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QUALITY OF CARE IN OSTEOPOROSIS (S SILVERMAN AND J CURTIS, SECTION EDITORS)

Quality Measures and Quality Improvement Initiatives in Osteoporosis—an Update

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Abstract

Purpose of Review The aims of this review are to summarize current performance for osteoporosis quality measures used by Centers for Medicare and Medicaid (CMS) for pay-for-performance programs and to describe recent quality improvement strategies around these measures.

Recent Findings Healthcare Effectiveness Data and Information (HEDIS) quality measures for the managed care population indicate gradual improvement in osteoporosis screening, osteoporosis identification and treatment following fragility fracture, and documentation of fall risk assessment and plan of care between 2006 and 2016. However, population-based studies suggest achievement for these process measures is lower where reporting is not mandated. Performance gaps remain, particularly for post-fracture care. Elderly patients with increased comorbidity are especially vulnerable to fractures, yet underperformance is documented in this population. Gender and racial disparities also exist. As has been shown for other areas of health care, education alone has a limited role as a quality improvement intervention. Multifactorial and systems-based interventions seem to be most successful in leading to measurable change for osteoporosis care and fall prevention.

Summary Despite increasing recognition of evidence-based quality measures for osteoporosis and incentives to improve upon performance for these measures, persistent gaps in care exist that will require further investigation into sustainable and value-adding quality improvement interventions.

Keywords Osteoporosis · Falls · Quality measure · Quality improvement · Medicare · MACRA/MIPS

Introduction

Osteoporosis is common, affecting approximately 10 million people in the USA [1]. Half of all post-menopausal women will experience an osteoporotic fracture in their lifetime while an estimated 15% will sustain a hip fracture [2, 3]. The current incidence of osteoporotic fractures is estimated at 2 million per year; however, this number is expected to increase as our population ages [4]. While osteoporosis is largely asymptomatic until fracture occurs, the economic and health consequences of fragility fractures are substantial. The annual healthcare cost of osteoporotic fractures is projected to reach 25 billion US dollars by 2025 [4]. In addition, fragility fractures are associated with poor health outcomes including decreased quality of life (QOL), reduced physical function and independence, and increased mortality [5–8]. Hip fractures in particular contribute to excess morbidity and mortality, as they are associated with an estimated 1-year mortality of 20–30% and requirement for long-term care in 25% of those who survive [9].

Given that osteoporosis is highly prevalent among post-menopausal women and is a treatable condition, the United States Preventive Services Task Force (USPTF) recommends universal screening for all women aged 65 and older with dual-energy X-ray absorptiometry (DXA) [10]. Similar recommendations for screening among postmenopausal women are endorsed by the National Osteoporosis Foundation (NOF) and American Association of Clinical Endocrinologists (AACE) clinical guidelines [11, 12]. Among men and women that have experienced a fragility

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fracture, bone mineral density (BMD) testing with DXA and treatment with osteoporosis pharmacotherapy is recommended for secondary prevention. Because falls contribute to a majority of fragility fractures, fall prevention is also a focus of care guidelines: the American Geriatric Society (AGS) guidelines recommend annual fall screening in all adults 65 and older, whereas the USPTF recommends selectively offering fall risk assessment and intervention to older adults at increased risk for falls. The USPTF highlights that more studies are needed to validate primary care tools to identify older adults at increased risk for falls and does not provide recommendations regarding routine screening. Falls, like many geriatric syndromes, are complex clinical problems with multiple underlying contributors; thus preventing falls necessitates multifactorial interventions [13–16].

Despite evidence-based guidelines and expanding treatment options for management of osteoporosis, many patients do not receive the recommended standard of care in the USA. To assess the extent of these gaps, the National Committee for Quality Assurance (NCQA) has developed quality measures that pertain to each of the areas of care defined by guidelines, including screening for osteoporosis, osteoporosis management following fragility fracture, and fall prevention. Some areas of care contain multiple indicators, such as post-fracture care where communication with the primary provider and BMD test or prescription for osteoporosis medication are independently assessed as high priority process measures (see Table 1). Most of these indicators are endorsed by the independent nonprofit organization National Quality Forum (NQF), which uses a consensus-based process to evaluate measures and shares the NCQA's mission of enhancing quality and performance of health care delivered across the USA. Performance on these measures is reported through the Healthcare Effectiveness Data and Information Set (HEDIS) and these data are used to benchmark performance for accreditation and pay-for-performance programs. Beginning in 2015, under the Merit-based Incentive Payment System (MIPS), individual providers and practices have been incentivized to report performance on quality measures, including the NCQA osteoporosis measures, to the Centers for Medicare and Medicaid Services (CMS) for value-based payment incentives [22]. A significant number of quality improvement initiatives have been developed, in part in response to these financial incentives. Notably, under the MIPS program, practices can select which of at least six quality measures to report, and thus are more likely to choose metrics for which they believe they are performing well on.

The purpose of this review was to summarize current performance for osteoporosis quality measures used by CMS in pay-for-performance programs and to describe recent quality improvement strategies around these measures.

Methods

We reviewed recent literature addressing US performance on the osteoporosis quality measures endorsed by CMS and quality improvement initiatives targeting these measures. Measures were identified by review of the CMS website [23]. First, in order to describe current performance for osteoporosis quality measures, we identified the most currently available performance based on HEDIS and CMS's former quality improvement incentive program Physician Quality Reporting System (PQRS) reports for each measure [17, 18, 20, 21]. Second, we performed a literature search (1) to identify reports of performance on quality measures outside of the HEDIS program and (2) to identify quality improvement interventions related to osteoporosis care. Using PubMed, Embase, and Web of Science databases from 2014 to 2019 and search terms listed in the Appendix, we identified 362 unique entries pertaining to our topic of interest which were reviewed by two reviewers (SDF and SC), with any discrepancies resolved by discussion with a third reviewer (GS). Additional manuscripts were selected by examining citation lists from papers identified through the structured search. Studies were included if the performance evaluation or quality improvement intervention were clearly described and addressed existing MIPS quality measures in the ambulatory setting for osteoporosis screening and falls prevention or for post-fracture care in any setting. Studies were excluded if they were not published in English or reported on fewer than 50 patients. Ultimately, 37 studies were included and summarized below.

Results

Current Performance on Osteoporosis Quality Measures

In the following section, we summarize performance for the quality indicators for osteoporosis screening, fragility fractures and secondary prevention, and fall prevention in the USA from HEDIS and PQRS as well as other studies using data from administrative sources or chart review.

