

## ORIGINAL RESEARCH

## Underuse and Overuse of Osteoporosis Screening in a Regional Health System: a Retrospective Cohort Study

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**BACKGROUND:** The United States Preventive Services Task Force (USPSTF) recommends screening for osteoporosis with dual-energy x-ray absorptiometry (DXA) for women aged  $\geq 65$  years and younger women with increased risk. "Choosing Wisely" initiatives advise avoiding DXA screening in women younger than 65 years without osteoporosis risk factors.

**OBJECTIVE:** We aimed to determine the extent to which DXA screening is used in accordance with USPSTF recommendations within a regional health system.

**DESIGN:** This was a retrospective longitudinal cohort study within 13 primary care clinics in the Sacramento, CA region.

**PATIENTS:** The study included 50,995 women aged 40–85 years without prior osteoporosis screening, diagnosis, or treatment attending primary care visits from 2006 to 2012, observed for a mean of 4.4 years.

**MAIN MEASURES:** We examined incidence of DXA screening. Covariates included age, race/ethnicity, and osteoporosis risk factors (body mass index  $< 20$ , glucocorticoid use, secondary osteoporosis, prior high-risk fracture, rheumatoid arthritis, alcohol abuse, and current smoking).

**KEY RESULTS:** Among previously unscreened women for whom the USPSTF recommends screening, 7-year cumulative incidence of DXA screening was 58.8% among women aged 60–64 years with  $\geq 1$  risk factor (95% CI: 51.9–65.8%), 57.8% for women aged 65–74 years (95% CI: 55.6–60.0%), and 42.7% for women aged  $\geq 75$  years (95% CI: 38.7–46.7%). Among women for whom the USPSTF does not recommend screening, 7-year cumulative incidence was 45.5% among women aged 50–59 years (95% CI 44.1–46.9%) and 58.6% among women aged 60–64 years without risk factors (95% CI 55.9–61.4%).

**CONCLUSIONS:** DXA screening was underused in women at increased fracture risk, including women aged  $\geq 65$  years. Meanwhile, DXA screening was common among women at low fracture risk, such as younger women without osteoporosis risk factors. Interventions may be needed to augment the value of population screening for osteoporosis.

**KEY WORDS:** osteoporosis; screening; dual-energy x-ray absorptiometry; overuse; underuse.

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## INTRODUCTION

Osteoporosis affects more than 10 million Americans,<sup>1</sup> causing more than 2 million fractures per year at a cost of more than \$17 billion.<sup>2</sup> While osteoporosis is asymptomatic until a fracture occurs, drug treatment significantly reduces the risk of osteoporotic fractures in women with osteoporosis identified by screening,<sup>3</sup> and the cost-effectiveness of screening increases with age due to greater risk and morbidity of fracture in older women.<sup>4</sup> The United States Preventive Services Task Force (USPSTF) recommends dual-energy x-ray absorptiometry (DXA) screening for women aged 65 and older and for younger women who have a fracture risk greater than or equal to the risk of a 65 year old white female with no additional risk factors.<sup>5</sup> The National Osteoporosis Foundation has issued similar recommendations.<sup>6</sup>

The extent to which clinicians adhere to USPSTF recommendations is unclear. In studies of Medicare beneficiaries aged 65 years and older, screening has been reported to be as low as 30%<sup>7</sup> and 48%<sup>8</sup> over a 7-year period. Meanwhile, overuse of DXA in younger, lower risk women has been a focus of the Choosing Wisely initiative.<sup>9</sup> Both the American Academy of Family Physicians and the American College of Physicians included use of DXA screening in their "top five" lists of frequently misused diagnostic tests or treatments, advising primary care physicians not to perform DXA screening in women younger than the age of 65 years without osteoporosis risk factors.<sup>10</sup> In a survey of women referred for DXA screening at one center, over 40% of screened women under the age of 65 years did not meet criteria for screening.<sup>11</sup> However, to our knowledge, the degree of DXA overuse across an entire screening population has not been reported.

We evaluated the incidence and cumulative incidence DXA screening among previously unscreened women in a regional health system to determine how screening rates differ by age and osteoporosis risk status. We hypothesized that our analysis

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would reveal both underuse among women for whom the USPSTF recommends screening and overuse among women at lower risk for osteoporotic fracture.

