osteoporosis and/or low-energy trauma [4]. Subtrochanteric fractures are located up to 5 cm distal from the lesser trochanter and occur in an area between trabecular and cortical bone where high levels of mechanical stress can occur [5,6]. They make up 3–4 % of annual hip fracture admissions in the Netherlands [7]. Subtrochanteric fractures are considered difficult to manage and associated with a higher risk of (sequelae of) complications, such as secondary (mal)displacement, implant failure, non-unions and reoperations [8,9].

In contrast to femoral neck and trochanteric fractures, subtrochanteric fractures follow a bimodal age distribution [6]. Fractures generally occur in young men due to high-energy trauma or in older patients with osteoporosis, often with an atypical fracture presentation. Recent studies also found positive associations between subtrochanteric fractures and sustained bisphosphonate use or diabetes [10–12]. Reported incidence rates are much lower than those of typical hip fractures. Wang et al. reported a 9.6 % increase (from 31.2 to 34.2 per 100,000 person-years) in the incidence of subtrochanteric fractures in the US between 1996 and 2007 in women [13]. In contrast, typical hip fracture

* Corresponding author at: Trauma Research Unit Department of Surgery, Erasmus MC, University Medical Center Rotterdam, P.O. Box 2040, 3000 CA Rotterdam, the Netherlands.
E-mail address: e.vanlieshout@erasmusmc.nl (E.M.M. Van Lieshout).

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incidence decreased by 32 % (1020.5 to 697.4 per 100,000 person-years) in the same period. Another study found an increase in incidence for combined subtrochanteric and femoral shaft fractures for both sexes, also contrasted by decreasing typical hip fracture incidence [14].

Whether these incidence changes and sex specific differences also hold true for the Dutch population is currently unknown, as no nationwide study on the burden of disease of subtrochanteric fractures in the Dutch population exists. Changes in incidence could provide targets for future research and (inter)national comparisons of disease burden and associated costs. Therefore, the aim of this study was to provide an overview of age and sex trends in incidence, hospital stay, and costs associated with subtrochanteric fractures in the Netherlands between 2000 and 2019.

Methods

Data for this retrospective epidemiological study were collected for patients admitted to hospitals in the Netherlands between January 1, 2000 and December 31, 2019, with a subtrochanteric fracture diagnosis. Methods used were similar as in previous studies [15–19] and data were extracted simultaneously with the data on femoral neck and trochanteric fractures [2]. Injury cases were extracted from the National Medical Registration (LMR) of the Dutch Hospital Database (DHD), Utrecht, The Netherlands. Patients are included in the LMR for their main diagnosis at discharge, defined by the International Classification of Diseases (ICD) 9th and (since 2010) 10th revision. All patients labeled with an ICD-9 code of 820.22 or ICD-10 code of 72.2, including al subdivisions, were classified as patients with a subtrochanteric fracture and were included in this analysis. Injuries include both traumatic and pathological fractures. These figures were then extrapolated to full national coverage for each year by the Dutch Consumer and Safety Institute ('VeiligheidNL').

Outcome measures

Outcome measures included sex- and age-specific incidence rates, hospital length of stay (HLOS), trauma mechanism, and costs for health care and lost productivity. Trauma mechanism was categorized as "fall due to all causes" versus "other". Costs for lost productivity were defined as the costs associated with production loss and replacement due to illness, disability, and premature death. Outcomes were calculated for 5-year age groups for each year of the study. Because of low patient numbers in the age groups below 50 years, the five-year groups were combined into 0–24 and 25–50 years. To calculate annual health care and productivity costs, data were averaged for the 2015–2019 period. For all costs calculations the reference year 2019 was used.

All analyses and calculations of outcomes were conducted as previously described [15–19]. Table 1 summarizes the performed analysis per outcome measure. All data used in figures can be found in Supplementary materials 1.

Table 1
Summary of performed analysis per included outcome measure.

