Incidence and Predictors of Repeat Bone Mineral Densitometry: A Longitudinal Cohort Study

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BACKGROUND: Existing guidelines for repeat screening and treatment monitoring intervals regarding the use of dual-energy x-ray absorptiometry (DXA) scans are conflicting or lacking. The *Choosing Wisely* campaign recommends against repeating DXA scans within 2 years of initial screening. It is unclear how frequently physicians order repeat scans and what clinical factors contribute to their use.

OBJECTIVE: To estimate cumulative incidence and predictors of repeat DXA for screening or treatment monitoring in a regional health system.

DESIGN: Retrospective longitudinal cohort study

PARTICIPANTS: A total of 5992 women aged 40–84 years who received initial DXA screening from 2006 to 2011 within a regional health system in Sacramento, CA.

MAIN MEASURES: Two- and five-year cumulative incidence and hazard rations (HR) of repeat DXA by initial screening result (classified into three groups: low or high risk of progression to osteoporosis, or osteoporosis) and whether women were prescribed osteoporosis drugs after initial DXA.

KEY RESULTS: Among women not treated after initial DXA, 2-year cumulative incidence for low-risk, high-risk, and osteoporotic women was 8.0%, 13.8%, and 19.6%, respectively, increasing to 42.9%, 60.4%, and 57.4% by 5 years after initial screening. For treated women, median time to repeat DXA was over 3 years for all groups. Relative to women with low-risk initial DXA, high-risk initial DXA significantly predicted repeat screening for untreated women [adjusted HR 1.67 (95% CI 1.40–2.00)] but not within the treated group [HR 1.09 (95% CI 0.91–1.30)].

CONCLUSIONS: Repeat DXA screening was common in women both at low and high risk of progression to osteoporosis, with a substantial proportion of women receiving repeat scans within 2 years of initial screening. Conversely, only 60% of those at high-risk of progression to osteoporosis were re-screened within 5 years. Interventions are needed to help clinicians make higher-value decisions regarding repeat use of DXA scans.

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INTRODUCTION

The United States Preventive Services Task Force (USPSTF) currently recommends screening for osteoporosis with dual-energy x-ray absorptiometry (DXA) in women aged 65 years and older, as well as in younger women with a fracture risk greater than or equal to that of a 65-year-old white woman. However, it remains unclear whether and when women should be re-screened, and the USPSTF does not make specific recommendations for repeat screening.[1] Repeat DXA scans may be performed for two principal purposes: 1) periodic repeat screening for women who are not deemed candidates for drug treatment based on earlier scans, or 2) monitoring of women who have been placed on an osteoporosis drug. Historically, expert opinion has guided clinical decisions on re-screening and monitoring, with consensus generally recommending re-screening 2 years after the initial DXA and monitoring DXA scans every 1–2 years while on medication,[2] which reflects the current guidelines of multiple specialty organizations.[1,3,4] In 2009, a secondary analysis of the Fracture Intervention Trial suggested that bone density monitoring in the first 3 years of treatment is unnecessary and is potentially misleading due to marked within-person variation in treatment response.[5] This interpretation was criticized by the National Osteoporosis Foundation (NOF) and the International Society for Clinical Densitometry (ISCD), both of which asserted that repeat bone densitometry could help identify non-compliant patients, medication non-responders, and cases of secondary metabolic bone disease, as well as providing periodic motivation for patients to continue their medication.[6,7]

More recent studies have found that women with an initial DXA scan result showing normal bone mineral density (BMD) or mild osteopenia have a low risk of progression to osteoporosis, with less than 10% of these women progressing to osteoporosis over a 15-year

follow-up period. In contrast, 10% of women with advanced and moderate osteopenia progressed to osteoporosis in 1.1 and 4.7 years, respectively.[8] Even so, evidence suggests that repeat DXA screening for untreated individuals does not add fracture prediction information beyond that found in the initial screening results.[9,10]

Through the *Choosing Wisely* initiative, the American College of Rheumatologists has identified the use of repeat DXA scans less than 2 years after initial screening as something to be questioned by physicians and patients.[11] One recent study of Medicare beneficiaries[12] found that approximately 10% of all DXA scans were performed less than 2 years after initial DXA; however, as a claims-based study, this study lacked the clinical details needed to understand what patient factors may have prompted overuse.

