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Health Insurance Coverage as a Social Determinant of Osteoporosis Diagnosis in a Population-Based Cohort Study of Older American Adults

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Abstract

Social determinants of health theoretical frameworks identify health insurance coverage as a determinant of older adults' osteoporosis diagnoses, which results in health inequities. In this research, we used the longitudinal Health and Retirement Study dataset of older United States adults, sampled biennially from 2012 to 2016. Logistic regressions estimated odds of osteoporosis diagnosis with and without a bone scan and/or hip fracture, holding insurance type, and health and demographic factors constant. Results were validated using the National Health and Nutrition Examination Survey. Probable underdiagnosing is present in older adults identifying as Black/African American and as males without a bone scan, regardless of fracture status, potentially as products of structural racism and sexism. Models including a bone scan show a reduction in disparities. These findings suggest having a bone scan is still crucial for addressing health inequities in older adults, and remedying barriers to accessing a scan is paramount.

Keywords

insurance, health disparities, access to care

What this paper adds

- Health insurance coverage can create inequities in older Americans as it relates to osteoporosis diagnosis.
- Access to a bone mineral density scan reduces health inequities for older adults identifying as Black/African American and men.
- These disparities/inequities may be a result of systemic racism and sexism.

Applications of study findings

- Practitioners should not use factors such as sex or race/ethnicity as determinants of postponing a bone scan.

Introduction

Access to health care and health outcomes are influenced by factors including socioeconomic status (SES), health insurance, and race- and sex-based inequities. In this study, we posit health insurance type, and receipt of a bone mineral density (BMD) scan, will be related to the likelihood of having received an osteoporosis diagnosis among older American adults, and these relationships will help explain diagnosis disparities across demographic groups.

High-quality health care is unequally distributed in the population, contributing to inequities in health outcomes through SES-related issues (Arpey et al., 2017) and racism (e.g., Williams, 1997). Phelan et al. (2010) suggest reducing health inequities among persons with low SES must come partly from policy changes that help equalize health care access for low-SES groups. Expanded health insurance coverage, whether from long-standing programs like Medicare, or newer legislation like the Patient Protection and

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Affordable Care Act (ACA), improves health care access (Sommers et al., 2015) and reduces patients' out-of-pocket spending (Busch et al., 2014), helping equalize access to quality health care, though inequities among those with coverage may remain.

Health insurance and financial resources are not solely responsible for health inequities. Systemic, or institutional, racism (racism ingrained in whole systems (e.g., health care) exacerbates health inequities (Braveman et al., 2022; Williams et al., 2019). The link between structural racism and health was described by DuBois more than 100 years ago, and evidence linking systemic racism to health has grown in recent years (Braveman et al., 2022; Williams et al., 2019). There are numerous potential mechanisms, including systemic discrimination (Braveman et al., 2022; Williams et al., 2019) and constrained access to monetary and other types of health-improving resources (Phelan et al., 2010). Systemic racism leads to an inequitable distribution of access to health care, disadvantaging populations of color (Yearby et al., 2022). Furthermore, the medical field has long used "race" erroneously as a biological factor to explain health disparities and physical functioning, which can lead to inequities in treatment, lack of diagnosis or misdiagnosis, and lack of appropriate medical care (Yearby, 2021).

Similarly, structural sexism impacts health although the underlying mechanism differs by sex (Homan, 2019). Homan (2019, p. 487) defines structural sexism as "systemic gender inequality in power and resources." Structural sexism influences health by shaping how health-promoting (e.g., financial resources and access to health care) and health-harming (e.g., discrimination, negative health behaviors) factors are distributed (Homan, 2019). Macro-level structural sexism harms men and women, though meso-level structural sexism benefits men and harms women (Homan, 2019). Therefore, structural sexism may play a role in development of osteoporosis and/or receiving an osteoporosis diagnosis.