Outcome measure	Summary of performed analysis
Incidence rates	Patient numbers were extracted from the LMR database. Direct standardization (based upon the Dutch mid-year standard population) was used in order to calculate incidence rates stratified for 5-year age groups and sex and reported per 100,000 person years.
Trauma mechanism	Data (patient numbers for subtrochanteric fracture by fall or by other causes) were extracted from the LMR database, stratified for age groups and sex. Fall included both domestic accidents (fall from person-height or fall from stairs) and non-domestic accidents such as fall from a bicycle or fall from height. The percentage of each trauma mechanism was calculated stratified for 10-year age groups and sex
HLOS	Data (HLOS per case and total HLOS) were extracted from the LMR database, stratified for 5-year age groups and sex
Health care costs	Data on patient numbers and healthcare use were extracted from the LMR database, stratified for age groups and sex. The Dutch Burden of Injury Model was used to assess the health care costs of injury (17, 19, 20). Patients were followed up to two years after trauma. Health care costs of injuries were calculated by multiplication of the incidence, health care volumes, and unit costs (as stated in national guidelines for healthcare costing (21)). Medical costs included ambulance care, in-hospital care, general practitioner (G.P.) care, home care, physical therapy, social support care, and rehabilitation/nursing home care. To calculate annual health care costs, data were averaged for the 2015–2019 period.
Productivity costs	Data on the number of patients unable to work after their fracture and the duration of their work absence were extracted by Dutch Consumer and Safety Institute for all patients aged 15–65 years. Costs were calculated using the Dutch Burden of Injury Model [18,20,21]. The friction cost method was used as health care needs are most substantial in the first year after injury [22]. To calculate annual costs for lost productivity, data were averaged for the 2015–2019 period.

Results

Incidence rates

A total of 14,399 patients were admitted with a subtrochanteric fracture in the 20-year study period. The annual number of admissions showed a slightly decreasing trend and a minor decline from 715 to 658 (−8.0 %) over the two decade period, with more fractures in women than in men. (Fig. 1A). The incidence rate also declines over time and dropped, by 15.5 % from 4.5 (in 2000) to 3.8 (in 2019) per 100,000 py (Fig. 1B). This decline was larger in women (6.4 to 5.2 per 100,000 py, −19.8 %) than in men (2.6 to 2.5 per 100,000 py, −4.0 %).

Fig. 1C shows the age-specific incidence rates for the four consecutive 5-year time periods. Incidence increases with age across all four time periods, with a steep rise seen in patients of 75 years and older. In the most recent period (2015–2019), the highest incidence rates were 62.4 per 100,000 py in men aged >90 years and 101.2 per 100,000 py in women aged >90 years. Incidence rates (2015–2019) were higher for women in all age-segments, except for the 0–24 (0.39 versus 0.29 per 100,000 py) and 25–50 years age groups, where incidence rates in men were over three times higher than in women (0.83 versus 0.26 per 100,000 py).

Similar to incidence rates, age-specific incidence rates have also declined over time from 2000 to 2019, from 27.4 to 15.9 per 100,000 py, in patients aged >65 years (−41.9 %) and from 0.7 to 0.4 per 100,000 py in patients <50 years (−40.6 %). All other age segments also showed declining incidence over time (Table 2). This effect was more pronounced in women than in men.

Trauma mechanism

The percentage of patients sustaining a subtrochanteric fracture due to a fall from any height increased with age (Fig. 2A). In the most recent time period (2015–2019), 57.1 % of patients under 25 years were admitted with a subtrochanteric fracture due to a fall. In patients over 65 years this proportion was 95 %. Fig. 2A shows high variation between the four time periods but the numbers of admissions due to fall generally increase with age. Patients up to 55 years show a decreasing trend for both men and women in the most recent time period, whereas the trends for older age groups (over 55 years) have remained relatively stable over time.