Osteoporosis Screening

Since 2007, the National Quality Forum (NQF) has endorsed a measure evaluating the percentage of women aged 65–85 years who ever had a DXA to screen for osteoporosis (Table 1). In addition, CMS has developed a measure of over-use of DXA scanning in women under 65 years old who do not meet the risk factor profile for osteoporotic fracture.

Table 1 Osteoporosis-related quality measures used by Centers for Medicare and Medicaid and eligible for Merit-based Incentive Payment System

Quality measure title	Measure description	Measure type	Primary steward	Other endorsement	Recently reported US performance
Screening for osteoporosis for women aged 65–85 years	Percentage of female patients aged 65–85 years who ever had a DXA	Process	NCQA	NQF, Joint Commission, USPTF, Surgeon General	72.7% for Medicare HMO, 80.5% for Medicare PPO (HEDIS 2016 [17],); 55.1–61.2% (PQRS 2009–2012 [18])
Appropriate use of DXA scans in women under 65 years who do not meet the risk factor profile for osteoporotic fracture	Percentage of female patients 50–64 years old without select risk factors for osteoporosis who received an order for DXA	Process	CMS		1.4% (2009 National Ambulatory Medical Care Survey [19],)
Osteoporosis management in women who had a fracture	Percentage of women age 50–85 who suffered a recent fracture who had a BMD test or a prescription for an osteoporosis medication within 6 months of fracture[a]	Process	NCQA	NQF, Joint Commission	46.7% for Medicare HMO, 39.1% for Medicare PPO (HEDIS 2017 [17],); 56.5–70.6% (PQRS 2009–2012 [18])
Communication with the physician or other clinician managing ongoing care post-fracture for men and women aged 50 years and older	Percentage of patients ≥ 50 years treated for fracture with documentation of communication between the physician treating the fracture and the clinician managing ongoing care that a fracture occurred and the patient should be considered for osteoporosis treatment or testing	Process	NCQA		Not reported
Falls: screening for future fall risk	Percentage of patients 65 years and older who were screened for future fall risk[b]	Process	NCQA	NQF, Joint Commission	44% for PQRS (PQRS 2008 [20])
Falls: risk assessment	Percentage of patients aged 65 and older with a history of falls that had a risk assessment for falls completed within 12 months	Process	NCQA	NQF, Joint Commission	32.7% for Medicare HMO, 37.6% for Medicare PPO (HEDIS 2016 [21],); 88.2% (PQRS 2009 [20])
Falls: plan of care for falls	Percentage of patients aged 65 and older with a history of falls that had a plan of care for falls documented within 12 months	Process	NCQA	NQF, Joint Commission	60.1% for Medicare HMO and 54.1% for Medicare PPO (HEDIS 2016 [21],); 86.8% for PQRS (PQRS 2009 [20])

NCQA National Committee on Quality Assurance, *NQF* National Quality Forum, *CMS* Centers for Medicare and Medicaid Services, *MIPS* Merit-based Incentive Payment System, *USPTF* U.S. Preventive Services Task Force, *HEDIS* Healthcare Effectiveness Data and Information Set

[a] HEDIS measure targets Women age 65–85 who suffered a fracture (note difference from MIPS target of women age 50–85)

[b] HEDIS measure evaluates the rate of falls risk assessment and intervention among Medicare beneficiaries with balance or walking problems or history of fall in the past 12 months

Performance on Quality Measures Based on HEDIS and PQRS Reports

Early literature from 1999 to 2005 identified significant performance gaps in this area, with only 30% of female Medicare beneficiaries ≥ 65 years old having received a DXA scan ever [24]. Since then, the Affordable Care Act was passed, requiring private insurance plans to cover recommended preventive services such as osteoporosis screening for postmenopausal women without patient cost-sharing. Based on more recent estimates from HEDIS for Medicare HMO beneficiaries, there has been nearly a 10% increase in the DXA testing rate between 2006 and 2016, with 2016 estimates reaching 72.7% (Table 1) [17]. This is similar to estimates from voluntary reporting to CMS through PQRS in 2009–2012 [18]. The appropriateness measure is not included in HEDIS or PQRS, so estimates of performance are not available.

Performance on Quality Measures Based on Other Sources

Our review found three recent studies around screening patterns for osteoporosis (Table 2). Amarnath et al. evaluated the rate of DXA screening among over 50,000 women seen in university-affiliated primary care clinics in Northern California using electronic health record (EHR) data and a radiology database [25•]. Gillespie et al. evaluated DXA rates among women without history of osteoporosis or hip fracture using claims data for 2 million privately insured women [26••]. Both studies showed persistent gaps in osteoporosis screening, with DXA rates ranging from 30 to 60% depending on the age group studied. Patient-level predictors of poor utilization of DXA screening included low socioeconomic status (SES), black race, advanced age (i.e., age ≥ 75 or ≥ 80), and decreased utilization or primary care [25•, 26••]. Disparities based on SES seemed to narrow over time [26••].

Conversely, significant over-use of DXA in younger women was found in the study by Amarnath et al., with around 50% of women between 50 and 65 years old without any osteoporosis risk factors seen in primary care clinics having received a DXA [25•]. Overutilization of BMD testing was included in the Top 5 List of the American Board of Internal Medicine (ABIM) Choosing Wisely Campaign of practices to avoid due to lack of cost-effectiveness [40]. Despite the efforts of this campaign, another recent retrospective study of 34 practices affiliated with an academic center found that the rate of DXA in women < 65 years old without risk factors for osteoporosis before and after the DXA Choosing Wisely recommendation was unchanged at around 3.0% [27].

These studies suggest that patient barriers to appropriate screening and health system issues contribute to patterns of underscreening and overscreening and should be addressed in designing population level interventions to enhance quality of care and decrease disparities.

Fragility Fractures and Secondary Prevention

The NCQA process measures pertaining to adults with fragility fracture focus on secondary prevention of fractures through appropriate diagnosis and treatment of osteoporosis (Table 1). The first measure defines the proportion of women with a new fracture who received either a BMD test or prescription for an osteoporosis medication within 6 months of their fracture and has been endorsed by the NQF since 2009. The second measure evaluates the rate of documentation of communication between the provider treating fragility fracture and the primary provider responsible for ongoing care.

Performance on Quality Measure Based on HEDIS and PQRS Reports

There was a modest improvement in performance on the HEDIS quality measure for post-fracture care from 2007 to 2017 (Table 1) [17], though significant underperformance persists with 2017 estimates reaching 39.1% for Medicare PPO and 46.7% for Medicare HMO beneficiaries. Performance documented in PQRS for the years 2009–2012 ranged from 56.5 to 70.6%, though in 2012 only 204,369 eligible providers (0.8%) chose to report on this measure in PQRS [18]. We did not find performance data for documentation of communication with primary care providers following a fracture event.