## METHODS

**Design, Setting, and Subjects.** We performed a retrospective, longitudinal cohort study of electronic health records (EHR) and linked radiology records for women aged 40 to 85 years who received primary care at University of California, Davis Health System (UCDHS) clinics from 1 January 2006 through 31 December 2012. UCDHS includes an academic medical center in central Sacramento and a large physician group offering community-based primary care in 13 clinics across the Sacramento region. The institutional review board of the University of California, Davis approved the study.

**Cohort Eligibility.** We identified annual samples of women based on these inclusion criteria: 1) age 40–85 years on 1 January 1st of the study year; 2) one or more primary care or obstetrics and gynecology (OB/GYN) visits during the study year; 3) no DXA test in a prior calendar year; and 4) no prior osteoporosis diagnosis or medication prescription for osteoporosis drugs (including bisphosphonates, raloxifene, teriparatide, calcitonin, denosumab, but not including estrogens, calcium, or vitamins). The EHR and radiology database were searched back to 2002 for evidence of prior DXA use and osteoporosis diagnosis and medications. Women were eligible for inclusion in multiple consecutive study years including the year they received DXA screening, but were excluded in years following DXA screening or when they ceased receiving primary care within the health system (e.g., due to transfer of care or death). However, we included women during years without primary care or OB/GYN visits if these years were preceded and followed by years with visits. When women had two or more consecutive years without primary care or OB/GYN visits followed by a subsequent year with primary care or OB/GYN visits, we included women in the first year following the two-year gap in visits, so that study data reflected the most recent period of continuous observation time.

**DXA Screening.** Incident DXA screening was defined as a DXA screening test that was completed and reported in the radiology records during the study period. We used this measure to determine the cumulative incidence of screening by age and risk factor status. DXA screening in UCDHS is completed at the central academic campus and one community-based radiology site. Women at some UCDHS primary care sites also complete ordered DXAs at outside radiology facilities. Primary care clinics routinely file outside radiology reports for scanning into the EHR. When outside DXA results are scanned into the EHR, the EHR signifies that the ordered DXA test was completed.

**Osteoporosis Risk Factors.** Based on risk factors in the Fracture Risk Assessment Tool (FRAX),<sup>12</sup> we identified from the EHR several osteoporosis risk factors. Age was determined as of January 1st of each study year, although baseline age (on January 1st of the first year of eligibility) was used for some stratified analyses. Smoking status was determined for each study year using social history information collected routinely by staff during outpatient encounters. If smoking status was not documented during or prior to the study year, the earliest recorded smoking status was used. Height and weight were used to calculate body mass index (BMI) as of January 1st of each study year. From pharmacy data, we collected glucocorticoid prescription information; we considered women to be glucocorticoid users if they received one or more prescriptions for a glucocorticoid during the study period. In a sensitivity analysis, we used an alternative specification based on average yearly glucocorticoid dosage. Using International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9-CM) codes given in Appendix A, we categorized women by the following diagnoses: possible secondary osteoporosis, previous high-risk fracture, rheumatoid arthritis, and alcohol abuse. We also created a binary indicator of whether the patient had one or more of the following six risk factors: BMI < 20, glucocorticoid use, possible secondary osteoporosis, previous high-risk fracture, rheumatoid arthritis, or alcohol abuse.

**Sociodemographics and Healthcare Utilization.** We collected information on race/ethnicity from the EHR, which includes predefined race and ethnicity categories. Since 2010, providers and office staff have been prompted to enter race/ethnicity information during office visits. For women with more than one race/ethnicity documented in EHR, we classified women using the following exclusive hierarchical categories: Hispanic, Asian, Black, other race/ethnicity, and White. If race/ethnicity was not listed, women were classified as unknown.

We categorized women into the following exclusive hierarchical categories based on their primary insurance: non-Medicare or non-Medicaid preferred provider organization/health maintenance organization (PPO/HMO), Medicare, Medicaid, other (e.g., CHAMPUS, county indigent health program, Workers' Compensation), and unknown.