Hospital length of stay

HLOS in patients across all ages has declined by 62.5 % from a mean of 21.6 days in 2000–2004 to 8.1 days in 2015–2019 (Fig. 2B). This declining trend has decreased in size in the more recent time periods and

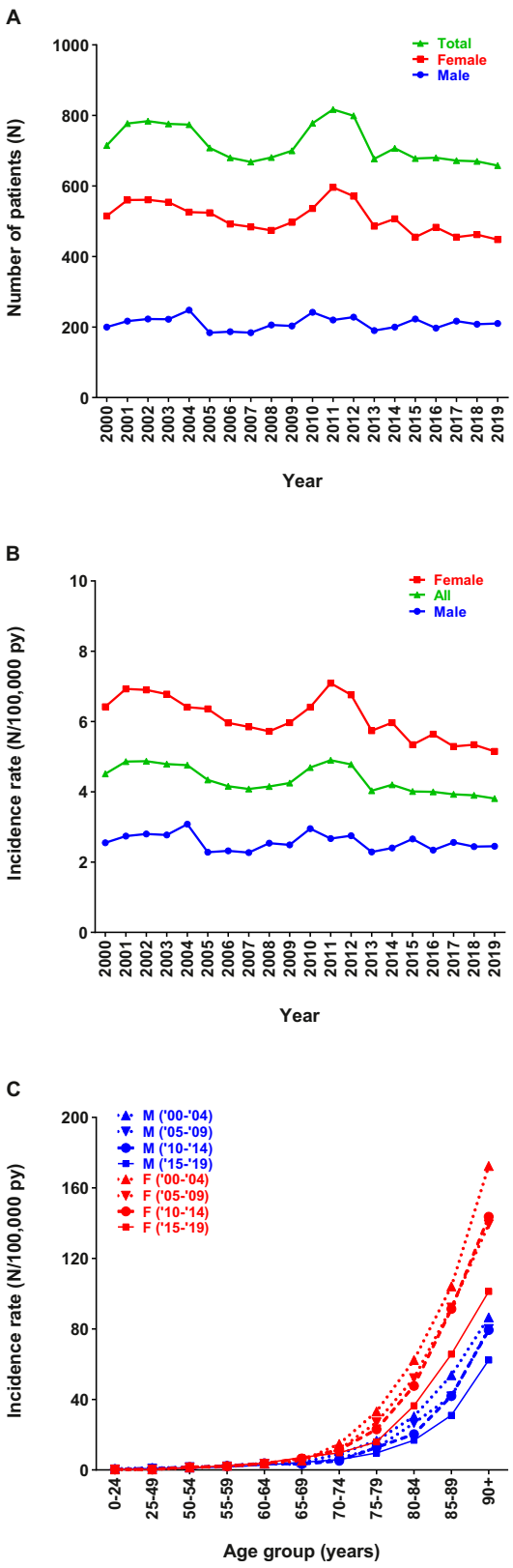

Fig. 1. Number of patients (A), incidence rates per 100,000 person-years (B), and age-related incidence rates per 100,000 person-years (C) of subtrochanteric fractures in the Netherlands in the 2000–2019 study period
Data are shown separately for males (blue), females (red) and all patients (green). For Figure C, data are averaged over 5-year periods (i.e., 2000–2004, 2005–2009, 2010–2014, and 2015–2019) and are shown for 0–24 years, 25–50 years, and subsequently in 5-year age groups up to and including 90+.

moves towards a plateau. HLOS increases with age from a mean of 5.4 days at 0–24 years to a mean of 8.7 days in patients over 90 years (2015–2019). This age-related trend has decreased substantially when compared to the 2000–2004 period (9.1 at 0–24 years versus 26.8 at 90+ years). Men (7.9 days) and women (8.1 days) shows similar mean HLOS in the most recent period (2015–2019) (Table 3). Mean HLOS in patients under 50 years (5.77 days) is substantially lower than in patients over 50 years (8.2 days). Annual cumulative HLOS in the same period reached a total of 5410 days, of which 30.6 % (1658 days) was attributed to men and 69.4 % (3752 days) to women. Cumulative HLOS has decreased by 67 % from an annual 16,496 days in 2000–2005 to 5410 days in 2015–2019.

