Post-Fracture Care and Predictors of Anti-Osteoporotic Treatment in Switzerland: A Nationwide Health Claims Analysis

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Data Sharing

Data can only be made available as de-identified and aggregated results, and only upon approval from the Board of the Swiss Osteoporosis Registry Association and Helsana.

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1. Abstract

Mini Abstract: This retrospective study using Swiss health insurance claims data found that 88% of hip and 77% of vertebral fracture patients did not receive osteoporosis treatment within 6 months post-fracture.

Purpose: The treatment gap in osteoporosis in Switzerland has previously been estimated at 83% based on T-scores and/or FRAX thresholds. However, real-world data on treatment rates following fractures remain limited. This study analysed treatment rates and their predictors in hospitalised patients aged ≥ 50 years with recent vertebral, hip, or other fractures, and the associated direct economic burden.

Methods: This retrospective cohort study utilised claims data from the largest Swiss health insurance provider. The incidence of vertebral, hip, and other fractures was assessed by age and gender, and treatment rates and predictors of anti-osteoporotic therapies at 12 months post-fracture were analysed. Additionally, hospitalisation duration, associated costs and care trajectories (nursing home placement, rehabilitation, home care services) were described for each fracture site, as well as mortality within 12 and 24 months post-fracture.

Results: From 2021 to 2023, there were 2,458 vertebral, 6,229 hip and 11,314 non-hip, non-vertebral fractures (59%, 70% and 74% in women, respectively). Inpatient rehabilitation was required in 8–11% of cases, and 18–21% of patients newly transitioned to nursing home placement within 3 months post-fracture. DXA scans were performed within 12 months in 10% of hip and 21% of vertebral fracture patients and represented the strongest predictor of treatment initiation (odds ratio 10.2, 9.1–11.5), with female sex, older age and greater comorbidity showing weaker effects. Treatment rates within 6 months post-fracture were 11.7% for hip fractures

(including 5.0% denosumab, 2.6% zoledronate, 2.1% alendronate), 23% for vertebral fractures (including 9.4% denosumab, 4.7% zoledronate, 3.6% ibandronate, 2.7% anabolic agents) and 12.5% for other fractures, with 8%, 13% and 11% of patients, respectively, already receiving osteoporosis therapy prior to the fracture.

Conclusion: Osteoporosis treatment rates after hip and vertebral fractures were low, with 88% and 77% of patients, respectively, not receiving treatment within 6 months. DXA scans, specialist consultations, and comorbidity burden were the strongest predictors of post-fracture treatment, highlighting key patient- and system-level factors that could guide interventions to close the treatment gap.

2. Introduction

In Switzerland, approximately 50% of women and 20% of men aged > 50 years experience a fragility fracture during their lifetime [1]. Thus, Switzerland has one of the highest prevalences and annual incidences of osteoporosis compared to other European countries, while access to dual-energy X-ray absorptiometry (DXA) evaluation is good and fracture-related mortality is low [2], [3]. Among all fragility fractures, hip fractures are associated with the highest burden in terms of complications, mortality and healthcare costs. However, any fragility fracture, regardless of its location, is associated with an increased risk of subsequent fractures [4]. Therefore, most clinical guidelines, including those in Switzerland, recommend fracture risk assessment following a fragility fracture, and anti-osteoporotic treatment is strongly advised, particularly after vertebral and hip fractures [5], [6]. Switzerland has one of the oldest populations globally, and life expectancy at birth has continued to rise over the past two decades, reaching 82.2 years for men and 85.8 years for women in 2023 [7]. At the same time, the number of hospitalisations for major osteoporotic fractures (MOF) (hip, clinical spine, forearm, humerus) has increased significantly, exceeding what would be expected from demographic ageing alone. This rise has been primarily driven by an increased incidence of non-hip fractures, although the incidence of hip fractures has declined over time in both sexes, more markedly in women than in men [8]. Fragility fractures are associated with substantial direct and indirect costs, including expenses related to hospitalisations and surgical interventions, as well as long-term costs due to disability and loss of quality-adjusted life years (QALYs). The SCOPE (Scorecard for Osteoporosis in Europe) review assessed these costs across 27 European Union countries, along with the United Kingdom and Switzerland [2]. However, the estimates for Switzerland were

generated using modelling approaches that relied on data from literature dating back to 2010 [9]. To accurately determine the true treatment gap—defined as the proportion of individuals at risk of fragility fractures who exceed the intervention threshold but remain untreated—and to evaluate the cost-effectiveness of strategies aimed at closing this gap (e.g., secondary fracture prevention through coordinated post-fracture care initiatives), it is essential to have real-world data on fracture-related costs and care trajectories. Therefore, this study used claims data from a major healthcare insurer in Switzerland to analyse osteoporosis treatment rates and their predictors in individuals aged ≥50 years with recent vertebral, hip or other fragility fractures, assess the associated economic impact and analyse subsequent care trajectories.

3. Methods

3.1. Data source

Health insurance is mandatory in Switzerland, and all residents are continuously covered, although individuals may switch insurers each year. Thus, healthcare claims data provide a reliable and representative source for population-level analyses. This study used data from one of the largest health insurance providers in the country, the Helsana Group, covering approximately 1.3 million individuals representing 15% of the Swiss population (2023). The claims data include comprehensive information on the sociodemographic attributes of the insured individuals, as well as outpatient and inpatient health services covered by mandatory health insurance. For this study, only data from hospitalised patients were available and considered. Inpatient diagnoses were classified according to ICD-10 codes, while procedure codes adhered to the Swiss Classification of Surgical Interventions (CHOP). Dispensed medications in the outpatient setting were identified using the Anatomical Therapeutic Chemical (ATC) classification system, as defined by the World Health Organization. Comorbidities were assessed in two ways: first, using a standardised chronic condition classification system, with Pharmaceutical Cost Groups (PCGs) as previously described [10]. Assignment to a PCG is based on specific medications prescribed in the year prior to the fracture hospitalisation. Second, the Charlson Comorbidity Index, a validated measure of comorbidity severity in hospitalised patients based on ICD-10 coded diagnoses [11], was assessed; higher scores indicate greater risk of complications or mortality, and this index applies to a single inpatient episode, in our case to the fracture hospitalisation.