As proxy measures of patient comorbidity and predisposition to use healthcare, we constructed several healthcare utilization variables, including: 1) counts of primary care (family medicine, internal medicine and OB/GYN) and specialist visits during each year, and 2) binary indicators of whether women had OB/GYN or endocrinologist visits during each year. We included a count of yearly hospitalizations as a proxy measure of comorbidity.<sup>13</sup> We also measured whether women obtained a screening mammogram during each study year, as mammography use may reflect underlying attitudes regarding preventive health service use.

**Data Quality Assessment.** The accuracy of all EMR-derived variables was assessed by serial review of a random sample of approximately 250 medical records by a physician investigator (either ADA or JFF). During review, study physicians compared variables abstracted from the EHR to variables defined by manual chart review. Discrepancies were discussed with EHR programming staff, and abstraction algorithms were modified until automated and manual abstractions achieved 97.5 % concordance.

**Statistical Analysis.** Analyses were performed in SAS (version 9.3, Cary, NC). We computed descriptive statistics of the overall sample and women who received incident DXA. We determined unadjusted incidence rates (and incidence rate differences) for women categorized into the following groups by baseline age: < 50 years (when screening is uncommonly indicated), 50–59 years (encompassing the average age of menopause), 60–64 years (when screening may often be recommended based on risk), 65–74 years (when screening is recommended), and 75 years and older (when screening is recommended if previously unscreened). We performed Cox proportional hazards regression to estimate hazards ratios (HR) of incident DXA as a function of fixed and time-varying patient-level covariates and calendar year. In Cox models, patient age was considered a time-varying covariate. Because many osteoporosis risk factors may change from year to year, the Cox model was specified with time-varying covariates. In a first model (Model 1), we modeled incident DXA as a function of sociodemographics, smoking status, health insurance, healthcare utilization, and each osteoporosis risk factor included as separate covariates. We then repeated the regression analysis using the binary risk factor covariate along with other covariates (Model 2). We performed a sensitivity analysis to assess whether there was a glucocorticoid dosage effect on the hazard ratio incident DXA screening. In this analysis, we categorized women based on average yearly glucocorticoid dose (in prednisone equivalents): none, 1–199 mg, 200–499 mg, 500–1499 mg, and  $\geq 1500$  mg. For each model, we examined the proportional hazards assumption graphically and statistically, and found no statistically significant evidence of violations. We used the Kaplan-Meier estimator to estimate the 3-year, 5-year, and 7-year cumulative incidences of DXA screening by baseline age and baseline risk factor status.

## RESULTS

**Sample Characteristics.** We identified 60,899 women aged 40 to 85 years who attended primary care or OB/GYN visits from

2006–2012. Of these women, 9,904 were excluded due to osteoporosis diagnosis, osteoporosis medication use, or DXA screening prior to 2006, resulting in an eligible cohort of 50,995 women. Women were followed a mean of 4.4 years (standard deviation: 2.1) for a total of 152,123 women-years of observation time. The average number of women in each study year was 21,732 (range: 20,717–22,953). Of the sample, 16.3 % had  $\geq 1$  risk factor for osteoporosis, and 20.2 % received DXA screening (Table 1).

**Predictors of Incident DXA.** Age was a strong predictor of incident DXA screening. In unadjusted analyses, incidence rates of DXA screening jumped substantially among women aged 50–59 years compared to women aged < 50 years (Table 2). Unadjusted incidence rates increased further among women aged 60–64 years and 65–74 years before declining among women aged  $\geq 75$  years. Compared to women aged 65–74 years, adjusted hazard ratios of DXA screening were approximately half among women aged 50–59 years, but were only slightly lower among women aged 60–64 (Table 3, model 1). Adjusted hazard ratios of DXA screening were approximately 30 % lower among previously unscreened women  $\geq 75$  years compared to women aged 65–74 years.

Compared to white women, DXA screening was significantly less common among Black women and among current smokers, while the adjusted hazard ratio of screening was significantly higher for women with a BMI < 20 (compared to a BMI of 20 to < 25), secondary osteoporosis, previous high-risk fracture, and rheumatoid arthritis, but not among glucocorticoid users (Table 3, model 1). The adjusted hazard ratio of DXA screening was slightly higher among women with  $\geq 1$  osteoporosis risk factor (HR 1.26, 95 % CI 1.20–1.32) (Table 3, model 2). In a sensitivity analysis, a categorical variable based on average daily dose of glucocorticoid had no statistically significant association with DXA screening (detailed results available from authors). Increased use of DXA screening was also significantly associated with greater numbers of primary care and specialty visits, having any visit with an endocrinologist, and receipt of a screening mammogram during the study year.

