

Cost-effectiveness of secondary fracture prevention intervention for Medicare beneficiaries

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Abstract

Background: Secondary fracture prevention intervention such as fracture liaison services are effective for increasing osteoporosis treatment rates, but are not currently widely used in the United States. We evaluated the cost-effectiveness of secondary fracture prevention intervention after osteoporotic fracture for Medicare beneficiaries.

Methods: An individual-level state-transition microsimulation model was developed to evaluate the cost-effectiveness of secondary fracture prevention intervention compared with usual care for U.S. Medicare patients aged 65 and older who experience a new osteoporotic fracture. Patients who initiated pharmacotherapy and remained adherent were assumed to be treated for 5 years. Outcome measures included subsequent fractures, average lifetime costs, quality-adjusted life-years (QALYs), and incremental cost-effectiveness ratios in 2020 U.S. dollars per QALY gained. The model time horizon was lifetime, and analysis perspective was payer.

Results: Base-case analysis results showed that the secondary fracture prevention intervention strategy was both more effective and less expensive than usual care—thus, it was cost-saving. Model findings indicated that the intervention would reduce the number of expected fractures by approximately 5% over a 5-year period, preventing approximately 30,000 fractures for 1 million patients. Secondary fracture prevention intervention resulted in an average cost savings of \$418 and an increase in QALYs of 0.0299 per patient over the lifetime; for 1 million patients who receive the intervention instead of usual care, expected cost savings for Medicare would be \$418 million dollars. One-way and probabilistic sensitivity analyses supported base-case findings of cost savings.

Conclusion: Secondary fracture prevention intervention for Medicare beneficiaries after a new osteoporotic fracture is very likely to both improve health outcomes and reduce healthcare costs compared with usual care. Expansion of its use for this population is strongly recommended.

KEYWORDS

cost-effectiveness analysis, fracture, osteoporosis, secondary fracture prevention

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INTRODUCTION

Osteoporosis affects more than 10 million older adults in the United States,¹ many of whom will experience a fragility fracture in their lifetimes,² with significant health consequences and costs.¹⁻⁶ The clinical and economic burden of osteoporotic fractures is projected to increase significantly over the next several decades with the aging of the U.S. population; a recent analysis estimated that annual number of fractures experienced by U.S. women aged 65 years and older will increase from 1.9 million in 2018 to approximately 3 million by 2040, with associated total societal costs rising from \$57 billion to \$95 billion.⁶

Despite numerous practice guidelines supporting osteoporosis screening and treatment,⁷⁻⁹ as well as a large body of evidence that screening and treatment are effective and cost-effective for reducing fracture risk and improving health outcomes among older adults,^{7,10-15} rates of appropriate osteoporosis care in the United States remain very low. Even after experiencing a fragility fracture, which is generally diagnostic for osteoporosis and an indication for treatment, only 10%–20% of patients initiate pharmacotherapy,^{16,17} and treatment rates have actually worsened in recent years.¹⁸ Initiation of osteoporosis treatment after a fracture is particularly impactful because patients are at especially high risk of a subsequent fracture within the following few years.^{19,20} Secondary fracture prevention interventions including coordinator-based fracture liaison services (FLS) or case management have been demonstrated to be effective for increasing treatment rates²¹⁻²³; however, these interventions are not widely used in the United States.

We performed a cost-effectiveness analysis to evaluate the potential impact on healthcare outcomes and costs of secondary fracture prevention intervention to increase

Key Points

- Secondary fracture prevention intervention after osteoporotic fracture is very likely to be cost-saving for Medicare beneficiaries, resulting in improved health outcomes and lower costs.

Why Does this Paper Matter?

Few patients receive osteoporosis treatment after a fracture; expansion of use of secondary fracture prevention intervention would be beneficial.

osteoporosis treatment rates after fracture for the U.S. Medicare population.