Little is currently known about how physicians make decisions regarding the use of repeat DXA scans in light of conflicting recommendations. The aim of our study is to characterize the use of repeat DXA scans among patients receiving primary care within a large regional health system and to examine the effect of initial screening result, use of an osteoporosis drug, and other patient factors that may contribute to the likelihood of having repeat DXA testing after initial screening.

METHODS

Design, Setting, and Subjects.—We performed a retrospective, longitudinal cohort study of women aged 40 to 85 who received primary care at one of 13 University of California, Davis, Health System (UCDHS) clinics and underwent initial DXA screening during the period from 2006 to 2011. The UCDHS is a large academic medical center located in central Sacramento, with a network of community-based physicians providing primary care across the greater Sacramento area. Data were obtained from the electronic health record (EHR) and linked radiology records. The institutional review board of the University of California, Davis, approved this study.

Cohort Eligibility.—The study cohort was derived from a larger cohort of women receiving primary care or obstetrical/gynecological (OB/GYN) care within the health system and who had undergone an initial screening DXA between 2006 and 2011. The methods used to identify the larger cohort have been described previously.[13] For the current study, we identified the subset of women who 1) had an initial DXA scan between January 1, 2006, and December 31, 2011; 2) had no osteoporosis diagnoses or osteoporosis drug prescriptions before the initial DXA scan; 3) were aged 40–85 years on January 1 of the DXA year; 4) had one or more primary care or OB/GYN visits during the study year and every subsequent year of follow-up; and 5) had complete T-score data available from their initial DXA report. Women who lacked one or more primary care or OB/GYN visits during a follow-up year were considered to have a gap in care and were censored. Women were followed until either a repeat DXA, a calendar year without primary care or OB/GYN visits, or December 31, 2012.

DXA screening and repeat DXA.—We defined repeat DXA as a DXA scan that was completed and reported at least 1 year after the initial DXA. UCDHS performs the majority of DXA screening at the central academic campus and one community-based radiology site. Natural language processing was used to capture T-scores reported on initial screening DXA scans for four primary sites: AP lumbar spine, lateral lumbar spine, left femoral neck, and left Ward's triangle. T-scores reported for other sites, such as distal forearm or distal radius, were categorized as "other site" T-scores. Because ISCD guidelines state that lateral spine and Ward's triangle should not be used for osteoporosis diagnosis,[14] we defined the femoral neck and AP lumbar spine as "mainsites" and all other sites as "non-mainsites."

Based on their initial screening DXA result, women were classified into one of three categories: low risk of progression to osteoporosis, high risk of progression to osteoporosis, or current osteoporosis. These categories were based on the definitions used by Gourlay et al.[8] in their classification of women based on initial DXA results. Although Gourlay et al. used mainsite BMD measures exclusively, UCDHS providers received T-scores at non-mainsites, and we wanted to conservatively account for potential use of non-mainsite measures in clinical decision-making. We defined low-risk women as those who had T-scores as follows: normal at all sites (T-score ≥ -1.0), mild to moderate mainsite osteopenia ($-2.0 \leq$ T-score < -1.0), or any non-mainsite osteopenia ($-2.5 <$ T-score < -1.0) with no mainsite advanced osteopenia ($-2.5 <$ T-score < -2.0). High-risk women were defined as those with T-scores showing advanced mainsite osteopenia or non-mainsite osteoporosis (T-score ≤ -2.5). Women with mainsite T-scores ≤ -2.5 were classified as having osteoporosis.