**Cumulative Incidence of DXA Screening.** Over a 7-year period, we estimate that 57.8 % (95 % CI 55.6–60.0 %) of previously unscreened women aged 65–74 years received DXA screening (Table 4). Compared to women aged 65–74, the 7-year cumulative incidence of DXA screening was lower for women aged 50–59 years with and without risk factors (52.5 % and 45.5 %, respectively), but was similar among women aged 60–64 years with and without risk factors (58.8 % vs. 58.6 %, respectively). Seven-year cumulative incidence among previously unscreened women aged  $\geq 75$  years (42.7 %) was similar to the cumulative incidence among women aged 50–59 without risk factors (45.5 %).

**Table 1. Incident DXA by Sample Characteristics**

Characteristic <sup>a</sup>	No. of Sample (column %)	No. with Incident DXA (row %)
Total	50,995 (100)	10,300 (20.2)
Age, years <sup>b</sup>		
40-49	15,415 (30.2)	874 (5.7)
50-59	19,819 (38.9)	4,713 (23.8)
60-64	5,883 (11.5)	1,758 (29.9)
65-74	6,717 (13.2)	2,243 (33.4)
≥ 75	3,161 (6.2)	712 (22.5)
Race/ethnicity <sup>c</sup>		
White	25,431 (49.9)	6,419 (25.2)
Hispanic	3,278 (6.4)	629 (19.2)
Black	3,021 (5.9)	454 (15.0)
Asian	2,574 (5.0)	613 (23.8)
Other <sup>d</sup>	2,865 (5.6)	488 (17.0)
Unknown	13,826 (27.1)	1,697 (12.3)
Smoking Status <sup>e</sup>		
Never	32,680 (64.1)	6,703 (20.5)
Current	5,192 (10.2)	778 (15.0)
Former	11,496 (22.5)	2,777 (24.2)
Unknown	1,627 (3.2)	42 (2.6)
BMI		
< 20	2,110 (4.1)	442 (20.9)
20-< 25	13,495 (26.5)	3,105 (23.0)
25-< 30	13,958 (27.4)	3,218 (23.1)
≥ 30	16,512 (32.4)	3,230 (19.6)
Unknown	4,920 (9.6)	305 (6.2)
Glucocorticoid Use <sup>f</sup>		
No	48,246 (94.6)	9,671 (20.0)
Yes	2,749 (5.4)	629 (22.9)
Secondary Osteoporosis <sup>g</sup>		
No	49,186 (96.5)	9,828 (20.0)
Yes	1,809 (3.5)	472 (26.1)
Previous High-Risk Fracture <sup>h</sup>		
No	49,831 (97.7)	9,801 (19.7)
Yes	1,164 (2.3)	498 (42.8)
Rheumatoid Arthritis <sup>i</sup>		
No	50,308 (98.7)	10,093 (20.1)
Yes	687 (1.3)	207 (30.1)
Alcohol Abuse <sup>j</sup>		
No	50,055 (98.2)	10,156 (20.3)
Yes	940 (1.8)	144 (15.3)
Risk Factors Combined <sup>k</sup>		
No	42,680 (83.7)	8,217(19.3)
Yes	8,315 (16.3)	2,083 (25.1)
Insurance		
PPO/HMO	35,501 (69.6)	6,955 (19.6)
Medicaid	1,603 (3.1)	218 (13.6)
Medicare	10,616 (20.8)	2,870 (27.0)
Other	1,852 (3.6)	172 (9.3)
Unknown	1,423 (2.8)	85 (6.0)
Primary Care Visit Count		
< 5	42,614 (83.6)	7,411 (17.4)
5 to 9	7,363 (14.4)	2,513 (34.1)
≥ 10	1,018 (2.0)	376 (36.9)
Specialist Visit Count		
< 5	42,988 (84.3)	7,949 (18.5)
5 to 9	5,450 (10.7)	1,548 (28.4)
≥ 10	2,557 (5.0)	803 (31.4)
Ob/Gyn Visit		
No	44,768 (87.8)	9,426 (21.1)
Yes	6,227 (12.2)	874 (14.0)
Endocrinology Visit		
No	49,537 (97.1)	9,802 (19.8)
Yes	1,458 (2.9)	498 (34.2)