Focusing on social determinants and structural inequities is important for understanding how chronic disease rises across the population, and efforts focused broadly on social determinants may provide a new pathway to improving and treating chronic diseases (Shi et al., 2009). Osteoporosis is one chronic disease of public health concern that has detectable disparities that may benefit from additional attention as it has been some time since the bulk of literature was published. Importantly, osteoporosis is a leading cause of fracture among older adults. Hansen et al. (2019) estimated in 2015 there were around 2.3 million fractures in Medicare beneficiaries and that reducing the fracture rate by 5–20% would save around US$310 million, including the cost of BMD screening (Hansen et al., 2019). The cost for fractures in the United States in 2018 was $57 billion (Lewiecki et al., 2019). These costs were exacerbated by cuts in funding by Congress to Medicare Part B in 2007 that created a barrier to BMD scanning (King & Fiorentino, 2011). Yet, there was not a large decrease in BMD scans as a result; there was a shift in timing: the number of women diagnosed with osteoporosis pre-fracture decreased, while post-fracture diagnosis increased in Medicare recipients (McAdam-Marx et al., 2012), and there was a corresponding shift in osteoporosis treatment from pre- to post-fracture in the privately insured (Weaver et al., 2017), indicating funding cuts increased costs and lowered quality of life. For those with private insurance, BMD scans went down 2009–2012 in younger, postmenopausal women (Overman et al., 2015). In 2011, the ACA reduced some barriers to getting a BMD scan (Hansen et al., 2019), which may have improved pre-fracture diagnosis once more. However, the shift—temporary or not—from scans pre to post-fracture indicates a move from preventative care to treatment of a potentially catastrophic life event that dramatically increases mortality risk.

To examine whether health insurance is a source of inequity for osteoporosis diagnosis, we investigate how insurance type relates to diagnosis among older American adults using the longitudinal Health and Retirement Study (HRS), comparing: (1) Medicare (all plans), (2) private (e.g., employer-sponsored insurance), and (3) a combination of 1 and 2. Further, we validate results using the National Health and Nutrition Examination Survey (NHANES). We assess whether accounting for experience of fracture and access to a BMD scan changes our understanding of disparities in osteoporosis diagnosis. The hypotheses tested are twofold: (H1) in the absence of a BMD scan, all insurance types will perform similarly to diagnose osteoporosis, but evidence of structural racism and sexism will be detectable; and (H2) private insurance will be better for diagnosing osteoporosis prior to a hip fracture using a BMD scan, although it may introduce health inequities. We compare results across sex and race/ethnicity.

Materials and Methods

The data are comprised of University of Michigan's longitudinal HRS, which is designed to be nationally representative: (1) Core data (including physical measures) comes from a combination of the RAND Longitudinal File and Fat Files (Health and Retirement Study, 2021; RAND HRS Longitudinal File 2016 (V2), 2020), (2) sensitive-health (restricted-use) Biomarker studies (Health and Retirement Study, 2020; collected from half of respondents in each wave), and (3) Cross-Wave Race and Ethnicity data (Health and Retirement Study, 2014). The sample spans 2012–2016, years in which osteoporosis diagnosis is available, and the study design and response rates are detailed elsewhere (Health and Retirement Study, 2017b; Sonnega et al., 2014). Respondents in this population-based cohort sample (N = 9330) of the HRS were aged 65–90, community-dwellers or nursing home residents, and intended to represent the racial/ethnic diversity of the United States. The other inclusion criterion was self-reported information on the variables described below. This secondary data study follows Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines and was

determined to be exempt by the University of La Verne Institutional Review Board (protocol number: 2019–13-CAS). The original study collected written informed consent from participants (see Health and Retirement Study, 2017a). Data are available through reasonable request from the Health and Retirement Study.

The outcome is a binary measure of the respondent reporting whether they have ever been told by a doctor they have osteoporosis. The exposure variable is self-reported health insurance type, which is a categorical variable of Medicare only, private insurance only, and both Medicare and private insurance (see Supplementary Appendix Sections A1 and A2 for detailed descriptions of insurance types included in "private"). Potential mediators of osteoporosis diagnosis and management include: whether the respondent has, in the last 2 years, or ever (if this is their first survey), had a BMD scan (binary); and whether the respondent has had a hip fracture (binary).

We included several variables shown to be important predictors or confounders of osteoporosis in the literature (i.e., Gough Courtney et al., 2021), including demographics and other health factors. We draw from social epidemiological frameworks described by Kubzansky et al. (2014) and Barr (2014), in which exposures such as poverty and stressful life events lead to changes in physiologic functioning that impact later-life health outcomes. We narrowed these using a filter method (Spearman's correlation) and a technique for identifying confounders (change-in-estimate method). Variables with no statistical impact were eliminated, including several initially expected to be important (e.g., low calcium intake, amount of exercise, history of smoking, and alcohol consumption). These factors were likely no longer important in this sample because as a population ages, individuals' health characteristics converge regardless of lifestyle factors that play an important role at younger ages.

