CLINICAL

Economic Burden of Osteoporotic Fractures in US Managed Care Enrollees

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ABSTRACT

OBJECTIVES: To examine healthcare resource utilization (HRU) and costs in a population of managed care enrollees who experienced an osteoporotic fracture.

STUDY DESIGN: Retrospective cohort study using the Optum Research Database (January 2007 to May 2017).

METHODS: All-cause and osteoporosis-related HRU and costs were analyzed in patients 50 years and older with a qualifying index fracture and continuous enrollment with medical and pharmacy benefits for 12 months preindex (baseline period).

RESULTS: Of 1,841,263 patients with fractures during the identification period, 302,772 met eligibility criteria. Two-thirds (66.6%) were 65 years and older, 71.6% were women, and 41.2% were commercial (not Medicare Advantage) enrollees. The most common fracture sites were spine (21.9%), radius/ulna (19.5%), and hip (13.7%). Mean (SD) total all-cause healthcare cost was $34,855 ($56,094), with most paid by health plans ($31,863 [$55,025]) versus patients ($2992 [$2935]). Most healthcare costs were for medical ($31,766 [$54,943]) versus pharmacy ($3089 [$6799]) services. Approximately 75% of patients received rehabilitation services (mean [SD] cost = $18,025 [$41,318]). Diagnosis of index fracture during an inpatient stay versus an outpatient visit (cost ratio, 2.16; 95% CI, 2.13-2.19) and fractures at multiple sites (cost ratio, 1.23; 95% CI, 1.21-1.26) were the leading predictors of cost. Kaplan-Meier estimated cumulative second-fracture rates were 6.6% at 1 year, 12.3% at 2 years, 16.9% at 3 years, and 20.9% at 4 years after index fracture.

CONCLUSIONS: These findings suggest a significant economic burden associated with fractures, including a high total all-cause cost of care. Early identification and treatment of patients at high risk of fractures are of paramount importance to reduce fracture risk and associated healthcare costs.

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Osteoporosis is characterized by compromised bone strength due to loss of bone mass and deterioration of bone quality, resulting in increased fracture risk.[1] Based on 2005-2010 National Health and Nutrition Examination Survey (NHANES) data, an estimated 10.2 million adults 50 years and older in the United States have osteoporosis.[2] Fracture Risk Assessment Tool–based estimates of the 10-year probability of hip and major osteoporotic fractures from an evaluation of 2013-2014 NHANES data indicate that 18.9% of adults 50 years and older (24.7% of women and 12.9% of men) are at a 3% or greater 10-year risk of hip fracture and 8.3% (14.1% of women and 2.2% of men) are at a 20% or greater 10-year risk of major osteoporotic fractures.[3] The number of older adults with osteoporosis is projected to increase by more than 30% between 2010 and 2030, based on population estimates and aging of the US population.[2]

Globally in both men and women, osteoporosis and osteoporotic fractures are important public health concerns because of related morbidity and mortality,[4,5] diminished health-related quality of life,[6,7] and associated costs.[8] In women, osteoporotic fractures account for more hospitalizations than myocardial infarction, stroke, or breast cancer (individually) and are more costly than breast cancer in aggregate.[8] Between 2006 and 2025, annual osteoporotic fracture events and costs for both men and women in the United States are projected to grow by more than 48%.[9]

There are a limited number of studies on the cost of illness associated with osteoporotic fractures.[8,10-16] More recent data help inform payer evidence requirements and help in the allocation of scarce healthcare resources. The current study used recent data through 2017 to estimate costs across care settings for both commercial and Medicare Advantage health plan members using the same methodology. The current study was undertaken to examine healthcare resource utilization (HRU) and costs related to office visits, outpatient visits, emergency department (ED) visits, acute hospital stays, long-term care, and pharmacy claims among patients who experienced an osteoporotic fracture in the year following the index fracture to better understand osteoporotic fracture costs from the payer and patient perspective. Appropriate management of chronic conditions improves overall health and reduces associated healthcare costs. Many patients who incur a fragility fracture also have existing comorbid conditions (ie, chronic obstructive pulmonary disease, heart failure), which can destabilize after fracture, leading to worse long-term outcomes. Therefore, the proposed study evaluated all-cause and osteoporosis-related HRU and costs.

TAKEAWAY POINTS

This retrospective database study identified increased healthcare resource utilization and significant economic burden for both all-cause and osteoporosis-related healthcare costs during the 12 months following index fracture. These findings highlight the need for effective fracture prevention strategies in patients at high risk of fracture.

- In the 12 months following a fracture, all-cause healthcare costs exceeded $30,000, of which an average of $3000 was paid by the patient.
- In this sample, 6.6% of patients with a fracture had at least 1 additional fracture within 12 months of index fracture, with cumulative incidence increasing to 20.9% after 4 years.
- The current findings suggest a need for better management of fragility fractures to reduce osteoporosis cost of illness.

METHODS

Data Source

This retrospective cohort study used a database of administrative medical and pharmacy claims and enrollment information available to Optum. The study included commercial and Medicare Advantage health plan members with evidence of a case-qualifying fracture between January 1, 2007, and May 31, 2017 (identification period). As of 2017, the database included data for approximately 66.3 million individuals and an additional 7.4 million (10%) Medicare Advantage enrollees. Both types of health plans have a wide geographic distribution across the United States. Data were maintained in a deidentified manner, thus were not subject to institutional review board review, and were accessed following protocols compliant with the Health Insurance Portability and Accountability Act. Optum analyzed the data. The funding organization authors participated in drafting the protocol, review and interpretation of results, and drafting and review of the publications prior to submission in collaboration with Optum and coauthors.

Patient Selection

Patients with a fragility or osteoporosis-related fracture during the identification period were selected for the study if they were at least 50 years old (increasing the likelihood that fractures were osteoporosis related) as of the index date. The index date was defined as the first fracture claim during the identification period after continuous enrollment in a commercial or Medicare Advantage health plan with medical and pharmacy benefits for 1 year (preindex period). Patients with Paget disease or malignancy (except nonmelanoma skin cancer) at baseline or during the first month of follow-up were excluded.