For the main analyses, data from January 1, 2021, to December 31, 2023, were analysed, as pandemic-related changes in Switzerland had largely stabilised by that

time. All hospitalisations related to fractures were extracted, along with relevant inpatient and outpatient care trajectories recorded during the 3 months following discharge. DXA scans and treatment rates were evaluated 12 months before fracture, as well as at 6 and 12 months after fracture, while mortality was assessed at 12 and 24 months. In addition, treatment rates by fracture site and sex were examined for the period 2013–2023 to assess trends over the previous decade. Accident-related fractures, such as those resulting from high-energy trauma, were not captured in the available health insurance data, as these cases are covered by accident insurance. According to our estimations, these accident-related fractures account for approximately 10% of all fractures in women and 15% in men.

3.2. Data processing and outcomes

Inclusion criteria were: (1) insured persons aged ≥ 50 years and (2) inpatient stays with a primary or secondary diagnosis (ICD-10) of hip, spine or other fractures between 2021 and 2023. Fracture diagnoses were classified as follows: hip (S72.0, S72.1, S72.2), spine (S22.0, S22.1, S32.0) and other fractures, including the following: humerus/shoulder (S422, S423, S424, S428, S429); radius and ulna (S520, S521, S522, S523, S524, S527, S528, S529); wrist (S525, S526); forearm (S620, S621); pelvic (S321, S322, S323, S324, S325); tibia, fibula and knee (S820, S821, S822, S823, S824, S825, S826); and sternum, clavicle and ribs (S222, S223, S420). Cases involving combinations of fractures were also included.

In the case of vertebral fractures, vertebroplasty (CHOP code 7A43) and kyphoplasty (CHOP code 7A44) procedures were considered in the cost analysis if performed within 3 months after or during the index hospitalisation. Prescribed medications considered within 6 and 12 months of a fracture diagnosis included alendronate (ATC M05BA04), risedronate (ATC M05BA07), ibandronate (ATC M05BA06), raloxifene

(ATC G03XC01), denosumab (ATC M05BX04), zoledronate (ATC M05BA08), teriparatide (ATC H05AA02) and romosozumab (ATC M05BX06). Outpatient consultations, inpatient stays, home care services and laboratory services were assessed for 3 months after hospital discharge**.** General internal medicine consultations also included patients in nursing homes. To calculate mean and median inpatient hospitalisation durations and costs (including the initial fracture hospitalisation, any re-hospitalisations, rehabilitation stays and nursing home stays) during the 3 months following a fracture, only patients with an actual stay were included. Similarly, only those receiving home care services, laboratory services, DXA scans and medications were included for cost calculations following fracture. For calculating the mean and median number of outpatient consultations and inpatient stays, all patients/cases were considered, regardless of whether they received the services. For assessing health services following a fracture inpatient stay (i.e., during the 3 or 6 months after discharge), only patients whose insurance coverage extended throughout the entire follow-up period were considered (except for calculating mortality rates).

3.3. Statistical analysis

For descriptive analyses, percentages were reported for categorical variables, while means and medians were calculated for continuous variables. Chi-square tests were performed for the statistical comparisons of proportions, and the Holm method was applied to adjust p-values for multiple comparisons.

A multivariable logistic regression analysis was used to identify predictors of osteoporosis treatment following fracture (data 2021–2023). Patients were excluded if they lacked continuous insurance coverage throughout the 12-month follow-up period due to death or insurance provider changes. The dataset was randomly split

into training (75%) and test (25%) sets, stratified by outcome. The model was trained on the training set, validated on the test set using the area under the curve and Brier score and refitted on the full dataset. Multicollinearity was assessed using generalised variance inflation factors, and sensitivity analyses excluding potentially collinear variables (ATC codes, PCGs, Charlson Comorbidity Index) and prior treatment did not alter the results. Odds ratios (ORs) and 95% confidence intervals were derived from the model, and average marginal effects were computed to estimate population-averaged adjusted differences in treatment probability.

To statistically assess changes in treatment probability over time (2013–2023), we conducted multivariable logistic regression analyses with post-fracture treatment status (yes/no) as the dependent variable, using the same set of predictors as described above, but additionally including year as a categorical predictor with the pre-defined contrasts. Separate models were fitted for each fracture type. Calendar year was modelled as a categorical variable in the regression analysis using pre-defined contrasts (2022–2023 vs. 2019–2021; 2019–2021 vs. 2016–2018; 2016–2018 vs. 2013–2015), and as a continuous variable in a sensitivity analysis.

All statistical analyses were performed using the R programming language (R Core Team 2025). As only anonymised and de-identified data were analysed, approval from an ethics committee was not required.

4. Results

4.1. Patient demographics, hospitalisation durations and costs across fracture sites

A total of 6,229 hip fracture patients (70% female, mean age 84 years), 2,458 vertebral fracture patients (59% female, mean age 80 years) and 11,314 patients with other fractures (74% female, mean age 78 years) were hospitalised between January 1, 2021, and December 31, 2023. Further details on age and sex distribution are provided in **Figure 1**. Fracture was listed as the primary diagnosis in 89% of hip fractures, 56% of vertebral fractures and 73% of other fractures, and was the secondary diagnosis in the remaining cases. The mean hospitalisation duration was 12 days for hip fractures, 11 days for vertebral fractures, and 9 days for other fractures. Corresponding mean costs covered by mandatory health insurance were 8,702 CHF, 7,247 CHF and 5,989 CHF. In Switzerland, health insurers cover 45% of hospitalisation costs, while the remaining 55% are borne by the cantons. Consequently, the actual costs are more than twice those reported above. Overall, 74–80% of patients lived in the German-speaking region, 11–17% in the French-speaking region and 7–9% in the Italian- or Romansh-speaking region, with 68–70% residing in urban areas. Comorbidities were common and are summarised in **Suppl. Table 1** according to PCGs and Charlson Comorbidity Scores. Briefly, 70–80% of patients across all fracture sites had cardiovascular diseases. Dementia was present in 9–12% of patients, and cancer in 3–6%. Rheumatic diseases were recorded in 27–37% of patients, and diabetes in 14–19%.