Health care costs and lost productivity

Between 2015–2019 subtrochanteric fractures were associated with total annual costs of €15.5 M, of which €14.1 M were health care costs and €1.3 M were costs due to lost productivity (Table 4). Of the total health care costs, 75.5 % (€10.7 M) was spent on women and 24.5 % (€3.5 M) on men. The largest health care cost drivers for both sexes were rehabilitation or nursing care (€7113 per case for men versus €12,699 for women), hospital care (€5974 per case for men and €6313 for women), home care (€1906 per case for men and €2611 for women), and physical therapy (€560 per case for men and €634 for women). The majority (91.6 %) of health care costs were made in patients aged >65 years (Table 4). Mean costs per case were lower in men (€16,394) than in women (€23,154). Health care costs increased with age from a mean of €7512 in patients under 50 years to mean of €25,539 in patients aged 80 years and older. Of the total annual number of patients, 181 (26.9 % of total) suffered work absenteeism due to subtrochanteric fractures. Only 27 (15.0 %) of these patients were female. The costs per case associated with lost productivity were €20,203 for men and €21,570 for women.

Discussion

This is the first nationwide study on the incidence rate and societal burden of subtrochanteric fractures in the Netherlands. This study found a decrease in the incidence rate of subtrochanteric fractures, across all age groups and sexes, of 15.5 % over the 2000–2019 study period. In the same timeframe, HLOS per case due to subtrochanteric fractures declined by 62.6 % to a mean of 8.1 days. Total health care and lost productivity costs associated with subtrochanteric fractures were €15.5 M per year.

Very few studies have been published on the incidence or costs of subtrochanteric fractures. Subtrochanteric fractures are an infrequent injury with an overall incidence rate of 3.81 per 100,000 py in the Netherlands. A French study in patients over 50 years found an incidence of 16.8 per 100,000 py for men and 41.2 per 100,000 py in women, for combined subtrochanteric and diaphyseal fractures in 2008 [14]. It showed an increase of 32 % in men and 13 % in women since 2002. A study from the USA also reported increasing subtrochanteric fracture incidence rates over the 1996–2007 study period (20.4 % increase to 34.2 per 100,000 py in women, no significant increase in men to 15.4 per 100,000 py) [13]. The current data show a decreasing incidence in both the complete population and also in patients >50 years (−16.% for men and −35.5 % for women), across the whole study period. In contrast to both Wang et al. and Maravic *et al.*, incidence rates in this study for, specifically 2008, were lower at 6.2 per 100,000 py for men over 50 years and 15.5 per 100,000 py for women over 50 years, a decrease of, respectively, −16 % and −22 % since 2002. The international differences and inclusion of also diaphyseal fractures could explain the inflated incidence rates found in the study by Maravic et al. Both studies could not provide an explanation for its increasing incidence rates over time but mentioned a possible association with increased bisphosphonate usage. Our data do not confirm this trend. Since 2011 a new GP guideline for osteoporosis treatment has changed

Table 2
Age- and sex related incidence rates (per 100,000 person-years) of subtrochanteric fractures in 2000 and 2019.

	2000						2019					
	Males		Females		Total		Males		Females		Total	
	n	Incidence	n	Incidence	n	Incidence	n	Incidence	n	Incidence	n	Incidence
< 50 years	53	0.95	22	0.41	75	0.68	28	0.53	14	0.27	42	0.41
> 50 years	147	6.52	493	18.78	640	13.11	182	5.46	434	12.11	616	8.90
> 65 years	122	13.87	468	36.77	590	27.41	145	9.48	383	21.47	528	15.93
> 80 years	61	40.30	315	90.26	376	75.15	73	23.70	256	52.15	329	41.19
Total	200	2.55	515	6.42	715	4.51	210	2.45	448	5.15	658	3.81

[1]Incidence rates per 100,000 person-years.