New Osteoporosis Drug.—We abstracted from EHR pharmacy data whether or not a woman had been prescribed a new osteoporosis drug during the year of her initial DXA or the following year. Drugs classified as osteoporosis drugs included bisphosphonates, raloxifene, teriparatide, calcitonin, and denosumab, but excluded estrogens, calcium, and vitamin D.

Osteoporosis Risk Factors, Sociodemographics, and Healthcare Utilization.—As previously described,[13] we used data from the EHR to specify variables for osteoporosis risk factors, patient sociodemographics, and healthcare utilization. In brief, we created a binary indicator of whether the patient had one or more of the following risk factors, based on the World Health Organization's Fracture Risk Assessment Tool (FRAX)[15]: body mass index (BMI) less than 20, glucocorticoid use, possible secondary osteoporosis, previous high-risk fracture, rheumatoid arthritis, or alcohol abuse. Age and smoking status were included as independent covariates. Sociodemographic information included race/ethnicity and insurance status (Medicaid insurance vs. other). We calculated healthcare utilization using separate counts of visits to primary

care, all specialists, obstetrician/gynecologists, and endocrinologists during each study year. We measured comorbidity burden using a count of hospitalizations in the prior calendar year.[16]

Data Quality Assessment.—Two physician investigators manually reviewed a random sample of 250 medical records taken from the EHR to assess the accuracy of electronically abstracted data. Based on discrepancies, the abstraction algorithms were modified until automated and manual abstraction achieved 97.5% concordance.

Statistical Analysis.—Data were analyzed using Stata version 14.0 software (StataCorp LP, College Station, TX). We used the Kaplan-Meier method to estimate the cumulative incidences of repeat DXA scan by initial DXA result and osteoporosis drug status, as well as the median time to repeat DXA in patient subgroups. We used log-rank tests to test for significant difference in cumulative incidence by initial DXA results. We used Cox proportional hazards regression to model repeat DXA screening as a function of initial DXA result and risk factor status while adjusting for other covariates. We fit separate models for women not prescribed osteoporosis drugs and women prescribed osteoporosis drugs after their initial screening DXA. We performed additional sensitivity analyses to identify predictors of repeat DXA screening among the subgroup of women classified as low-risk based on initial DXA results; we performed these sensitivity analyses among

Table 1 Baseline Characteristics by Selected Covariates

Variable	*N* (%)	New drug Rx (%)	Initial DXA result		
			Low-risk* (%)	High-risk† (%)	Osteoporosis‡ (%)
Total	5992 (100)	29.4	73.5	12.8	13.7
Initial DXA risk category					
Low-risk*	4404 (73.5)	19.1	100	—	—
High-risk†	767 (12.8)	46.2	—	100	—
Osteoporosis‡	821 (13.7)	68.9	—	—	100
Osteoporosis risk factors§					
None	4774 (79.7)	28.0	74.2	13.1	12.7
1 or more	1218 (20.3)	34.8	66.3	13.7	20.0
Age, years					
40–64	4539 (75.8)	25.1	77.9	11.9	10.2
65–74	1116 (18.6)	40.8	62.4	15.3	22.3
75–84	337 (5.6)	49.6	51.0	16.0	32.9
Race/ethnicity					
White	3785 (63.2)	27.5	77.0	11.7	11.3
Asian	454 (7.6)	40.3	53.7	20.0	26.2
Black	321 (5.4)	26.5	67.6	11.5	20.9
Hispanic	422 (7.0)	31.0	72.0	14.7	13.3
Other	281 (4.7)	37.7	68.0	10.3	21.7
Unknown	729 (12.2)	29.5	73.3	14.4	12.3
Insurance					
Other	5841 (97.5)	29.0	73.7	12.7	13.6
Medicaid only	151 (2.5)	45.7	66.9	15.2	17.9
Smoking status					
Never smoker	3981 (66.4)	28.8	73.8	13.0	13.1
Current smoker	431 (7.2)	35.3	69.8	11.8	18.3
Former smoker	1580 (26.3)	29.1	73.7	12.5	13.9
Hospitalization in prior year					
No	5571 (93.0)	28.9	74.0	12.8	13.2
Yes	421 (7.0)	35.9	67.2	13.1	19.7
Primary care visits					
0–1	762 (12.7)	19.3	78.2	10.5	11.3
2–3	2238 (37.4)	27.6	74.7	13.5	11.8
4–5	1543 (25.8)	31.6	72.0	13.5	14.5
6 or more	1449 (24.2)	35.1	70.8	12.1	17.0
Specialist visits					
0–1	3568 (59.6)	29.9	73.4	13.2	13.4
2–3	988 (16.5)	28.6	71.1	13.8	15.2
4 or more	1436 (24.0)	28.6	75.5	11.1	13.4
OB/GYN visits					
0	5491 (91.6)	29.9	72.9	13.0	14.0
1 or more	501 (8.4)	23.4	79.6	10.4	10.0
Endocrine visits					
0	5706 (95.2)	29.4	73.8	12.7	13.5
1 or more	286 (4.8)	28.7	67.8	14.3	17.8