Performance on Quality Measure Based on Other Sources

Our review found 11 recent studies evaluating quality in post-fracture care (Table 2). A majority of these studies used claims data to assess performance. There is clear unmet need for both diagnosis and treatment following fragility fractures, with rates of pharmacotherapy after fragility fracture hovering around 25%. Notably, there was a significant decline in osteoporosis medication use in the first decade of the 2000s that was evident across multiple studies [28, 29••, 32••, 36••]. Advanced age, male gender, lower SES, and higher comorbidity are potential risk factors for poor utilization of osteoporosis medication post-fracture [29••, 36••, 37]. Conversely, receipt of primary care, baseline history of osteoporosis, or prior osteoporosis medication use were associated with higher likelihood of receiving osteoporosis pharmacotherapy post-fracture [29••, 30, 36••]. Osteoporosis medication use prior to fracture was the greatest predictor of osteoporosis medication use after fracture [29••, 37••]. Not surprisingly, having a BMD test has also been shown to be associated with increased odds of bisphosphonate treatment after fragility fracture in the setting of a quality improvement RCT [41]. Poor adherence to osteoporosis treatment was observed in studies that measured medication possession ratio using dispensed prescription data [30, 31]. Overall, the recent literature points to a significant missed opportunity for osteoporosis care following fragility

Table 2 Recent studies evaluating performance gaps for osteoporosis measures

Study and year	Study population	Years of study	Study design	Outcome assessed	Performance	Risk factors for poor performance
Osteoporosis screening						
Amarnath et al. 2015 [25•]	Women 65 and older seen in 13 university-affiliated primary care clinics in Northern California without prior DXA, history of osteoporosis, or prior OP drug use	2006–2012	Retrospective cohort study using electronic health record (EHR) and radiology database	Osteoporosis screening rates with DXA	57.8% of women aged 65-74 years and 42.7% of women aged ≥ 75 years received a DXA during the 7-year observation period	Age ≥ 75, low utilization of primary care and other preventive screening, black race, current smoker
Gillespie et al. 2017 [26••]	Privately insured women aged ≥ 50 years without history of osteoporosis, prior OP drug use, or history of hip fracture	2008–2014	Retrospective analysis of administrative claims data for Medicare Advantage or commercial insurance	Osteoporosis screening rates with DXA	Cumulative DXA rates were 44.3%, 51.5%, and 31.6% among women ages 50–64, 65–79, and 80+ years respectively	Low utilization of primary care, black race, low SES, age ≥ 80
Lasser et al. 2016 [27]	Women aged 50–64 years receiving primary care within 34 ambulatory practices across Maryland and Washington, DC	2011–2012	Retrospective analysis of EHR data before and after implementation of the DXA Choosing Wisely recommendation	Trends in rates of DXA ordering for patients without risk factor for osteoporosis	Mean DXA order rate per patient was 2.6%. pre-initiative and 2.0% post-initiative. The average percent DXA ordered by clinic was 25.7% pre-initiative and 32.2% post-initiative. There was no significant change in trend in DXA ordering	Patients with low BMI, current smoker status, and osteopenia were the most common characteristics indicating potentially appropriate DXA orders
Fragility fractures and secondary prevention						
Balasubramanian et al. 2014 [28]	Community-dwelling individuals aged ≥ 50 years with new diagnosis of fragility fracture	2001–2009	Retrospective cohort analysis using a commercial health insurance database	Osteoporosis management within 12 months of fragility fracture (BMD test and/or medication)	19% of women and 10% of men received OP pharmacotherapy and 30% of women and 15% of men underwent BMD testing and/or pharmacotherapy following fracture. Overall treatment rates decreased over the decade of observation	Wrist or humoral fracture (vs. vertebral or hip) were associated with low medication use. Among women, rate of DXA was lower following hip, wrist, or humoral fracture (vs. vertebral)
Solomon et al. 2014 [29••]	Patients ≥ 50 years hospitalized for hip fracture	2001–2011	Retrospective analysis of U.S. administrative claims for a sample of beneficiaries with commercial or Medical supplemental insurance	Osteoporosis pharmacologic treatment within 12 months following fragility fracture	There was a significant decline in osteoporosis medication use between 2001 and 2011 from 40 to 21% (p for trend < 0.001)	Older age, male gender, higher comorbidity, no prior osteoporosis medication use
Wilk et al. 2014 [30]	Women ≥ 50 years with first time osteoporotic fracture	2003–2012	Retrospective analysis of US administrative claims dataset for managed care	Osteoporosis pharmacologic treatment within 90 days and 12 months following fragility fracture	18% initiated medication within 90 days and 23% within 1 year of fracture (68% had received osteoporosis medication pre-fracture)	Younger, non-hip and non-vertebral fracture, no baseline osteoporosis diagnosis or prior osteoporosis therapy
Kim et al. 2015 [31]	Patients aged ≥ 65 years hospitalized for hip fracture	2003–2012	Retrospective cohort analysis of health insurance claims data for US Medicare and commercial health insurers	Osteoporosis pharmacologic treatment within 3 and 6 months after fracture	16.7% of patients with US Medicare insurance and 18.2% with US commercial insurance received osteoporosis medication within 6 months after fracture	Not reported
Kim et al. 2016 [32••]	Adults aged ≥ 50 years with hospitalization for hip fracture	2004–2013	Retrospective analysis of US commercial health insurance claims	Bisphosphonate treatment within 6 months after fracture	Overall 14.5% received a bisphosphonate within 6 months of fracture. Over the study period, bisphosphonate prescription decreased from 15% in 2004 to 6% in 2013	Younger age, male gender, no diagnosis of osteoporosis
Munson et al. 2016 [33]		2007–2011	Retrospective analysis of 40% random sample of Medicare	Osteoporosis pharmacotherapy	Rates of osteoporosis pharmacotherapy were low (17.9–23.7%). In addition, most	Not reported

Table 2 (continued)