4.2. Care trajectories and services following fractures

Care trajectories and services following fractures are listed in **Table 1**. Outpatient care within 3 months was common, with around 70% of patients across all groups

seeing a general internal medicine provider. Hospital outpatient visits were even more frequent—over 80% for most groups. However, specialist consultations were rare: only 1–3% of patients had contact with rheumatologists, and a similar proportion with endocrinologists or diabetologists. In Switzerland, these are the only specialists who can prescribe anabolic agents such as teriparatide or romosozumab. Re-hospitalisation within 3 months occurred in 28% of vertebral fracture patients (the highest), compared with 20% in hip and 18% in other fractures. Hospitalisation durations averaged 13–16 days and mean costs ranged from ~8,300 to ~9,900 CHF. Rehabilitation stays were relatively infrequent: 11% for hip, 10.5% for vertebral, 7.6% for other and 15% for combined fractures. Inpatient rehabilitation durations averaged 26–33 days, with mean costs ranging from ~8,000 CHF (hip) to ~11,800 CHF (combined). On the other hand, nursing home admissions (both permanent and transient) were common, particularly in hip (44%) and combined (45%) fracture patients. Even after excluding prior residents, approximately 21% of hip and vertebral fracture patients and 18% of other fracture patients required new institutional placements. The associated costs for the health insurer ranged from 4,000 to 5,500 CHF within 3 months post-fracture; however, as with hospitalisations, part of the total costs was borne by the municipalities and cantons. Home care services were used by 38–43% of patients across all groups, with mean costs of ~1,800–2,100 CHF. Lab services were used by 58–68% of patients, with consistent average total costs of ~250–300 CHF within 3 months after discharge. DXA scans were rarely performed: at 6 months, only 7% of hip fracture patients and 7% of other fracture patients had a scan, compared with 17% of vertebral fracture patients. By 12 months, these rates increased slightly (hip, 10%; vertebral, 21%; other, 11%) but were still low. Scans within the preceding 12 months of fracture admission were low, with rates between

3.3% and 5.3%. In Switzerland, the cost of a DXA scan is relatively low, typically around 50 CHF per examination.

4.3. Estimation of the direct economic burden of fractures

When considering the entire 3-month post-fracture trajectory—including hospitalisations (adjusted to reflect 100% of costs, i.e., insurer plus cantonal share), re-hospitalisations, rehabilitation, institutional placements, home care, outpatient consultations and laboratory and DXA services—the total mean cost per patient was markedly higher than hospitalisation costs alone: approximately 40,000–42,000 CHF for hip fractures, 34,000–36,000 CHF for vertebral fractures and 28,000–30,000 CHF for other fractures.

4.4. Treatment rates and mortality after fractures

Medication treatment rates within 6 months post-fracture were generally low: 11.7% of hip fracture patients received at least one osteoporosis medication, with denosumab (5.0%), zoledronate (2.6%) and alendronate (2.1%) being the most commonly prescribed (**Figure 2**). In patients with clinical vertebral fractures, the overall treatment rate was higher at 23%: 9.4% received denosumab, 4.7% zoledronate, 3.6% ibandronate and 2.7% anabolic agents. For non-hip, non-vertebral fractures, the overall treatment rate was 12.4% (**Suppl. Table 2**). On the other hand, 8% of hip, 13% of vertebral and 11% of other fracture patients were already on treatment prior to the fracture, making the rate of new treatment initiation even smaller. Additional drug- and gender-specific treatment rates are detailed in **Suppl. Table 3**. In general, medication treatment rates were higher in women than in men. Denosumab generally has high prescription rates in Switzerland, as it is reimbursed both as first- and second-line therapy and as preventive treatment for patients undergoing hormone ablative therapy.

Between 2013 and 2023, treatment rates showed a modest overall increase in both men and women, although in regression analysis this increase was not statistically significant (data not shown), with the most pronounced changes observed in patients with hip and vertebral fractures. In patients with hip fractures, treatment rates increased from 5.9% to 10.6% in men and from 16.4% to 19.7% in women. Among patients with vertebral fractures, treatment rates rose from 14.0% to 20.3% in men and from 31.2% to 37.4% in women. Overall, these findings suggest a gradual increase in post-fracture treatment uptake over the past decade, although this change was not statistically significant (**Figure 3**).

Mortality rates within 12 and 24 months after fracture, stratified by gender and fracture location, are presented in **Figure 4**. Twelve-month mortality rates in women and men were, respectively, 22% and 25% for hip fractures, 15% and 24% for vertebral fractures and 11% and 16% for non-hip, non-vertebral fractures. Mortality rates were consistently and significantly higher in men than in women.

4.5. Predictors of anti-osteoporotic treatment initiation

Differences between treated and untreated patient groups were first examined descriptively in a univariate analysis (**Suppl. Table 4**). In a multivariable regression model, marginal effects were used to estimate population-averaged adjusted differences in the probability of anti-osteoporotic treatment initiation (risk differences). A multivariable regression model identified several factors that increased or decreased the likelihood of treatment, as shown in **Figure 5.** The strongest predictor was a DXA scan before or after the fracture (OR 6.3, 5.4–7.4 and OR 10.2, 9.1–11.5, respectively) and a rheumatology or endocrinology consultation post-fracture (OR 2.2, 1.8–2.7). Other predictors included an existing diagnosis of osteoporosis, higher comorbidity burden and polypharmacy. In contrast, certain comorbidities were

associated with a lower probability of treatment initiation, such as diabetes (OR 0.6, 0.5–0.7), cardiovascular disease (OR 0.7, 0.6–0.8) and dementia (OR 0.9, 0.7 – 0.99). Nursing home residency, either pre- or post-fracture, and post-fracture mortality were also associated with lower treatment probability. Vertebral fractures and multiple fractures—in contrast to hip fractures—were more likely to be treated than other fractures, along with female sex, older age and urban living.

5. Discussion

This study analysed data from Helsana, a large healthcare provider in Switzerland, and found that osteoporosis treatment rates after hip and vertebral fractures were low, with 88% and 77% of patients, respectively, not receiving treatment within 6 months. By 12 months, these rates improved slightly (hip, 84%; vertebral, 70%; other, 83%), but remained low. Given that 8% of hip fracture patients and 13% of vertebral fracture patients were already receiving treatment before the fracture, the number of new treatment initiations post-fracture was even smaller. The majority of treated patients received denosumab, followed by zoledronate and ibandronate, and a minority received anabolic agents (3% of vertebral fracture patients). These findings are consistent with data from other European countries. In Germany, post-hip fracture treatment rates were similarly low, with 11.5% of patients receiving anti-osteoporosis medication within 1 year of the fracture [12]. In Austria, 18% of women and 8% of men received osteoporosis treatment within 4 months after a major osteoporotic fracture [13]. The trend in post-menopausal osteoporosis treatment in France has shown a marked decline, with more than a twofold decrease in the rate of women receiving any anti-osteoporosis medication from 2007 to 2016 [14]. In Switzerland, the overall treatment gap was previously estimated to be 83% in 2019, based on T-scores and/or Fracture Risk Assessment (FRAX) threshold [2], [15]. Further, the number of patients receiving osteoporosis treatments increased steadily beginning in the late 1990s, peaked around 2008, and then gradually declined until 2018. This decline coincided with the introduction of intravenous bisphosphonates and denosumab. Thus, despite broader treatment options, the proportion of untreated individuals at high risk for osteoporotic fractures has remained largely unchanged over the past two decades. A strong, though not necessarily causal,