Abbreviations: DXA, bone densitometry; OB/GYN, obstetrician/gynecologist

**Low risk on initial DXA is defined as normal at all sites (T-score ≥ −1.0), mild osteopenia (−2.0 < T-score < −1.0) at the femoral neck or anterior-posterior spine, or any osteopenia at other sites (−2.5 < T-score < −1.0)*

†High risk on initial DXA is defined as advanced mainsite osteopenia (−2.5 < T-score < −2.0), or non-mainsite osteoporosis (T-score ≤ −2.5)

‡Osteoporosis on initial DXA is defined as mainsite T-score ≤ −2.5

§Osteoporosis risk factors included in this composite binary variable: body mass index (BMI) < 20, glucocorticoid use, possible secondary osteoporosis, previous high-risk fracture, rheumatoid arthritis, and alcohol abuse

low-risk women with and without new osteoporosis drug prescriptions following initial DXA. For all covariates in the models, we assessed plots of scaled Schoenfeld residuals over time for evidence of violation of the proportional hazards assumption; because violations were suggested for insurance status, we estimated hazard ratios for other covariates using Cox regression stratified by insurance status.

RESULTS

Sample Characteristics.—Of the original cohort of 50,995 women without osteoporosis or prior DXA screening who attended primary care or OB/GYN visits from 2006 to 2012, 10,300 (20.2%) received an initial DXA scan. Of the 10,300 women who received initial DXA, 7345 (71.3%) were younger than 65 years at the time of the initial scan, reflecting the substantial use of DXA in younger women in this health system.[13] Of the 10,300 women who received initial DXA from 2006 to 2012, 5992 women had complete T-score data on initial DXA and met the inclusion criteria for assessment for subsequent repeat DXA. Women were followed a mean of 2.9 years after the initial DXA screening test (range 0.05 to 6.99 years), for a total of 17,614 women-years of observation time. Based on the initial DXA result, 73.5% of women were classified as low-risk and 12.8% as high-risk for progression to osteoporosis, and 13.7% as having osteoporosis (Table 1). Of the 5992 women, 1760 (29.4%) were prescribed a new osteoporosis drug after initial DXA, ranging from 19.1% of women with low-risk initial DXA results to 68.9% of women with osteoporosis.

Cumulative Incidence of Repeat DXA.—Median time to repeat screening by risk group ranged from 4.2 to 5.9 years in the non-drug group and 3.2 to 3.7 years in the drug group (Table 2). Women who were not prescribed a new osteoporosis drug after initial DXA had a 2-year cumulative incidence of repeat DXA of 7.3% for low-risk, 11.2% for high-risk, and 16.6% for osteoporotic women. At 5 years, over 40% of low-risk women and approximately 60% of high-risk or osteoporotic women had undergone repeat DXA scans. Meanwhile, among women prescribed drugs after initial DXA, nearly 20% had repeat DXA within 2 years of initial screening, and over 60% had repeat DXA within 5 years, regardless of initial DXA results. Log-rank tests for differences in survival distribution for the different risk categories were statistically significant for women not treated with drugs after initial DXA (Fig. 1) but not among women treated with drugs (Fig. 2).

