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ORIGINAL ARTICLE

Trends in incidence, health care consumption, and costs for proximal femoral fractures in the Netherlands between 2000 and 2019: a nationwide study

M.L. Zeelenberg[1] · D. Den Hartog[1] · M.J.M. Panneman[2] · S. Polinder[3] · M.H.J. Verhofstad[1] · E.M.M. Van Lieshout[1]

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Abstract

Summary This study evaluated the incidence rates and societal burden of hip fractures in The Netherlands. Although incidence in the elderly population is decreasing and hospital stay is at an all-time low, the burden of medical costs and crude numbers of proximal femoral fractures are still rising in our aging population.

Purpose The aim of this nationwide study was to provide an overview of the incidence rate and economic burden of acute femoral neck and trochanteric fractures in The Netherlands.

Methods Data of patients who sustained acute proximal femoral fractures in the period January 1, 2000, to December 31, 2019, were extracted from the National Medical Registration of the Dutch Hospital Database. The incidence rate, hospital length of stay (HLOS), health care and lost productivity costs, and years lived with disability (YLD) were calculated for age- and sex-specific groups.

Results A total of 357,073 patients were included. The overall incidence rate increased by 22% over the 20-year study period from 16.4 to 27.1/100,000 person-years (py). The age-specific incidence rate in elderly > 65 years decreased by 16% (from 649.1 to 547.6/100,000 py). The incidence rate in men aged > 90 has surpassed the incidence rate in women. HLOS decreased in all age groups, hip fracture subtypes, and sexes from a mean of 18.5 to 7.2 days. The mean health care costs, over the 2015–2019 period, were lower for men (€17,723) than for women (€23,351) and increased with age to €26,639 in women aged > 80. Annual cumulative costs reached €425M, of which 73% was spent on women.

Conclusion The total incidence of hip fractures in The Netherlands has increased by 22%. Although incidence in the elderly population is decreasing and HLOS is at an all-time low, the burden of medical costs and crude numbers of proximal femoral fractures are still rising in our aging population.

Keywords Proximal femoral fracture · Epidemiology · Incidence rate · Hospital length of stay · Health care costs · Years lived with disability

Introduction

Proximal femoral fractures are one of the leading causes of disability and mortality in the elderly population worldwide [1, 2]. Due to an aging population, the burden of disease is expected to increase further in the upcoming decades [3–5].

Proximal femoral fractures are generally subdivided into three subcategories: femoral neck, trochanteric, and subtrochanteric/proximal shaft fractures [6, 7]. Proximal femoral fractures are most common in female and elderly patients. The elderly mainly sustain a hip fracture after a simple fall, and these fractures are often associated with osteoporosis. Less than 10% of hip fractures occur in adults aged < 50 years [8, 9]. Fractures in the younger population are often

✉ E.M.M. Van Lieshout
e.vanlieshout@erasmusmc.nl

1 Trauma Research Unit Department of Surgery, Erasmus MC, University Medical Center Rotterdam, P.O. Box 2040, 3000 CA Rotterdam, The Netherlands

2 Consumer Safety Institute, Amsterdam, The Netherlands

3 Department of Public Health, Erasmus MC, University Medical Center Rotterdam, Rotterdam, The Netherlands

associated with chronic, endocrine, or neurological diseases or high-energy trauma [10].

Hartholt et al. reported that between 1981 and 2008, the absolute number of hip fractures in The Netherlands doubled in patients aged 65 years or older [11]. The incidence rates of hip fracture-related hospital admissions increased with age, and the age-adjusted incidence rate increased from 52.0 to 67.6 per 10,000 persons per year. During the 25-year study, the total number of hospital days was reduced by a fifth, due to a reduced admission duration in all age groups. This study, however, also showed a worrying increasing trend of fracture incidence in men over 80 years, one of the fastest growing segments of aging societies, and forecasted more growth in fractures in this segment of the population. More than a decade later, this poses the question of whether we have adequately stemmed the trend by providing better care and more effective prevention measures and having more experience treating an aging population. Can we expect this epidemic of hip fractures to continue or have we already passed the peak?

No recent epidemiological analysis of the Dutch hip fracture population, in the last decade, has been published and few studies publish data on specific fracture locations. Population-based knowledge on the occurrence of specific fracture types and age groups is essential for the allocation of health care services, optimization of preventive measures, and providing a more accurate forecast for the future. The aims of this study were to examine long-term population-based trends in the incidence rate, trauma mechanism, and hospital length of stay and to assess the current health care costs, lost productivity costs, and years lived with disability for patients with femoral neck or trochanteric hip fractures, admitted to a hospital in The Netherlands between 2000 and 2019.

