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ORIGINAL ARTICLE

Hospitalizations for major osteoporotic fractures in Switzerland: a long-term trend analysis between 1998 and 2018

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Abstract

Summary Between 1998 and 2018, the number of hospitalizations for major osteoporotic fractures increased. After standardization for age, these numerical increases translated into a reduced incidence of hospitalizations for hip fractures and an increased incidence of hospitalizations for spine, proximal humerus, and distal radius fractures in both sexes.

Introduction The longterm epidemiological trends of hospitalizations for major osteoporotic fractures (MOF) between 1998 and 2018 in Switzerland are unknown.

Methods The absolute number of acute hospitalizations for MOF (hip fractures and fractures of the spine, proximal humerus, and distal radius) and related length of acute hospital stay were extracted from the medical database of the Swiss Federal Office of Statistics. Age-standardized incidence rates were calculated using 1998 as the reference year.

Results Hospitalizations for MOF increased from 4483 to 7542 (+68.2%) in men and from 13,242 to 19,362 (+46.2%) in women. The age-standardized incidence of hospitalizations for MOF increased by 5.7% in men ($p=0.002$) and by 5.1% in women ($p=0.018$). The age-standardized incidence of hip fractures decreased by 15.3% in men ($p<0.001$) and by 21.5% in women ($p<0.001$). In parallel, the age-standardized incidence of MOF other than hip fractures increased by 31.8% in men ($p<0.001$) and by 40.1% in women ($p<0.001$). The mean length of acute hospital stays for MOF decreased from 16.3 to 8.5 days in men and from 16.9 to 8.1 days in women.

Conclusion Between 1998 and 2018, the number of hospitalizations for MOF increased significantly by a larger extent than expected based on the ageing of the Swiss population alone. This increase was solely driven by an increased incidence of MOF other than hip fractures as incident hip fractures decreased over time in both sexes, more so in women than in men.

Keywords Epidemiology · Hip fractures · Major osteoporotic fractures · Osteoporosis · Switzerland

Introduction

Osteoporosis is defined as a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture [1]. While a patient with osteoporosis may present a fracture of any bone, these occur preferentially at the hip, spine, distal radius, and proximal humerus. The latter are typically referred to as major osteoporotic fractures (MOF) [2–4].

Fractures, the most debilitating consequence of osteoporosis, have been projected to increase in number worldwide with large differences between regions and countries [5–7]. In countries neighboring Switzerland, and more generally in the EU [8], reasonable epidemiological data is available for hip fractures [9–12] but much less is known about fractures of the spine, distal radius, and proximal humerus [12–15].

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Furthermore, long-term trends covering several decades generally rely on extrapolations [16]. Finally, data reporting may vary by country and by publication, ranging from absolute numbers or crude incidences [11] to age-standardized incidences [9, 10, 12, 15].

Switzerland ranks among the oldest populations worldwide. Life expectancy at birth has been continuously increasing since 1900 reaching 81.9 years for men and 85.6 years for women in year 2019 [17]. According to all demographic projection scenarios, this trend is expected to continue until 2050, by when the proportion of the population aged 65 years or older will have increased to 26%, from 19% in 2020 [18]. Hospitalizations for MOF in both men and women aged 45 years or more have been reported to having increased between 2000 and 2007, although hospitalizations for hip fractures had declined [4]. Early reports (1991–2000) limited to the region of Geneva, Switzerland, had already identified such a decrease in the age-standardized incidence of hip fractures, interpreted as a reversal of a secular trend, and driven by decreasing numbers of hip fractures in nursing homes [19, 20]. Whether these trends have continued or altered is unknown and subject of the present study.

Methods

Data source

The administrative and medical statistics database of the Swiss Federal Statistical Office (SFSO) was queried. Since 1998, all Swiss hospitals are bound to report an administrative and medical core dataset for each hospitalized patient to the SFSO. As part of the stringent quality control measures, a proprietary plausibility testing software (MedPlaus version 6.0) developed by the SFSO is applied to all reports and more than 700 plausibility checks are run for each case, including with regard to coding for diseases according to the International Classification of Diseases (ICD-10) [21]. Further checks ensure consistency in reporting across cantons prior to consolidation at the federal level. The representativeness was 62.2% in year 1998, increased to more than 98% as of year 2005, and reached 100% from year 2010 onwards. In addition, the SFSO publishes the structure of the Swiss population by 5-year age groups on an annual basis.