Study and year	Study population	Years of study	Study design	Outcome assessed	Performance	Risk factors for poor performance
	Community-dwelling Medicare beneficiaries who sustained a hip, shoulder, or wrist fracture		beneficiaries with Part D medication coverage	120 days before and after fracture	patients (76%) were exposed to at least one medication associated with increased fracture risk	
Yang et al. 2016 [34]	Women ≥ 65 years with osteoporosis-related fracture	2012	Retrospective analysis of insurance claims for Medicare beneficiaries using the Humana database	Osteoporosis pharmacotherapy among women with OP diagnosis or an OP-related fracture during 2007–2011	75.9% of patients with baseline fractures did not receive osteoporosis medication during follow-up.	No prior use of osteoporosis therapy pre-fracture, higher comorbidity burden
Yusuf et al. 2016 [35]	Medicare enrollees ≥ 66 years with fragility fracture	2008–2011	Retrospective analysis of CMS 20% sample Medicare claims data	Osteoporosis medication prescription within 12 months after fracture	30.4% received an osteoporosis medication in the 12-months post-fracture. Of those not on medication pre-fracture, 14.9% were newly initiated on therapy post--fracture	Men, no diagnosis of osteoporosis or BMD test prior to fracture
Gillespie et al. 2017 [36••]	Women aged ≥ 50 years hospitalized with hip fracture without prior diagnosis of osteoporosis, OP med use, or fracture	2008–2013	Retrospective analysis of medical and pharmacy claims data for commercial or Medicare advantage plans using the OptumLabs Data Warehouse	BMD testing and/or osteoporosis pharmacotherapy within 6 and 12 months after fracture	17.1% and 23.1% had BMD testing and/or OP medication within 6 or 12 months of fractures respectively. 13.0% underwent BMD testing and 7.2% initiated osteoporosis medication within 6 months. There was a downward trend in initiation of OP medication over time	Advanced age (≥ 80 years), Medicare advantage plan (compared to commercial plan), lower primary care utilization, lower SES
Keshishian et al. 2017 [37]	Women ≥ 65 years who were hospitalized or had an outpatient/ER service for fragility fracture	2010–2012	Retrospective analysis of Medicare fee-for-service insurance administrative claims data	Osteoporosis medication within 12 months after fracture, subsequent fractures, and medication discontinuation	27.7% were treated with OP medication within 12 months of index fracture. 8.3% had recurrent fracture. After adjustment for covariates, the treated group had 20.9% lower risk of subsequent fracture compared to the untreated group during the 12 months after index fracture	Black race, non-vertebral fracture, no prior BMD test or treatment for osteoporosis pre-fracture
Barton et al. 2019 [38]	Patients ≥ 50 years presenting to an emergency department with a new vertebral fracture at a tertiary care hospital	2008–2014	Retrospective chart review of the EHR	Osteoporosis management after fracture (DXA testing and/or osteoporosis medication within 1 year of fracture)	Only 2% of patients received a DXA scan within the preceding 2 years or 1 year following fracture and 7% were started on OP medication. 21% were on OP med prior to fracture.	Not reported
Fall prevention						
Qin et al. 2016 [39•]	Adults ≥ 65 years who completed the California Health Interview Survey (CHIS)	2011–2012	Retrospective review of survey data	Fall assessment	12.2% fell multiple times in the prior year. Of those with falls, only 38.9% reported receiving medical advice on fall prevention and 40.1% received medical treatment	Not reported

OP osteoporosis, *DXA* dual-energy X-ray absorptiometry, *BMD* bone mineral density, *EHR* electronic health record, *CHIS* California Health Interview Survey, *CMS* Centers for Medicare and Medicaid Services

fractures, with a treatment gap that widened over the preceding decade.

Fall Prevention

Although approximately one-third of adults age 65 and older will experience at least one fall per year [42], less than half of these patients seek care after falls or discuss fall prevention with their provider [43]. The NCQA quality measures attempt to capture the percentage of older patients screened for fall risk and the percentage of patients with history of falls that had a fall risk assessment and documentation of a plan of care (Table 1).

Performance on Quality Measure Based on HEDIS and PQRS Reports

Among Medicare beneficiaries, 32.7–37.6% of patients with a history of falls had a fall risk assessment completed and 54.1–60.1% had a plan of care for falls documented in 2016 based on HEDIS estimates (Table 1) [21]. Higher performance was seen through PQRS voluntary reporting, though few providers reported on these measures [20].

Performance on Quality Measure Based on Other Sources

An older study of the US Medicare Current Beneficiary Survey suggests that fall risks among older patients are not being adequately addressed in clinical practice [43]. In that study, 22% of beneficiaries experienced a fall in the prior year; however, less than half of these individuals talked to a healthcare provider about falls and only 31% of women and 24% of men discussed fall prevention. Our review found one more recent study around fall care, which also utilized survey data to estimate the prevalence of falls and measures to address fall risk (Table 2) [39•]. This study found that patients with a history of falls are still not consistently receiving professional recommendations for fall prevention. Among adults aged 65 and older who responded to the 2011–2012 California Health Interview Survey, 12.2% reported multiple falls in the prior year but only 38.9% of those individuals had discussed how to avoid falls with a physician [39•]. Prior reviews also highlight gaps in fall prevention efforts [44]. A recent analysis comparing self-reported fall-related injuries to administratively obtained fall-related injuries from Medicare claims data suggests that falls continue to be underreported, which is important to recognize and address for preventive efforts [45]. Overall, recent literature suggests most patients with history of falls—those at highest risk for future falls—never discuss them with a medical provider nor receive recommended interventions for fall prevention. However, large population-based studies evaluating current performance for fall screening and prevention measures are lacking.

Quality Improvement Interventions in Osteoporosis

In the following section, we summarize recently published quality improvement interventions for the quality indicators for osteoporosis screening, secondary prevention of fragility fractures, and fall prevention and describe some of the challenges of translating evidence into real-world clinical practice.

Osteoporosis Screening

Our review found five recent studies describing quality improvement interventions for osteoporosis screening (Table 3), including two systematic reviews with meta-analysis assessing a range of provider, patient, and health system interventions, two RCTs of QI interventions targeting patient activation, and a study of a national QI program incorporating patient-specific prescriber feedback and education targeting providers and patients [46, 47, 48•, 49, 50•].

Consistent with prior work, studies in our review suggest that neither patient nor provider education initiatives consistently increase rates of diagnosis or treatment of osteoporosis [51, 52]. While education alone seems to have limited capacity for promoting practice change, when incorporated into complex interventions with multiple targets or with provider feedback and follow-up, education may improve BMD screening [48•, 50•]. Patient and provider-directed interventions that incorporate activation strategies for patients to discuss BMD testing with their provider or alerts for primary care providers with patient-specific feedback also show promise [47, 49], with provider-directed intervention likely having the largest impact on increase in DXA screening rates [49]. Innovative approaches to automation or engagement of ancillary staff in DXA ordering may also prove beneficial in this area [53]. In another study from Kaiser, invitation for self-referral for DXA among women 65 and older without recent screening led to a fivefold increase in completion rates [46]. While self-referral is a creative approach to removing barriers to screening, it is unlikely that this strategy is generalizable to implementation in an open healthcare system given the added complexity of reimbursement for DXA among mixed payers.