(continued on next page)

**Table 1. (continued)**

Characteristic <sup>a</sup>	No. of Sample (column %)	No. with Incident DXA (row %)
No. of Inpatient Admissions		
None	47,504 (93.2)	9,626 (20.3)
≥ 1	3,491 (6.8)	674 (19.3)
Mammogram Completed		
No	31,934 (62.6)	2,947 (9.2)
Yes	19,061 (37.4)	7,353 (38.6)

Abbreviations: DXA Dual-energy X-ray absorptiometry; BMI Body mass index, PPO/HMO Preferred provider organization/health maintenance organization, OB/Gyn Obstetrics/Gynecology

<sup>a</sup> During last year of study eligibility unless otherwise noted

<sup>b</sup> As of January 1st of last year of study eligibility (i.e., the year of DXA for women who received DXA)

<sup>c</sup> If more than one listed, grouped in the following order: Hispanic, Asian, Black, Other, White, Unknown

<sup>d</sup> Includes American Indian, Alaska Native, Native Hawaiian, Other Pacific Islander, North African, Iranian, Other Asian/Mideastern or Other

<sup>e</sup> If unknown during last year of study eligibility but known at time of data abstraction, status as listed at time of data abstraction

<sup>f</sup> Received ≥ 1 glucocorticoid prescription

<sup>g</sup> The following ICD-9-CM diagnoses: diabetes mellitus, type 1 (250.x1, 250.x3), osteogenesis imperfecta (756.51), hyperthyroidism (242.x), premature menopause (256.3), malnutrition (260-263), malabsorption (579.x), or chronic liver disease or cirrhosis (571.x)

<sup>h</sup> The following ICD-9-CM diagnoses: humeral fractures (812.x, 733.11); Colles' fracture of wrist (813.41, 813.51, 733.12); spinal compression fracture (805.2, 805.4, 805.6, 805.8, 733.13, 829, Y15.51); and hip fracture (820.X, 733.14)

<sup>i</sup>Diagnosis of rheumatoid arthritis or other inflammatory polyarthropathies (ICD-9-CM 714.xx)

<sup>j</sup> The following ICD-9-CM diagnoses: alcohol dependence or abuse (303.x, 305.0), alcohol psychosis and withdrawal (291.1-291.9), or alcoholic liver disease (571.1-571.2)

<sup>k</sup> One or more of the following: BMI < 20, glucocorticoid use, secondary osteoporosis, previous fracture, rheumatoid arthritis or alcohol abuse

**Table 2. Incidence Rates of DXA Screening by Age**

Age, y*	Crude Incidence Rate (per 100 woman-years) (95 % CI)	Incidence Rate Differences vs. Next Younger Age Group
< 50	0.50 (0.48-0.53)	...
50-59	2.25 (2.18-2.31)	1.74
60-64	3.38 (3.22-3.55)	1.13
65-74	3.52 (3.37-3.68)	0.14
≥ 75	2.62 (2.40-2.86)	-0.9