Predictors of Repeat DXA.—For women not prescribed an osteoporosis drug after initial DXA screening, the initial DXA result influenced the likelihood of repeat screening, with women at high risk of progression to osteoporosis and those diagnosed with osteoporosis having greater likelihood of repeat screening than women at low risk on initial screening (Table 3). The presence of one or more osteoporosis risk factors was not associated with increased likelihood of repeat DXA. Additional significant predictors of repeat DXA included the following: age greater than the reference group (65–74 years), having more than one primary care visit, having four or more specialty visits, and being seen by an endocrinologist. Women in the non-drug group who were black, were current smokers, or had been hospitalized in the prior year were significantly less likely to have repeat DXA scans.

For women prescribed osteoporosis drugs after initial screening, the initial DXA result did not predict repeat screening. Among women taking osteoporosis drugs, repeat DXA was significantly more likely in younger women (aged 40–64 vs. 65–74 years), those having a greater number of primary care visits, and those having any visit with an endocrinologist. Among women taking osteoporosis drugs, those who were aged 75–84 years (vs. 65–74 years), who were black, who were current smokers, or who were hospitalized during the prior year were significantly less likely to have repeat DXA scans (Table 3). Sensitivity analyses assessing predictors of repeat DXA among women with low-risk initial DXA scans revealed essentially identical results in both the drug and non-drug groups.

Table 2 Cumulative Incidence and Median Time to Repeat DXA by Drug* Status and Initial DXA Result

	Initial DXA scan result	*n*	% at 2 years (95% CI)	% at 5 years (95% CI)	Median time to repeat DXA (years)
No drug prescribed after initial DXA	Low-risk†	3564	8.0 (7.1–8.9)	42.9 (40.5–45.3)	5.9
	High-risk‡	413	13.8 (11.0–17.9)	60.4 (53.2–67.6)	4.5
	Osteoporosis§	257	19.6 (15.3–24.8)	57.4 (49.2–65.9)	4.2
	Total	4232	8.2 (7.4–9.2)	44.6 (42.4–47.0)	5.5
Drug prescribed after initial DXA	Low-risk	840	18.8 (16.2–22.5)	68.0 (63.0–73.0)	3.2
	High-risk	354	20.2 (16.2–25.8)	68.6 (62.1–78.4)	3.2
	Osteoporosis	566	15.5 (12.7–19.5)	60.6 (54.2–67.0)	3.7
	Total	1760	19.3 (17.4–21.3)	65.1 (61.8–68.3)	3.3

Abbreviations: DXA, bone densitometry

**Drug refers to a new osteoporosis drug having been prescribed after initial DXA scan. Osteoporosis drugs included bisphosphonates, raloxifene, teriparatide, calcitonin, and denosumab*

†Low risk on initial DXA is defined as normal at all sites (T-score ≥ −1.0), mild osteopenia (−2.0 < T-score < −1.0) at the femoral neck or anterior-posterior spine, or any osteopenia at other sites (−2.5 < T-score < −1.0)

‡High risk on initial DXA is defined as advanced mainsite osteopenia (−2.5 < T-score < −2.0) or non-mainsite osteoporosis (T-score ≤ −2.5)