Methods

In this retrospective epidemiological study, data were collected for patients admitted to a hospital in The Netherlands with a hip fracture in the period January 1, 2000, up to and including December 31, 2019. The methods are similar to previous studies [12–15]. Injury cases were extracted from the National Medical Registration (LMR) of the Dutch Hospital Database (DHD), Utrecht, The Netherlands. The DHD collects hospital data from all hospitals in The Netherlands with a uniform classification system and has an almost complete national coverage (missing values < 5%, except in 2007 12%). These figures were extrapolated by The Netherlands knowledge center for injury prevention (VeiligheidNL) to full national coverage for each year. An extrapolation factor was estimated by comparing the adherence population of the participating hospitals with the total Dutch population each year using the population data obtained from the Statistics Netherlands [16]. 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. Codes for hip fractures are presented in Online Resource 1: Table S1. Injuries include both traumatic and pathological fractures. This study mainly focused on the femoral neck and trochanteric fracture subtypes. Subtrochanteric fractures were considered a separate entity within the hip fracture population, with a different age distribution and a larger proportion of high-energy and pathological fractures [17]. Subtrochanteric fractures, 3.9% of proximal femoral fracture in the 20-year study period, were therefore excluded from the analysis.

The study was exempted by the local Medical Research Ethics Committee Erasmus MC (MEC-2022-0326).

Outcome measures and analysis

Incidence rates

Age- and sex-specific incidence rates were calculated in 5-year age groups for each year of the study. Due to low incidence rates in the age groups below 50 years, those groups were combined into 0–24 and 25–50 years. Incidence rates were standardized for age (per age group) and sex using a direct standardization method, as used in previous studies [12]. In short, the age- and sex-specific incidence rates per 100,000 person-years were calculated based on the Dutch mid-year standard population (calculated using the formula $(N_{2005} + N_{2019})/2$). In 2013, there was a change in diagnosis registration systems, leading to a decrease in registration numbers for this year and, to a lesser degree, the following 2 years.

Trauma mechanism and hospital length of stay

Data regarding hospital length of stay (HLOS) and trauma mechanism were extracted from the LMR database for the previously mentioned age groups. Trauma mechanisms were categorized as "fall due to all causes" versus "other." 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 a height. To assess the trends in HLOS and trauma mechanisms over time, the mean HLOS and percentage of trauma mechanisms were averaged over 5-year intervals from 2000 to 2019. Cumulative HLOS was calculated by multiplying the means per case with the total number of cases.

Health care costs and loss of productivity

To assess the current health care costs and loss of productivity, data on patient numbers and health care use were retrieved from the LMR database for 5-year age categories and males and females separately. These were supplemented with data from a patient follow-up survey with questions relating to health care use outside the hospital, work absence, and health-related quality of life (HRQoL) using the EQ-5D questionnaire, conducted in a random sample of patients at 2.5, 5, 9, and 24 months after injury [18]. The Dutch Burden of Injury Model was used to assess the health care costs of injury [15, 19, 20]. Health care costs of injuries were calculated by multiplication of the incidence, health care volumes (e.g., length of stay in hospital or institution, the number of outpatient visits, general practitioner visits, home care hours, and physical therapy treatments), and unit costs (e.g., costs per day in hospital). National guidelines for health care costing were used to estimate unit costs [21]. Medical costs included ambulance care, in-hospital care, general practitioner (GP) care, home care, physical therapy, social support care, and rehabilitation/nursing home care.

Productivity costs were defined as the costs associated with production loss and replacement due to illness, disability, and premature death [22]. Loss of productivity costs were assessed using data from the LMR and a patient survey on health care use as described previously [15, 18, 23]. To estimate costs for productivity loss for all patients aged 15–64 years, the absenteeism model was used. Additionally, the friction cost method was used because health care needs are most substantial in the first year after injury for the majority of injuries [24]. To calculate the annual costs, data were averaged for the 2015–2019 period. For all cost calculations, 2019 was used as the index year. Costs were calculated for the previously mentioned age categories and for males and females separately.

Years lived with disability

The number of years lived with disability (YLD) was calculated as described previously [12, 15, 21]. HRQL was assessed using the EQ-5D questionnaire, mentioned above [18]. The YLD was obtained by linking the incidence data (subdivided into injury diagnosis groupings) with disability information which is the proportion of injury cases with lifelong consequences, and injury-specific disability weights of temporary and lifelong consequences. The disability weights were derived from empirical follow-up data on the health-related quality of life of individual trauma patients and adjusted for population norms, age, and gender [18, 25]. The disability weight reflects the impact of a health condition in terms of health-related quality of life; it has a value ranging from 1, indicating the worst imaginable health state, to 0, indicating full health [25]. To assess the trends over time, data were averaged over 5-year intervals from 2000 to 2019. Data were calculated for the previously mentioned age categories and for males and females separately.