inverse association was observed between treatment rates and hip fracture incidence [16]. Interestingly, treatment rates following vertebral fractures were nearly twice as high (23%) as those observed after hip fractures (12%). This was somewhat unexpected, as hip fractures are typically considered the most serious type of osteoporotic fracture due to their strong association with both morbidity and excess mortality. Moreover, hip fractures sometimes lead directly to treatment initiation, even without further DXA testing, particularly in the context of fracture liaison services [17]. One possible explanation is that patients with hip fractures are typically older and more frail than those with other types of fractures, making it more challenging to provide them with coordinated post-fracture care. Our data showed that 20–25% of patients with hip fractures and 8–10% of those with vertebral or other fractures were already living in a nursing home at the time of the fracture. Additionally, general practitioners may be hesitant to initiate osteoporosis treatment in this population due to the high competing risk of mortality, which can reduce the perceived benefit of fracture prevention. We found that mortality rates 12 months after a hip fracture were 22% and 25% in women and men, respectively. Mortality was slightly lower following vertebral fractures and significantly lower following other fracture types. These figures are comparable to those reported in other European countries, such as France, the Netherlands and Austria [14], [18], [19]. Finally, new admissions to nursing homes were common, particularly among patients with hip or vertebral fractures, with both groups experiencing rates of 21%. When including individuals who were already residing in a nursing home at the time of their fracture, the overall proportions increased to 44% for hip fracture patients and 29% for those with vertebral fractures. These findings are consistent with previous data from Switzerland [20], [21].

Interestingly, although most patients are seen by a general practitioner within 3 months after a fracture, only a small proportion undergo DXA scanning. While this rate increases slightly by 12 months, it remains low—around 20% for vertebral fractures and 10% for hip and other fractures. Given the good DXA accessibility in Switzerland and the fact that costs are covered post-fracture, the reasons for this gap warrant further investigation. This highlights the potential value of initiating treatment during the hospital stay—for example, administering zoledronate after a hip fracture—which has been shown to be not only cost-effective but also cost-saving [22]. On the other hand, a DXA scan before or after a fracture was the strongest predictor of post-fracture treatment, as previously described [23], [24]. Weaker predictors included female sex, older age, higher comorbidity burden, polypharmacy, fracture type (vertebral or multiple fractures) and consultations with specialists, whereas certain comorbidities, nursing home residency and post-fracture mortality were associated with a lower probability of post-fracture treatment.

A report from 2014 estimated the clinical and economic burden of osteoporosis fractures in Switzerland [9]. It suggested that fragility fractures contributed to an estimated 24,000 QALYs lost per year. Based on 74,000 incident fractures, this corresponds to an average cost of 21,000 CHF per fracture and 0.32 QALYs lost per case. Hip fractures were estimated to incur the highest costs (~33,000 CHF), followed by other (~21,000 CHF), vertebral (~17,000 CHF) and forearm fractures (~9,000 CHF), according to standard cost-weighting models [25]. Our analyses produced higher estimates, highlighting the importance of contemporary data for informing national healthcare planning and evaluating the cost-effectiveness of fracture prevention strategies. Notably, treatment costs, particularly for anabolic agents, remain high. Therefore, identifying patients who benefit most from these

therapies is essential to ensure their cost-effective use within a responsible and sustainable healthcare system [26].

5.1. Limitations and strengths

Our study has several limitations. First, it analysed only fractures that resulted in hospitalisation. Although hip fractures are typically treated in hospital settings, data on non-hip fractures capture only a portion of the total burden of incident fractures. According to a nationwide Swiss population survey, an estimated 22–29% of vertebral fractures, 28–34% of distal radius fractures and 42–53% of proximal humerus fractures led to subsequent hospitalisation [27]. However, in the context of secondary prevention programmes such as Fracture Liaison Services, these are typically the fractures that can be identified and captured. Another limitation is that indirect costs were not captured. These costs—such as lost productivity and increased dependency—are less well studied and vary widely, ranging from 2–50% of total fracture-related costs, depending on the population and methods used. While vertebral fractures in working individuals may result in substantial indirect costs, the majority of fragility fracture patients in Switzerland are elderly and retired, making direct healthcare costs the dominant burden [28], [29]. However, since new nursing home placements were quite common in this analysis, the indirect costs are presumably much higher, as these are permanent cost drivers and only 3 months were captured in our cost model. Finally, accident-related fractures in working individuals, which were estimated by this analysis to represent about 10% of all fractures in women and 15% in men, were not captured in the health insurance data, as they are covered by accident insurance. Likewise, DXA scans performed pre-fracture as preventive examinations—though assumed to be very rare—are not covered by mandatory health insurance and were therefore not part of the data.

Major strengths of the study include the use of a representative dataset, detailed analysis by fracture type, gender and age group, and a focus not only on treatment rates but also on other clinically relevant outcomes, providing a comprehensive picture of the post-fracture burden.

5.2. Conclusion and outlook

In Switzerland, osteoporosis treatment rates after hip and vertebral fractures are low, as demonstrated by this study in which 88% and 77% of patients, respectively, did not receive treatment within 6 months. In addition, fractures are associated with high direct (and indirect) costs, as many patients are re-hospitalised or require rehabilitation, home care services or admission to nursing homes. Notably, mortality rates within 12 months after fractures were high, not only after hip fractures (22–25%) but also after clinical vertebral fractures (14% in women, 24% in men). Performing post-fracture DXA scans was the strongest predictor of post-fracture treatment, highlighting the importance of evaluating the impact of coordinated post-fracture care approaches. Such evidence can help inform policymakers on how best to address the economic and societal burden of fragility fractures.

6. References

[1] Lippuner K, Johansson H, Kanis JA, Rizzoli R (2009) Remaining lifetime and absolute 10-year probabilities of osteoporotic fracture in Swiss men and women. Osteoporosis International. 20(7):1131-40. doi: 10.1007/s00198-008-0779-8.

[2] Kanis JA, Norton N, Harvey NC et al. (2021) SCOPE 2021: a new scorecard for osteoporosis in Europe. Arch Osteoporos, 16(1):82. doi: 10.1007/s11657-020-00871-9.

[3] Willers C, Norton N, Harvey NC et al. (2022) Osteoporosis in Europe: a compendium of country-specific reports," Arch Osteoporos, 26;17(1):23. doi: 10.1007/s11657-021-00969-8.