Abbreviations: DXA Dual-energy X-ray absorptiometry

\* As of January 1st of first year of study eligibility

Table 3. Hazard Ratio of Incident DXA by Subject Characteristics

Characteristic	Model 1 Hazard Ratio (95 % CI)	Model 2 Hazard Ratio (95 % CI)
Age		
< 50	0.10 (0.09–0.11)	0.10 (0.09–0.11)
50–59	0.55 (0.52–0.59)	0.55 (0.52–0.59)
60–64	0.85 (0.79–0.92)	0.82 (0.77–0.89)
65–74	Ref	Ref
≥ 75	0.73 (0.67–0.79)	0.77 (0.71–0.84)
Race/ethnicity <sup>a</sup>		
White	Ref	Ref
Hispanic	0.93 (0.86–1.01)	0.90 (0.83–0.97)
Black	0.60 (0.54–0.65)	0.55 (0.51–0.61)
Asian	1.04 (0.96–1.13)	1.16 (1.07–1.25)
Other <sup>b</sup>	0.95 (0.87–1.04)	0.95 (0.87–1.03)
Unknown	1.01 (0.96–1.06)	1.03 (0.98–1.08)
Smoking Status <sup>c</sup>		
Never	Ref	Ref
Current	0.91 (0.85–0.98)	0.93 (0.86–0.99)
Former	0.99 (0.95–1.03)	0.98 (0.94–1.02)
Unknown	0.51 (0.36–0.73)	0.48 (0.35–0.64)
BMI		
< 20	1.25 (1.14–1.38)	—
20–< 25	Ref	—
25–< 30	0.84 (0.80–0.88)	—
≥ 30	0.61 (0.58–0.64)	—
Glucocorticoid Use <sup>d</sup>	1.01 (0.93–1.09)	—
Secondary Osteoporosis <sup>e</sup>	1.20 (1.10–1.32)	—
Previous High-Risk Fracture <sup>f</sup>	1.35 (1.24–1.47)	—
Rheumatoid Arthritis <sup>g</sup>	1.43 (1.26–1.63)	—
Alcohol Abuse <sup>h</sup>	0.92 (0.79–1.08)	—
Risk Factors Combined <sup>i</sup>	—	1.26 (1.20–1.32)
Insurance		
PPO/HMO	Ref	Ref
Medicaid	0.82 (0.72–0.93)	0.76 (0.67–0.87)
Medicare	0.98 (0.91–1.04)	0.95 (0.89–1.01)
Other	0.72 (0.63–0.84)	0.70 (0.60–0.80)
Unknown	0.52 (0.41–0.65)	0.53 (0.43–0.65)
Primary Care Visits in Study Year		
< 5	Ref	Ref
5 to 9	1.22 (1.17–1.27)	1.15 (1.10–1.20)
≥ 10	1.16 (1.05–1.29)	1.06 (0.96–1.18)
Specialist Visit Count in Study Year		
< 5	Ref	Ref
5 to 9	1.31 (1.24–1.39)	1.29 (1.22–1.37)
≥ 10	1.45 (1.35–1.57)	1.43 (1.33–1.54)
≥ 1 Ob/Gyn Visit in Study Year	0.95 (0.89–1.02)	0.97 (0.91–1.04)
≥ 1 Endocrinology Visit in Study Year	1.57 (1.44–1.71)	1.52 (1.39–1.65)
No. of Inpatient Admissions in Study Year	0.95 (0.91–1.00)	0.94 (0.90–0.99)
Mammogram Completed in Study Year	3.19 (3.06–3.33)	3.31 (3.18–3.46)

Abbreviations: DXA Dual-energy X-ray absorptiometry, BMI Body mass index, PPO/HMO Preferred provider organization/health maintenance organization, OB/Gyn Obstetrics/Gynecology

<sup>a</sup> If more than one listed, grouped in the following order: Hispanic, Asian, Black, Other, White, Unknown

<sup>b</sup> Includes American Indian, Alaska Native, Native Hawaiian, Other Pacific Islander, North African, Iranian, Other Asian/Mideastern or Other

<sup>c</sup> If unknown during study, status as listed at time of data abstraction

<sup>d</sup> Received ≥ 1 glucocorticoid prescription

<sup>e</sup> The following diagnoses: diabetes mellitus, type 1 (ICD-9-CM 250.x1, 250.x3), osteogenesis imperfecta (ICD-9-CM 756.51), hyperthyroidism (ICD-9-CM 242.x), premature menopause (ICD-9-CM 256.3), malnutrition (ICD-9-CM 260–263), malabsorption (ICD-9-CM 579.x), or chronic liver disease or cirrhosis (ICD-9-CM 571.x)

<sup>f</sup> The following diagnoses: humeral fractures (ICD-9-CM 812.X, 733.11); Colles' fracture of wrist (ICD-9-CM 813.41, 813.51, 733.12); spinal compression fracture (ICD-9-CM 805.2, 805.4, 805.6, 805.8, 733.13, 829, V15.51); and hip fracture (ICD-9-CM 820.x, 733.14)

<sup>g</sup> Diagnosis of rheumatoid arthritis or other inflammatory polyarthropathies (ICD-9-CM 714.xx)