Available data did not allow for extrapolation of costs and YLD for hip fracture subtypes. Analyses for both costs and YLD were all performed for the combined fracture population including femoral neck and trochanteric fractures.

Tables containing all data used in figures and the total Dutch population per year, used for incidence rate calculations, can be found in Online Resource 3.

Results

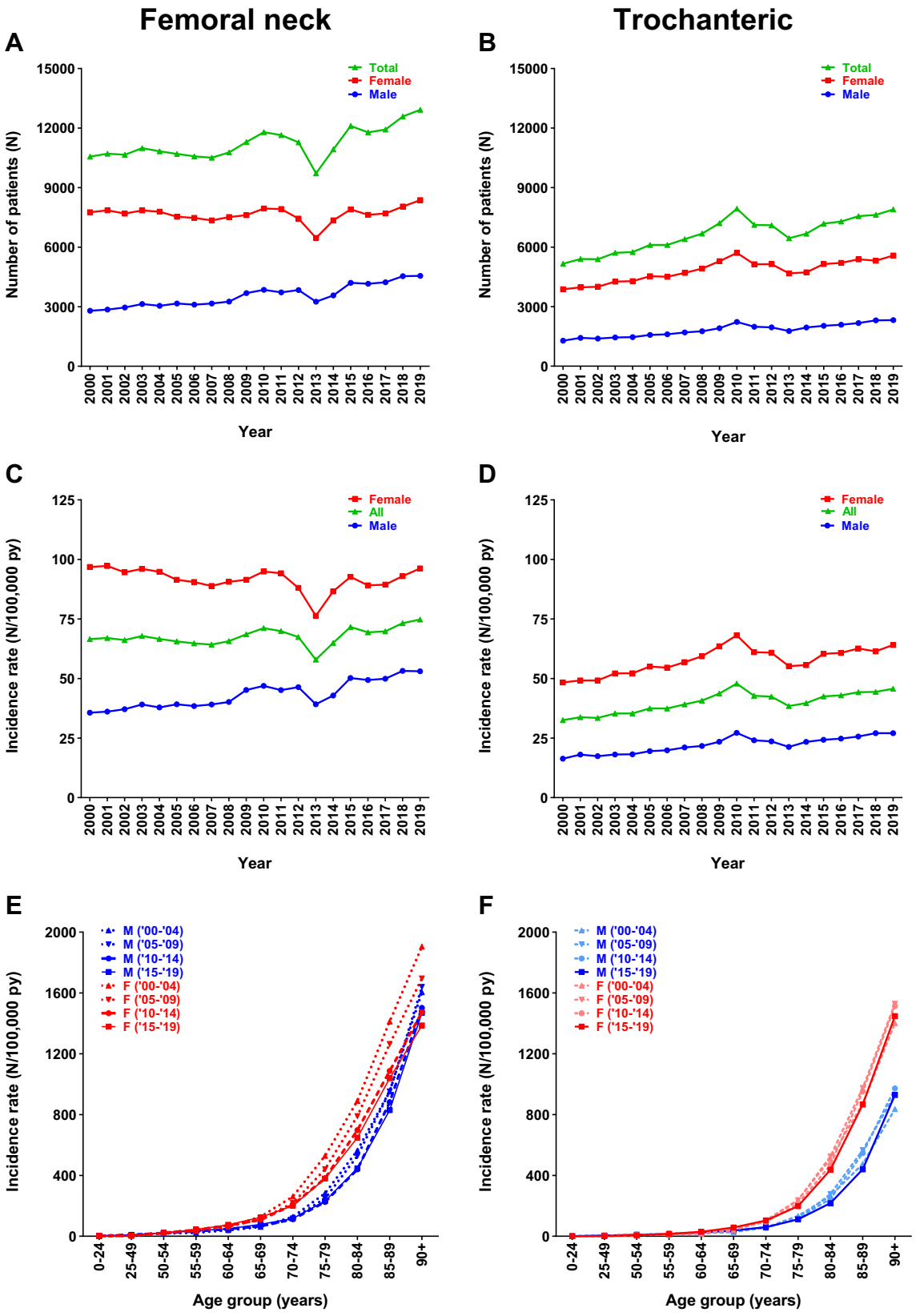
Incidence rates

Between 2000 and 2019, 357,073 patients were admitted with a femoral neck (224,307) or trochanteric fracture (132,766) in The Netherlands. Figure 1A, B shows the total number of femoral neck and trochanteric fractures per year. During the study period, the total number of femoral neck and trochanteric fractures shows an increasing trend for both sexes.