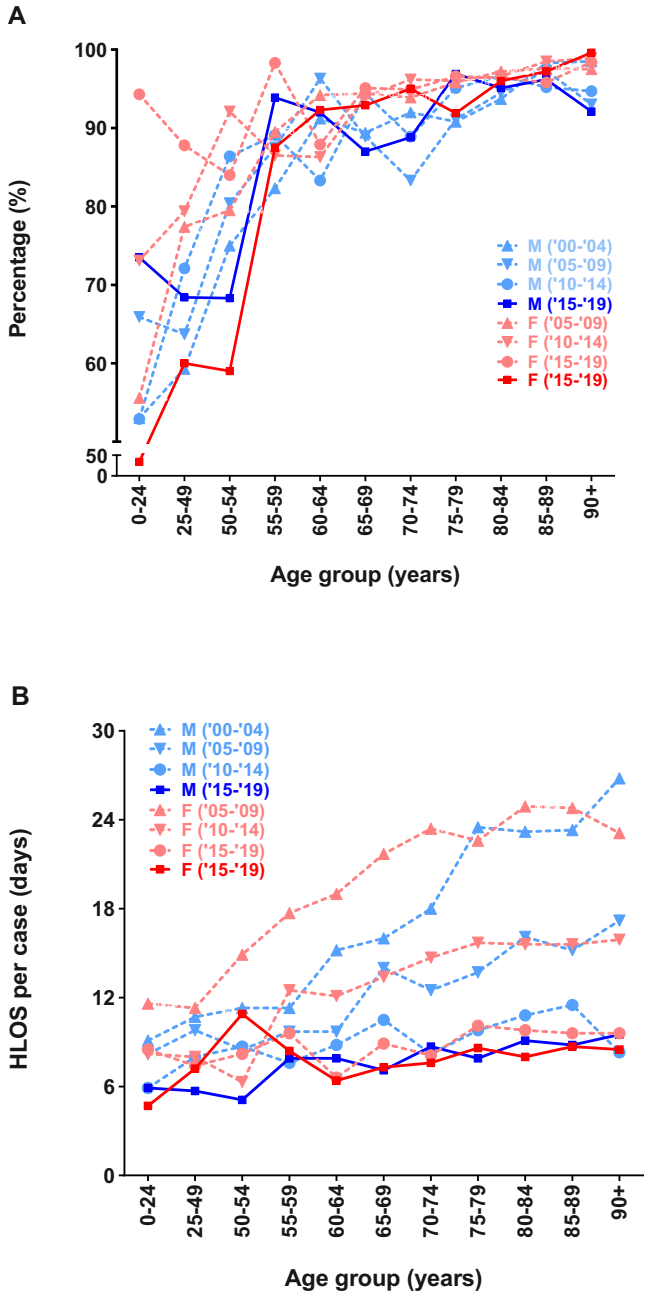

Fig. 2. Percentage of patients per age group sustaining a subtrochanteric fracture due to a fall (A) and age-related hospital length of stay per case (B) for patients with a subtrochanteric fracture in the 2000–2019 period
Data are averaged over 5-year periods (i.e., 2000–2004, 2005–2009, 2010–2014, and 2015–2019) and are shown for 0–24 years, 25–50 years, and subsequently in 5-year age groups up to and including 90+.

the indication for bisphosphonates to only high fracture-risk patients and their annual daily doses prescribed decreased from 84 M doses in 2013 to 74 M doses in 2019 (−11 %) while the elderly population steadily increased [23–25]. However, the decreasing trend in fracture incidence was already clearly visible before 2011 and might be more related to a general increase in (hip) fracture and osteoporosis prevention campaigns, medication and awareness, than a decrease in bisphosphonate usage. In literature, subtrochanteric fractures are known to have a bimodal incidence, with a peak in young adults, often described in males between 20 and 40 years, and a second peak at elderly age [6,26-28]. In this study, incidence increased with advancing age but no clear peak can be found in the 0–24 or 25–49 age groups, for both sexes. However, younger men do show a higher incidence in these age groups than women. While subtrochanteric fractures, and hip fractures in general, are an injury most common in older women, the higher likelihood for high-energy trauma in younger men will have increased these incidence rates [29,30]. These differences, all below 0.6 per 100,000 py, are overshadowed by incidence rates well over 50 per 100,000 py in older patients. Smaller peaks in the younger age groups could have been masked by the larger 25-year range of the two youngest age groups.