Fragility Fractures and Secondary Prevention

Our review found nine recent studies describing quality improvement interventions around post-fracture care (Table 4). Several studies document the importance of communication between the emergency room or inpatient provider taking care of a patient with fragility fracture and the primary provider managing ongoing care as an outpatient as a crucial component to improving the diagnosis and treatment of osteoporosis [63], though it is unclear how often this is performed.

Table 3 Recent QI interventions for quality measure: BMD screening

Study and year	Study population	Study design	Target of intervention	Intervention	Outcome	Results	Predictors of response
Warriner et al. 2014 [46]	Women ≥ 65 without a DXA in past 5 years at Kaiser Permanente Northwest and Georgia	RCT	Patient and health system	Invitation for self-referral for DXA via mail compared to UC	DXA completion rate at 90 days and medication receipt at 180 days	Women randomized to self-referral were more likely to receive DXA (13.0–24.1% self-referral vs. 4.9–5.9% UC, $p < 0.05$)	Increased treatment rates reported for Kaiser Northwest plan
Heyworth et al. 2014 [47]	Women aged 50–64 years with high risk for OP within a non-profit health plan (Harvard Pilgrim Health Care) without prior BMD testing or treatment	RCT	Patient	Interactive voice response outreach call vs patient mailing with educational materials compared to UC	DXA completion at 12 months	Incidence of BMD testing was increased in the interactive voice response group compared with UC (24.6% vs. 18.6%, $p < 0.001$). No difference was seen between the patient mailing group and the usual care group ($p = 0.3$)	Not reported
Tzortziou Brown et al. 2016 [48•]	Professional interventions for GPs that aim to improve the management of musculoskeletal conditions in primary care	Systematic review and meta-analysis	Provider and patient	Cochrane review of studies assessing GP alerting ± patient directed education	DXA completion over 6–12 months follow-up	Combination of GP-alerting system and patient education improved DXA rates (RR 4.44, 95% CI 3.54–5.55) and prescribing rates (RR 1.71, 95% CI 1.50–1.94)	Patient-directed component of intervention adds little benefit to GP-alerting
Kalisch Ellet et al. 2017 [49]	Australian women (70–79 years) and men (75–85 years) receiving primary care at the VA without prior prescription for OP med	Retrospective cohort analysis	Patient and provider	National QI program incorporating patient-specific feedback to GPs and tailored educational info to patients and GPs	Cumulative rate of BMD testing and initiation of OP treatment	BMD testing was increased twofold among targeted patients vs controls ($p < 0.001$). Initiation of OP medication increased in targeted men by 20–30% but not women	Men were more likely to start OP pharmacologic treatment with intervention
Kastner et al. 2018 [50•]	Post-menopausal women and men ≥ 65 in USA, Canada, UK, and Australia	Systematic review and meta-analysis	Provider and patient	Complex interventions (including two or more components and/or targets)	BMD testing and initiation of OP medication	Complex interventions with at least education + follow up improved BMD testing. Complex interventions with education + feedback + follow up improved treatment rates	Complex interventions with multiple components including patient education improve OP management

UC usual care, *DXA* dual-energy X-ray absorptiometry, *OP* osteoporosis, *BMD* bone mineral density, *GP* general practitioner, *UC* usual care

Table 4 Recent QI interventions for quality measure: BMD test or OP treatment following fragility fracture

Study and year	Study population	Study design	Target of intervention	Intervention	Outcome	Results	Predictors of response
Hofflich et al. 2014 [54]	Hospitalized patients ≥ 50 with fragility fracture at UCSD	Retrospective review	Healthcare system	Standardized endocrine osteoporosis consult	OP discharge diagnosis, prescription, order for DXA, OP med initiation within 60 days	Med initiation within 60 days increased from 21% to 84% ($p < 0.001$). Order for DXA increased from 4% to 75% ($p < 0.001$)	Length of stay, outpatient follow up
Bunta et al. 2016 [55•]	Patients ≥ 50 with fragility fracture seen in orthopedic offices and hospitals participating in the AOA's national QI program	Cohort study with web-based registry	Healthcare system	Fracture liaison coordinator	BMD test and/or OP medication with 90 days of fracture	Increased performance of BMD test or OP med to 53% within 5 years. 84.3% of PCPs were provided consultation letters	Not reported
Fojas et al. 2017 [56]	Hospitalized patients ≥ 50 with fragility fracture at Ohio State University Medical Center	Retrospective review	Healthcare system	NP-led Fracture Liaison Service (FLS) vs physician-led Fracture Prevention Program (FPP) vs UC	BMD test and/or prescription of OP med at 3 months	FLS group was more likely to have DXA scan scheduled at discharge (69.7% vs. 25%, $p < 0.001$) but rates of DXA completion at 3 months were similar. OP med initiation was higher in the FPP group c/w FLS group (65.3% vs. 24%, $p < 0.001$)	Clinic follow up was associated with younger age, female gender, surgical repair, lower Charlson Comorbidity Index scores
Merle et al. 2017 [57]	Women aged 50–85 years attending a French hospital for fragility fracture	RCT	Patient and healthcare system	Dedicated case manager to provide patient education and PCP follow-up	BMD test and/or prescription for OP med at 6 months	BMD testing was increased in the intervention group vs UC (41% vs. 25%, OR 2.12, 95% CI 1.4–3.2). There was no significant change in rates of prescription	BMD testing was higher among those with wrist fracture and younger age
Anderson et al. 2017 [58]	Patients 65 and older with fragility hip fracture at University of Colorado Medical Center	Retrospective review	Healthcare system	Geriatric hip fracture program with hospitalist co-management and auto- referral to Metabolic Bone Clinic	Percent of patients receiving OP evaluation and treatment	Intervention resulted in follow up in Metabolic Bone Clinic in 28% vs. 3% with UC ($p < 0.001$), and 85% vs. 34% of patients were initiated on OP medication ($p < 0.001$)	Not reported
Beaton et al. 2017 [59]	Fragility fracture patients 50 and older in Ontario, Canada	Interrupted time series analysis of control and intervention hospitals	Healthcare system	Fracture Liaison Service	BMD test and OP medication initiation	BMD testing increased from 17% to 20.9% ($p < 0.01$). OP med prescription increased from 21.6 to 24% ($p < 0.02$)	Not reported
Danila et al. 2018 [60]	Women with fracture after age 45 from U.S. Global Longitudinal Study of Osteoporosis in Women (GLOW) study	RCT	Patient	Direct-to-patient tailored educational video vs UC	Self-report OP medication use after 6 months	There was no difference in OP med use (11.7% vs. 11.4%, $p = 0.8$) or BMD testing (61.8% vs. 57.1%, $p = 0.2$) in the intervention vs UC groups	Non-BP med use and BMD testing was increased in women without prior BMD test or OP treatment
Dunn et al. 2018 [61]	Patients ≥ 50 years with fragility fracture hospitalized at Geisinger Medical Center	Retrospective review	Healthcare system	Inpatient FLS with rheumatology consultation and outpatient HiROC clinic	OP medication initiation	Prescription rates were 75.4% among patients who followed up in high-risk OP	Not reported