Dataset

For women and men aged 45 years or older, all cases of MOF having led to an acute hospitalization (i.e., clinically symptomatic fractures requiring hospitalization in an acute care setting) between year 1998 and 2018 were retained. For inclusion, the reported fracture had to be the main reason for hospitalization (primary diagnosis). Fractures only listed as co-diagnoses (secondary diagnoses) were not included. Hospitalizations in rehabilitation clinics were excluded to avoid double counting, assuming the absence of acute hospitalizations for clinical fractures in rehab settings. Double-counting was further prevented by excluding rehospitalizations for the same fracture that occurred within 2 months following the index event, in accordance with SFSO recommendations. The length of acute hospital stay for all fractures and the age at admission for hip fracture were also extracted. Based on the relevant ICD-10 codes and consistent with earlier work [4], the MOF were categorized as follows: *hip fractures* (S72.0 Fracture of the femoral neck, S72.1 Pertrochanteric fracture, and S72.2 Subtrochanteric fracture), *spine fractures* (S22.0 Fracture of the thoracic spine, S22.1 Multiple fractures of the thoracic spine, S32.0 Fracture of the lumbar spine, S32.7 Multiple fractures of the lumbar spine, and S32.8 Other fractures of the lumbar spine), *fractures of the distal radius* (S52.5 Fracture of the distal radius and S52.6 Combined fracture of the distal radius/ulna), and *fractures of the proximal humerus* (S42.2 Fracture of the proximal humerus).

Data processing/outcomes

The absolute number of hospitalized MOF (hip, spine, distal radius, and proximal humerus fractures) was calculated for each year, by sex and 10-year age groups from age 45 onwards. Where appropriate (i.e., before year 2010), the absolute numbers were extrapolated linearly to 100%. Crude (unadjusted) incidence rates were calculated as the number of cases per 100,000 person-years. As first suggested by Lewinnek [22] and in order to adjust for age-dependent population shifts over time in a rapidly aging society, age-standardized incidence rates and incidence rate ratios with corresponding 95% confidence intervals were calculated using 1998 as the reference year. For a given year, the age-standardized incidence rate is the summary rate that would be observed, given the single age-specific rates in that year, in a population with the age composition of the reference population (here 1998). Thus, age-standardization allows populations with different age structures to be compared. After verifying that the residuals were randomly distributed around the fitted regression line, a linear regression model was used to test for time trends with the age-standardized annual incidence as a dependent variable and the calendar year as a predictor, a two-tailed $p < 0.05$ was considered significant. In addition, the mean length of stay was calculated for each fracture category, by year and sex. Finally, the median age at admission for hip fracture was calculated by year and sex. All calculations were performed using the StatsDirect statistical software, version 3.3.5 developed by Statsdirect Ltd, Birkenhead, Merseyside, UK.

Results

Hospitalizations for major osteoporotic fractures — cases

Between 1998 and 2018, the number of hospitalized MOF in patients aged 45 years or older increased from 4483 to 7542 (+68.2%) and from 13,242 to 19,362 (+46.2%) in men (Fig. 1a) and women (Fig. 1b), respectively. Hip fractures increased more in men from 2478 to 3517 (+41.9%) as compared to women from 7512 to 8322 (+10.8%) within the same period of time. Corresponding percent increases for spine, proximal humerus, and distal radius fractures were 69.4%, 90.2%, and 176.1% in men and 70.2%, 66.5%, and 127.7% in women, respectively. The associated increasing trends over 21 years were statistically significant for all fractures taken individually in both sexes with a p value for trend < 0.001 at the exception of hip fractures in women ($p = 0.046$).

Hospitalizations for major osteoporotic fractures — age-standardized incidences and trends

Between 1998 and 2018, the number of people aged 45 years or older increased from 1.3 to 1.9 million (+47.0%) in men and from 1.5 to 2.1 million (+36.0%) in women. Especially the oldest age groups have grown considerably, with almost a doubling of the men aged 85 + and an increase of almost 50% of the women belonging to this age group (Fig. 2). Thus, in this context of a rapidly ageing society, the calculation of annual age-standardized incidences, adjusting for the changing age profiles and using 1998 as the reference year, is warranted.

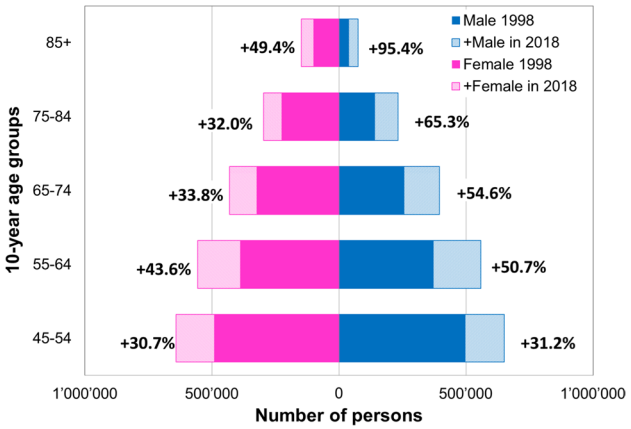

Fig. 2 Age pyramid of persons aged 45 years or more living in Switzerland in 2018 compared with 1998. The increment (+Male and +Female in the legend) is shown in lighter color