METHODS

Model design and overview

We developed an individual-level state-transition microsimulation model to evaluate the cost-effectiveness of secondary fracture prevention intervention compared with usual care for Medicare patients who experience a new osteoporotic fracture. During each cycle of the model (a 3-month time period), a patient could sustain another osteoporotic fracture or not, and either survive or die from fracture-related mortality or age-related mortality (Figure 1). The model time horizon was lifetime (simulating individuals until death), analysis perspective was payer (included direct healthcare costs only), and primary outcomes were average lifetime costs, quality-adjusted

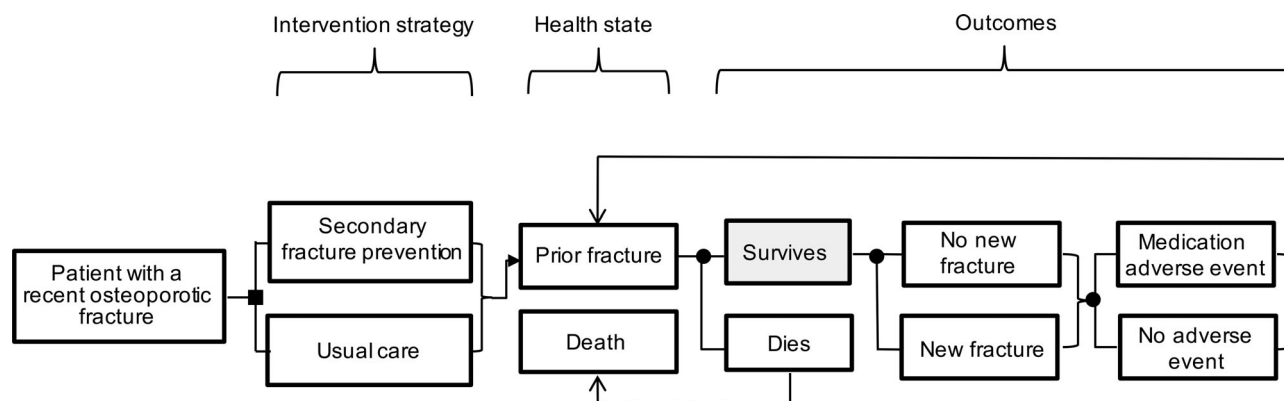


FIGURE 1 Model schematic representation. The model compares secondary fracture prevention intervention versus usual care for older adults with a new osteoporotic fracture. Events that may occur during each simulated individual's remaining lifetime include a subsequent osteoporotic fracture, osteoporosis medication adverse event, and survival or death from either age-related mortality or fracture-related mortality. Simulated individuals move through the outcomes section of the model in 3-month cycles

life-years (QALYs), and incremental cost-effectiveness ratios (ICERs) in 2020 U.S. dollars per QALY gained. We assumed patients were 75 years old at time of initial fracture in base-case analysis, and that 70% of patients were female and 30% were male in accordance with findings from a recent analysis of the economic and clinical impact of osteoporotic fractures among Medicare beneficiaries by the independent actuarial firm Milliman and commissioned by the National Osteoporosis Foundation.²⁴ TreeAge Pro 2018 software (TreeAge Software, Williamstown, MA) was used to develop and analyze the model. Table 1 shows key model parameter assumptions.

Strategies compared

The strategies compared were a hypothetical secondary fracture prevention intervention, such as FLS or case management, versus usual care only. We assumed the intervention

would be implemented for all patients with a clinical osteoporotic fracture of any type (hip, vertebral, or nonvertebral), and would increase the likelihood of osteoporosis treatment initiation compared with usual care. Base-case assumptions for percentage of patients who initiated treatment after fracture were 15% of patients receiving usual care and 35% of patients receiving the intervention; we obtained estimates of the efficacy of secondary fracture prevention intervention for increasing treatment rates compared with usual care from two recent meta-analyses,^{21,22} and selected a mid-range estimate for usual care treatment rates after fracture from several previous investigations.^{16,17,25,26}

Treatment

We assumed that individuals who initiated osteoporosis treatment would receive a medication with a fracture risk reduction efficacy for all types of fracture of 35% (relative