Fractures, including pathologic ones, were considered case-qualifying if they occurred during an inpatient stay (in any position on the medical claim) or during an outpatient visit with a repair procedure code, based on a primary or secondary *International Classification of Diseases, Ninth Revision* or *Tenth Revision* code listed on the same claim. For spine fractures, noninpatient claims also needed to be accompanied by a claim for imaging test(s) within 30 days of the diagnostic claim. For each fracture site, case-qualifying fracture diagnoses, non–case-qualifying fracture diagnoses, and aftercare codes were used for site-specific fracture episodes and continued until a gap of at least 90 days was observed between consecutive claims related to the specific fracture site. Case-qualifying fracture diagnoses at the same site that occurred after a gap of at least 90 days were used to identify subsequent incident fractures at that same site. This algorithm was run to identify fracture episodes for each of the 9 sites (spine, pelvis, shoulder, radius/ulna, carpal/wrist, hip, femur, tibia/fibula, ankle) and multiple sites. The index date was considered the start of the earliest episode. Up to 2 episodes were identified for each fracture site; subsequent fractures at the same site beyond the second were not included in the analysis. Because some fractures at different sites could come to clinical attention before others that happened simultaneously, all episodes that started within 30 days of the index date were considered part of the initial event and defined as *fracture at multiple sites*. Episodes that started more than 30 days after the index date at a different fracture site were considered subsequent fractures. This approach has been shown in validation studies to have high accuracy, with a positive predictive value that exceeds 90%.[17]

Patient Characteristics

Patient characteristics at the preindex date (baseline) were collected, including demographic and clinical characteristics. In addition, the anatomical site of index fracture and the setting where the fracture was diagnosed (inpatient/outpatient) were noted. Comorbidity scores were calculated per the Quan-Charlson Comorbidity Index (CCI) using diagnosis codes in the preindex period and categorized as 0, 1 to 2, 3 to 4, and 5 or more.[18]

Preindex use of oral corticosteroids (OCS) was assessed. Only OCS prescriptions (cortisone acetate, oral hydrocortisone, prednisone, methylprednisolone, dexamethasone, and betamethasone) received through the pharmacy were included. Claims for OCS were converted to prednisone equivalent dose, and the average daily dose was calculated in the 6-month preindex period as the total OCS dose of all OCS claims filled in the 6-month period divided by 182 days. Patients were classified per dosage received (0 mg [no use], >0-<7.5 mg/day, or ≥7.5 mg/day).

Outcome Measures

HRU. Patient HRU and costs were calculated overall and by patient cohorts based on type of insurance (commercial or Medicare) for

TABLE 1. Baseline Patient Characteristics

	Overall (N = 302,772)
Age in years, mean (SD)	70.74 (11.28)
Age group in years, n (%)	
<65	101,079 (33.4)
≥65	201,693 (66.6)
Gender, n (%)	
Female	216,680 (71.6)
Male	86,092 (28.4)
Insurance type, n (%)	
Commercial	124,788 (41.2)
Medicare Advantage	177,984 (58.8)
Region, n (%)	
Northeast	42,615 (14.1)
South	123,575 (40.8)
Midwest	98,572 (32.6)
West	37,957 (12.5)
Other	53 (0.02)
Osteoporosis diagnosis and treatment status, n (%)	
Not diagnosed and not treated	240,412 (79.4)
Diagnosed but not treated	27,992 (9.2)
Not diagnosed but treated	14,045 (4.6)
Diagnosed and treated	20,323 (6.7)
Quan-Charlson Comorbidity Index score, n (%)	
0	163,064 (53.9)
1-2	92,867 (30.7)
3-4	35,162 (11.6)
≥5	11,679 (3.9)

patients with at least 12 months follow-up post index fracture. All-cause and osteoporosis-related HRU were calculated for office, outpatient, and ED visits and included acute hospital stays (including transfers between hospitals) and long-term care. Rehabilitation care was included in all-cause HRU (spanning all sites of care) and was calculated separately. HRU was classified as osteoporosis related if there was a diagnosis of osteoporosis, fracture, or aftercare of fracture on the medical claim. For acute inpatient stays and long-term care, counts represented the total number of days of service.

Healthcare costs. All-cause and osteoporosis-related healthcare costs were computed for patients with at least 12 months follow-up post index fracture as the total amounts paid by the health plan and patient. Costs were deemed attributable to osteoporosis if the claim had a diagnosis for osteoporosis, fracture, or aftercare of fracture or was a pharmacy or medical claim for an osteoporosis treatment. Diagnoses of osteoporosis, fracture, and aftercare could occur in any position on the medical claim.

Payments were estimated based on coordination-of-benefits information obtained by the health plan in its usual course of business. This study incorporated the amounts estimated to be paid by other payers for a total paid or allowable amount.[19] For total all-cause and total osteoporosis-related healthcare costs, the amount paid by the health plan and the patient's responsibility were determined. Rehabilitation costs were included as part of the all-cause healthcare costs (but not osteoporosis-related costs) at the site where they were received and were also calculated separately. Costs were adjusted to 2017 US dollars using the annual medical care component of the Consumer Price Index.[20]

The total costs of all osteoporosis-related medications were determined during follow-up. All medications indicated for osteoporosis that could have been administered inpatient or outpatient or filled through pharmacy for self-administration were considered. The total number of days with a claim for rehabilitation was identified during follow-up. The costs of rehabilitation services were identified as the total costs of all medical claims with a rehabilitation code (in any position on the claim).

Additional outcome measures included a second fracture in patients experiencing an index fracture and the time to second fracture.

Statistical Analyses

All study variables were analyzed descriptively. Numbers and percentages are provided for categorical variables. Means, medians, and SDs are provided for continuous variables. Time to second fracture analysis was conducted using the Kaplan-Meier method with percentage estimated at 1, 2, 3, and 4 years after index fracture. The number at risk is based on whether or not an individual had 1, 2, 3, or 4 years of follow-up and did not experience a second fracture. Evaluation of mortality was not in the scope of the current study. In the event of death, follow-up ended on the day that a patient was disenrolled from the plan.

Generalized linear models (GLMs) with a gamma distribution and log link estimating the level of cost were used to assess costs of fractures controlling for demographic characteristics, fracture sites, baseline treatment/diagnosis cohort, comorbidities, medications, OCS use, and bone mineral density (BMD) testing. Independent variables included outpatient versus inpatient claim, medical versus pharmacy services, and Medicare versus commercial insurance. Coefficients from a GLM are estimated cost ratios. Cost ratios, 95% CIs, and *P* values are presented for each covariate included in the final model.