In men, as shown in Table 1, the age-standardized incidence for hospitalizations for MOF increased from 344 (95%CI 334–354) to 364 (356–372) per 100,000 person-years (+5.7%, two-tailed $p = 0.002$ for trend) between 1998 and 2018. As shown in Fig. 3a, this overall finding summarizes a significant decrease in the incidence of hip fractures (from 190 in 1998 to 161 in 2018, −15.3%, p value for trend < 0.001) and significant increases in the incidence of hospitalizations for fractures of the spine (from 71 to 77, +7.7%, $p < 0.001$), proximal humerus (from 46 to 58, +24.4%, $p < 0.001$), and distal radius (from 36 to 68, +89%, $p < 0.001$). Using 1998 as the reference year, the corresponding incidence rate ratios (95%CI) in year 2018 were 1.06 (1.02–1.10) for MOF, 0.85 (0.80–0.89) for hip fractures, and 1.08 (0.99–1.17), 1.24 (1.30–1.37), and 1.89 (1.70–2.10) for fractures of the spine, proximal humerus, and distal radius, respectively.

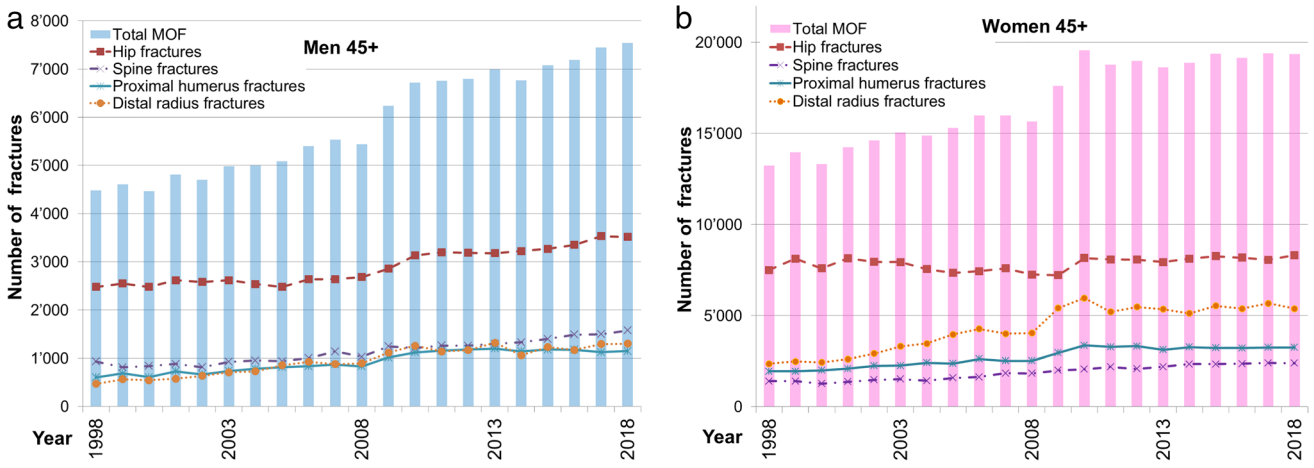

Fig. 1 Absolute number of hospitalizations (cases) for major osteoporotic fractures in men (**a**) and women (**b**) aged 45 years or older between 1998 and 2018 in Switzerland

Table 1 Age-standardized incidences of major osteoporotic fractures in men and women aged 45 years or older per 100,000 person-years (95% confidence intervals) — Reference year 1998