TABLE 1 Key model parameter values

Parameter	Base-case value	Sensitivity analysis values (range) ^a
Age at occurrence of initial osteoporotic fracture	75	65–85
Percentage of usual care patients who initiate treatment after fracture	15	10–20
Percentage of secondary fracture prevention intervention patients who initiate treatment after fracture	35	25–45
Percentage of usual care patients who are adherent (of those who initiate treatment)	50	40–60
Percentage of secondary fracture prevention intervention patients who are adherent (of those who initiate treatment)	65	50–80
New osteoporotic fracture annual incidence rates per 10,000 for Medicare beneficiaries by age group (Age 65–74/75–84/≥85)	276.7/554.8/1043.8 ^b	221.4–332.0/443.8–665.8/835.0–1252.6
Relative risk of new fracture for patients on osteoporosis treatment	0.65 ^c	0.60–0.70
Average annual cost of osteoporosis treatment	600	300–900
Direct medical cost of subsequent osteoporotic fractures	24,155 ^{b,d}	19,324–28,986
Per patient costs of secondary fracture prevention intervention	182 ^e	127–237
Health-state utility multiplier for first year after a new osteoporotic fracture ^f	0.860 ^g	0.834–0.886
Health-state utility multiplier for subsequent years after an osteoporotic fracture ^f	0.965 ^g	0.936–0.994
Multiplier for increased mortality risk relative to age-related mortality for patients in first year after new osteoporotic fracture (Age <75/75–84/≥85)	5.80/3.80/2.12 ^h	4.64–6.96/3.03–4.55/1.70–2.55

^aUniform distributions assumed for probabilistic sensitivity analysis.

^bMilliman report.²⁴

^cStrom et al.²⁷

^dCost inflated to 2020 dollars using the Consumer Price Index for Medical Care.

^eCost incorporates a nurse practitioner visit (CPT code 99204, 85% of physician reimbursement rate) and DXA testing (CPT code 77080) using 2020 Medicare national reimbursement rates.

^fBaseline health-state utility values according to age and sex multiplied by these values to obtain values associated with postfracture states.

^gHiligsmann et al.³⁶

^hMultipliers calculated from data presented in Milliman report²⁴ and adjusted downward by 10% to account for proportion of excess mortality attributable to comorbidities.

risk of fracture on treatment 0.65), as reported in a recent large cohort study of the real-world effectiveness of osteoporosis treatment.²⁷ We assumed individuals would be treated for 5 years, and that adherence for the entire treatment period would be 50% in usual care group and approximately 15% higher (65%) in the intervention group,^{22,26,28} with the remainder of patients fully non-adherent. We assumed that residual fracture risk reduction efficacy after discontinuing treatment declined linearly over the course of 5 years after discontinuation to no remaining benefit.²⁹ We included risk of possible rare serious adverse events of osteoporosis treatment of atypical subtrochanteric femoral fractures or osteonecrosis of the jaw for patients on treatment, with rates obtained from a published review paper.³⁰ We assumed that if an individual sustained either of these adverse events they would discontinue treatment.

Fracture rates

Age-stratified rates of new osteoporotic fracture (combined rates for hip, nonvertebral, and clinical vertebral fractures) for Medicare beneficiaries reported in the Milliman report were used for baseline fracture incidence rates for patients of different ages; overall rates for each age group (65–74, 75–84, and 85+) were further adjusted up or down for females or males, respectively, to account for women having approximately 79% greater fracture rates than men after adjusting for age.²⁴ After a new osteoporotic fracture, we assumed that the short-term risk of a subsequent fracture was 3.1 times higher than baseline,²⁴ and that this elevated short-term fracture risk persisted for 5 years after the fracture.^{19,20,31}