§Osteoporosis on initial DXA is defined as mainsite T-score ≤ −2.5

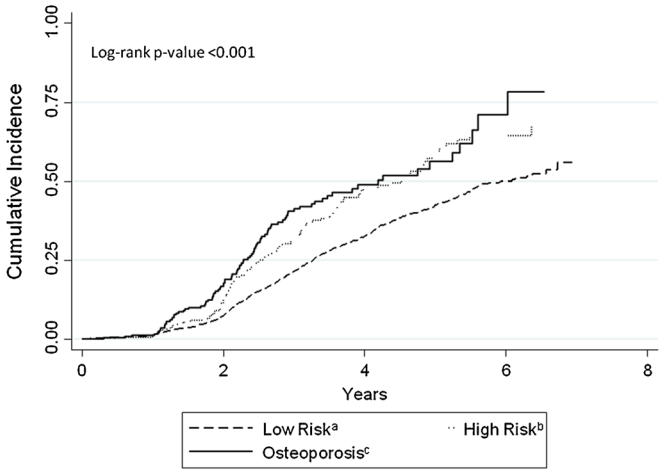

Figure 1 Cumulative incidence of repeat bone densitometry (DXA) for women not placed on osteoporosis drug* after initial DXA, by initial DXA result. *Drugs classified as osteoporosis drugs included bisphosphonates, raloxifene, teriparatide, calcitonin, and denosumab, but not estrogens, calcium, or vitamin D. [a]Low risk on initial DXA is defined as normal at all sites (T-score ≥ −1.0), mild osteopenia (−2.0 < T-score < −1.0) at the femoral neck or anterior-posterior spine, or any osteopenia at other sites (−2.5 < T-score < −1.0). [b]High risk on initial DXA is defined as advanced mainsite osteopenia (−2.5 < T-score < −2.0) or non-mainsite osteoporosis (T-score ≤ −2.5). [c]Osteoporosis on initial DXA is defined as mainsite T-score ≤ −2.5.

DISCUSSION

Within a regional health care system, we found high cumulative incidence of repeat DXA use among all patient subgroups, including those with a low risk of progression to osteoporosis based on initial DXA. Because of the substantial use of initial DXA among younger women in this health system, our sample included predominantly women at low risk of progression to osteoporosis. Nevertheless, within 5 years after initial DXA, over 40% of women in the low-risk non-drug group, and over 50% of women in all other groups, had undergone repeat DXA scans. Initial DXA results significantly predicted repeat screening in women who had not been placed on an osteoporosis drug after screening. For women who *had* been placed on a drug after initial screening, the initial DXA result was not a significant predictor of repeat DXA.

Most women receiving an initial DXA screening are not prescribed drugs after screening. In our study, over 8% of all women not initially treated with drugs had repeat DXA within 2 years: a potential marker of overuse. This finding is consistent with the research based on Medicare claims,[12] but expands on it by examining a screening population of all ages and demonstrating that the initial DXA result only modestly influenced the likelihood of short-interval re-screening. Despite the latest research suggesting that repeat screening within a low-risk group is unlikely to be helpful up to 16 years after initial screening,[10] over 40% of these women had repeat screening within 5 years. Short-interval repeat DXA was even