[4] Lorentzon M, Litsne H, Axelsson KF (2024) The significance of recent fracture location for imminent risk of hip and vertebral fractures—a nationwide cohort study on older adults in Sweden. Osteoporosis International. 35(6):1077-1087. doi: 10.1007/s00198-024-07072-x.

[5] Ferrari S, Everts-Graber J, Meier C (2025), Osteoporosis therapy - Update 2025, Part 1: Antiresorptive and osteoanabolic therapy options], Ther Umsch. ;82(1):26-31. doi: 10.23785/TU.2025.01.006.

[6] Meier C, Everts-Graber J, Ferrari S, (2025) Osteoporosis therapy - Update 2025, Part 2: Sequential osteoporosis therapy, Ther Umsch. 82(1):32-34. doi: 10.23785/TU.2025.01.007.

[7] https://www.bfs.admin.ch/bfs/de/home/statistiken/bevoelkerung/geburten-todesfaelle/lebenserwartung.html. Accessed July 12, 2025.

[8] Lippuner K, Rimmer G, Stuck AK et al. (2022) Hospitalizations for major osteoporotic fractures in Switzerland: a long-term trend analysis between 1998 and 2018, Osteoporosis International, doi: 10.1007/s00198-022-06481-0.

[9] Svedbom A, Ivergård M, Hernlund E, Rizzoli R, Kanis JA (2014) Epidemiology and economic burden of osteoporosis in Switzerland. 9:187.doi: 10.1007/s11657-014-0187-y.

[10] Huber CA, Szucs TD, Rapold R, Reich O (2014) Identifying patients with chronic conditions using pharmacy data in Switzerland: An updated mapping approach to the classification of medications. BMC Public Health 30:13:1030 doi: 10.1186/1471-2458-13-1030.

[11] Charlson ME, Carrozzino D, Guidi J, and Patierno C (2022) Charlson Comorbidity Index: A Critical Review of Clinimetric Properties, Psychother Psychosom 91(1):8-35. doi: 10.1159/000521288.

[12] Sing CW, Lin TC, Bartholomew S et al (2023) Global Epidemiology of Hip Fractures: Secular Trends in Incidence Rate, Post-Fracture Treatment, and All-Cause Mortality. Journal of Bone and Mineral Research. 1064-1075, doi: 10.1002/jbmr.4821.

[13] Malle O, Borgstroem F, Fahrleitner-Pammer A, Svedbom A, Dima SV, Dimai HP (2021) Mind the gap: Incidence of osteoporosis treatment after an osteoporotic fracture – results of the Austrian branch of the International Costs and Utilities Related to Osteoporotic Fractures Study (ICUROS) Bone, 142:115071 doi: 10.1016/j.bone.2019.115071.

[14] Cortet B, Schott AM, Désaméricq G et al (2022) Trends in postmenopausal osteoporosis treatment in France during the period 2007–2016: A nationwide claims database analysis. Bone 154:116255 doi: 10.1016/j.bone.2021.116255.

[15] McCloskey E, Rathi J, Hejimans S et al (2021) The osteoporosis treatment gap in patients at risk of fracture in European primary care: a multi-country cross-sectional observational study," Osteoporosis International, 32(2):251-259, doi: 10.1007/s00198-020-05557-z.

[16] Lippuner K, Moghadam BY and Schwab P (2023) The osteoporosis treatment gap in Switzerland between 1998 and 2018," Arch Osteoporos; 18(1):20., doi: 10.1007/s11657-022-01206-6.

[17] Fan W, Sun X, Leder B et al (2024) Zoledronic acid for hip fracture during initial hospitalization, J Bone Miner Res 39(8):1061-1070. doi: 10.1093/jbmr/zjae101

[18] Brozek W, Reichardt B, Kimgerger O et al (2014) Mortality after hip fracture in Austria 2008-2011," Calcif Tissue Int, 95(3):257-66, doi: 10.1007/s00223-014-9889-9.

[19] Burrack N, Hatfield LA, Bakx P et al., (2023) Variation in care for patients presenting with hip fracture in six high-income countries: A cross-sectional cohort study," J Am Geriatr Soc, ;71(12):3780-3791, doi: 10.1111/jgs.18530.

[20] Pretto M, Spirig R, Kaelin R *et al (2010)* Outcomes of elderly hip fracture patients in the Swiss healthcare system: A survey prior to the implementation of DRGs and prior to the implementation of a Geriatric Fracture Centre," Swiss Med Wkly, 140:w13086. doi: 10.4414/smw.2010.13086.

[21] Bachmann N, Zumbrunn A, and Bayer-Oglesby L (2022) Social and Regional Factors Predict the Likelihood of Admission to a Nursing Home After Acute Hospital Stay in Older People With Chronic Health Conditions: A Multilevel Analysis Using Routinely Collected Hospital and Census Data in Switzerland," Front Public Health, 9:10:871778., doi: 10.3389/fpubh.2022.871778.

[22] Lyles KW, Colon-Emeric C, Magaziner JS et al (2007), Zoledronic Acid and Clinical Fractures and Mortality after Hip Fracture," New England Journal of Medicine, 357(18):1799-809, doi: 10.1056/nejmoa074941.

[23] Walsh M, Nerdrum M, Fahey T, Moriarty F (2021) Factors associated with initiation of bone-health medication among older adults in primary care in Ireland," Age Ageing, 11;50(5):1649-1656. doi: 10.1093/ageing/afab033.

[24] Majumdar S, McAlister FA, Johnson J *et al.* (2014) Critical impact of patient knowledge and bone density testing on starting osteoporosis treatment after fragility fracture: Secondary analyses from two controlled trials," *Osteoporosis International*, 25(9):2173-9. doi: 10.1007/s00198-014-2728-z.

[25] Hernlund E, Swedbom A, Ivergard M et al (2013) Osteoporosis in the European Union: Medical management, epidemiology and economic burden: A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA)," Arch Osteoporos, 8(1):136 doi: 10.1007/s11657-013-0136-1.

[26] Zinger G, Davidson A, Sylvetsky N, Levy Y, Peyser A (2023) Cost Analysis of a Fracture Liaison Service: A Randomized Controlled Trial for the Secondary Prevention After Fragility Fractures of the Hip," Endocrine Practice, 29(10):794-802, doi: 10.1016/j.eprac.2023.07.030.

[27] Suhm N, Lamy O, Lippuner K (2008), Management of fragility fractures in Switzerland: Results of a nationwide survey," Swiss Med Wkly, 138(45-46):674-83, doi: 10.4414/smw.2008.12294.