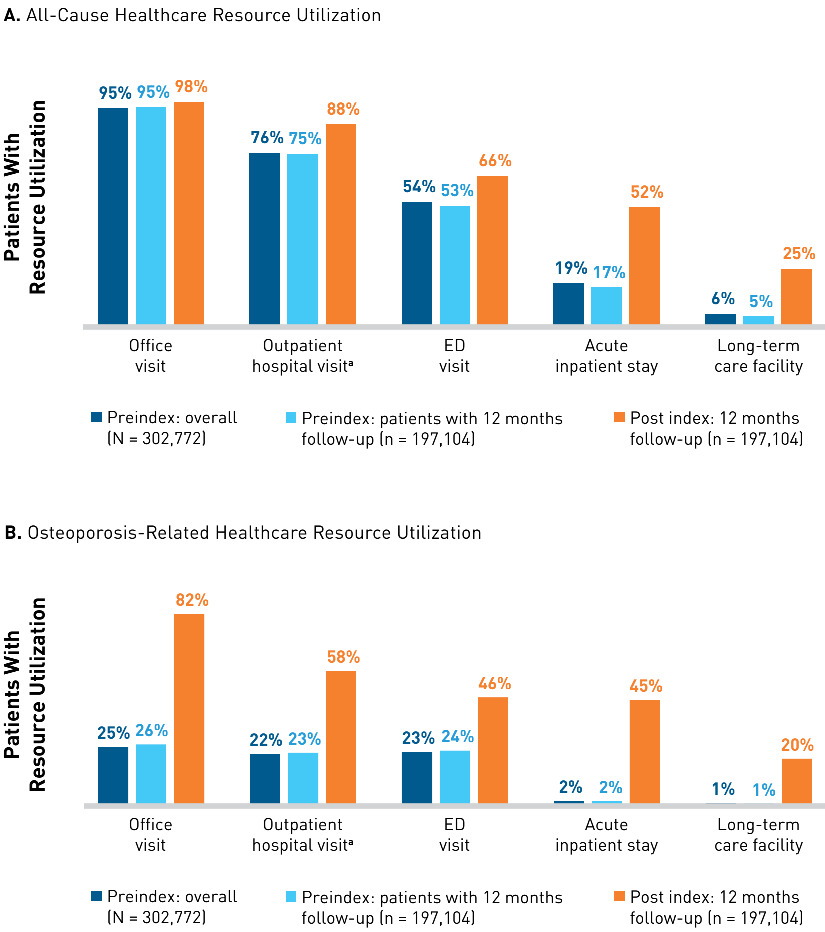
RESULTS

Study Disposition and Baseline Patient Characteristics

Overall, 1,841,263 patients had a diagnosed fracture during the 11-year identification period. More than 500,000 were 50 years and older and met the case-qualifying criteria. A total of 302,772 patients met all the inclusion and exclusion criteria. Almost two-thirds of patients (n = 197,104; 65.1%) had at least 12 months of follow-up. The mean (SD) length of follow-up was 786.7 (735.6) days.

Patient baseline (index fracture date) characteristics are summarized in **Table 1** and **eAppendix Tables 1** and **2** (**eAppendix** available at **ajmc.com**). More than half (58.8%) were covered under a Medicare

FIGURE 1. Healthcare Resource Utilization: Percentage of Patients



ED indicates emergency department.
[a]Outpatient hospital visits consisted of routine outpatient procedures.

Advantage health plan. Most patients (79.4%) had neither a diagnosis of osteoporosis nor treatment for osteoporosis in the 12 months before index fracture.

Approximately 10% of the sample had a BMD test at the 12-month baseline, 13.2% had a BMD test at the 6-month follow-up, and 19.1% had a BMD test at the 12-month follow-up. Baseline BMD testing was most common among patients who had a diagnosis of osteoporosis during the baseline period (diagnosed but not treated, 31.4%; diagnosed and treated, 40.0%). BMD testing was less common among patients who did not have a diagnosis (treated but not diagnosed, 16.9%; not diagnosed and not treated, 4.9%).

The most commonly observed fracture sites were spine (21.9%), radius or ulna (19.5%), and hip (13.7%). Other fracture sites included multiple sites (2 or more of the individual sites listed; 12.4%), shoulder only (11.8%), ankle only (11.8%), tibia/fibula only (3.5%), pelvis only (2.8%), femur only (1.6%), and carpal/wrist only (1.0%).

HRU

There was a trend toward increased all-cause and osteoporosis-related HRU in the year following the index fracture compared with preindex across all care settings (**Figure 1** [A and B]). Overall, HRU counts increased for both all-cause and osteoporosis-related care during 12 months of follow-up (**Table 2**). All-cause healthcare utilization counts were higher for Medicare versus commercial patients both pre- and post index fracture, with the exception of ED visits preindex and office visits post index (Table 2). Osteoporosis-related HRU counts for acute inpatient stays and long-term care were incrementally higher for Medicare versus commercially insured patients preindex, and acute inpatient stays, long-term care, and ED visits were higher post index.

Healthcare Costs

During the preindex period, mean (SD) total all-cause healthcare costs were $16,037 ($37,837) and mean (SD) total osteoporosis-related costs were $1193 ($8028) (**Table 3**). For patients with at least 12 months of follow-up, mean (SD) total all-cause healthcare costs were $34,855 ($56,094) and mean (SD) total osteoporosis-related costs were $19,470 ($36,894). The majority of all-cause healthcare costs were paid by health plans (mean [SD] = $31,863 [$55,025]) versus the patient ($2992 [$2935]) and were for medical services ($31,766 [$54,943]) rather than pharmacy services ($3089 [$6799]). The largest mean (SD) all-cause medical costs incurred were for acute inpatient stays ($16,883 [$40,515]), followed by outpatient hospital visits ($6820 [$21,388]). Approximately 75% of patients received rehabilitation services (either inpatient or "other" [ie, outpatient]) and the mean (SD) costs of rehabilitation among all patients were $18,025 ($41,318). All-cause healthcare costs were lower for Medicare patients compared with commercially insured patients for all categories of care except ED visits and long-term care both pre- and post index fracture (Table 3).

Almost all osteoporosis-related costs after 12 months of follow-up were for medical services (mean [SD] = $19,330 [$36,869]), whereas mean (SD) pharmacy costs were $140 ($1046) when only osteoporosis treatments received at the pharmacy were included (Table 3). When the costs of infused osteoporosis treatments (medication costs only; not including facility or visit costs [eg, chair time, intravenous administration fees]) were included in the treatment cost, the mean (SD) costs increased to $162 ($1072). The largest

TABLE 2. Counts of Healthcare Resources Utilized During the Preindex Period and Over 12 Months of Follow-up