Costs

The direct healthcare costs associated with subsequent osteoporotic fractures were estimated to be \$24,155 in 2020 dollars in base-case analysis, calculated from the incremental medical cost of a subsequent osteoporotic fracture for Medicare beneficiaries reported as approximately \$20,700 in 2015 adjusted to 2020 dollars using the Consumer Price Index for Medical Care.²⁴ We assumed an average annual cost of medication for osteoporosis treatment of \$600 in base-case analysis—this figure was approximated based on published data that show approximately 80% of Medicare beneficiaries treated for osteoporosis are prescribed generic medications (mostly bisphosphonates), and 20% of patients are prescribed more expensive nonbisphosphonate medications.^{32,33} We estimated the cost of the secondary fracture prevention

intervention per patient to be \$182, including the cost of a nurse practitioner visit (CPT code 99204, 85% of physician reimbursement rate) and DXA testing (CPT code 77080) applying 2020 Medicare reimbursement rates. We assumed that the costs associated with treatment of adverse events of atypical subtrochanteric femoral fracture and osteonecrosis of the jaw were \$50,000 and \$1000, respectively (both assumed). Future costs were discounted at 3% annually.³⁴

Health-state utilities

For baseline health-states utility values for patients with prior osteoporotic fracture history (all individuals simulated in the model), population norms for U.S. women and men of different ages were obtained from a study publishing representative values from a national survey,³⁵ and then multiplied by 0.965, a multiplier value for prior vertebral fracture reported in a systematic review of utility values associated with osteoporotic fractures.³⁶ For patients who then experienced a subsequent fracture, to estimate the reduced utility value in the first year after fracture we multiplied by 0.860, a value reported for patients in the first year after vertebral fracture (the most common type of osteoporotic fracture) in the same systematic review.³⁶ We assumed that the utility multiplier in the first year after the adverse event of atypical subtrochanteric femoral fracture was 0.797 and in subsequent years was 0.899, which are multipliers reported for hip fracture³⁶; and that disutility (reduction in health-state utility value) associated with the adverse event of osteonecrosis of the jaw was 0.13.³⁷ Future utilities were discounted at 3% annually.³⁴

Mortality rates

National Vital Statistics mortality data from 2017 was used for baseline mortality rates for women and men aged 65 through 100,³⁸ and Social Security actuarial data were used for individuals over age 100.³⁹ Individuals with a new osteoporotic fracture were assumed to have increased mortality risk in the year following fracture, with the factor by which mortality risk was greater than baseline for patients of different age ranges obtained from the Milliman report,²⁴ and then adjusted downward by 10% to account for a portion of this excess mortality being secondary to comorbidities.⁴⁰

Analyses

We performed base-case analysis; one-way sensitivity analyses varying key individual parameters; and

probabilistic sensitivity analysis to evaluate the impact of joint input parameter uncertainty on model findings. Base-case and one-way sensitivity analyses were performed with 1 million trials each, simulating 1 million individual patients receiving secondary fracture prevention intervention or usual care postfracture. Probabilistic sensitivity analysis was performed with 1000 samples and 100,000 trials.

Model validation

Model estimates for fracture outcomes and life expectancy were compared with published reference data.^{38,41}

RESULTS

Model validation

Mean life expectancy predicted by the model for 75-year-old patients who sustained a new osteoporotic fracture and received usual care was 84.3 years, compared with 2017 National Vital Statistics life expectancy figures for all women and men aged 75 of 87.3 years³⁸; however, a shorter life expectancy for the modeled population is not unexpected, as our model included a population with significantly increased short-term mortality risk within the first year following a new osteoporotic fracture. When we removed the increased mortality risk associated with a new fracture from the modeling analysis to test whether this accounted for the life expectancy difference, the predicted life expectancy changed to 87.1 years, very close to the National Vital Statistics figure. The model prediction for percentage of 75-year olds who received usual care that would sustain at least one other osteoporotic fracture (nonvertebral or clinical vertebral) in their lifetimes was 62.0%, similar to a reported 20-year nonvertebral fracture cumulative incidence of 54.4% for U.S. women age 65 years and older (mean age 73.4 years) with prior history of nonvertebral fracture⁴¹; this is not a perfect comparison for several reasons, such as our model includes clinical vertebral fractures in addition to nonvertebral fractures, and our model includes men as well as women.