Figure 1C, D shows the incidence rates per 100,000 person-years (py) for both fracture locations. In femoral neck fractures, men showed an increasing trend (35.7/100,000 py in 2000 to 53.0/100,000 py in 2019), while the incidence in women remained relatively constant over time (96.8/100,000 py in 2000 to 96.2/100,000 py in 2019). Trochanteric fracture incidence increased both in men (from 16.4 to 27.1/100,00 py) and in women (from 48.4 to 64.1/100,000 py). Overall, this amounts to an increase of 22% in incidence rate across both subtypes of fractures over the 20-year period (99.1 to 120.5/100,000 py).

Despite this overall increase in incidence rate, the elderly of 65 years and older (Table 1) display a different trend. In this subgroup, incidence even decreased by 16% overall (from 649.2 per 100,000 py in 2000 to 547.6 per 100,000 py in 2019). This can primarily be attributed to a decrease in female > 65 years fracture incidence 850.0 to 706.5 per 100,000 py (− 17%) versus 358.5 to 362.5 per 100,000 py (0.1% increase) for males. In the same time period, the incidence rates of femoral neck fractures in all patients > 65 years decreased by 23% (431.5 to 332.4 per 100,000 py), where trochanteric fracture rate decreased by only 1.1% (217.7 to 215.2 per 100,000 py).

Figure 1E, F shows the age-specific incidence rate for the four consecutive 5-year time periods of the study. Incidence rates increase with age for both fracture types, but the increase becomes less prominent over time. However, in femoral neck fractures, incidence rates for men in the highest age group (2015–2019; 90+ years) have surpassed


Femoral neck
Trochanteric
A
B
C
D
E
F
Total
Female
Male
All
M ('00-'04)
M ('05-'09)
M ('10-'14)
M ('15-'19)
F ('00-'04)
F ('05-'09)
F ('10-'14)
F ('15-'19)
Number of patients (N)
Incidence rate (N/100,000 py)
Year
Age group (years)
0-24
25-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85-89
90+

◂**Fig. 1** Patient numbers (**A**, **B**), incidence rate (per 100,000 person-years) (**C**, **D**), and age-related incidence (per 100,000 person-years) (**E**, **F**) of femoral neck fractures (**A**, **C**, **E**) and trochanteric fractures (**B**, **D**, **F**) in The Netherlands in the years 2000–2019. Data are shown for all patients (green) and for males (blue) and females (red) separately. For **E** and **F**, 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+

incidence in women (men 1470/100,000 py versus women 1386/100,000 py). While age-specific incidence rates have decreased over time in femoral neck fractures, in trochanteric fractures, an increase in incidence rate could be seen up to 2010 in the highest age group in men, after which incidence rates stop increasing and seem to have plateaued in the most recent years. The overall incidence in trochanteric fractures has slightly decreased in the most recent 5-year period in both sexes.

Trauma mechanism

The proportion of patients sustaining a femoral neck or trochanteric fracture due to a fall increased with age from 65.0% and 62.5% in the 0–24 age group to 97.3% and 98.0% in the 90+ age group for femoral neck and trochanteric fractures, respectively (Online Resource 2: Fig. S1). This effect remained fairly constant over time in the 4 study periods. During the entire study period, the proportion of falls was consistently slightly higher in women than in men, except for the youngest age group. In the 0–24 year age group in 2015–2019, men show a notably larger fall percentage than women for both fracture types (femoral neck: 73.8% versus 67.9%; trochanteric: 65.5% versus 42.9%).

Hospital length of stay

Hospital length of stay in four consecutive 5-year periods for both fracture categories is shown in Fig. 2. Mean HLOS per patient (Fig. 2A, B) has decreased over time for both fracture types, from an overall mean of 18.4 days in 2000–2004 to 7.2 days in 2015–2019. The magnitude of this decrease is declining in the more recent time periods. In the most recent time period (2015–2019), the mean HLOS per case was similar in femoral neck fractures (7.0 days) and in trochanteric fractures (7.5 days). For both fracture types, HLOS increased with age up to the 85–89 age group and decreased slightly in the 90+ age group. The mean HLOS per patient in 2015–2019 is similar in men (7.3 days) and in women (7.2 days).

Total HLOS due to femoral neck and trochanteric fractures (Fig. 2C, D) increased with age following the incidence trends and, correspondingly, decreases in more recent cohorts. Total HLOS per year (Table 2) in the 2015–2019 cohort is higher in femoral neck fractures (86,439 days) than in trochanteric fractures (56,363 days). In this time period, total HLOS per year for women (95,478 days) was two times higher than in men (47,324 days).