Subtrochanteric fractures form only a small portion of the total burden of hip fractures in the Netherlands. With an incidence of 120.5 (femoral neck/trochanteric) versus 3.8 (subtrochanteric) per 100,000 py in 2019 for the whole Dutch population, the burden of subtrochanteric fractures is small when compared to other hip fracture subtypes [2]. This is also reflected in the cost of subtrochanteric fractures. Although subtrochanteric fractures are expensive injuries per patient when compared to other trauma cases like rib, ankle, humerus, or tibia fractures, at €21,030 health care costs per patient [16,17,19,31]. They have similar, though slightly higher, costs when compared with cervical neck or trochanteric fractures (€21,495) from a previous study [2]. Due to lower incidence, the total annual health care costs of subtrochanteric fractures are 'only' €14.1 M. An amount that is over 30 times outnumbered by the total costs €425.1 M for the other hip fracture subtypes [2]. The total costs of lost productivity are even lower at an annual total of €1.3 M in 65 patients. While rare in the working population, subtrochanteric fractures can lead to long periods of absence (mean 438 days) and are associated with a high cost per case.

HLOS for subtrochanteric fractures follows the general decreasing pattern seen in other injuries and has decreased from a mean of 21.6 days in 2000 to 8.1 days in 2019 [1,15,17,19]. The effect of age on HLOS has also decreased over time. It has changed from a difference of 11.7 days between the youngest and oldest age groups (0–24 years and 90+ years) in 2000–2004, to a difference of 3.2 days in 2015–2019. These changes can be explained by the implementation of dedicated clinical pathways, improved surgical and rehabilitation techniques, and changes in health care organization that moved large parts of the treatment and revalidation process out of the hospital [32,33]. Annual total HLOS is only 5410 days, less than 4 % of HLOS due to all hip fracture subtypes [2].

Although subtrochanteric fractures are only a small fraction of the total hip fracture burden, more insight into their epidemiology and costs can lead to a better (inter)national overview of (hip-)fracture subtypes and related future health care demands. Future research should focus on

Table 3
Annual age-related hospital length-of-stay per case and annual total hospital length-of-stay for subtrochanteric fractures in the 2015–2019 period.

	Males			Females			Total		
	n	HLOS/case	Total HLOS	n	HLOS/case	Total HLOS	N	HLOS/case	Total HLOS
< 50 years	33	5.72	186	14	5.90	83	47	5.77	269
> 50 years	178	8.25	1472	447	8.22	3669	625	8.23	5141
> 65 years	145	8.50	1235	404	8.25	3331	549	8.32	4566
> 80 years	75	9.07	680	278	8.42	2340	353	8.56	3020
Total	211	7.86	1658	461	8.14	3752	672	8.06	5410

HLOS, hospital length-of-stay.

Table 4
Annual health care costs determinants and loss of productivity costs for both sexes in 2015–2019 period, including age-specific medical costs.

Cost determinant		**Male**			**Female**		
		n/year	Costs/case (€)	Total costs (€)	n/year	Costs/case (€)	Total costs (€)
Direct costs	Ambulance care	211	736	155,194	461	803	396,648
	Hospital care	211	5974	1260,596	461	6313	2907,746
	Rehabilitation/Nursing care	211	7113	1500,750	461	12,699	5849,194
	Home care	211	1926	406,332	461	2611	1202,762
	Physical therapy	211	560	118,062	461	634	292,126
	G.P. care	211	86	18,164	461	94	43,446
Indirect costs	Productivity loss[1]	38	20,203	762,750	27	21,570	586,137
Total costs	Total costs[2]	211	20,009	4221,848	461	24,427	11,251,061
Age specific direct (medical) costs		**Male**			**Female**		
		n/year	Costs/case (€)	Total costs (€)	n/year	Costs/case (€)	Total costs (€)
< 50 years		33	7065	230,308	14	8555	119,770
> 50 years		178	18,099	3228,790	447	23,612	10,545,154
> 65 years		145	19,808	2880,130	404	24,929	10,061,164
> 80 years		75	21,148	1586,074	278	26,725	7424,118
Total		211	16,394	3459,098	461	23,154	10,664,924

All costs are averaged over the 2015–2019 period and are calculated for index-year 2019.
GP, general practitioner.
[1] Only for population with loss of productivity.
[2] Average for complete population including patients with and without loss of productivity.

establishing if there is a causal link between bisphosphonate use and major changes in (atypical) subtrochanteric fracture incidence.