The demographic variables identified consist of sex (binary measure of male or female), race/ethnicity (due to sample size restrictions it is categorized as identifying as: White/European American, Black/African American, another race/ethnicity), and marital status (married/cohabiting, separated/divorced, widowed, never married). Health factors include allostatic load and weight (in kilograms). Allostatic load is a continuous index counting how many measures the respondent has values greater than the 75th percentile: systolic blood pressure (mmHg), diastolic blood pressure (mmHg), pulse (bpm), total cholesterol (mg/dL), hs-CRP (mg/L), A1c (%), Cystatin C (mg/L); and increased waist circumference (>35 inches for women, > 40 inches for men) (adapted from McCrory et al., 2019). Allostatic load is potentially important because environmental, health, and social factors can lead to increased stress, inducing a biological response from the hypothalamic-pituitary-adrenal (HPA) axis that can lead to chronic inflammation (Barr, 2014) and may pose a risk for diseases of inflammation, such as osteoporosis.

Multivariable logistic regression was employed using McFadden's adjusted pseudo R^2 to evaluate model fit, and multicollinearity was assessed with the variance inflation factor (VIF). As the HRS uses complex survey sampling design, we estimated models to reduce response bias, as in prior work (Gough Courtney et al., 2021), using sample stratum, sample PSU, and biomarker weights with the survey package (Lumley, 2004) in R (R Core Team, 2020), which uses Horvitz-Thompson standard errors to improve robustness. These standard errors, combined with a wave variable (as a proxy for year of data collection), address the repeated measures nature of these data. Missing data were addressed using listwise deletion.

Five models examine health insurance and its relationship to osteoporosis. Model 1 includes all variables except having a BMD scan or hip fracture (H1). Models 2 and 3 incorporate BMD scans (to investigate whether insurance type facilitates access to BMD scans) to report odds ratios on all important demographic characteristics (Model 2) and, for STROBE purposes, unbiased odds ratios (Model 3; H2). Model 4 adds the hip fracture variable (H2). Model 5 removes BMD scans to estimate odds ratio for hip fractures accounting for insurance type (H1). Preliminary models included measures of income and education, but these variables were not significant predictors (Appendix Section A3, Online Supplementary Tables 1 and 2).

For validation, we estimated similar models (ages 65–90) using NHANES data for 2013–14 (Centers for Disease Control and Prevention [CDC], 2013) and 2017–18 (Centers for Disease Control and Prevention [CDC], 2017). The NHANES sample is also designed to be nationally representative. Similar sex, race/ethnicity, osteoporosis, and insurance variables were included, along with an objective, categorical measure of osteoporosis (present/absent) derived from total femur *T*-scores (Looker et al., 1998). Models 6 and 7 paralleled Model 1, estimating (a) osteoporosis diagnosis by a doctor using insurance type and (b) osteoporosis diagnosis based on femur *T*-score by insurance type. Model 8 added the objective osteoporosis measure to Model 6 to emulate Model 3.

Results

Approximately 10% of the HRS sample reported an osteoporosis diagnosis, and about half identified as female (Table 1). Approximately 87% of respondents identified as White/European American, 9% as Black/African American (consistent with the national profile of older adults in the United States (Administration for Community Living, 2021)), and 4% as another race/ethnicity. About 0.86% of the sample reported hip fractures. Medicare coverage levels (96%) were comparable to national statistics (94%), but dual-insurance coverage (45%) was underrepresented (52%) (Administration for Community Living, 2021).

Model 1 (Table 2) yielded a very good McFadden's pseudo R^2: 0.17 (McFadden, 1977), indicating the model explained the outcome well. Odds ratios exceeding 1, indicating a higher probability/risk of osteoporosis diagnosis, were generated for identifying as female (as opposed

Table 1. Descriptive Statistics for Weighted Health and Retirement Study Models 1–5 Mean/Percent of Sample (Standard Error).