Men 45 +	**1998 (Ref)**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Total MOF	**344 (334–354)**	**347 (337–357)**	**334 (324–343)**	**353 (343–363)**	**339 (329–349)**	**351 (341–360)**	**345 (335–354)**	**342 (333–351)**	**354 (345–364)**	**353 (344–362)**	**338 (329–347)**
Hip fractures	190 (183–198)	192 (184–199)	185 (178–192)	192 (184–199)	186 (179–193)	183 (176–190)	174 (167–181)	165 (159–172)	171 (164–177)	166 (160–172)	163 (157–170)
Spine fractures	71 (67–76)	61 (57–65)	63 (58–67)	65 (61–69)	59 (55–63)	65 (61–70)	66 (62–70)	63 (59–68)	66 (62–70)	74 (69–78)	65 (61–69)
Prox. humerus fractures	46 (43–50)	52 (48–55)	45 (42–49)	54 (50–58)	48 (44–52)	52 (48–56)	53 (50–57)	55 (51–59)	55 (51–59)	56 (52–60)	52 (49–56)
Distal radius fractures	36 (33–39)	43 (39–46)	41 (37–44)	42 (39–46)	46 (42–50)	50 (47–54)	51 (47–54)	58 (54–62)	62 (48–66)	57 (54–61)	57 (53–61)
Men 45 +	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	
Total MOF	**378 (368–387)**	**394 (385–404)**	**386 (377–395)**	**378 (369–387)**	**379 (370–388)**	**357 (348–365)**	**366 (357–375)**	**362 (353–370)**	**368 (360–376)**	**364 (356–372)**	
Hip fractures	169 (163–176)	180 (174–186)	179 (172–189)	173 (167–179)	167 (161–173)	165 (159–170)	163 (158–169)	162 (157–168)	167 (161–172)	161 (156–166)	
Spine fractures	76 (72–81)	72 (68–76)	73 (69–77)	71 (67–75)	71 (67–75)	71 (67–75)	73 (69–77)	76 (72–80)	75 (71–79)	77 (73–81)	
Prox. humerus fractures	62 (59–66)	67 (63–71)	67 (63–71)	67 (63–71)	66 (62–70)	62 (58–65)	63 (59–66)	61 (57–64)	58 (54–61)	58 (54–61)	
Distal radius fractures	69 (65–74)	76 (71–80)	67 (63–71)	67 (64–71)	75 (71–79)	59 (55–62)	67 (63–71)	63 (59–66)	69 (65–72)	68 (65–72)	
Women 45 +	**1998 (Ref)**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Total MOF	**870 (855–885)**	**906 (891–921)**	**859 (844–873)**	**907 (892–922)**	**921 (906–936)**	**928 (913–949)**	**907 (893–921)**	**917 (902–931)**	**940 (925–954)**	**920 (906–934)**	**884 (871–898)**
Hip fractures	494 (482–505)	527 (515–538)	490 (479–501)	520 (509–531)	503 (492–514)	490 (480–501)	462 (451–472)	441 (431–451)	436 (427–446)	435 (425–445)	407 (397–416)
Spine fractures	93 (88–98)	91 (86–100)	82 (77–86)	87 (83–92)	93 (89–98)	94 (89–99)	87 (82–91)	95 (90–99)	97 (92–101)	107 (102–111)	104 (99–109)
Prox. humerus fractures	128 (123–134)	126 (121–132)	129 (123–135)	133 (128–139)	142 (136–147)	139 (134–145)	147 (141–153)	143 (137–148)	154 (149–160)	146 (140–152)	144 (138–149)
Distal radius fractures	155 (149–162)	161 (155–168)	158 (151–164)	167 (160–173)	183 (177–190)	204 (197–211)	211 (204–218)	238 (231–246)	252 (245–260)	232 (225–239)	230 (223–237)
Women 45 +	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	
Total MOF	**976 (962–991)**	**1068 (1053–1083)**	**1004 (990–1018)**	**999 (985–1013)**	**964 (950–977)**	**957 (944–971)**	**967 (953–980)**	**937 (924–950)**	**933 (920–946)**	**914 (902–927)**	
Hip fractures	396 (387–405)	443 (434–453)	429 (420–439)	422 (413–431)	407 (399–416)	408 (400–417)	409 (400–417)	396 (387–404)	383 (375–391)	387 (379–396)	
Spine fractures	111 (106–116)	113 (108–118)	117 (112–122)	110 (106–115)	114 (110–119)	120 (115–125)	117 (113–122)	116 (112–121)	116 (112–121)	114 (110–119)	
Prox. humerus fractures	165 (159–171)	185 (178–191)	177 (171–183)	176 (170–182)	163 (157–169)	167 (161–173)	162 (157–168)	158 (153–164)	158 (152–163)	155 (150–160)	
Distal radius fractures	303 (295–311)	327 (319–335)	280 (273–288)	290 (282–297)	279 (271–286)	262 (255–269)	279 (271–287)	266 (259–273)	276 (269–283)	258 (251–265)	

Bold entries correspond to the two lines in the table which are the sum of the four following lines for men and women