Table 4 (continued)

Study and year	Study population	Study design	Target of intervention	Intervention	Outcome	Results	Predictors of response
						clinic vs. 19.7% among patients seen in primary care	
Nayak et al. 2018 [62•]	Patient populations with recent or prior fracture	Systematic review and meta-analysis	Provider, patient, and healthcare system	Multifaceted interventions targeting the provider and patient, FLS, case management, fracture clinic, patient education and/or activation	BMD testing and OP medication after fracture	Multifaceted interventions targeting providers and patients and FLS or case management interventions were effective for increasing BMD testing and osteoporosis treatment following fracture	Not reported

HiROC high-risk osteoporosis clinic, *BP* bisphosphonate, *OP* osteoporosis, *MOF* major osteoporotic fracture, *PCP* primary care physician, *UC* usual care, *CM* case manager, *FLS* fracture liaison service, *FPP* fracture prevention program, *AOA* American Orthopedic Association, *HiROC* high-risk osteoporosis clinic

Several models for collaborative care with a systems-based approach have demonstrated efficacy in improving post-fracture osteoporosis care, including ortho-geriatric services [64], auto-consultation of specialists dedicated to bone health [54], having a dedicated case manager focused on coordination of osteoporosis care [57], and fracture liaison services. On the other hand, electronic health record (EHR)-based intervention using an osteoporosis order set appears to have limited ability on its own to improve rates of BMD testing or osteoporosis treatment [65].

Arguably the most effective and well-studied quality intervention for post-fracture care is implementation of a fracture liaison service or other coordinator-based system with dedicated personnel to help to address fragmentation of care [55•, 56, 57, 59, 61, 62•, 64]. A meta-analysis by Nayak et al. suggested multiple effective strategies for improving BMD testing post-fracture, including fracture liaison service (FLS) or dedicated case manager, multifaceted intervention targeting patients and providers, and patient education or activation [62•]. However, osteoporosis treatment was only increased with FLS/case management or multifaceted interventions targeting patients and providers [62•]. A study of two FLS models at separate academic institutions participating in American Orthopedics Association's national QI program suggested that the FLS model that implemented immediate care, including initiation of pharmacologic therapy during hospitalization, had better rates of osteoporosis treatment within 6 months of fracture compared with the model where recommendations were communicated to the primary care physician after discharge (67% vs. 30%, $p < 0.001$) [66]. This finding that FLS models that identify, diagnose, and initiate pharmacotherapy are more effective than models that rely on the primary care physician is corroborated by a meta-analysis and a recent study that compared a NP-led fracture liaison service to a physician-led fracture prevention program [56, 67]. Rates of DXA completion were similar in the two programs, but osteoporosis medication initiation was higher with the physician-led fracture prevention program where the coordinator had the ability to place orders as opposed to only communicate recommendations. Quality standards for fracture liaison services have now been proposed by the International Osteoporosis Foundation (IOF) as a tool for benchmarking performance, with the Capture the Fracture Best Practice Framework [68, 69].

Despite the potential benefits of a fracture liaison services, they have not been widely implemented in the USA. Several organizations including the American Orthopedic Association, the American Society for Bone and Mineral Research Task Force on Secondary Fracture Prevention, and the National Bone Health Alliance have ongoing initiatives to promote adoption of FLS. Future studies should evaluate if these efforts translate into uptake and maintenance of sustainable FLS programs.

Fall Prevention

Exercise-based interventions as well as multifactorial interventions with fall risk assessment and customized treatment tailored to address individual risk factors have been shown to be effective for fall prevention [14, 16, 70]. However, implementation of fall prevention interventions in non-research settings has had variable success. Our review found eight recent studies describing quality improvement interventions around fall prevention (Table 5). The CDC Stopping Elderly Accidents, Deaths, and Injuries (STEADI) initiative launched in 2012 with a toolkit to incorporate American Geriatric Society (AGS) clinical practice guidelines for fall prevention into primary care [79]. Implementation of the STEADI approach has been shown to be feasible in two large academic primary care clinics with early successes in increasing rates of fall screening [73, 74•]. The STEADI approach was also incorporated into a QI program among interprofessional teams in the ambulatory and long-term care setting in North Carolina that used education workshops to increase adoption of fall screening and prevention strategies [75].

Another successful model for quality improvement for geriatric conditions including falls is the Assessing Care of Vulnerable Elders (ACOVE) clinical practice model [80]. This model promotes clinical practice redesign with multicomponent intervention including nursing prescreening for falls, prompts and decisional support for providers, and educational materials for patients. The model emphasizes case finding, delegated clinical data collection by office staff, structured visit notes, and patient and physician education. Implementation of ACOVE led to 60% of patients at intervention sites receiving recommended care for falls vs. 37.6% of patients at control sites in one study ($p < 0.001$) [81]. Further analysis of ACOVE interventions for practice improvement of geriatric conditions suggests that delegation of selected tasks to non-physician healthcare providers is associated with higher quality of care [80, 82•]. Other studies also show improvement with pre-visit screening by ancillary medical staff [78•], emphasizing the benefit of multidisciplinary quality improvement teams and including non-physicians in clinical workflow, particularly for point-of-care measures like falls screening. Team-based care is also a pillar of high-performing primary care [83].

Because most of the evidence regarding fall risk assessment and intervention has been developed for primary care practice, it is unclear how best to implement these in other settings such as the emergency room or care in the community. However, given that emergency room physicians and paramedics are often first-line health care professionals to manage falls, care delivered in these settings represents an opportunity for intervention [84, 85]. Attempts at delivering interventions by paramedics and ER physicians with referral pathways for community-based fall services have been met with variable success [86–88]. More work is needed to define reliable and feasible means of identifying high-risk fallers and effective interventions in the emergency care setting.

Quality improvement interventions for falls, regardless of the setting, are resource intensive and further studies are needed to understand what elements are key to success. The time required for screening and intervention and issues around reimbursement are potential barriers to wider implementation of sustainable quality interventions in this area.