[28] Ruiz-Adame M and Correa M (2020) A systematic review of the indirect and social costs studies in fragility fractures. Osteoporos int (7):1205-1216 doi: 10.1007/s00198-020-05319-x.

[29] Eekman DA, Ter Wee MM, Coupé V et al (2014) Indirect costs account for half of the total costs of an osteoporotic fracture: A prospective evaluation," Osteoporos Int, 25(1):195-204doi: 10.1007/s00198-013-2505-4.

7. Tables

Table 1: Care trajectories after fractures at 3, 6 and 12 months after discharge.

	Hip N = 6,229	**Vertebral** N = 2,464	**Other** N = 11,318	***Combo** N = 1,116
Insurance Coverage				
Covered 3 m after Discharge, n (%)	5,148 (82.6%)	2,142 (87.1%)	10,368 (91.6%)	904 (81.1%)
Covered 6 m after Discharge, n (%)	4,876 (78.3%)	2,036 (82.8%)	10,045 (88.8%)	859 (77%)
Covered 12 m after Discharge, n (%)	4,444 (71.3%)	1,890 (76.9%)	9,500 (84%)	781 (70%)
Outpatient Consultations (3 months)				
≥ 1 General Internal Medicine Consultations, N (%)	3,665 (71.2%)	1,528 (71.3%)	7,094 (68.4%)	651 (72%)
≥ 1 Rheumatology Consultations, N (%)	88 (1.7%)	77 (3.6%)	263 (2.5%)	16 (1.8%)
≥ 1 Endocrinology/Diabetology Consultations, N (%)	52 (1%)	24 (1.1%)	117 (1.1%)	< 10 (< 1%)
≥ 1 Outpatient Hospital Consultations, N (%)	4,148 (80.6%)	1,695 (79.1%)	8,673 (83.7%)	749 (82.9%)
Re-hospitalisation (3 months)				
≥ 1 Acute Hospital Stays, N (%)	1,030 (20%)	595 (27.8%)	1,863 (18%)	241 (26.7%)
Acute Hospital Stay Length, days (Mean / Median)	13.8 / 10	15.8 / 11	13.5 / 9	13.7 / 9
Acute Hospital Stay Cost (Mean / Median)	8,384 / 6,332	9,873 / 6,472	8,684 / 5,475	9,717 / 6,138
Rehabilitation Stays (3 months)				
≥ 1 Rehabilitation Stays, N (%)	574 (11.1%)	225 (10.5%)	792 (7.6%)	137 (15.2%)
Rehabilitation Stay Length, days (Mean / Median)	26.4 / 21	28.7 / 21	28.6 / 22	33.0 / 28
Rehabilitation Stay Cost (Avg / Median)	7,969 / 6,624	10,475 / 6,768	9,038 / 6,995	11,755 / 8,182
Nursing Home Stays (3 month)				
Nursing Home Residents, Total, N (%)	2,266 (44%)	628 (29.3%)	2,675 (25.8%)	405 (44.8%)
Nursing Home Residents, Post-Fracture Only, N (%)	1,072 (20.8%)	441 (20.6%)	1,818 (17.5%)	245 (27.1%)
Nursing Home Stay, Post-Fracture, (Mean / Median)	76.7 / 90	66.8 / 82	66.5 / 82	68.5 / 80
Nursing Home Costs Post-Fracture (Mean / Median)	5,483 / 5,578	4,036 / 3,782	4,303 / 4,112	4,614 / 4,666
Home Care Services and Laboratory Costs (3 months)				

≥ 1 Home Care Services, N (%)	1,977 (38.4%)	926 (43.2%)	4,182 (40.3%)	376 (41.6%)
Home Care Costs (Mean / Median)	1,918 / 1,145	2,105 / 1,366	18,412 / 1,133	1,751 / 1,073
≥ 1 Laboratory Services, N (%)	3,187 (61.9%)	1,452 (67.8%)	5,980 (57.7%)	571 (63.2%)
Total Laboratory Costs (Mean / Median)	256 / 177	306 / 204	260 / 178	265 / 203
DXA (6 and 12 months)				
≥ 1 DXA Scan, N (%), 12 m before	190 (3.7%)	128 (6%)	552 (5.3%)	50 (5.5%)
≥ 1 DXA Scan, 6 m, N (%)	337 (6.9%)	345 (16.9%)	703 (7%)	63 (7.3%)
DXA Costs, 6 mths (Mean / Median)	50 / 50	50 / 50	50 / 50	50 / 50
≥ 1 DXA Scan, 12 m, N (%)	447 (10.1%)	398 (21.1%)	1,086 (11.4%)	92 (11.8%)
DXA Costs, 12 mths (Mean / Median)	50 / 50	50 / 50	50 / 50	50 / 50
Pre-Fracture Osteoporosis Treatment, N (%) (12 mths)	**497 (8.0%)**	**309 (13%)**	**1,268 (11%)**	**118 (11%)**

Costs are in CHF and rounded to 1 CHF. *Combo: Combination of any of these fractures.

Suppl. Table 1: Comorbidities of patients with hip, vertebral or other fractures

	Hip N = 6,229	**Vertebral** N = 2,464	**Other** N = 11,318	***Combo** N = 1,116
Comorbidities				
No. of PCGs	3.84 (2.17)	4.28 (2.31)	3.46 (2.30)	3.87 (2.25)
(Missing)	67	36	136	10
PCG **Diabetes Mellitus**	999 (16%)	469 (19%)	1,573 (14%)	157 (14%)
(Missing)	67	36	136	10
PCG **Respiratory Diseases**	827 (13%)	431 (18%)	1,647 (15%)	143 (13%)
(Missing)	67	36	136	10
PCG **Cancer**	275 (4.5%)	137 (5.6%)	472 (4.2%)	35 (3.2%)
(Missing)	67	36	136	10
PCG **Cardiovascular Diseases**	4,660 (76%)	1,939 (80%)	7,797 (70%)	850 (77%)
(Missing)	67	36	136	10
PCG **Dementia**	741 (12%)	257 (11%)	996 (8.9%)	133 (12%)
(Missing)	67	36	136	10
PCG **Parkinson's Disease**	434 (7.0%)	163 (6.7%)	550 (4.9%)	77 (7.0%)
(Missing)	67	36	136	10
PCG **Pain**	2,724 (44%)	1,249 (51%)	4,221 (38%)	496 (45%)
(Missing)	67	36	136	10
PCG **Rheumatic Diseases**	1,636 (27%)	891 (37%)	3,170 (28%)	336 (30%)
(Missing)	67	36	136	10
Charlson Comorbidity Index (CCI)				
0	2,330 (37%)	1,031 (42%)	6,178 (55%)	457 (41%)
1	1,617 (26%)	534 (22%)	2,221 (20%)	258 (23%)
2–3	1,516 (24%)	540 (22%)	1,935 (17%)	247 (22%)
4–6	568 (9.1%)	244 (9.9%)	697 (6.2%)	111 (10.0%)
> 6	196 (3.1%)	113 (4.6%)	283 (2.5%)	40 (3.6%)

Data are presented as n (%). PCG: Pharmaceutical Cost Group. *Combo: Combination of any of these fractures.