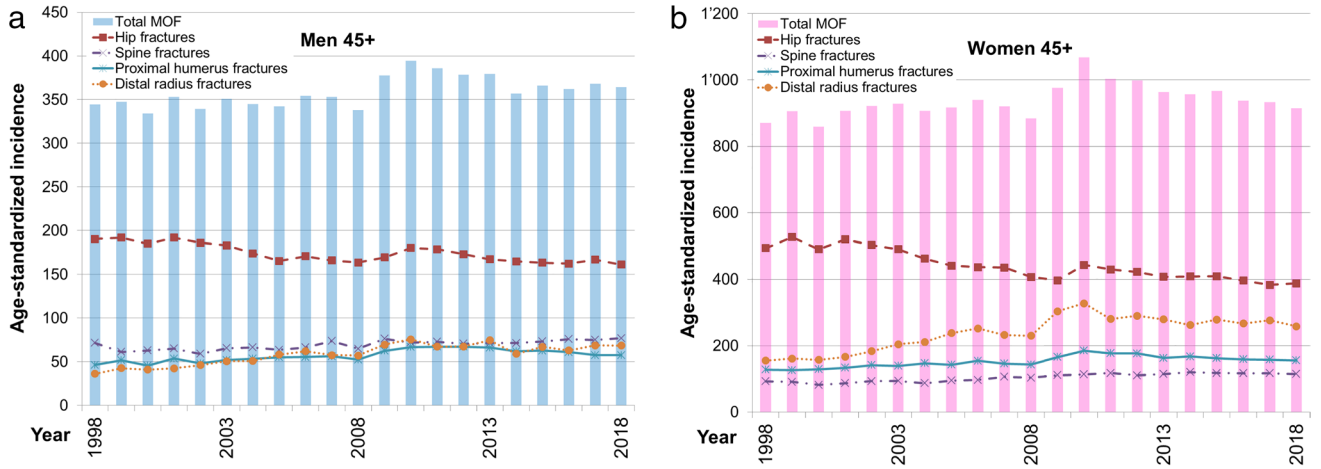

Fig. 3 Age-standardized incidence of hospitalizations for major osteoporotic fractures (MOF) and fractures of the hip, spine, proximal humerus, and distal radius per 100,000 person-years between 1998 and 2018 in men (**a**) and women (**b**) aged 45 years or older

In women, a more pronounced pattern was observed, as shown in Table 1 and Fig. 3b. The age-standardized incidence for hospitalizations for MOF increased from 870 (95%CI 855–885) in year 1998 to 914 (902–927) in year 2018, + 5.1% (two-tailed p value for trend = 0.018). The incidence of hip fractures decreased significantly from 494 to 387, corresponding to a 21.5% decrease ($p < 0.001$), while the incidence of hospitalizations for spine, proximal humerus, and distal radius fractures increased significantly by 23.2%, 21.0%, and 65.9%, respectively ($p < 0.001$ for all). With 1998 as the reference year, the corresponding incidence rate ratios (95%CI) in 2018 were 1.05 (1.03–1.07) for MOF, 0.78 (0.76–0.81) for hip fractures and 1.23 (1.15–1.32), 1.21 (1.14–1.28), and 1.66 (1.58–1.74) for spine, proximal humerus, and distal radius fractures, respectively.

Changes in crude incidences of hospitalizations for fracture by age groups

The crude incidences of hospitalizations for MOF by 10-year age groups are shown in Fig. 4a and b for men and women, respectively. Between 1998 and 2018, the crude incidence of hospitalizations for MOF increased significantly in men in each of the three groups between 45 and 74 years of age (p values for trend ranging from < 0.001 to 0.003), but trends in the two older age groups (75–84 years and 85 + years) were not significant. In women, the incidence of hospitalizations for MOF increased significantly in the three groups of 45–74 years of age ($p < 0.001$ for all), decreased significantly in the age group of 75–84 years ($p = 0.007$), and decreased only numerically