<sup>h</sup> The following diagnoses: alcohol dependence or abuse (ICD-9-CM 303.x, 305.0), alcohol psychosis and withdrawal (ICD-9-CM 291.1–291.9), or alcoholic liver disease (ICD-9-CM 571.1–571.2)

<sup>i</sup> One or more of the following: BMI < 20, glucocorticoid use, secondary osteoporosis, previous fracture, rheumatoid arthritis or alcohol abuse

Table 4. Cumulative Incidence of DXA by Age and Risk Factor Status\*

	3-Year Cumulative Incidence % (95 % CI)	5-Year Cumulative Incidence % (95 % CI)	7-Year Cumulative Incidence % (95 % CI)
Age 50–59 without risk factors	18.4 (17.7–19.1)	34.3 (33.3–35.4)	45.5 (44.1–46.9)
Age 50–59, ≥1 risk factor	21.3 (19.5–23.2)	39.4 (36.8–42.1)	52.5 (49.1–56.0)
Age 60–64 without risk factors	24.9 (23.4–26.4)	44.0 (41.9–46.1)	58.6 (55.9–61.4)
Age 60–64, ≥ 1 risk factor	27.0 (23.3–30.7)	43.3 (38.1–48.1)	58.8 (51.9–65.8)
Age 65–74	27.3 (26.0–28.5)	45.3 (43.5–47.0)	57.8 (55.6–60.0)
Age ≥75	20.1 (18.1–22.0)	34.1 (31.2–37.0)	42.7 (38.7–46.7)

Abbreviations: DXA Dual-energy X-ray absorptiometry

\* Age and risk factor status as of Jan 1 of first year of study eligibility. Risk factors included one or more of the following: BMI < 20, glucocorticoid use, secondary osteoporosis, previous fracture, rheumatoid arthritis or alcohol abuse

## DISCUSSION

Within a large regional health system, patient age was strongly associated with DXA screening, while most osteoporosis risk factors and patient-level covariates were either unassociated or weakly associated with screening. Over 40 % of eligible women aged 65–74 years and almost 60 % of previously unscreened women aged ≥ 75 years did not receive recommended DXA screening over a 7-year period. Overuse of DXA also seemed to be prevalent; about half of women aged < 65 years without risk factors received screening over a 7-year period. These results support the inclusion of DXA screening in low-risk women as a target for quality improvement by the Choosing Wisely Initiative.

Health systems barriers may impede optimal use of DXA screening. During the study period, health system clinicians received no decision support from EHR systems to optimize use of DXA screening. In 2013, the UCDHS implemented a reminder to alert physicians when women ≥ 65 years have not completed DXA screening. However, EHR-based reminders have had inconsistent effects on preventive service use,<sup>14</sup> and primary care physicians do not rate them as highly useful.<sup>15</sup> In addition, the reminder does not provide decision support to alert providers that younger, high-risk women may be eligible for screening or to avert inappropriate screening among younger, low-risk women. While patient reminder letters have been shown to increase adherence rates with some recommended services,<sup>16</sup> the health system does not conduct systematic outreach to patients about recommended preventive health care.

Patient-level barriers to DXA screening may include lack of knowledge or misinformation about current screening recommendations. Underuse of other preventive screening has been associated with lower education levels and lack of knowledge regarding risk.<sup>17</sup> The same may be true regarding osteoporosis screening, as women at intermediate or high risk of fracture often perceive themselves as lower risk.<sup>18</sup> Socioeconomic barriers that have been linked to reduced cancer screenings may also contribute to lower osteoporosis screening rates.<sup>19</sup>

While we documented significant underuse, our study suggests that DXA screening is also commonly overused, particularly in younger women without osteoporosis risk factors. Several factors may contribute to DXA overuse. First, providers may be uncertain or doubtful about current screening recommendations. Some may view DXA as a screening tool that is appropriate for all menopausal women regardless of age or other risk factors, consistent with a previous World Health Organization recommendation.<sup>20</sup> Some clinicians may believe that DXA screening in postmenopausal average-risk women has a low-risk of harm and may plausibly yield small benefits. In this respect, the inclusion of this service in “top five” lists is perhaps best justified on the grounds of unfavorable cost-effectiveness, rather than an adverse balance of benefits and harms.<sup>21</sup> In addition, patient requests for DXA screening may conceivably prompt physicians to order DXA for low-risk patients,<sup>22</sup> though we suspect that DXA screening in low-risk women is more commonly prompted by a physician recommendation than a patient request.