Suppl. Table 2. Treatment rates within 6 months after hip, vertebral, other or a combination of these fractures.

Medications (within 6 and 12 months)	Hip N = 6,229		Vertebral N = 2,464		Other N = 11,318		*Combo N = 1,116	
	6 m	12 m	6 m	12 m	6 m	12 m	6 m	12 m
≥ 1 Alendronate (%)	2.1	2.5	3.5	4.6	2.1	2.6	2.6	3.3
Alendronate Cost (Mean)	137	237	139	212	138	220	114	183
≥ 1 Risedronate (%)	0.1	0.1	0.1	0.1	0.1	0.2	0	0
Risedronate Cost (Mean)	186	251	113	151	132	218	0	0
≥ 1 Ibandronate (%)	1.6	2.1	3.6	4.3	2.5	3.2	2.8	3.3
Ibandronate Cost (Mean)	112	181	111	187	114	186	106	177
≥ 1 Raloxifene (%)	0.1	0.1	0	0.1	0.1	0.1	0	0
Raloxifene Cost (Mean)	176	385	0	107	189	275	0	0
≥ 1 Denosumab (%)	5	6.6	9.4	13	5.2	6.7	8	10.8
Denosumab Cost (Mean)	340	533	407	654	361	566	326	497
≥ 1 Zoledronate (%)	2.6	4.8	4.7	7.1	2.1	4.2	3	6.1
Zoledronate Cost (Mean)	295	300	276	296	281	299	285	287
≥ 1 Teriparatide (%)	0.5	0.7	2	2.6	0.4	0.7	1.4	1.7
Teriparatide Cost (Mean)	2,399	3,430	1,421	2,668	1,674	2,669	1,391	2,903
≥ 1 Romosozumab (%)	0.2	0.3	0.7	1.2	0.3	0.4	0.6	0.9
Romosozumab Cost (Mean)	1,910	3,474	2,063	3,986	1,984	3,499	1,176	3,581

Costs are in CHF and rounded to 1 CHF. *Combo: Combination of any of these fractures.

Suppl. Table 3: Prescription rates by gender and fracture type

	Hip		Vertebral		Other		*Combo	
	Male	Female	Male	Female	Male	Female	Male	Female
Any Medication (6 m)	7.71%	13.30%	14.68%	27.89 %	4.96 %	14.88 %	15.90%	18.58 %
Any Medication (12 m)	10.54%	18.71%	21.61%	35.27 %	7.02 %	20.11 %	21.32%	25.62 %
Risedronate (6 m)	0.22%	0.03%	0.00%	0.16%	0.00 %	0.16%	0.00%	0.00%
Risedronate (12 m)	0.24%	0.06%	0.00%	0.17%	0.04 %	0.19%	0.00%	0.00%
Alendronate (6 m)	1.66%	2.21%	2.75%	4.01%	1.26 %	2.39%	3.18%	2.26%
Alendronate (12 m)	2.25%	2.66%	3.80%	4.98%	1.45 %	2.95%	3.88%	3.06%
Ibandronate (6 m)	0.43%	2.01%	1.57%	4.79%	0.89 %	2.97%	2.12%	3.13%
Ibandronate (12 m)	0.48%	2.69%	2.19%	5.56%	0.96 %	3.85%	2.71%	3.63%
Zoledronate (6 m)	2.09%	2.84%	4.19%	4.95%	1.18 %	2.37%	3.18%	2.95%
Zoledronate (12 m)	3.54%	5.34%	7.15%	7.14%	2.54 %	4.78%	5.81%	6.31%
Raloxifene (6 m)	0.00%	0.11%	0.00%	0.00%	0.00 %	0.09%	0.00%	0.00%
Raloxifene (12 m)	0.00%	0.12%	0.00%	0.08%	0.00 %	0.14%	0.00%	0.00%
Denosumab (6 m)	2.95%	5.76%	4.98%	12.02 %	1.59 %	6.39%	6.71%	8.68%
Denosumab (12 m)	3.54%	7.84%	8.03%	15.85 %	2.06 %	8.17%	8.14%	12.05 %
Teriparatide (6 m)	0.58%	0.40%	1.05%	2.51%	0.08 %	0.57%	0.71%	1.74%
Teriparatide (12 m)	0.88%	0.56%	1.31%	3.40%	0.18 %	0.80%	1.16%	1.91%
Romosozumab (6 m)	0.00%	0.23%	0.39%	0.86%	0.04 %	0.33%	0.00%	0.87%
Romosozumab (12 m)	0.00%	0.37%	0.73%	1.41%	0.04 %	0.55%	0.00%	1.34%

Suppl. Table 4: Differences between treated and untreated patient groups (12 months post-fracture)