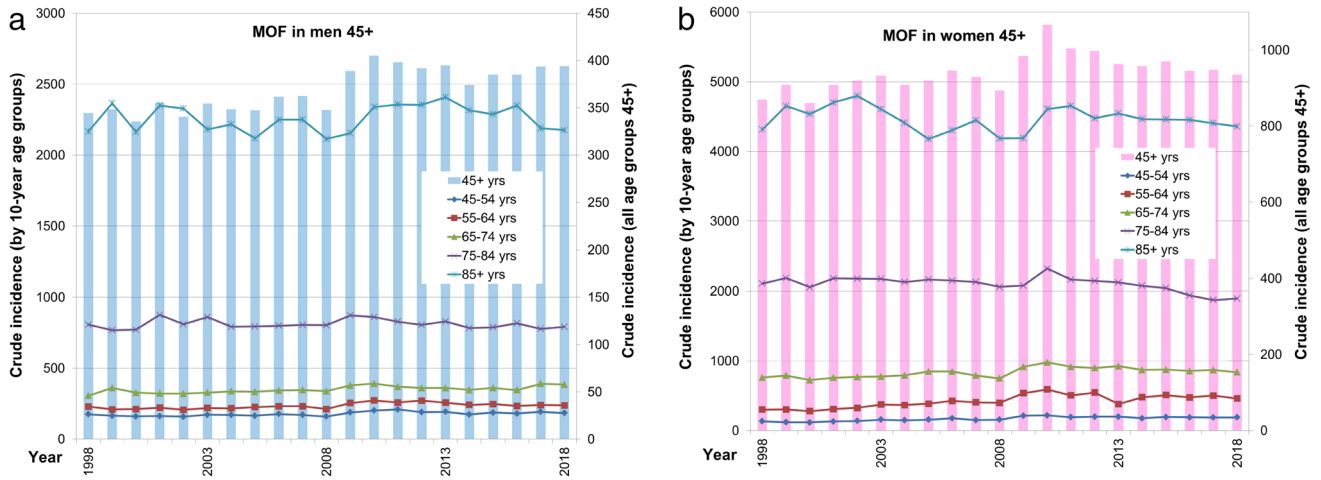

Fig. 4 Crude incidence of hospitalizations for MOF per 100′000 person-years between 1998 and 2018 in men (**a**) and women (**b**) aged 45 years or older. Lines refer to individual 10-year age groups (left vertical axis); bars refer to all aged 45 years and older (right vertical axis)

in the oldest old aged 85 + years without reaching statistical significance.

The crude incidences of hospitalizations for hip fractures in men and women are shown by 10-year age groups in Fig. 5a and b, respectively. In men, the crude incidence trend was negative (i.e., decreasing) and reached statistical significance in all age groups, except the 65–74 year-old. In women, a similar albeit more pronounced decreasing trend was observed and reached statistical significance in all age groups.

By contrast, the pooled incidence for any non-hip MOF (spine, proximal humerus, distal radius fractures) increased significantly between 1998 and 2018 in all age groups and in both sexes ($p < 0.001$ for all).

Length of stay

In men, the number of acute hospitalization days for MOF decreased over the 21 years of observation, from 73,103 in 1998 to 64,086 in 2018 (− 12.3% vs. 1998, − 0.7%/year). Such a decrease was seen for hip fractures (from 46,561 to 40,009 days, − 14.1%), spine fractures (from 14,432 to 12,522, − 13.2%), and fractures of the proximal humerus (from 8889 to 7384, − 16.9%) but not for fractures of the distal radius (from 3222 to 4171, + 29.4%).

Even more pronounced changes were observed in women for whom acute hospital days for MOF decreased from 223,684 in year 1998 to 156,827 in year 2018 (− 29.9%, − 2.3%/year). In-hospital days decreased for hip fractures (from 149,294 to 92,111, − 38.3%), spine fractures (from 23,497 to 21,614, − 8.0%), fractures of the proximal humerus (from 31,048 to 24,560, − 20.9%), and fractures of the distal radius (from 19,844 to 18,542, − 6.6%).

The mean length of acute hospital stay for MOF decreased from 16.3 to 8.5 days in men and from 16.9 to 8.1 days in women, having been approximately halved in 21 years. The mean length of stay for hip fractures decreased from 18.8 to 11.4 days in men and from 19.9 to 11.1 days in women. Corresponding reductions in the mean length of hospital stay went from 15.5 to 7.9 days in men and 16.6 to 9.0 days in women for spine fractures; from 14.7 to 6.4 days in men and from 15.9 to 7.6 days in women for fractures of the proximal humerus; from 6.8 to 3.2 days in men and from 8.4 to 3.4 days in women for fractures of the distal radius. The mean length of stay decreased steadily for all fractures, year over year, with no acceleration or deceleration between 1998 and 2018.

Median age at admission for hip fracture

The median age at admission for hip fracture increased between 1998 and 2018 in both sexes, by overall 3 years in men and 2 years in women. In men, age at admission was 77.0 years in 1998, increased to 78.0 years in 1999–2000, reached 79.0 years in 2001–2005, and finally plateaued at 80.0 years in 2006–2018. In women, age at admission was 83.0 years in 1998–2005, increased to 84.0 years in 2006–2015, and reached 85.0 years during 2016–2018.

Discussion

This long term (21 years) retrospective analysis of acute hospitalizations for major osteoporotic fractures revealed that the absolute number of hospitalizations for any MOF (hip, spine, proximal humerus, and distal radius fractures) has considerably increased in both sexes, more so in men