	Entire Patient Cohort			Subgroups by Insurance Type			
	Preindex		Post Index	Preindex (N = 302,772)		Post Index (n = 197,104)	
	Overall Population (N = 302,772)	Patients With ≥12 Months Follow-up (n = 197,104)	Patients With ≥12 Months Follow-up (n = 197,104)	Commercial (n = 124,788)	Medicare (n = 177,984)	Commercial (n = 84,866)	Medicare (n = 112,238)
All-Cause, Mean (SD)							
Office visit,[a] n	12.89 (12.90)	12.95 (12.91)	17.72 (15.51)	12.01 (12.68)	13.51 (13.02)	19.21 (16.24)	16.60 (14.83)
Outpatient hospital visit,[a] n	6.34 (9.61)	6.02 (8.95)	9.00 (10.62)	5.60 (8.20)	6.86 (10.46)	8.53 (9.45)	9.36 (11.42)
ED visit,[a] n	1.30 (3.11)	1.20 (2.84)	1.55 (3.21)	1.30 (3.40)[b]	1.30 (2.90)[b]	1.40 (3.36)	1.65 (3.09)
Acute inpatient stay,[a] n	0.32 (0.87)	0.27 (0.77)	0.92 (1.35)	0.19 (0.63)	0.41 (0.99)	0.60 (1.02)	1.15 (1.52)
Length in days[c]	2.00 (7.50)	1.64 (6.43)	6.09 (13.06)	1.12 (5.35)	2.62 (8.64)	3.73 (9.70)	7.88 (14.86)
Long-term care facility,[a] n	0.10 (0.52)	0.08 (0.45)	0.49 (1.14)	0.03 (0.30)	0.15 (0.62)	0.19 (0.76)	0.71 (1.31)
Length in days[c]	1.74 (10.79)	1.33 (9.40)	10.22 (25.08)	0.67 (7.38)	2.48 (12.59)	4.23 (18.47)	14.75 (28.27)
Rehabilitation care, length in days[d]	–	–	21.90 (38.16)	–	–	14.63 (28.32)	27.39 (43.37)
Osteoporosis Related,[e] Mean (SD)							
Office visit,[a] n	0.51 (1.44)	0.53 (1.47)	4.95 (7.63)	0.56 (1.49)	0.48 (1.40)	6.28 (8.77)	3.94 (6.47)
Outpatient hospital visit,[a] n	0.48 (1.18)	0.49 (1.16)	2.46 (3.81)	0.72 (1.27)	0.32 (1.08)	2.71 (3.83)	2.27 (3.79)
ED visit,[a] n	0.25 (0.48)	0.25 (0.48)	0.56 (1.08)	0.26 (0.48)	0.24 (0.49)	0.44 (0.90)	0.64 (1.19)
Acute inpatient stay,[a] n	0.03 (0.19)	0.02 (0.18)	0.59 (0.81)	0.02 (0.14)	0.03 (0.21)	0.41 (0.66)	0.72 (0.89)
Length in days[c]	0.17 (1.99)	0.15 (1.73)	4.37 (10.07)	0.10 (1.51)	0.22 (2.26)	2.77 (7.60)	5.57 (11.44)
Long-term care facility,[a] n	0.02 (0.15)	0.01 (0.14)	0.30 (0.73)	0.01 (0.09)	0.02 (0.18)	0.12 (0.48)	0.44 (0.84)
Length in days[c]	0.30 (4.61)	0.24 (3.98)	7.70 (20.80)	0.12 (3.11)	0.42 (5.42)	3.10 (14.88)	11.17 (23.76)

ED indicates emergency department.

[a]Office visits, outpatient hospital visits, ED visits, acute inpatient stay, and long-term care facility are mutually exclusive.

[b]Indicates *P* value was not significant for the commercial cohort versus the Medicare cohort. *P* values were significant ($P < .001$) for all other comparisons in the subgroup analysis.

[c]All patients were included in the calculation of mean length of acute inpatient and long-term care facility stays; patients with no stays contributed 0 days to the mean.

[d]Rehabilitation care counts are also included in the healthcare utilization counts for the care setting in which they occurred (office, outpatient hospital, ED, acute inpatient, or long-term care facility).

[e]Osteoporosis-related claims are claims with evidence of an osteoporosis diagnosis, case-qualifying fracture, or fracture-related aftercare.

osteoporosis-related medical costs incurred were for acute inpatient stays (mean [SD] = $12,988 [$33,735]), followed by outpatient hospital visits ($2696 [$6309]). Osteoporosis-related healthcare costs were lower for Medicare versus commercially insured patients for all categories of care except ED visits and long-term care both pre- and post index fracture (Table 3).

Time to Second Fracture

Among all patients, the Kaplan-Meier estimated cumulative second-fracture rates were 6.6% at 1 year, 12.3% at 2 years, 16.9% at 3 years, and 20.9% at 4 years after index fracture (**Figure 2**).

Multivariable Analysis

GLMs examining the characteristics associated with total all-cause costs and total osteoporosis-related healthcare costs are presented in **eAppendix Table 3**.

Given the large sample size, many of the covariates in both models were statistically significant. When examining total all-cause healthcare costs, higher CCI score was associated with higher costs, and patients with hip fracture had costs as high as or higher than those of patients with fractures of the other sites (with the exception of femur fractures and fractures at multiple sites).

The variable with the largest cost ratio in both the all-cause and osteoporosis-related models was whether the index fracture was managed inpatient versus outpatient (cost ratios, 2.16 [all-cause] and 3.60 [osteoporosis related]). Another predictor of higher all-cause costs was fractures at multiple sites versus hip only (cost ratio, 1.23; 95% CI, 1.21-1.26). In the osteoporosis-related analysis, the only sites that were more expensive relative to hip fracture were femur fracture (cost ratio, 1.06; 95% CI, 0.99-1.12) and multiple fracture sites (cost ratio, 1.35; 95% CI, 1.31-1.39).

DISCUSSION

This retrospective database study examined the economic burden of osteoporotic fractures using administrative claims data. Most patients who had a fracture did not have a diagnosis of or treatment for osteoporosis at baseline. Increased HRU and significant economic

TABLE 3. Healthcare Resource Costs During the Preindex Period and Over 12 Months of Follow-up