This is the first study on trends in incidence and costs of subtrochanteric fractures in the Dutch population and, although a with a smaller sample size then compared to other hip fracture subtypes, it provides reliable population-based data from the National Hospital database over a 20-year period. Like other population-based studies, it has limitations. Subtrochanteric fracture patients were selected based on ICD codes from the LMR and researchers did not receive or interpret individual patient data including specific operation characteristics or patients' comorbidities that could influence HLOS or costs. Outcomes should be interpreted on a population level. The LMR categorizes patients based on exclusively their main diagnosis, which is generally their most severe injury. While hip fracture is a severe injury and is often isolated, especially in the elderly, fractures in polytrauma patients could be missed. This may have deflated the incidence rates, especially in younger patients. Also, no distinction could be made between diagnoses in the calculation of HLOS, as patients with a main diagnosis of subtrochanteric fracture could have longer HLOS due to other injuries. Although ICD-codes are validated for differentiating between hip fracture subtypes, no distinction could be made between pathological, typical, or atypical subtrochanteric fractures [34]. As a result no changes in incidence and possible associations with medication used (i.e. bisphosphonate use), based on different subtrochanteric fracture subtypes or risk factors could be studied. Due to a national change in registration systems, the crude numbers and incidence rates for the year 2013 are lower than expected and are higher than expected for the preceding years 2010–2012, as most likely cases have not been correctly registered (for the right year). While adequate registration was restored in the following years, these numbers should be interpreted with care. A final limitation is the fact that this study focused on the Dutch healthcare system. This makes interpretation and extrapolation of results to other nations challenging. However, trends in incidence, HLOS, and costs could be of value in international comparisons of changes in the (economical) burden of disease.

Conclusion

Subtrochanteric fractures are a relatively infrequent subtype of hip fracture with an incidence rate in 2019 of 3.81 per 100,000 py. Incidence is higher in women and shows a steep increase in the 75+ age-groups. In the two-decade (2000–2019) study period its incidence has decreased by 15.5 % for the complete Dutch population. This decrease was larger in women (−19.8 %) than in men (−3.0 %). Increasing incidence rates, possibly linked to bisphosphonate usage, and a bimodal age distribution found in previous international studies, were not found in the Dutch population. HLOS consistently decreased over time with 62.6 % from 21.6 days to 8.1 days in 2015–2019. In this latest period the cumulative annual HLOS was 5410 days. Subtrochanteric fractures were associated with healthcare costs per patient of €16,394 for men and €23,154 for women. The total annual burden of costs in the 2015–2019 period was €14.1 M in healthcare costs with an additional €1.4 M in costs due to lost productivity.

Ethical statement

This study has been exempted by the Medical Research Ethics Committee of the Erasmus Medical Centre, Rotterdam, The Netherlands with reference number: MEC-2022–0326.

CRediT authorship contribution statement

Miliaan L. Zeelenberg: Conceptualization, Data curation, Formal analysis, Visualization, Writing – original draft. **Esther M.M. Van**

Lieshout: Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Visualization, Writing – review & editing, Project administration. **Suzanne Polinder:** Conceptualization, Formal analysis, Methodology, Writing – review & editing. **Martien J.M. Panneman:** Data curation, Formal analysis, Methodology, Writing – review & editing. **Michael H.J. Verhofstad:** Conceptualization, Supervision, Writing – review & editing. **Dennis Den Hartog:** Conceptualization, Supervision, Writing – review & editing.

Declaration of competing interest

Miliaan L. Zeelenberg, Esther M.M. Van Lieshout, Suzanne Polinder, Martien J. M. Panneman, Michael H. J. Verhofstad, and Dennis Den Hartog declare they did not receive support from any organization for the submitted work and have no competing interests to declare that are relevant to the content of this article.

Data availability

The data supporting the findings of this study are available on reasonable request from the corresponding author. All data used in figures can be found in Online Resource 1.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.injury.2024.111461.

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