Health care costs and lost productivity

The annual health care costs in the period 2015–2019 were €425M. These costs can be split into €116M (27%) for men and €310M (73%) for women. An overview of costs per case (E, F) and total population costs (G, H) is shown in Fig. 2. The mean health care costs per case are €17,723 for men and €23,351 for women (Table 3). For both sexes, costs per patient increased with age; this increase was more prominent in women (up to a maximum at > 80 years of €21,162 for men and €26,639 for women). Total health care costs also increase with age and peak at 85–89 years for both sexes. The main cost driver is rehabilitation/nursing care, with up to €7958 per case for men versus up to €12,789 per case for women (Table 4). Costs per case < 50 years were substantially lower for both sexes (mean €7638) than in the ≥ 50-year age groups and increase evenly with increasing age. Costs in the < 50 age group make up only 1.1% (€4.6M) of the cumulative yearly costs, with patients ≥ 80 making up 65.1% (€277M) of the cumulative yearly costs.

Between 2015 and 2019, an annual average of 860 (13.1% of total) men and 641 (4.8% of total) women suffered work absenteeism due to their hip fracture, with a mean duration of absence per case of 402 days in males and 472 days in females. Costs per case due to lost productivity were slightly higher for females (Fig. 2E, F), with a mean of €20,366 for men and €21,240 for women. The total costs of lost productivity, due to both types of fracture, were higher in men (annual total of €17.5M) than in women (annual total of €13.6M) (Table 4). The total combined health care and loss of productivity costs amounted to €456M and increased with age following the pattern of incidence (Fig. 2G, H). Loss of productivity makes up only 6.8% of this total number. Men have a lower total combined cost per patient than women (€20,408 versus €24,379). Due to higher incidence rates, women also had substantially higher total costs for health care and lost productivity combined (€323M) than men (€133M).

Years lived with disability

YLD per case declined approximately linearly with age from 4.2 years in the 0–24 age group to 0.59 years in the 90+ age group, with a mean of 1.3 years (Online Resource 2: Fig. S2). This decline seemed unrelated to sex, although YLD for women was higher than for men, especially in the 0–24 age group (5.1 versus 3.7). Total YLD increased with age following the overall hip fracture incidence pattern and peaks

Table 1 Age-related incidence rates (per 100,000 person-years) of the femoral neck and trochanteric fractures for both sexes in 2000 and 2019

Age group	Femoral neck						Trochanteric					
	2000			2019			2000			2019		
	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total
Incidence rate[1]												
< 50 years	5.2	2.9	4.0	5.7	2.5	4.1	2.2	0.9	1.6	2.5	0.9	1.7
≥ 50 years	111.2	289.9	207.3	127.6	230.0	180.6	51.3	146.0	102.2	65.7	154.4	111.6
≥ 65 years	245.8	559.7	431.5	239.2	412.5	332.4	112.7	290.3	217.7	123.4	294.0	215.2
≥ 80 years	759.8	1,239.0	1,094.1	673.8	911.3	819.7	353.5	751.9	631.4	357.2	769.7	610.7
Total	35.7	96.8	66.6	53.0	96.2	74.8	16.4	48.4	32.5	27.1	64.1	45.7

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

at the 75–79 age group for men (1057 years) and the 80–84 age group for women (2596 years). The total cumulative annual YLD due to femoral neck and trochanteric fractures was 24,764 years.

Discussion

Between 2000 and 2019, a total of 357,073 patients sustained a femoral neck or trochanteric fracture in The Netherlands. Across the study period, the data show an increase in combined femoral neck and trochanteric fracture incidence, while it shows a decrease in fracture incidence in the elderly (> 65) population. It further shows that while HLOS is decreasing, total health care costs due to hip fractures continue to rise in the aging Dutch population.

During this 20-year period, the overall incidence rate of femoral neck and trochanteric fractures increased by 22%. This increase can be mostly attributed to an increase in femoral neck fractures in men and an increase in trochanteric fractures in both sexes. A study by Hartholt et al. [11] reported an increase of 20.6% over the years 1981–2008 in patients ≥ 65 years in a similar nationwide study. They reported an incidence rate of 66.5/10,000 py in the elderly. The current study shows an incidence rate of 62.9/10,000 for patients ≥ 65 years in 2008, which decreased to 54.8/10,000 py in 2019 (13% decrease). This effect was strongest in women. So, while the overall incidence rate has increased, the incidence rate in elderly patients is decreasing. Answering the question posed by Hartholt et al.: "Are we on the right track?", in terms of incidence in the elderly population, we are. This change in incidence, however, can largely be explained by population dynamics. While the current study finds an increasing number of hip fractures each year, an increase of 18% in absolute numbers from 2008 to 2019, the ≥ 65 population has decreased by 37% in the same time period. Other factors, outside the scope of this study, that are likely lowering hip fracture incidence in the elderly are the increase in anti-osteoporosis drug use, more awareness of nutritional deficiencies (specifically calcium and vitamin D), exercise, fall prevention, and other fracture prevention and awareness programs [26–29]. This study's findings of decreasing incidence in the elderly, in contrast with increasing crude numbers, are also consistent with other recent European and Japanese studies [30–34].