	Entire Patient Cohort			Subgroups by Insurance Type			
	Preindex		Post Index	Preindex (N = 302,772)		Post Index (n = 197,104)	
	Overall Population (N = 302,772)	Patients With ≥12 Months Follow-up (n = 197,104)	Patients With ≥12 Months Follow-up (n = 197,104)	Commercial (n = 124,788)	Medicare (n = 177,984)	Commercial (n = 84,866)	Medicare (n = 112,238)
All-Cause Costs in $, Mean (SD)							
Total to payers	14,173 (36,891)	12,992 (33,298)	31,863 (55,025)	16,526 (50,021)	12,524 (23,543)	37,275 (74,954)	27,771 (32,097)
Total to patient	1864 (2345)	1772 (2132)	2992 (2935)	2007 (2334)	1763 (2348)	3058 (2963)	2942 (2913)
Total to payers and patient	16,037 (37,837)	14,765 (34,199)	34,855 (56,094)	18,533 (50,864)	14,288 (24,780)	40,333 (75,834)	30,712 (33,726)
Medical	13,005 (36,114)	11,824 (32,646)	31,766 (54,943)	15,417 (49,366)	11,314 (22,431)	37,039 (74,669)	27,778 (32,382)
Office visit	1981 (4179)	2003 (3449)	2542 (3610)	2233 (5263)	1805 (3195)	3123 (4298)	2102 (2911)
Outpatient hospital visit	3870 (18,850)	3602 (17,310)	6820 (21,388)	6224 (28,257)	2220 (6169)	10,979 (31,316)	3676 (6234)
ED visit	753 (2054)	656 (1698)	975 (2454)	371 (1247)	1021 (2431)	488 (2255)	1343 (2533)
Acute inpatient stay	4908 (23,117)	4264 (20,732)	16,883 (40,515)	5073 (30,072)	4791 (16,583)	18,623 (54,842)	15,566 (24,586)
Long-term care facility	434 (3098)	331 (2667)	2515 (7884)	148 (2342)	634 (3519)	942 (6893)	3705 (8362)
Other[a]	1060 (6852)	968 (6675)	2030 (9717)	1369 (10,038)	844 (3018)	2883 (14,309)	1385 (3168)
Pharmacy	3032 (7714)	2940 (6615)	3089 (6799)	3115 (6818)	2973 (8285)	3295 (6943)	2934 (6683)
Rehabilitation[b]	–	–	18,025 (41,318)	–	–	18,263 (54,697)	17,845 (27,127)
Osteoporosis-Related Costs in $,[c] Mean (SD)							
Total to payers	986 (7864)	974 (7769)	18,063 (36,205)	1350 (10,910)	730 (4647)	20,653 (48,732)	16,104 (22,302)
Total to patient	207 (888)	186 (776)	1407 (2052)	196 (665)	214 (1015)	1341 (2028)	1457 (2068)
Total to payers and patient	1193 (8028)	1160 (7913)	19,470 (36,894)	1546 (11,045)	945 (4895)	21,994 (49,196)	17,562 (23,492)
Medical	1121 (7998)	1081 (7883)	19,330 (36,869)	1463 (11,016)	881 (4857)	21,831 (49,172)	17,439 (23,467)
Office visit	87 (358)	91 (350)	664 (1227)	113 (464)	68 (257)	896 (1417)	489 (1027)
Outpatient hospital visit	285 (1470)	289 (1460)	2696 (6309)	567 (2134)	88 (624)	4404 (8756)	1405 (2838)
ED visit	126 (427)	125 (416)	316 (969)	99 (352)	145 (472)	200 (764)	404 (1090)
Acute inpatient stay	441 (6958)	409 (6744)	12,988 (33,735)	471 (9630)	420 (4162)	14,564 (46,182)	11,795 (19,558)
Long-term care facility	87 (1334)	72 (1214)	2004 (6577)	28 (964)	129 (1540)	700 (5108)	2990 (7347)
Other[a]	95 (2566)	95 (2856)	662 (4774)	185 (3984)	31 (254)	1067 (7157)	355 (1036)
Pharmacy	72 (489)	79 (468)	140 (1046)	83 (530)	64 (458)	163 (1081)	123 (1019)
Osteoporosis treatment[d]	81 (504)	88 (483)	162 (1072)	89 (540)	75 (476)	179 (1106)	149 (1044)

ED indicates emergency department.

[a]Exclusive of other categories and may include home care, laboratory/radiology, and urgent care.

[b]Rehabilitation costs are also included in the healthcare utilization costs for the care setting in which they occurred (office, outpatient hospital, ED, acute inpatient, or long-term care facility).

[c]Osteoporosis-related claims are claims with evidence of an osteoporosis diagnosis, case-qualifying fracture, or fracture-related aftercare.

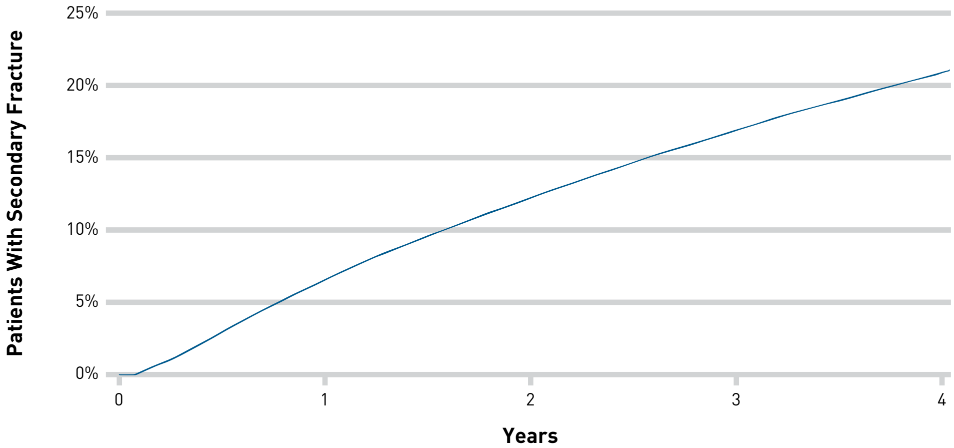
[d]Osteoporosis treatment costs are also included in the medical or pharmacy costs and include all pharmacy costs and medical costs for osteoporosis treatments.

burden were observed for both all-cause and osteoporosis-related healthcare costs during 12 months of follow-up post fracture. Most healthcare costs were for medical services versus pharmacy services, reflecting the high cost of inpatient stays and low rate of osteoporosis treatment. Within the services rendered under the medical benefit, approximately half of costs were for acute inpatient stays, which reflects the high cost of fracture repair services during an inpatient stay, and an additional 21.4% were for outpatient services. Overall, baseline comorbidities, hip fractures, and multiple fractures were significantly associated with an increased cost of care during the 12-month follow-up.

Most healthcare costs were paid by the health plans; however, patients incurred approximately $3000 in costs during the 12-month follow-up. The amount paid by the patient is likely the result of their benefit structure. For example, if the fracture occurred near the end of the calendar year, especially if their index fracture was repaired during an inpatient stay, they were likely to have already paid their annual maximum.