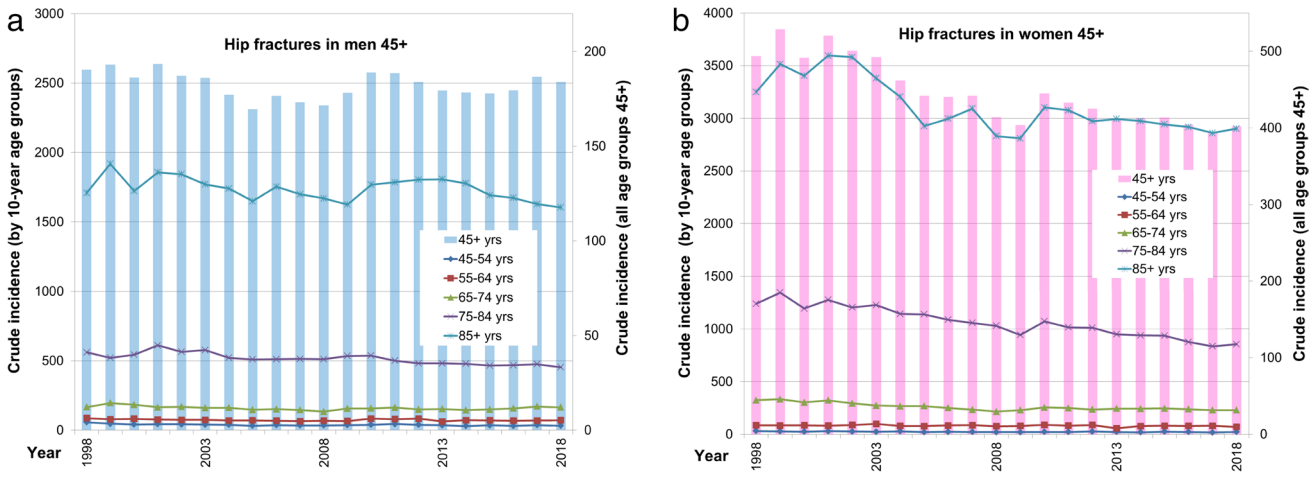

Fig. 5 Crude incidence of hospitalizations for hip fractures per 100,000 person-years between 1998 and 2018 in men (**a**) and women (**b**) aged 45 years or older. Lines refer to individual 10-year age groups (left vertical axis); bars refer to all aged 45 years and older (right vertical axis)

(+68%) than in women (+46%). However, after adjustment for age, the incidence of hospitalization for MOF had increased by only 5% (5.7% in men and 5.1% in women). This consolidated finding is the aggregate of two opposite trends: a marked decrease in the age-standardized incidence of hospitalizations for hip fracture and a strong increase in hospitalizations for non-hip fractures, at all ages and in both sexes. However, the reduction in hip fracture hospitalizations was more pronounced in older women and younger men, while the increase in non-hip MOF was predominantly observed in younger women and older men. Finally, the mean length of acute hospital stays for any MOF was approximately halved throughout all different fracture types and in both sexes.

Over the past 21 years, the number of hospitalizations for MOF has continuously increased in Switzerland, which is consistent with the projected rapid expansion of the elderly population. Nevertheless, even after correction for age, the overall incidence of hospitalization for MOF has increased in both sexes, more so in men than in women. An analysis of the German National Hospital Discharge Registry between 2002 and 2017 also reported similar increases in hospitalizations for lower and upper extremity fractures. While most of the hospitalizations occurred in women, the larger increases over time were seen in men. Unfortunately, age-standardized incidences were not reported, precluding further comparisons [12, 23].

A more in-depth analysis unveiled that while the age-standardized incidence of hospitalizations for hip fractures had decreased in both sexes (by − 15% in men and − 22% in women), hospitalizations for the pooled non-hip MOF (spine, proximal humerus, and distal radius fractures) had increased by 32% in men and 40% in women. While hip fractures were and still are always hospitalized, hospitalizations for non-hip MOF do only reflect the tip of the iceberg. In a nationwide Swiss population survey conducted between 2004 and 2006, it was estimated that 29% of the vertebral fragility fractures, 28% of the distal radius fractures, and 42% of the proximal humerus fractures led to subsequent hospitalization in men with corresponding percentages of 22%, 34%, and 53% in women, respectively [24, 25]. However, these percentages should be considered with caution when considering that the duration of observation was 21 years. Patient preferences may have changed over time, including based on systemic incentives such as reimbursement conditions. Progress and innovation in anesthesia and orthopaedic methods may also have led to preferring surgical fracture treatment approaches over conservative options. While we are not aware of such progresses regarding fractures of the distal radius or the proximal humerus, traumatic but also osteoporotic spine fractures are increasingly treated by balloon kyphoplasty [26]. The SFSO database used for the present analysis does not include the surgical procedures undertaken after the indexed fractures preventing a more in depth analysis. Of note, of all non-hip fractures, the number of hospitalizations for spine fractures increased far less than for the two typical upper limb fractures.

In January 2009, a new tariff system based on diagnosis-related groups (DRG) was introduced in Switzerland with full implementation in 2012. In contrast to the former system in which the amount paid for by the health insurance was closely linked to the duration of hospitalization, the DRG system is a standardized diagnosis- and case-based payment for inpatient care based on flat rates for medical and surgical procedures. Such a system change may have desired and undesired effects. The DRG system imposes specific minimal and maximal hospitalization durations for each coded diagnosis and procedure, such that shorter or longer hospitalizations come at a financial loss for the hospital. As a consequence, acute hospitals may tend to shorten the hospital stay towards the lower end of the time range by discharging patients as early as possible to maximize profits. During the period covered by the present analysis, acute hospitalization duration has been more than halved for non-hip MOF and slightly less than halved for hip fractures. An analysis by discharge status could not be performed but would help shedding light on whether the shortened acute hospitalization durations have resulted in true cost reduction or in cost reallocation to rehabilitation clinics. While the DRG system may have contributed to the observed reductions in length of hospital stay and to the preferential hospitalization of non-hip fractures in younger patients, the observed trend was sustained and almost linear, i.e., without acceleration or deceleration, since 1998 through 2018.