This study also found that the incidence rate of femoral neck fractures in men, in the highest age group (> 90 years), while decreasing over time, has surpassed incidence in women. Incidence is decreasing faster in women than in men. This trend was already described by Hartholt et al. and has persisted in the previous decade [11]. Possible explanations are more effective diagnosis and treatment of osteoporosis in women and faster growth of this age segment (approximate 1000% increase for men versus 700% for women) of the male population in the previous two decades [16, 35]. More attention should be paid to the subpopulation of elderly men in future fracture prevention campaigns to prevent further expansion of this trend.

This study shows a gradual decrease in both mean and total HLOS over time, a decrease that is shrinking in size and seems to be moving towards a plateau. Hartholt et al. [11] reported decreasing HLOS since 1981 and presented a mean HLOS of 14 days in 2008. Current data showed a mean of 7.2 days over the 2015–2019 period, which indicates that the downward trend has persisted, at least until recently. While crude numbers of hip fractures and overall incidence are increasing, the total burden on hospital occupancy for this group is decreasing and now constitutes 1.7% of total yearly hospital occupancy based on data from the Statistics Netherlands [16]. This trend can be explained by several developments in the past decades including the implementation of dedicated clinical pathways, improved surgical techniques and revalidation, and changes in health care organizations that moved a large proportion of revalidation and treatment outside the initial hospital stay [36, 37].