Our study suggests that women aged ≥ 75 years frequently do not receive DXA screening, despite the favorable cost-effectiveness of screening in this high-risk subpopulation.<sup>4</sup> One potential explanation is that the women aged ≥ 75 years in our study comprise a group that is disproportionately resistant to DXA screening recommendations, as women aged ≥ 75 years who received DXA screening at younger ages were ineligible for inclusion in our cohort. However, descriptive analyses of the 8,733 women excluded from our study due to DXA receipt from 2002–2005 show that most of these women were aged 50–65 years at the time of screening (results available from authors). These findings reassure that cohort effects are unlikely to explain differences in cumulative incidence by age group. Among older women, clinicians may also focus attention on comorbidities rather than prevention,<sup>23,24</sup> which may reduce the odds of DXA screening despite high fracture risk among patients.

DXA screening in our population was associated with greater numbers of visits to primary care and specialist

providers, particularly endocrinologists. These associations may reflect greater opportunities for patients to receive recommendations for DXA, unmeasured patient attitudes associated with greater medical care use, or endocrinologists' clinical focus on within-specialty conditions. Threefold greater use of DXA among women receiving screening mammograms may be attributable to favorable attitudes toward prevention among mammography users, or the possibility that clinicians may simultaneously recommend mammography and DXA during preventive visits.

There are several potential limitations to our study. Like all observational studies, our results may be affected by unmeasured confounding. Second, EHR-derived study variables may be prone to measurement error. Some variables (e.g., prior fracture history, alcohol abuse) may be relatively specific but insensitive, while others (e.g., glucocorticoid use) may be the opposite. We also lacked measures of some osteoporosis risk factors, such as premature menopause and oophorectomy. Our data source also limited our ability to determine exact glucocorticoid dosage over time, although a sensitivity analysis found no impact of cumulative glucocorticoid dose on the likelihood of DXA screening. Third, clinical information was available from the EHR of only one health system, and not all subjects had continuous observation time during the study period. Some women may have obtained screening at different facilities before transitioning care to our health system, or have obtained screening between two periods of observation, leading to incomplete ascertainment of incident or prior screening. Incomplete ascertainment of DXA screening would potentially lead to exaggeration of the extent of underuse in older women, while also underestimating of the extent of overuse. Study data derived from 2006–2012 and current practice may vary from this time period. We also did not assess how provider characteristics may influence DXA screening incidence.

## CONCLUSIONS

Compared to age, other osteoporosis risk factors were weak predictors of DXA screening. Underuse of DXA screening in women aged  $\geq 65$  years and older was common, as was overuse in younger women without osteoporosis risk factors. Additional research is needed to elucidate patient, physician, and health system barriers to evidence-based screening so that interventions can maximize the value of population screening for osteoporosis.

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## APPENDIX

Table 5. ICD-9 Definitions for Risk Factors

Risk Factor	ICD-9 Definition
Secondary Osteoporosis	Diabetes mellitus, type 1 (ICD-9 250.x1, 250.x3), osteogenesis imperfecta (ICD-9 756.51), hyperthyroidism (ICD-9 242.x), premature menopause (ICD-9 256.3), malnutrition (ICD-9 260-263), malabsorption (ICD-9 579.x), or chronic liver disease or cirrhosis (ICD-9 571)
Previous High-Risk Fracture	Humeral fractures (ICD-9 812.X, 733.11); Colles' fracture of wrist (ICD-9 813.41, 813.51, 733.12); spinal compression fracture (ICD-9 805.2, 805.4, 805.6, 805.8, 733.13, 829, V15.51); and hip fracture (ICD-9 820.X, 733.14)
Rheumatoid Arthritis	Rheumatoid arthritis or other inflammatory polyarthropathies (ICD-9 714.xx)
Alcohol Abuse	Alcohol dependence or abuse (ICD-9 303.X, 305.0), alcohol psychosis and withdrawal (ICD-9 291.1-291.9), or alcoholic liver disease (ICD-9 571.1-571.2).

*Abbreviations: ICD-9 International Classification of Diseases, Ninth Edition*