	Model 1	Model 2	Model 3	Model 4	Model 5
	(*N* = 9330)	(*N* = 9208)	(*N* = 9214)	(*N* = 9184)	(*N* = 9306)
Variable	Mean/Percent (SE)	Mean/Percent (SE)	Mean/Percent (SE)	Mean/Percent (SE)	Mean/Percent (SE)
Osteoporosis diagnosis by doctor (all years)					
No	90.2 (0.3)	90.2 (0.3)	90.2 (0.3)	90.2 (0.3)	90.2 (0.3)
Yes	9.8 (0.3)	9.8 (0.3)	9.8 (0.3)	9.8 (0.3)	9.8 (0.3)
Sex					
Female	49.1 (0.5)	51.1 (0.5)	51.0 (0.5)	51.1 (0.5)	50.9 (0.5)
Age	73.6 (0.1)	73.5 (0.1)	73.5 (0.1)	73.6 (0.1)	73.6 (0.1)
Race/Ethnicity					
White/European American	86.9 (0.8)	86.8 (0.8)		86.8 (0.8)	86.8 (0.8)
Black/African American	8.9 (0.5)	8.9 (0.5)		8.9 (0.5)	8.9 (0.5)
Another race/ethnicity	4.3 (0.5)	4.3 (0.5)		4.3 (0.5)	4.3 (0.5)
Marital status					
Married	63.6 (0.7)	63.6 (0.7)	63.7 (0.7)	63.6 (0.7)	63.5 (0.7)
Separated/divorced	11.7 (4.3)	11.8 (0.4)	11.8 (0.4)	11.8 (0.4)	11.8 (0.4)
Widowed	20.3 (0.5)	20.3 (0.5)	20.3 (0.5)	20.4 (0.5)	20.4 (0.5)
Never married	4.3 (0.4)	4.3 (0.4)	4.3 (0.4)	4.3 (0.4)	4.3 (0.4)
Weight (kg)	81.0 (0.3)	81.0 (0.3)	81.0 (0.3)	81.0 (0.3)	81.0 (0.3)
Allostatic load	2.3 (0.2)				
Type of health insurance					
Medicare only	51.5 (1.0)	51.5 (1.0)	51.5 (1.0)	51.6 (1.0)	51.6 (1.0)
Private only	3.4 (0.3)	3.4 (0.3)	3.4 (0.3)	3.3 (0.4)	3.3 (0.4)
Medicare and private	45.1 (1.0)	45.1 (1.0)	45.1 (0.9)	45.2 (1.0)	45.1 (1.0)
BMD scan					
Yes		46.9 (0.7)	46.8 (0.7)	46.8 (0.7)	
Hip fracture					
Yes				0.8 (0.1)	0.9 (0.1)
Wave	12.0 (1.1)	12.0 (1.1)	12.0 (1.1)	12.0 (1.1)	12.0 (1.1)
Osteoporosis diagnosis by doctor (2012)[a]					
No	2915	2872	2873	2865	2908
Yes	619	613	613	611	617
Osteoporosis diagnosis by doctor (2014)[a]					
No	2956	2920	2921	2917	2953
Yes	195	192	192	191	194
Osteoporosis diagnosis by doctor (2016)[a]					
No	2494	2461	2465	2450	2483
Yes	151	150	150	150	151

[a]Counts of respondents reporting an osteoporosis diagnosis.

to male) and being separated/divorced or widowed (compared to being married). Odds ratios less than 1, indicating a lower probability/risk of osteoporosis diagnosis, were produced for identifying as Black/African American (compared to identifying as White/European American), greater allostatic load, and higher weight. All levels of the categorical insurance type variable were not significant.

The pseudo R^2 for Models 2 (which added a BMD scan) and 3 (unbiased odds ratios model; Table 2) increased to an excellent value: 0.21 (McFadden, 1977). In Model 2, identifying as female (as opposed to male) stayed significant and positive, although the odds ratio reduced. After accounting for the BMD scan variable, race/ethnicity and allostatic load were no longer significant and dropped for the unbiased odds ratios model. Participants reporting having a BMD scan were

Table 2. Logistic Regression with Osteoporosis Diagnosis as the Outcome Variable for Models 1–5 from Health and Retirement Study.