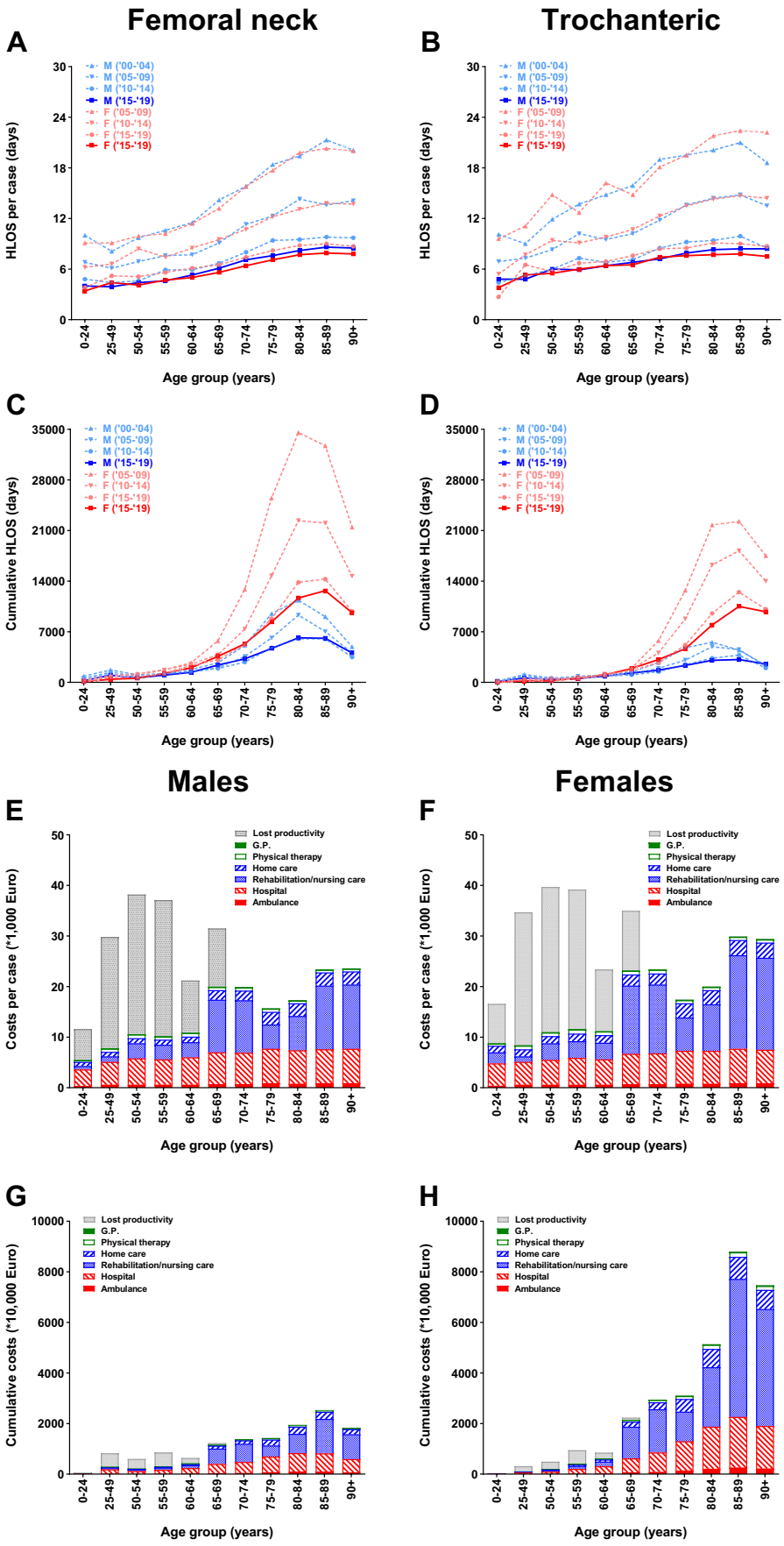


Fig. 2 Age-related hospital length of stay per case (**A**, **B**); total hospital length of stay (**C**, **D**); direct medical costs, indirect medical costs, and loss of productivity costs per case (**E**, **F**); and total population costs (**G**, **H**). Data are averaged over 5-year periods (i.e., 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+. HLOS data is shown for the cervical neck (**A**, **C**) and trochanteric (**B**, **D**) fracture subgroups separately with blue for male and red for female patients. Costs data is shown for the combination of both fracture types and is split between males (**E**, **G**) and females (**F**, **H**). Costs described are mean annual costs per case (**E**, **F**) and annual total population costs (**G**, **H**) over the 2015–2019 period

Table 2 Age-related yearly hospital length-of-stay (HLOS) per case and total yearly HLOS for the femoral neck and trochanteric fractures for both sexes in 2015–2019

Age group	Femoral neck			Trochanteric		
	Males	Females	Total	Males	Females	Total
HLOS per case						
< 50 years	3.90	4.18	3.98	4.83	5.06	4.88
≥ 50 years	7.36	7.05	7.16	7.72	7.51	7.57
≥ 65 years	7.83	7.32	7.48	7.97	7.59	7.69
≥ 80 years	8.43	7.78	7.98	8.37	7.70	7.85
Total	7.12	7.01	7.05	7.54	7.49	7.50
HLOS total						
< 50 years	1205	510	1715	686	204	890
≥ 50 years	29,649	55,074	84,723	15,784	39,690	55,473
≥ 65 years	26,639	51,264	77,903	14,039	37,910	51,949
≥ 80 years	16,317	33,986	50,303	8728	28,203	36,932
Total	30,855	55,584	86,439	16,470	39,894	56,363

HLOS hospital length-of-stay

The average health care cost per patient is €17,723 for men and €23,351 for women. This difference is even more evident when comparing the total cumulative costs, where women make up 73% of total health care costs, mainly due to the large difference in incidence rate between the sexes. In 2007, the Dutch National Institute for Public Health and the Environment reported a total health care cost for hip fractures of €102M for men and €276M for women (0.39% of the total yearly health care expenditure) [38]. This increased to €130M and €331M in 2017 (0.48% of total expenditure), an increase of 17% [39]. Findings of the current study, using the average costs over the 2015–2019 period, are consistent with these numbers and those found in other studies and show an increasing trend in health care costs of hip fractures [39, 40]. The costs per patient are higher than those of other fracture types, and hip fracture is the most costly fracture subtype in total health care costs and poses a significant strain on national health care expenditure [14, 15, 23, 39, 41]. Loss of productivity plays a marginal role in the total cumulative costs due to the mainly geriatric population, costing only 6.8% of the total yearly economic burden. Relatively low productivity costs with a long average work absence of 431 days can be explained by the use of the friction cost method for cost calculation, as employers generally replace long absent workers to reduce productivity loss [22].