Base-case analysis

Base-case analysis results showed that the secondary fracture prevention strategy was both more effective (resulted in fewer subsequent fractures and more QALYs) as well as less expensive than usual care—thus, it was cost-

saving compared with usual care. The model predicted that within 5 years of the initial osteoporotic fracture, approximately 642,000 new fractures would be experienced by 456,000 individuals out of 1 million who receive usual care (some individuals would experience multiple fractures), versus 608,000 new fractures experienced by 438,000 individuals out of 1 million who receive the intervention. Thus, under base-case assumptions secondary fracture prevention intervention would reduce the number of expected fractures by approximately 5% over a 5-year period. The intervention strategy resulted in an average lifetime cost per patient of \$28,848 and an average of 6.0094 QALYs, and the usual care strategy resulted in an average lifetime cost of \$29,266 and an average of 5.9795 QALYs; thus, the intervention resulted in an average lifetime cost savings of \$418 and an increase in QALYs of 0.0299 per patient (Table 2). When summing the per-patient findings for the 1 million trials run (simulating 1 million patients), results for total lifetime QALYs gained and costs saved from secondary fracture prevention intervention were approximately 30,000 QALYs gained and \$418 million dollars saved for 1 million Medicare beneficiaries who receive the intervention.

Sensitivity analyses

Results of one-way sensitivity analyses of key parameters are shown in Figure 2, in a tornado diagram; the range of values evaluated for each parameter are shown in Table 1. For almost all key parameters, the secondary fracture prevention strategy remained cost-saving compared with usual care across the ranges of values evaluated. The parameter that had the most impact was patient age, with greater cost savings per QALY gained from the intervention associated with older age. For 65-year-old patients, secondary fracture prevention intervention was highly cost-effective but not cost-saving, with a lifetime increased average cost of \$25 and an increase in QALYs of 0.0201 per patient compared with usual care (ICER \$1226/QALY); whereas intervention for 85-year-old patients resulted in an average cost savings of \$821 and an increase in QALYs of 0.0213 per patient. For all other key parameters, the intervention was cost saving for all values evaluated, and the impact of parameters other than patient age on the magnitude of cost savings from secondary fracture prevention was more moderate to negligible. For example, varying the parameter of base-line annual osteoporotic fracture rate had a moderate effect; when assuming a 20% lower fracture rate than the base-case assumption, the intervention resulted in an average cost savings of \$232 per patient and an increase

TABLE 2 Base-case analysis results for 75-year-old patients

Treatment strategy	Lifetime cost (\$) ^a	Incremental cost (\$) ^a	Quality-adjusted life-years (QALYs) accrued	Incremental QALYs	Incremental cost-effectiveness ratio (ICER) ^b
Secondary fracture prevention intervention	28,848	–	6.0094	–	Cost-saving ^c
Usual care	29,266	418	5.9795	–0.0299	Dominated ^d

^aDirect healthcare costs in 2020 U.S. dollars.

^bIncremental cost-effectiveness ratios represent the cost per QALY gained for a strategy compared with the next less costly nondominated strategy. ICERs are not shown for strategies that are cost-saving/dominant or dominated.

^cMore effective and less expensive than usual care.

^dLess effective and more expensive than the intervention strategy.