Our findings are consistent with cost estimations found in other studies. Controlling for patient demographic characteristics, comorbidity score, and osteoporosis diagnosis and treatment, Christensen et al observed mean 1-year follow-up costs for hip

FIGURE 2. Kaplan-Meier Estimated Time to Cumulative Incident Osteoporotic Fracture



Percentage with second fracture	0	6.6	12.3	16.9	20.9
Number at risk	302,772	178,159	108,700	66,794	40,904

fracture of $38,699 (commercial patients) and $33,975 (Medicare Advantage patients).[10] Similarly, Rousculp et al identified 1-year follow-up adjusted predicted healthcare costs of $33,238 for hip fractures and lower costs for fractures of other sites (eg, $19,672 for hand/fingers, $18,982 for forearm/wrist).[15]

Previous studies have also shown that healthcare costs increase with subsequent fractures. Song et al estimated the 1-year incremental costs due to a second fracture to be $18,645 to $47,351, depending on the payer and site of the initial fracture, in patients 50 years and older with commercial or Medicare insurance.[21] Likewise, Weaver et al reported that total medical and pharmacy costs were $14,100 higher in Medicare patients and $20,370 higher in commercially insured patients who experienced a subsequent fracture versus those who did not.[22] Our study findings suggest that fracture risk increases for a few years post fracture, with minimal difference for time to second fracture within the first 3 years. Together, these data support the need for early initiation of targeted therapy and implementation of a treatment program to reduce long-term fracture risk.

Limitations

This study has some limitations inherent to the use of claims data. The Optum database, like other claims databases, is structured largely to collect information to aid billing purposes and not for research. Diagnosis and procedure codes were used to identify osteoporosis, fractures, and medications including osteoporosis treatments. Although all patients were required to have a case-qualifying fracture, these were not confirmed with medical records. However, we relied on claims-based algorithms shown to have positive predictive values higher than 90% compared with the gold standard of medical record review. Other factors not examined in this study could also affect costs during the follow-up period. For example, cost data for procedures such as kyphoplasty and vertebroplasty were not considered. In addition, osteoporosis-related rehabilitation costs were not separately calculated, and all rehabilitation costs were taken into account and accrued as part of the total cost calculations. However, because all patients included in the analysis had a fracture, it was assumed that all rehabilitation care was for the fracture. Finally, death was not ascertained in this study and therefore was not considered in follow-up data calculations.

CONCLUSIONS

Patients who experience an osteoporotic fracture face a significant health and economic burden. In the 12 months following the fracture, patients can expect to incur healthcare costs of more than $30,000, of which an average of $3000 will be paid by the patient. Following the index fracture, refracture incidence within 12 months is 6.6%, with cumulative incidence increasing to 20.9% after 4 years. Costs increase incrementally with subsequent fractures. Given the decline in osteoporosis diagnosis and treatment observed in the past decade, policies that incentivize timely diagnosis and treatment may help reduce fracture rates and associated costs. ■

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eAppendix Table 1. Comorbidities of Interest at Baseline (Pre-Index)[a]

	Total (N=302,772)
Comorbidities that increase fall risk, n (%)	
History of stroke	20,869 (6.9)
History of falls	129,932 (42.9)
Mobility impairments	86,335 (28.5)
Vision impairments	19,688 (6.5)
Parkinson's disease	6,605 (2.2)
Dementia	46,081 (15.2)
Muscle atrophy / muscle weakness / sarcopenia	31,081 (10.3)
Comorbidities that lengthen healing, n (%)	
Diabetes	79,759 (26.3)
Renal disease	54,612 (18.0)
Lung disease (COPD, asthma)	68,408 (22.6)
Liver disease	21,704 (7.2)
Other comorbidities, n (%)	
Rheumatoid arthritis	11,545 (3.8)
Hypertension	210,461 (69.5)
Arthritis	111,767 (36.9)
Musculoskeletal pain	267,863 (88.5)
Respiratory diseases	123,421 (40.8)
Alzheimer's disease	16,005 (5.3)
Depression	62,602 (20.7)
Anxiety	46,633 (15.4)
Sleep disorders	43,084 (14.2)
Cardiovascular diseases	240,415 (79.4)
Hypothyroidism	68,373 (22.6)
Obesity	30,373 (10.0)

COPD, chronic obstructive pulmonary disease.
[a]Diagnoses could be in any position on the claim. Only nondiagnostic claims were utilized.

eAppendix Table 2. Patient Medical History

	Overall (N=302,772)
Index year, n (%)	
2007	21,954 (7.3)
2008	23,013 (7.6)
2009	23,421 (7.7)
2010	25,306 (8.4)
2011	27,109 (9.0)
2012	29,123 (9.6)
2013	32,126 (10.6)
2014	29,662 (9.8)
2015	33,392 (11.0)
2016	38,178 (12.6)
2017	19,488 (6.4)
Index admission	
Inpatient	125,029 (41.3)
Non-inpatient	177,743 (58.7)
BMD testing pre-index, n (%)	30,944 (10.2)
Corticosteroid use[a] (6 months pre-index), n (%)	
Any	37,252 (12.3)
0–7.5 mg	32,370 (10.7)
≥7.5 mg	4,882 (1.6)
Site of fracture, n (%)	
Spine only	66,172 (21.9)
Radius/ulna only	58,999 (19.5)
Hip only	41,512 (13.7)
Shoulder only	35,654 (11.8)
Ankle only	35,742 (11.8)
Tibia/fibula only	10,648 (3.5)
Pelvis only	8368 (2.8)
Femur only	4918 (1.6)
Carpal/wrist only	3107 (1.0)
Multiple sites	37,652 (12.4)

BMD, bone mineral density; SD, standard deviation.
[a]Average daily dose of prednisone-equivalent medication.

eAppendix Table 3. Multivariate Cost-Adjusted Models for All-Cause and Osteoporosis-Related Costs During 12 months Follow-Up (Gamma Distribution, Log Link)