In Switzerland, antiresorptive drugs proven to reduce fracture risk in clinical fracture trials are available since 1996 (bisphosphonates followed by denosumab in 2010) [27, 28]. However, reimbursement of these drugs is limited to patients with a DXA T-score at or below − 2.5 or having presented one or more prior fragility fractures. In practice, most of the patients treated in Switzerland are 65 to 90 years old women, men representing only approximately 10 to 20% of all patients, which is consistent with the observations made in many other industrialized countries [24, 29, 30]. Furthermore, an important treatment gap was reported; i.e., many patients at inacceptable fracture risk still remain untreated. The latter was estimated in year 2010 at 36% and 58% in men and women, respectively [16]. In the core population having reimbursed access to antiresorptive treatment in Switzerland, important reductions in hip fracture incidence were observed in women aged 65–84 and to a far lesser extent in men of the same age group. This may be interpreted as a direct consequence of the strong focus on treating osteoporosis in women, still perceived as a women's rather than a men's disease. Furthermore, of all three non-hip fractures constitutive of MOF, the lowest increase in hospitalization

incidence was seen for vertebral fractures which would also be consistent with the effects of antiresorptives in terms of fracture risk reduction. Finally, fractures of the distal radius occur early in the course of osteoporosis and are typically referred to as index or early sentinel fractures. These are inaugural to a strongly increased risk for subsequent osteoporotic fractures [31]. In the present analysis, the risk of hospitalization for fractures of the distal radius was significantly increased in women, possibly indicative of a higher occurrence as we are not aware of progresses in orthopedic surgery that would justify a higher hospitalization rate today than twenty years ago. By contrast, hip fracture incidence in women has decreased significantly over the 21 years of observation. Considering that patients often get access to osteoporosis treatment only after having suffered an index fracture, the prevalence of osteoporosis may be increasing although hospitalizations for hip fractures are decreasing.

The Swiss population belongs to the oldest worldwide and life expectancy at birth has further increased over the past two decades. The latter was 77 years in year 2000 and 81 years in years 2020 (+4 years) in men. Corresponding numbers for women are 83 and 85 years (+2 years) [32]. As shown in the present analysis, the median age at admission for hip fracture was 77 years in 1998 and 80 years in 2018 (+3 years) for men. Corresponding numbers for women were 83 and 85 years (+2 years). Thus, both life expectancy and age at admission for hip fracture have increased over the past 20 years, more so in men than in women. This is consistent with the decrease in hip fracture incidence observed in both sexes. It also raises the important and growingly urgent need for evidence-based interventions aimed at preventing hip fractures in the oldest old.

The present study has some strengths and limitations. It is one of the very few studies reporting the epidemiology of MOF with a high level of granularity and internal consistency. Only hospitalized MOFs are reported. While this may be considered an acceptable surrogate for hip fractures, it should not for non-hip MOF: most spine fractures are paucisymptomatic and/or do not lead to hospitalizations; most fractures of the upper extremity (wrist, radius, and humerus) undergo ambulatory/conservative treatment. This study was limited to the acute care setting as post-acute care data were not available. Whether shorter acute care stays resulted in longer inpatient rehabilitation stays deserves further research. In the light of the potential externalities that may influence the decision of hospitalization, including the tariff system as detailed above, new prospective studies are warranted. These should aim at assessing the percentage of inpatient vs. ambulatory care by fracture type to get a better estimate of the total number of fractures.

In conclusion, the number of hospitalizations for MOF has increased in Switzerland between 1998 and 2018, more so in men than in women. The age-standardized incidences of hip and non-hip MOF followed opposite trends, with decreasing hospitalizations for hip fractures, more so in women than in men, and increasing hospitalizations for non-hip fractures, more so in men than in women.

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Declarations

Ethics approval Not required by Swiss law for database analyses without individual patient data.

Consent to participate Not applicable.

Consent for publication All authors have made substantial contributions to conception and design (KL, GR) and/or analysis and interpretation of the data (KL, GR, AKS, PS) and/or important contributions to the manuscript (KL, GR, OB). All authors have seen and approved the final version of the manuscript.

Conflict of interest None (AKS, OB, GR, PS). KL has served as an expert in advisory board meetings of Amgen Switzerland AG and UCB Pharma AG Switzerland.

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