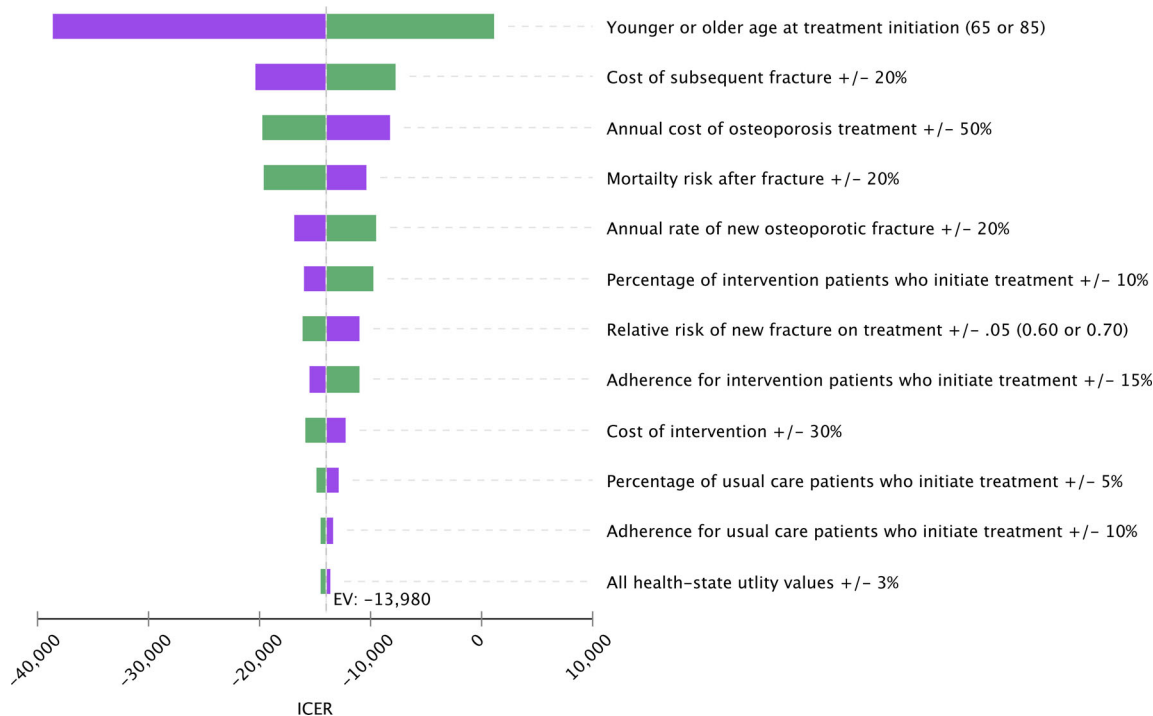


FIGURE 2 Tornado diagram of one-way sensitivity analysis results. One-way sensitivity analysis results are shown for key model parameters, demonstrating change in incremental cost-effectiveness value (ICER) for secondary fracture prevention intervention versus usual care relative to base-case results which are shown as vertical line (EV). For each parameter varied, the purple bar represents the result for the highest parameter value evaluated, and the green bar represents the result for the lowest parameter value evaluated. More negative ICER values indicate greater cost savings per quality-adjusted life-year (QALY) gained

in QALYs of 0.0246 per patient, whereas when assuming a 20% higher fracture rate than the base-case assumption, the intervention resulted in an average cost savings of \$568 per patient and an increase in QALYs of 0.0337 per patient.

Probabilistic sensitivity analysis results are presented in Figure 3. The secondary fracture prevention intervention strategy was favored in 100% of the iterations for a willingness-to-pay threshold of \$50,000/QALY, and was cost-saving in 76% of the iterations.

DISCUSSION

This cost-effectiveness analysis comparing secondary fracture prevention intervention to usual care for Medicare beneficiaries who experience an osteoporotic fracture found that the intervention is very likely to be both more effective (result in fewer future fractures and more QALYs) as well as less expensive than usual care—that is, secondary fracture prevention intervention is likely cost-saving. Our findings indicate that secondary fracture