	All-Cause			Osteoporosis-Related		
Independent Variables	**Estimate (SE)**	**Cost Ratio (95% CI)**	***P***	**Estimate (SE)**	**Cost Ratio (95% CI)**	***P***
Intercept	9.74 (0.03)	–	<0.001	8.91 (0.04)	–	<0.001
Demographics						
Age (scaled for 10-year increments)	0.005 (0.00)	1.001 (1.00, 1.01)	0.164	0.05 (0.01)	1.06 (1.05, 1.07)	<0.001
Males (ref. = Female)	0.10 (0.01)	1.11 (1.09, 1.12)	<0.001	0.05 (0.01)	1.05 (1.03, 1.07)	<0.001
Medicare Advantage (ref. = Commercial)	−0.59 (0.01)	0.56 (0.55, 0.57)	<0.001	−0.67 (0.01)	0.51 (0.50, 0.52)	<0.001
Region: Northeast	−0.05 (0.01)	0.95 (0.93, 0.97)	<0.001	−0.08 (0.01)	0.92 (0.90, 0.95)	<0.001
Region: Midwest	−0.21 (0.01)	0.81 (0.80, 0.83)	<0.001	−0.25 (0.01)	0.78 (0.76, 0.80)	<0.001
Region: South	−0.10 (0.01)	0.91 (0.89, 0.92)	<0.001	−0.13 (0.01)	0.88 (0.86, 0.90)	<0.001
Region: West	ref.	–	–	–	–	–
Region: other	−0.29 (0.22)	0.75 (0.49, 1.15)	0.192	0.03 (0.30)	1.03 (0.58, 1.84)	0.919
Charlson comorbidity score[a]	0.06 (0.00)	1.06 (1.06, 1.07)	<0.001	0.00 (0.00)	1.00 (0.10, 1.01)	0.479
Index year						
2007	ref.	–	–	–	–	–
2008	0.04 (0.01)	1.04 (1.01, 1.07)	0.005	0.05 (0.02)	1.05 (1.02, 1.09)	0.005
2009	0.05 (0.01)	1.05 (1.02, 1.08)	<0.001	0.09 (0.02)	1.09 (1.06, 1.13)	<0.001
2010	0.03 (0.01)	1.04 (1.01, 1.06)	0.009	0.08 (0.02)	1.09 (1.05, 1.12)	<0.001
2011	0.03 (0.01)	1.03 (1.00, 1.05)	0.033	0.10 (0.02)	1.10 (1.07,1.14)	<0.001
2012	0.03 (0.01)	1.03 (1.00, 1.06)	0.023	0.10 (0.02)	1.11 (1.07, 1.15)	<0.001
2013	0.03 (0.01)	1.03 (1.00, 1.05)	0.044	0.12 (0.02)	1.13 (1.09, 1.17)	<0.001
2014	0.03 (0.01)	1.03 (1.00, 1.05)	0.040	0.13 (0.02)	1.14 (1.10, 1.18)	<0.001
2015	0.04 (0.01)	1.04 (1.02, 1.07)	<0.001	0.14 (0.02)	1.14 (1.11, 1.18)	<0.001
2016	0.03 (0.01)	1.03 (1.00, 1.06)	0.054	0.14 (0.02)	1.15 (1.11, 1.19)	<0.001

Independent Variables	All-Cause			Osteoporosis-Related		
	Estimate (SE)	Cost Ratio (95% CI)	*P*	Estimate (SE)	Cost Ratio (95% CI)	*P*
Index facture type						
Hip only	ref.			ref.		
Ankle only	−0.31 (0.01)	0.73 (0.72 0.75)	<0.001	−0.45 (0.02)	0.64 (0.62, 0.66)	<0.001
Carpal/wrist only	−0.58 (0.03)	0.56 (0.53, 0.59)	<0.001	−1.27 (0.04)	0.28 (0.26, 0.30)	<0.001
Femur only[b]	0.06 (0.02)	1.07 (1.02, 1.12)	0.008	0.05 (0.03)	1.06 (0.99, 1.12)	0.090
Pelvis only	−0.22 (0.02)	0.80 (0.78, 0.83)	<0.001	−0.34 (0.02)	0.71 (0.68, 0.75)	<0.001
Radius or ulna only	−0.32 (0.01)	0.73 (0.71, 0.75)	<0.001	−0.47 (0.02)	0.62 (0.61, 0.64)	<0.001
Shoulder (shoulder, humerus, clavicle) only	−0.20 (0.01)	0.822 (0.80, 0.84)	<0.001	−0.32 (0.02)	0.73 (0.71, 0.75)	<0.001
Spine only	−0.07 (0.01)	0.93 (0.91, 0.95)	<0.001	−0.18 (0.02)	0.84 (0.81, 0.86)	<0.001
Tibia or fibula only	−0.17 (0.02)	0.84 (0.81, 0.87)	<0.001	−0.31 (0.02)	0.73 (0.70, 0.76)	<0.001
Multiple	0.21 (0.01)	1.23 (1.21, 1.26)	<0.001	0.30 (0.02)	1.35 (1.31, 1.39)	<0.001
Index event type						
Inpatient	0.77 (0.01)	2.16 (2.13, 2.19)	<0.001	1.28 (0.01)	3.60 (3.53, 3.67)	<0.001
Non-inpatient	ref.	–	–	–	–	–
Osteoporosis cohort						
Baseline osteoporosis diagnosis & treatment	0.07 (0.01)	1.07 (1.05, 1.10)	<0.001	0.23 (0.02)	1.26 (1.22, 1.30)	<0.001
Baseline Osteoporosis Diagnosis & no treatment	0.01 (0.01)	1.012 (0.99, 1.03)	0.23	0.11 (0.01)	1.11 (1.08,1.14)	<0.001
Baseline osteoporosis treatment & no Diagnosis	0.06 (0.01)	1.06 (1.04, 1.09)	<0.001	0.13 (0.02)	1.13 (1.10, 1.17)	<0.001
No baseline Osteoporosis treatment or diagnosis	ref.	–	–	–	–	–