Variable	**Overall** N = 16,617 (100%)[1]	**Not Treated** N = 13,511 (81%)[1]	**Treated** N = 3,106 (19%)[1]	**p-value**[2]
Sex				< 0.001
Male	4,465 (27%)	3,970 (29%)	495 (16%)	
Female	12,152 (73%)	9,541 (71%)	2,611 (84%)	
Age	80 (72, 87)	80 (72, 87)	80 (74, 86)	0.2
Age Category (years)				< 0.001
50–59	871 (5.2%)	779 (5.8%)	92 (3.0%)	
60–69	2,360 (14%)	1,994 (15%)	366 (12%)	
70–79	4,739 (29%)	3,751 (28%)	988 (32%)	
80–89	6,102 (37%)	4,828 (36%)	1,274 (41%)	
Language Region				0.084
German	12,668 (76%)	10,289 (76%)	2,379 (77%)	
French	2,551 (15%)	2,056 (15%)	495 (16%)	
Italian/Romansh	1,398 (8.4%)	1,166 (8.6%)	232 (7.5%)	
Location				< 0.001
Rural	2,059 (12%)	1,741 (13%)	318 (10%)	
Intermediate	3,125 (19%)	2,625 (19%)	500 (16%)	
Urban	11,433 (69%)	9,145 (68%)	2,288 (74%)	
Fracture Type				< 0.001
Other	9,502 (57%)	7,891 (58%)	1,611 (52%)	
Hip	4,442 (27%)	3,713 (27%)	729 (23%)	
Spine	1,892 (11%)	1,314 (9.7%)	578 (19%)	
Combo	781 (4.7%)	593 (4.4%)	188 (6.1%)	
Fracture, Hip	4,798 (29%)	3,992 (30%)	806 (26%)	< 0.001
Fracture, Spine	2,369 (14%)	1,667 (12%)	702 (23%)	< 0.001
Fracture, Other	10,239 (62%)	8,452 (63%)	1,787 (58%)	< 0.001
DXA (Pre-Fx 12 m)	870 (5.2%)	410 (3.0%)	460 (15%)	< 0.001
DXA (Post-Fx 12 m)	2,025 (12%)	893 (6.6%)	1,132 (36%)	< 0.001
Osteoporosis Diagnosis (M80/ M81/M82)	3,109 (19%)	1,875 (14%)	1,234 (40%)	< 0.001
Pre-Fracture Osteoporosis Treatment (12 m)	1,777 (11%)	333 (2.5%)	1,444 (46%)	< 0.001
PCG Diabetes	2,384 (15%)	1,988 (15%)	396 (13%)	0.004
PCG Cardiovascular	11,667 (71%)	9,405 (70%)	2,262 (73%)	< 0.001
PCG Dementia	1,574 (9.6%)	1,241 (9.3%)	333 (11%)	0.010
PCG Rheumatic Disease	4,790 (29%)	3,660 (27%)	1,130 (37%)	< 0.001
PCG Parkinson	895 (5.4%)	705 (5.3%)	190 (6.2%)	0.049
PCG Cancer	615 (3.7%)	456 (3.4%)	159 (5.2%)	< 0.001
PCG Pain	6,300 (38%)	4,857 (36%)	1,443 (47%)	< 0.001
PCG Respiratory	2,291 (14%)	1,789 (13%)	502 (16%)	< 0.001
No. of PCGs	3.0 (2.0, 5.0)	3.0 (2.0, 5.0)	4.0 (2.0, 6.0)	< 0.001
Charlson Comorbidity Index (CCI	0.0 (0.0, 1.0)	0.0 (0.0, 1.0)	0.0 (0.0, 2.0)	0.5
CCI Category				
0	8,958 (54%)	7,278 (54%)	1,680 (54%)	
1	3,538 (21%)	2,927 (22%)	611 (20%)	
2–3	2,902 (17%)	2,327 (17%)	575 (19%)	
4–6	938 (5.6%)	759 (5.6%)	179 (5.8%)	
> 6	281 (1.7%)	220 (1.6%)	61 (2.0%)	

CCI: Dementia	1,810 (11%)	1,550 (11%)	260 (8.4%)	< 0.001
CCI: Rheumatology	412 (2.5%)	267 (2.0%)	145 (4.7%)	< 0.001
Nursing Home (pre-Fx 3 m)	1,914 (12%)	1,670 (12%)	244 (7.9%)	< 0.001
Nursing Home (only post-Fx 3 m)	2,973 (18%)	2,448 (18%)	525 (17%)	0.11
Number of Drugs (post-Fx 12 m)				< 0.001
0–5	1,225 (7.4%)	1,136 (8.4%)	89 (2.9%)	
6–10	2,409 (14%)	2,067 (15%)	342 (11%)	
11–19	6,246 (38%)	5,163 (38%)	1,083 (35%)	
20–30	4,974 (30%)	3,855 (29%)	1,119 (36%)	
> 30	1,763 (11%)	1,290 (9.5%)	473 (15%)	
Mortality (within 12–24 m post-Fx)	1,837 (11%)	1,583 (12%)	254 (8.2%)	< 0.001
Contact GP (post-Fx 3 m)	11,388 (69%)	9,177 (68%)	2,211 (71%)	< 0.001
Contact Rheumatology/Endocrinology (post-Fx 3 m)	578 (3.5%)	314 (2.3%)	264 (8.5%)	< 0.001
Rehabilitation (post-Fx 3 m)	532 (3.2%)	416 (3.1%)	116 (3.7%)	0.061
Home Care (post-Fx 3 m)	6,737 (41%)	5,272 (39%)	1,465 (47%)	< 0.001

[1] n (%); Median (IQR) [2] Pearson's Chi-squared test; Wilcoxon rank sum test; Fisher's exact test.

Abbreviations: CCI: Charlson Comorbidity Index, DXA: dual-energy X-ray absorptiometry, Fx: Fracture, m: months, GP: general practitioner, PCG: Pharmaceutical Cost Group

8. Legends

Figure 1: Gender and age distributions of vertebral, hip and other fractures

Gender and age distributions of patients aged > 50 years with hip (B), vertebral (C) and other (D) fractures.

Figure 2: Treatment rates (%) within 6 and 12 months after hip, vertebral and other fractures

“Bisphosphonates” include alendronate, risedronate, ibandronate (oral and intravenous) and zoledronic acid. “SERM” refers to raloxifene. “Anabolic agents” include teriparatide and romosozumab. "Other fractures" comprise all non-hip, non-vertebral fracture types. “Any medication” includes all osteoporosis-related medications (alendronate, risedronate, ibandronate, raloxifene, denosumab, zoledronate, teriparatide, romosozumab).

Figure 3: Treatment rates after hip, vertebral and other fractures over 10 years

Treatment rates after hip (A), vertebral (B) and other (C) fractures by sex from 2013 to 2023. Percentages represent the proportions of patients receiving any osteoporosis medication within 12 months post-fracture, with Wald confidence intervals.

Figure 4: Mortality rates at 12 and 24 months post-fracture by sex and fracture type

Mortality rates by fracture type and sex at 12 and 24 months post-fracture. Comparisons were made using Pearson’s chi-squared test. * indicates $p < 0.05$; *** indicates $p < 0.001$; p-values adjusted for multiple testing using the Holm method.

Figure 5: Predictors of anti-osteoporotic treatment initiation post-fracture

Left: population-averaged adjusted risk differences (absolute change in predicted treatment probability). Right: corresponding odds ratios (ORs), 95% confidence intervals (CIs), and p-values from the multivariable logistic regression. Model performance: on the test data set, including 75% of data, the model showed an area under the curve of 0.84 and a Brier score of 0.11.