Discussion

In this review, we provide an update on current performance for osteoporosis quality measures used by CMS for pay-for-performance programs such as MIPS, and describe recent quality improvement strategies around these measures. Based on HEDIS reporting, we found that performance on measures in the managed care population showed gradual improvement in osteoporosis screening, identification and treatment following fragility fracture, and documentation of fall risk assessment and plan of care between 2006 and 2016. However, evidence from population-based studies suggested achievement for these process measures was lower where reporting was not mandated; performance gaps remain, particularly for post-fracture care. The discrepancy between performance assessed by CMS through PQRS or MIPS and population-based studies is likely explained by the fact that practices can select which measures to report for pay-for-performance programs and are more likely to choose areas where they already excel.

We also summarize a series of recent quality improvement initiatives around osteoporosis care. As has been shown for other areas of health care that require complex behavior change, passive intervention with education alone is not sufficient for improving quality of care for osteoporosis [89]. Interventions targeting the healthcare system, the provider, and the patient have all been studied with varying degrees of success for osteoporosis measures, though in general, greater efficacy has been demonstrated for multifaceted interventions that engage multiple stakeholders in the care process.

Areas for Future Work

1. Defining outcome measures in osteoporosis: Current quality measures for osteoporosis management and fall prevention are all process measures focused on the appropriate delivery of care. Process measures are typically more actionable, measurable in real-time, and make it easier to hold providers accountable compared to outcome measures. Ultimately, the goal of these processes is to improve health outcomes, and process measures require a strong process-outcome link in order to justify

Table 5 Recent QI interventions for quality measure: fall prevention

Study and year	Study population	Study design	Target of intervention	Intervention	Outcome	Results	Predictors of response
Landis et al. 2014 [71]	Patients ≥ 65 years seen in primary care in Asheville, NC	Pre/post design retrospective cohort review	Patient and provider	Standardized care protocol for PQRS falls measures in primary care with decision support, EHR prompts, patient education materials, and falls registry	CMS PQRS fall measures and outcome of ER visits or hospitalization for falls	% of patients screened and assessed for falls increased from 17% to 76% over 12 months. Plan of care was documented for 72.7% of patients who had risk assessments. Rate of falls requiring ER visit or hospitalization did not change significantly	Not reported
Ganz et al. 2015 [72•]	Patients 75 and older who screened positive for fall risk in UCLA affiliated community-based primary care practices	Retrospective analysis of Medicare claims data comparing intervention and control practice sites	Patient and provider	ACOVE multifactorial intervention including clinician education, decision support prompts, and patient education handouts	Episodes of care for fall-related injuries	Intervention patients received 60% of recommended care for falls during the intervention period, compared to 37.6% for controls ($p < 0.001$). There was no difference in incidence of fall-related injuries	Not reported
Parker et al. 2015 [73]	Adults 65 and older seen in United Health Services primary care clinics in upstate NY	Retrospective review prior to and following STEADI implementation using CPT performance codes	Patient and provider	Integration of STEADI fall prevention program into primary care, including point-of-care clinical decision support	Rate of fall risk screening and assessment	69% of patients were screened and 76% of those screened had further fall risk assessments	Not reported
Casey et al. 2016 [74•]	Adults 65 and older seen at the OHSU Internal Medicine and Geriatrics Clinics	Retrospective review using CPT coding data collected with the STEADI EHR tool	Patient and provider	Implementation of STEADI in primary care	Fall risk screening, assessment and plan of care documentation	On a weekly basis, STEADI screenings increased from 30% to nearly 50% and 45% of eligible patients were screened overall within 18 months of implementation	Not reported
Eckstrom et al. 2016 [75]	Interprofessional clinical teams in ambulatory and long-term care settings in collaboration with the Oregon Rural Practice Based Research Network	Retrospective chart review pre- and post-intervention	Provider and healthcare system	Interprofessional educational workshops focused on evidence-based strategies to decrease the risk of falls	Adherence to fall prevention strategies, rate of falls, ER visits and hospitalizations for falls	Fall risk assessment increased from 42.5 to 51.7% ($p < 0.001$). Rate of falls, ED visits for falls, and hospitalizations for falls-related injuries did not change significantly during the 3-month	Long-term care teams had greater uptake of fall prevention strategies (already had mandated fall risk screening)

Table 5 (continued)

Study and year	Study population	Study design	Target of intervention	Intervention	Outcome	Results	Predictors of response
						post-intervention data collection period	
Ritchey et al. 2017 [76]	Patients with osteopenia or osteoporosis seen at the outpatient osteoporosis clinic at the Seattle VA	Chart review 12 months after program start	Healthcare system	Integrated fall screening program with self-completed screening questionnaire and dedicated physical therapist in an osteoporosis clinic	(1) Feasibility of program implementation (2) fall and fracture risk of patients screened (3) fall-related processes of care	Screening for fall risk increased 5-fold. 24% of eligible patients declined screening and 10% were not screened due to time constraints. 40% of patients screened reported history of falls and 67% were recommended an exercise program	Not reported
Johnston et al. 2018 [77]	Adults 65 and older seen in United Health Services primary care clinics in upstate NY	Retrospective review pre- and post-intervention evaluating fall-related ER visits and hospitalization in those at risk for fall	Patient and provider	Implementation of the STEADI initiative	(1) Documentation of fall-plan-of care (FPOC) (2) Fall-related ER visits (3) Fall-related hospitalization	Among adults with a fall risk, 60.9% had documented FPOC after implementation of STEADI intervention. There was no difference in fall-related ER visits between patients with and without FPOC, but those with a FPOC were less likely to have a fall-related hospitalization (OR 0.6, 95% CI 0.3–1.0, $p = 0.041$)	Women were more likely to have fall-related visits than men and age was associated with increased likelihood of hospitalization
Stoeckle et al. 2019 [78•]	Adults 65 and older seen in a large urban family medicine practice in Philadelphia	Retrospective review of internally collected data for CMS Group Practice Reporting Option (GPRO) over a 10- month intervention period.	Healthcare system	Incorporation of falls and depression screening into medical assistants' pre-visit workflow	(1) Rate of depression screening (2) Rate of falls screening	Average monthly fall screening rate increased from 19.2% pre-intervention to 61.3% post-intervention ($p < 0.001$)	Not reported

PQRS Physician Quality Reporting System; *ACOVE* Assessing Care of Vulnerable Elders; *STEADI* Stopping Elderly Accidents, Deaths, and Injuries; *CMS* Centers for Medicare and Medicaid Services; *CPT* current procedural terminology; *OHSU* Oregon Health & Science University; *EHR* electronic health record; *FPOC* fall plan-of-care

their use and the resource investment required for their continued measurement.