Independent Variables	All-Cause			Osteoporosis-Related		
	Estimate (SE)	Cost Ratio (95% CI)	*P*	Estimate (SE)	Cost Ratio (95% CI)	*P*
Comorbidities that increase the risk of fracture						
Prior history of stroke	0.14 (0.01)	1.15 (1.12, 1.17)	<0.001	0.15 (0.02)	1.16 (1.13, 1.20)	<0.001
History of falls	0.04 (0.01)	1.04 (1.03, 1.05)	<0.001	0.10 (0.01)	1.11 (1.09, 1.12)	<0.001
Mobility impairments	0.15 (0.01)	1.16 (1.15, 1.18)	<0.001	0.13 (0.01)	1.14 (1.12, 1.17)	<0.001
Vision impairments	0.06 (0.01)	1.07 (1.04, 1.09)	<0.001	0.03 (0.02)	1.03 (1.00,1.06)	0.034
Parkinson's disease	0.12 (0.02)	1.13 (1.09, 1.18)	<0.001	0.09 (0.03)	1.09 (1.04, 1.15)	0.001
Muscle atrophy/muscle weakness/sarcopenia	0.01 (0.01)	1.01 (0.99, 1.04)	0.290	0.03 (0.02)	1.03 (1.00, 1.06)	0.044
Medications that increase fall risk						
Alpha blockers	0.06 (0.01)	1.06 (1.03, 1.09)	<0.001	−0.03 (0.02)	0.97 (0.93, 1.00)	0.078
Anticholinergic antihistamines	0.12 (0.01)	1.13 (1.10, 1.16)	<0.001	0.08 (0.02)	1.08 (1.05, 1.12)	<0.001
Antipsychotics	0.16 (0.03)	1.18 (1.11, 1.256)	<0.001	0.03 (0.04)	1.03 (0.95, 1.13)	0.466
Barbiturates	0.07 (0.07)	1.07 (0.94, 1.23)	0.296	−0.00 (0.09)	0.10 (0.83, 1.19)	0.969
Benzodiazepines	0.08 (0.01)	1.09 (1.07, 1.105)	<0.001	−0.01 (0.01)	0.99 (0.97, 1.02)	0.584
Beta blockers	0.03 (0.01)	1.03 (1.01, 1.04)	<0.001	−0.02 (0.01)	0.98 (0.96, 0.10)	0.023
Muscle relaxants	0.08 (0.01)	1.08 (1.06, 1.10)	<0.001	−0.03 (0.01)	0.97 (0.95, 0.99)	0.010
Nonbenzodiazepine, benzodiazepine receptor agonists	0.09 (0.01)	1.09 (1.07, 1.11)	<0.001	0.00 (0.02)	1.00 (0.97, 1.03)	0.959
Opioids	0.09 (0.01)	1.10 (1.08, 1.11)	<0.001	0.18 (0.01)	1.19 (1.17, 1.21)	<0.001
Proton pump inhibitors	0.10 (0.01)	1.10 (1.09, 1.12)	<0.001	−0.00 (0.01)	0.10 (0.98, 1.02)	0.729
Selective serotonin reuptake inhibitors	0.03 (0.01)	1.03 (1.01, 1.05)	<0.001	0.01 (0.01)	1.01 (0.99, 1.03)	0.582

Independent Variables	All-Cause			Osteoporosis-Related		
	Estimate (SE)	Cost Ratio (95% CI)	*P*	Estimate (SE)	Cost Ratio (95% CI)	*P*
Tricyclic antidepressants	0.11 (0.02)	1.12 (1.08, 1.15)	<0.001	0.01 (0.02)	1.01 (0.97, 1.06)	0.535
Vasodilators	0.13 (0.01)	1.13 (1.10, 1.17)	<0.001	0.01 (0.02)	1.01 (0.98, 1.05)	0.530
Comorbidities that lengthen healing						
Diabetes	0.15 (0.01)	1.16 (1.15, 1.18)	<0.001	0.02 (0.01)	1.02 (1.01, 1.04)	0.012
Renal disease	0.21 (0.01)	1.23 (1.21, 1.25)	<0.001	0.14 (0.01)	1.15 (1.12, 1.17)	<0.001
Liver disease	0.08 (0.01)	1.08 (1.05, 1.10)	<0.001	0.06 (0.02)	1.06 (1.03, 1.10)	<0.001
Other comorbidities						
Rheumatoid arthritis	0.13 (0.02)	1.14 (1.10, 1.17)	<0.001	0.03 (0.02)	1.03 (0.99, 1.08)	0.104
Arthritis[c]	0.06 (0.01)	1.06 (1.05, 1.08)	<0.001	−0.02 (0.01)	0.98 (0.96, 0.99)	0.005
Musculoskeletal pain	0.05 (0.01)	1.05 (1.04, 1.07)	<0.001	−0.01 (0.01)	0.99 (0.97, 1.01)	0.336
Hypertension	−0.02 (0.01)	0.98 (0.96, 0.10)	0.016	−0.06 (0.01)	0.94 (0.92, 0.96)	<0.001
Respiratory diseases[d]	0.17 (0.01)	1.19 (1.17, 1.20)	<0.001	0.15 (0.01)	1.15 (1.14, 1.18)	<0.001
Lung disease (COPD, asthma)	0.03 (0.01)	1.03 (1.02, 1.05)	<0.001	0.01 (0.01)	1.01 (0.99, 1.03)	0.442
Alzheimer's disease	−0.02 (0.02)	0.98 (0.95, 1.02)	0.305	−0.03 (0.02)	0.97 (0.93, 1.02)	0.206
Dementia[e]	0.03 (0.01)	1.03 (1.01, 1.05)	0.006	0.06 (0.01)	1.06 (1.03, 1.09)	<0.001
Depression	0.08 (0.008)	1.08 (1.06, 1.10)	<0.001	0.05 (0.01)	1.05 (1.03, 1.07)	<0.001
Anxiety	0.02 (0.01)	1.02 (1.01, 1.04)	0.013	0.03 (0.01)	1.03 (1.01, 1.06)	0.006
Sleep disorders	0.04 (0.01)	1.04 (1.03, 1.06)	<0.001	−0.02 (0.01)	0.99 (0.96, 1.01)	0.198
Cardiovascular diseases	0.21 (0.01)	1.23 (1.21, 1.26)	<0.001	0.13 (0.01)	1.14 (1.11, 1.17)	<0.001
Hypothyroidism	0.02 (0.01)	1.02 (1.00, 1.03)	0.014	−0.02 (0.01)	0.98 (0.97, 1.00)	0.063
Obesity	0.09 (0.01)	1.09 (1.07, 1.11)	<0.001	0.10 (0.01)	1.10 (1.08, 1.13)	<0.001
OCS use in 6 months before index fracture						
OCS daily dose: 0–7.5 mg	0.07 (0.01)	1.08 (1.06, 1.10)	<0.001	0.01 (0.01)	1.01 (0.98, 1.03)	0.602

Independent Variables	All-Cause			Osteoporosis-Related		
	Estimate (SE)	**Cost Ratio (95% CI)**	***P***	**Estimate (SE)**	**Cost Ratio (95% CI)**	***P***
OCS daily dose: 7.5+ mg	0.28 (0.02)	1.32 (1.26, 1.38)	<0.001	0.23 (0.03)	1.26 (1.18, 1.34)	<0.001
OCS daily dose: 0 mg (no use)	ref.	–	–	–	–	–
Baseline BMD testing performed	−0.04 (0.01)	0.96 (0.95, 0.98)	<0.001	−0.08 (0.01)	0.93 (0.90, 0.95)	<0.001

BMD, bone mineral density; CI, confidence interval; COPD, chronic obstructive pulmonary disease; OCS, oral corticosteroid; Ref, reference; SE, standard error.

[a]Charlson comorbidity scores that were >6 were set to 6 due to the limited number of patients with scores >6.

[b]"Femur" includes mid and lower femur. Femur fractures of the hip are included in the hip category.

[c]"Arthritis" includes osteoarthritis, secondary osteoarthritis and other arthritides.

[d]"Respiratory disease" refers to etiologies other than COPD or asthma.

[e]"Dementia" refers to etiologies other than that Alzheimer's disease.