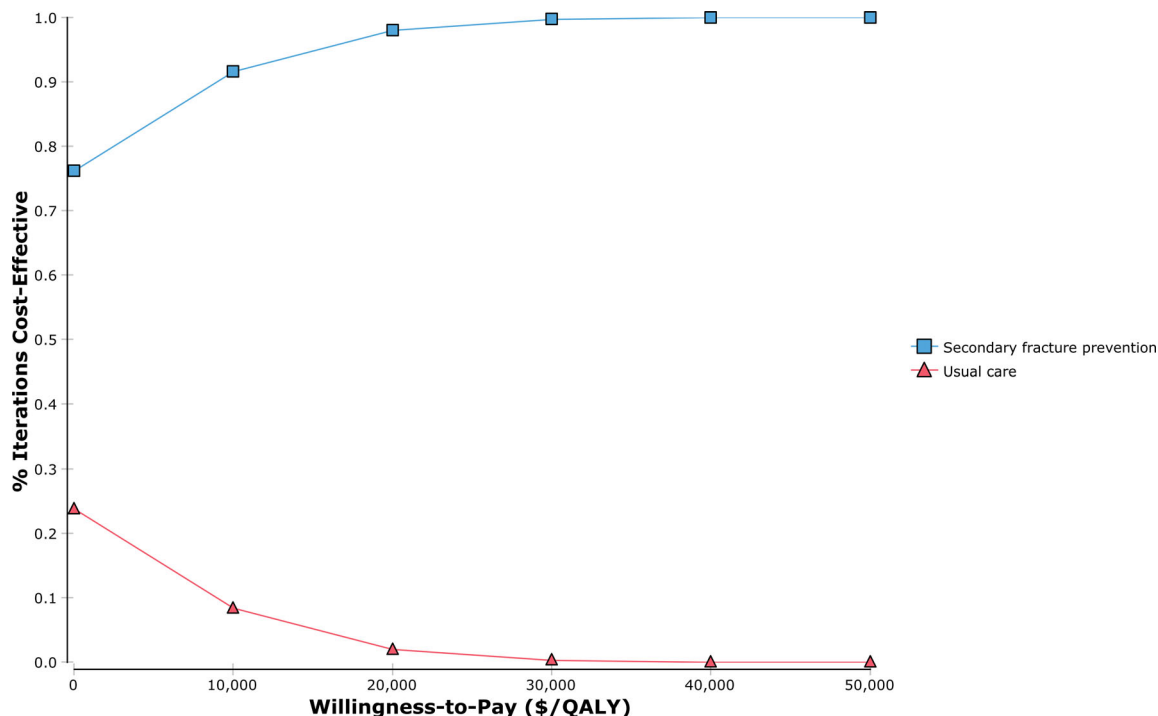


FIGURE 3 Probabilistic sensitivity analysis cost-effectiveness acceptability curves. Probabilistic sensitivity analysis cost-effectiveness acceptability curves are shown for willingness-to-pay thresholds up to \$50,000 per quality-adjusted life-year (QALY). The y-axis shows the proportion of iterations that secondary fracture prevention or usual care were favored for the willingness-to-pay thresholds (in 2020 dollars per QALY) shown on the x-axis [Color figure can be viewed at wileyonlinelibrary.com]

prevention intervention for Medicare beneficiaries who experience a new osteoporotic fracture would be expected to reduce subsequent fractures in the following 5 years by approximately 5%, and that for 1 million individuals who receive the intervention, a total of 30,000 QALYs would be gained and \$418 million dollars saved over their lifetimes. One-way sensitivity analysis findings showed that cost savings per QALY gained increase with age, and are greatest for older patients. Several other studies have also found that treating older patients for osteoporosis, who are at particularly high risk of fractures and consequent morbidity and mortality, is even more cost-effective than treating younger patients or cost-saving.^{42–46} For this reason, prioritizing identification and treatment of older patients with osteoporosis is especially important and beneficial.

We are aware of one prior cost-effectiveness analysis that evaluated the cost-effectiveness of secondary fracture prevention intervention, specifically FLS, after osteoporotic fracture for U.S. older adults; the study by Solomon and colleagues differed from ours in several ways, including that FLS was only evaluated for patients after hip fracture (not all clinical osteoporotic fractures), and treatment with bisphosphonates only was assumed.³⁷ Nevertheless, Solomon and colleagues also found that FLS reduced fractures, increased QALYs, and saved costs, and