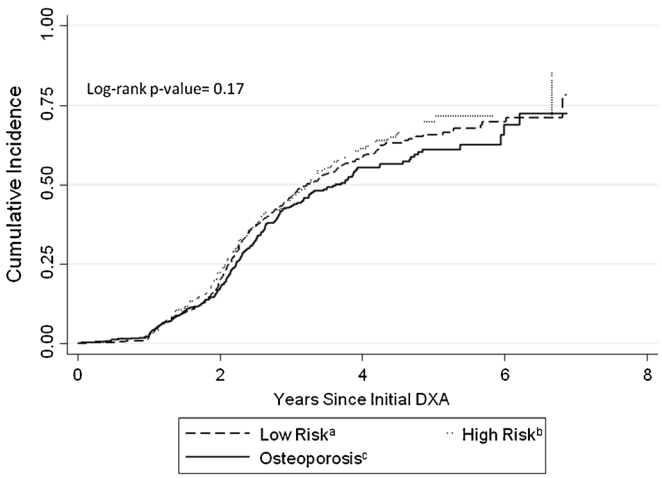

Figure 2 Cumulative incidence of repeat bone densitometry (DXA) for women placed on osteoporosis drug* after initial DXA, by initial DXA result. *Drugs classified as osteoporosis drugs included bisphosphonates, raloxifene, teriparatide, calcitonin, and denosumab, but not estrogens, calcium, or vitamin D. [a]Low risk on initial DXA is defined as normal at all sites (T-score ≥ −1.0), mild osteopenia (−2.0 < T-score < −1.0) at the femoral neck or anterior-posterior spine, or any osteopenia at other sites (−2.5 < T-score < −1.0). [b]High risk on initial DXA is defined as advanced mainsite osteopenia (−2.5 < T-score < −2.0) or non-mainsite osteoporosis (T-score ≤ −2.5). [c]Osteoporosis on initial DXA is defined as mainsite T-score ≤ −2.5.

Table 3 Hazard Ratios of Repeat DXA Screening by Osteoporosis Drug Status and Patient-Level Covariates

	Not prescribed osteoporosis drug* after initial DXA scan (*N* = 4232)		Prescribed osteoporosis drug after initial DXA scan (*N* = 1760)	
Variable	HR† (95% CI)	*p*	HR† (95% CI)	*p*
Initial DXA risk category				
Low-risk (reference)‡	1.00	—	1.00	—
High-risk§	1.67 (1.40–2.00)	<0.001	1.09 (0.91–1.30)	0.35
Osteoporosis‖	2.08 (1.67–2.59)	<0.001	0.99 (0.84–1.16)	0.87
Osteoporosis risk factors¶				
None (reference)	1.00	—	1.00	—
1 or more	0.95 (0.82–1.10)	0.46	0.99 (0.84–1.16)	0.86
Age, years				
40–64	0.90 (0.78–1.04)	0.14	1.20 (1.02–1.41)	0.03
65–74 (reference)	1.00	—	1.00	—
75–84	0.71 (0.53–0.94)	0.02	0.72 (0.56–0.92)	0.009
Race/ethnicity				
White (reference)	1.00	—	1.00	—
Asian	0.81 (0.64–1.03)	0.08	0.84 (0.66–1.07)	0.15
Black	0.62 (0.47–0.82)	0.001	0.53 (0.36–0.80)	0.002
Hispanic	0.83 (0.65–1.05)	0.12	0.80 (0.61–1.05)	0.11
Other	0.75 (0.54–1.03)	0.08	0.61 (0.43–0.86)	0.006
Unknown	1.05 (0.85–1.28)	0.67	1.01 (0.80–1.28)	0.91
Smoking status				
Never smoker (reference)	1.00	—	1.00	—
Current smoker	0.64 (0.48–0.84)	0.002	0.68 (0.52–0.91)	0.008
Former smoker	0.91 (0.80–1.03)	0.14	0.93 (0.79–1.08)	0.33
Hospitalization in prior year				
No	1.00	—	1.00	—
Yes	0.68 (0.53–0.88)	0.003	0.68 (0.52–0.91)	0.008
Primary care visits				
0–1 (reference)	1.00	—	1.00	—
2–3	1.39 (1.17–1.66)	<0.001	1.20 (0.97–1.50)	0.09
4–5	1.40 (1.15–1.69)	0.001	1.33 (1.05–1.68)	0.01
6 or more	1.64 (1.34–2.00)	<0.001	1.33 (1.04–1.70)	0.02
Specialist visits				
0–1 (reference)	1.00	—	1.00	—
2–3	1.13 (0.96–1.33)	0.14	0.97 (0.80–1.18)	0.78
4 or more	1.48 (1.29–1.71)	<0.001	1.12 (0.94–1.33)	0.20
OB/GYN visits				
0 (reference)	1.00	—	1.00	—
1 or more	1.03 (0.86–1.23)	0.74	0.92 (0.72–1.18)	0.53
Endocrine visits				
0 (reference)	1.00	—	1.00	—
1 or more	1.43 (1.16–1.78)	0.001	2.49 (1.97–3.14)	<0.001

Abbreviations: DXA, bone densitometry; OB/GYN, obstetrician/gynecologist

**Drugs classified as osteoporosis drugs included bisphosphonates, raloxifene, teriparatide, calcitonin, and denosumab, but not estrogens, calcium, or vitamin D*