Table 3 Yearly age-related medical costs per case and cumulative medical costs for femoral neck and trochanteric hip fractures in males and females in 2015–2019

Age group	Males	Females	Total
Costs per case (€)			
< 50 years	7366	8394	7638
≥ 50 years	18,492	23,537	21,939
≥ 65 years	19,886	24,652	23,218
≥ 80 years	21,162	26,639	25,158
Total	17,723	23,351	21,495
Cumulative costs (€)			
< 50 years	3,333,144	1,363,150	4,685,294
≥ 50 years	112,260,582	308,179,972	420,440,554
≥ 65 years	102,706,682	295,921,622	398,628,304
≥ 80 years	63,006,286	214,014,216	277,020,502
Total	115,582,726	309,543,122	425,125,848

The mean YLD per case in patients with a proximal femoral fracture in The Netherlands is 1.3 years, and this decreases with advancing age. This is likely caused by decreased life expectancy for elderly patients with hip fractures and lower baseline life expectancy before fractures for elderly patients. Hagen et al., in a 2020 Norwegian study, report an average YLD of 0.83 years for women and 0.92 for men in the 55+ age group [42]. While our mean YLD is higher, the current data included the complete population including younger patients with higher expected YLD values. Cultural differences may also have been attributed to this difference.

The strength of this study is that it provides a nationwide overview of femoral neck and trochanteric hip fracture incidence rates, HLOS, costs for health care and lost productivity, and YLD and provides a continuation of previous epidemiological research in the Dutch population. Secondly, it is the first nationwide study providing incidence numbers on specific hip fracture subtypes with long-term trends and reliable population-based data. Like any population-based study, however, the current study also has limitations. Due to a change in registration systems, the crude numbers and incidence rates for the year 2014 and to a lesser degree adjacent years are lower than expected, as most likely cases have

Table 4 Direct and indirect costs per case and for complete population by gender

Cost determinant		Male		Female	
		Costs/case (€)	Total costs (€)	Costs/case (€)	Total costs (€)
Direct costs	Ambulance care	777	5,046,216	812	10,768,460
	Hospital care	6236	40,672,488	6367	84,397,984
	Rehabilitation/nursing care	7958	51,897,250	12,789	169,533,298
	Home care	2105	13,730,496	2654	35,175,664
	Physical therapy	560	3,651,784	635	8,420,506
	GP care	87	566,492	94	1,247,210
	Total direct costs	17,723	115,582,726	23,351	309,543,122
Indirect costs	Productivity loss[1]	20,366	17,511,129	21,240	13,618,093
Total costs	Total costs[2]	20,408	133,093,855	24,379	323,161,215

GP general practitioner

[1]Only for the population with loss of productivity

[2]Average for the complete population including patients with and without loss of productivity

not been registered (correctly). These numbers should be interpreted with care. Registration quality was restored in the following years which still allowed an accurate analysis of fracture trends and incidence over the two-decade period. Patient selection using ICD codes in the LMR uses only patients' main diagnosis at discharge, usually the most severe injury. Patients with more severe injuries than hip fractures could be missing. Another limitation is the lack of clinical information about patients and injury mechanisms. Most injuries, however, can be expected to be low-energy traumatic hip fractures in elderly (osteoporotic) patients with relative certainty. The diversity in trauma mechanisms and patient characteristics will be higher in the younger population, although the incidence in this group is much lower. Secondary injuries could affect HLOS and YLD. This study was specifically focused on the Dutch population and the Dutch health care system. This makes the extrapolation of results to other countries challenging, especially concerning costs, as most countries use different valuations and health care frameworks. Trends in incidence, HLOS, and costs can however be compared to assess the international changes in the burden of disease and the progress of the hip fracture epidemic.

Conclusion

This study shows an increase in the femoral neck and trochanteric fracture incidence of 22% across the 2000–2019 study period, although the age-specific incidence ≥ 65 years is decreasing in recent years. This trend was strongest in elderly female patients with femoral neck fractures and affirms the effect of improved operation techniques, health care organization, and (pharmacological) prevention campaigns of the past decades. In contrast, male incidence rates of femoral neck fractures in the 90+ age category have surpassed female incidence. This subpopulation could benefit from more attention in future hip fracture prevention and management campaigns. In the past 20 years, HLOS has decreased in all age groups, hip fracture subtypes, and sexes from an average of 18.4 to 7.2 days. The average health care costs over the 2015–2019 period are higher in women, costing €17,723 for men versus €23,351 for women, and rise with increasing age. Yearly cumulative costs in the same period reach €425M, with women accounting for 73% of these costs. The total costs for lost productivity is €31M (€20,366 for men versus €21,240 for women) and makes up only 6.8% of the total combined cost burden. YLD decreases with age and is similar between sexes. Although hip fracture incidence in the elderly population is decreasing and HLOS is at an all-time low, the societal burden of costs and crude numbers of hip fractures are still rising in our aging population.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00198-023-06774-y.

Data Availability All data used in figures are presented in Online resource 3. The corresponding author can be contacted for additional requests or questions regarding the data or analysis.

Declarations

Conflicts of interest None

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