thus was cost-saving according to base-case parameter estimates.³⁷ Our study, which used updated and Medicare-specific data for key parameters including fracture rates and costs,²⁴ evaluated intervention after any clinical osteoporotic fracture (not just hip fractures), and assumed higher treatment costs in base-case analysis to reflect that approximately 20% of patients are treated with more expensive medications than generic bisphosphonates,³² also found that secondary fracture prevention is highly likely to be cost-saving. These results support the widespread use of effective secondary fracture prevention interventions, such as coordinator-based FLS or case management, for U.S. older adults who experience an osteoporotic fracture, with strong evidence that expanding their use would be expected to both improve health outcomes and reduce healthcare costs. Our finding that secondary fracture prevention intervention is cost-saving, not just cost-effective, is notable; one review of the cost-effectiveness literature found that fewer than 20% of evaluated healthcare interventions are identified as cost-saving.⁴⁷ Medicare spending is a large and rising portion of the federal budget; in 2018, Medicare accounted for 15 percent of federal spending, and costs are expected to increase over the next decade resulting in projections that it will account for 18 percent of federal spending by 2029.⁴⁸ If Medicare were to incentivize

secondary fracture prevention such that more beneficiaries would receive this cost-saving intervention after fragility fracture, the number of future fractures and consequent spending, with total associated costs for Medicare beneficiaries for osteoporotic fractures estimated to be \$57 billion in 2018 and projected to rise to \$95 billion in 2040, could be reduced.⁶ Thus, it would be prudent for Medicare to prioritize expanding use of secondary fracture prevention for beneficiaries, for example by providing financial incentives (pay-for-performance) to providers or healthcare systems for achieving osteoporosis treatment initiation for patients who experience fracture.

In addition to incentivizing secondary fracture prevention interventions, incorporating individualized patient counseling about risks and benefits of treatment into the interventions to directly address concerns that many patients have about potential rare serious adverse events of osteoporosis medication such as osteonecrosis of the jaw or atypical subtrochanteric femoral fractures may help improve treatment rates. Rare adverse events of osteoporosis treatment have received significant media coverage, which has contributed to a reduction in osteoporosis medication use due to widespread poor understanding of the balance of benefits and risks of treatment.⁴⁹ Providing patients with individualized education as part of secondary fracture prevention intervention to address their concerns about potential medication adverse events may increase osteoporosis treatment acceptance.

This study had several limitations. The validity of results of any modeling analysis is dependent on the accuracy of assumptions for key model parameter estimates, and whether all factors relevant to the decision being modeled are incorporated into the structure of the model. We searched for the highest quality estimates available in the literature for key parameters, including updated and Medicare-specific estimates where available, and were conservative in the choice of estimates to minimize potential for bias in favor of secondary fracture prevention intervention; despite this, it is possible that some parameter estimates may have been biased and could have affected the validity of our findings. Although we factored low medication adherence into the analysis, we did not additionally incorporate estimates of reduced persistence over several years of treatment, due to lack of persistence data availability for individuals who receive secondary fracture prevention interventions compared with usual care. However, sensitivity analyses findings suggested that even if the base-case estimates for a variety of key parameters were off by significant margins, our results appeared relatively robust. Another source of potential bias is whether the model structure incorporated all important elements of the decision being

studied. Although our model and analyses met most of the recommended criteria for conduct of an economic evaluation of osteoporosis recently published by an international group of experts in the field,⁵⁰ we made some simplifying model structure decisions such as considering all clinical fractures collectively due to the nature of the highest quality data available on Medicare fracture rates and costs. We believe the model structure is sound, though it is possible it may be biased in ways we did not detect. Additionally, we made a simplifying assumption about treatment duration, assuming 5 years of treatment; individuals may be treated for shorter or longer durations.

In conclusion, our findings show that secondary fracture prevention intervention for Medicare beneficiaries who experience an osteoporotic fracture is highly likely to be cost-saving, both improving future health outcomes and reducing healthcare spending compared with usual care. Expansion of use of secondary fracture prevention intervention for Medicare beneficiaries is strongly recommended.

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CONFLICT OF INTEREST

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AUTHOR CONTRIBUTIONS

Study concept and design: Nayak, Singer, Greenspan. *Acquisition of subjects and/or data:* Nayak. *Analysis and interpretation of data:* Nayak. *Preparation of the manuscript:* Nayak, Singer, Greenspan.

SPONSOR'S ROLE

The National Osteoporosis Foundation had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

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