†Hazard ratios estimated using Cox proportional hazards regression, stratified by insurance status (Medicaid vs. other)

‡Low risk on initial DXA is defined as normal at all sites (T-score ≥ −1.0), mild osteopenia (−2.0 < T-score < −1.0) at the femoral neck or anterior-posterior spine, or any osteopenia at other sites (−2.5 < T-score < −1.0)

§High risk on initial DXA is defined as advanced mainsite osteopenia (−2.5 < T-score < −2.0) or non-mainsite osteoporosis (T-score ≤ −2.5)

‖Osteoporosis on initial DXA is defined as mainsite T-score ≤ −2.5

¶Osteoporosis risk factors included in this composite binary variable: body mass index (BMI) < 20, glucocorticoid use, possible secondary osteoporosis, previous high-risk fracture, rheumatoid arthritis, and alcohol abuse

more common in women initially treated with drugs after initial DXA (over 15% for all groups).

On the other hand, underuse of repeat screening may be a concern in the group defined as high-risk based on initial DXA results. According to Gourlay et al.,[9] at 5 years from initial screening, over 50% of these women will convert to osteoporosis, which would qualify them for treatment. In our sample, just over half (60.4%) of women in this high-risk group had been re-screened at 5 years. Meanwhile, providers ordered repeat DXA scans for women already diagnosed with osteoporosis at a very similar frequency to their low-risk counterparts, but it is unclear how repeat DXA would have changed management recommendations for women with previously established osteoporosis.

For women placed on drugs after initial DXA, clinical predictors of repeat screening were lacking. Baseline DXA results did not show a significant association with likelihood of retesting. Other than status as a current smoker, the presence of measured osteoporosis risk factors was not associated with increased likelihood of retesting. The strongest predictors of repeat DXA in this group were demographics (e.g., black or other race/ethnicity), greater number of primary care visits, and having any visit with an endocrinologist.

In general, patient-level predictors of repeat DXA screening were in agreement with other studies of initial DXA screening. Black women or current smokers tended to receive fewer repeat DXA scans. Notably, an endocrinologist visit within the study year was the strongest predictor of having a repeat

DXA scan among the drug group, and one of the stronger predictors in the non-drug group. This may reflect a tendency to follow specialty-specific guidelines, which continue to recommend obtaining repeat DXA every 1 to 2 years after starting treatment.[3,4,17] Several studies have found that the correlation between bone density changes on repeat DXA and actual fracture risk is poor,[5,18,19] and the most recent systematic review of the evidence from the Agency for Healthcare Policy and Research found insufficient evidence to recommend ever repeating a DXA in treated women.[20] Updating specialty-specific guidelines to reflect this evidence may represent a key target area for reducing overuse of repeat DXA.

To our knowledge, this is the first study to describe over- and underuse of repeat DXA scans in a large regional healthcare system using linked medical record, radiology and pharmacy data. Nevertheless, the study had limitations. As this is an observational study, unmeasured confounding is possible. In particular, we lacked robust measures of socioeconomic status. Additionally, while steps were taken to maximize the accuracy of EHR-derived data, measurement error may affect study estimates. Our data was available from only one health system, which may limit generalizability. The time span of our data is concentrated prior to some of the more recent literature on repeat DXA scans[8] and prior to the *Choosing Wisely* recommendations.[11] Practice patterns may have changed in the meantime. We also did not obtain DXA results or drug prescription data on repeat DXA scans, so we could not characterize outcomes of repeat DXA tests.

In conclusion, within a large regional health care system, we observed both overuse of low-value repeat DXA scans and underuse of repeat DXA scans that would be more likely to lead to beneficial changes in management. Our results suggest that many clinicians are uncertain about the indications for repeat DXA testing, leading to haphazard ordering of repeat DXA scans among previously screened women. Interventions are needed to augment the value of repeat DXA scans.

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