Direct evidence for the benefit of osteoporosis and fall prevention process measures in relationship to fracture outcomes is limited. Two recent large RCTs examined community-based osteoporosis screening interventions, one which found no reduction in major osteoporotic fractures and the other which found a small absolute reduction in hip fractures over 5 years of follow up [90, 91]. When evaluating the efficacy of screening for preventing fracture outcomes, it is important to consider that strategies that are effective for improving rates of BMD testing still may not improve treatment rates [92]. Data is also limited for fracture liaison services and subsequent fracture outcomes [93, 94]. A recent study of FLS across several UK hospitals found no difference in time to second fracture with implementation of FLS, though 30-day and 1-year morality were improved [64]. Lastly, a study of a multicomponent intervention for fall prevention showed no difference in fall-related injuries despite improving the care of falls [72•]. Overall incidence of falls requiring emergency room visit or hospitalization was similarly unchanged in another study of an intervention despite improved performance on fall process measures [71]. All together, these data remind us that processes of care may be necessary but not sufficient for reduction in osteoporotic fractures and falls.

2. Improving information capture for effective quality measurement: While quality measurement and value-based payment models hold great promise for improving adherence to standards of care, they also have led to increased demands on health systems and providers to collect performance data for reporting. A reliable, accurate, and feasible approach to identify patients in both the denominator and numerator for quality measures is essential. However, the electronic specification of the denominator and numerator both represent unique challenges from the perspective of cost and precision.

For example, fall-related quality measures rely on identification of patients at high risk for falls in the denominator; however, because falls are underreported, an EHR or claims-based history of falls alone would underascertain the at-risk population [43, 45]. Consensus around the use of tools for fall screening are lacking, making consistent, structured documentation difficult [13]. The use of natural language processing and machine learning approaches in the electronic specification of quality measures is starting to be explored [95, 96]. For example, Zhu et al. used natural language processing to identify fall risk screenings not documented by administrative codes; they found that 43% of patients had fall screening documented only in clinical notes but not coded in administrative data [97]. In the future, leveraging electronic health record-based data extraction using unstructured data may reduce the burden of data collection on the providers of care.

3. Capturing information on patient preferences: The ability to capture reasons why care is not provided is a valuable tool for quality measurement and can help to inform QI interventions. A study using a random 5% sample of US Medicare claims-based reporting data for PQRS osteoporosis quality measures evaluated physician-reported reasons for not providing recommended care with DXA screen or prescription for osteoporosis medication [98]. The authors found that 24% of claims documented that care was considered but not provided because care was either not indicated for a medical reason (e.g., comorbidity contraindication; 6.4%), patient reason (e.g., refusal; 4.1%), system reason (e.g., cost; 1.6%), or could not be provided for another reason (12.9%). These findings indicate that it may be difficult to improve performance on such a measure much higher than 75%. Future studies should continue to evaluate patient and systems reasons associated with missed quality measures in an effort to address modifiable risk factors. Shared decision making is an integral part of delivering high-quality care, and patient willingness to undergo and sustain treatment may need to be accounted for in any osteoporosis-related outcome measures that are developed.

4. Addressing the cost-effectiveness of quality measurement and quality improvement: Although often under-appreciated, the cost-effectiveness of quality measurement and quality improvement interventions are inherent in our conception of them as value-adding [99]. This issue of provider burden of documentation has to date not been addressed for osteoporosis quality measures, save for several evaluations of the cost-effectiveness of fracture liaison services [98, 100–102, 103••]. Overall, these studies have found that fracture liaison services ultimately result in cost savings, though the upfront investment of hiring dedicated staff for FLS may be a barrier to implementation in an open healthcare system with a mixed-payment model. These cost-effectiveness analyses are an important part of the equation for determining success of quality improvement strategies based not only on outcomes achieved but also value provided, and thus the willingness of healthcare systems to pay for their implementation.

In summary, the NCQA and MIPS measures for osteoporosis screening, secondary prevention after fragility fracture, and fall prevention are supported by strong evidence-based

guidelines and qualify for value-based incentives through CMS. Over the last decade of measurement, the care of osteoporosis and falls has improved, though persistent performance gaps warrant investment in refining quality improvement interventions that impact process measures and clinical outcomes. Multifactorial and systems-based interventions likely have the greatest potential for impacting measurable change. As much as possible, systems that facilitate accuracy and ease of measurement should be further developed to address the reality of practice limitations, including cost and time required for quality measurement.

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Compliance with Ethical Standards

Conflict of Interest Sonam Choden and Sarah French declare no conflict of interest. Gabriela Schmajuk reports grants from Russell/Engleman Rheumatology Research Center, grants from American College of Rheumatology, grants from AHRQ, grants from Alpha Foundation, outside the submitted work.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Appendix

Search strings used in each database are listed below.

Pubmed

osteoporosis AND ("quality measures" OR "Merit-Based Incentive Payment System" OR "MIPS" OR "Medicare Access and CHIP Reauthorization Act" OR "MACRA")

(osteoporosis AND ("Quality of Health Care"[MAJR] OR "quality measures" OR "Merit-Based Incentive Payment System" OR "MIPS" OR "Medicare Access and CHIP Reauthorization Act" OR "MACRA"))

(osteoporosis AND ("quality of health care"[mesh] OR "quality measures" OR "Merit-Based Incentive Payment System" OR "MIPS" OR "Medicare Access and CHIP Reauthorization Act" OR "MACRA"))

(falls AND ("quality of health care"[mesh] OR "quality measures" OR "Merit-Based Incentive Payment System" OR "MIPS" OR "Medicare Access and CHIP Reauthorization Act" OR "MACRA"))

Embase

('osteoporosis'/exp OR osteoporosis) AND ('health care quality'/exp OR 'health care quality' OR 'quality measures') AND [2014-2019]/py

('osteoporosis'/exp OR osteoporosis) AND ('health care quality'/exp OR 'health care quality' OR 'quality measures') AND [2014-2019]/py AND ([cochrane review]/lim OR [systematic review]/lim OR [meta analysis]/lim OR [controlled clinical trial]/lim OR [randomized controlled trial]/lim)

Web of Science

(osteoporosis OR "osteoporosis"[mesh]) AND ("Quality of Health Care"[MAJR] OR "quality measures" OR "Merit-Based Incentive Payment System" OR "MIPS" OR "Medicare Access and CHIP Reauthorization Act" OR "MACRA")

(osteoporosis OR "osteoporosis"[mesh]) AND (Quality of Health Care"[mesh] OR "quality of care" OR "quality measures" OR "Merit-Based Incentive Payment System" OR "MIPS" OR "Medicare Access and CHIP Reauthorization Act" OR "MACRA")

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- • Of importance
- •• Of major importance

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