	Model 1		Model 2		Model 3	
	(*N* = 9330)		(*N* = 9208)		(*N* = 9214)	
Variable	OR 95% CI	*p*-value	OR 95% CI	*p*-value	OR 95% CI	*p*-value
Intercept	346.01 (85.01–1408.37)	<.001***	1480.19 (328.15–6676.75)	<.001***	1563.22 (361.71–6755.79)	<.001***
Sex						
Female	6.74 (5.13–8.87)	<.001***	2.57 (1.81–3.65)	<.001***	2.54 (1.81–3.56)	<.001***
Race/Ethnicity						
Black/African American	0.50 (0.34–0.74)	.001**	0.68 (0.45–1.03)	.07		
Another race/ Ethnicity	0.85 (0.53–1.38)	.52	0.94 (0.59–1.48)	.78		
Marital status						
Separated/Divorced	1.38 (1.09–1.73)	.01*	1.44 (1.13–1.83)	.01*	1.40 (1.10–1.77)	.01*
Widowed	1.21 (1.01–1.43)	.04*	1.27 (1.07–1.50)	.01*	1.25 (1.06–1.48)	.01*
Never married	1.36 (0.84–2.19)	.21	1.36 (0.80–2.31)	.26	1.28 (0.76–2.15)	.35
Allostatic load	0.92 (0.87–0.98)	.02*				
Weight (kg)	0.98 (0.98–0.99)	<.001***	0.98 (0.97–0.98)	<.001***	0.98 (0.97–0.98)	<.001***
Type of health insurance						
Private only	0.75 (0.39–1.44)	.39	0.78 (0.40–1.54)	.48	0.80 (0.40–1.57)	.51
Medicare and private	0.85 (1.17–0.62)	.07	0.79 (0.67–0.94)	.01*	0.81 (0.68–0.96)	.02*
BMD scan						
Yes			5.81 (4.10–8.23)	<.001***	5.97 (0.98–0.98)	<.001***
Wave	0.51 (0.46–0.57)	<.001***	0.50 (0.45–0.56)	<.001***	0.50 (0.45–0.56)	<.001***

	Model 4		Model 5	
	(*N* = 9184)		(*N* = 9306)	
	OR 95% CI	*p*-value	OR 95% CI	*p*-value
Intercept	2076.35 (457.16–9430.50)	<.001***	484.04 (113.18–2070.08)	<.001***
Sex				
Female	2.56 (1.81–3.62)	<.001***	6.41 (4.88–8.42)	<.001***
Race/Ethnicity				
Black/African American	0.68 (0.45–1.02)	.07	0.49 (0.33–0.72)	.001**
Another race/ ethnicity	0.93 (0.59–1.48)	.77	0.85 (0.53–1.37)	.50
Marital status				
Separated/divorced	1.45 (1.15–1.84)	.004**	1.37 (1.10–1.72)	.01*
Widowed	1.28 (1.08–1.51)	.01*	1.18 (1.00–1.40)	.06
Never married	1.36 (0.81–2.29)	.25	1.35 (0.84–2.15)	.22
Weight (kg)	0.98 (0.97–0.98)	<.001***	0.98 (0.98–0.99)	<.001***
Type of health insurance				
Private only	0.72 (0.36–1.45)	.36	0.68 (0.35–1.34)	.28
Medicare and private	0.79 (0.67–0.94)	.01*	0.86 (0.73–1.02)	.10
BMD scan				
Yes	5.80 (4.10–8.21)	<.001***		
Hip fracture				
Yes	1.50 (0.74–3.04)	.27	1.46 (0.76–2.79)	.26
Wave	0.51 (0.45–0.57)	<.001***	0.51 (0.46–0.57)	<.001***

*$p < .05$.
**$p < .01$.
***$p < .001$.

Table 3. Descriptive Statistics for Weighted National Health and Nutrition Examination Survey Sample, Percent of Sample (Standard Error).

	Model 6	Model 7	Model 8
	(*N* = 1606)	(*N* = 1239)	(*N* = 1232)
Variable	Mean/Percent (SE)	Mean/Percent (SE)	Mean/Percent (SE)
Osteoporosis diagnosis by doctor			
No	82.1 (1.6)		85.6 (1.4)
Yes	17.9 (1.6)		14.4 (1.4)
Sex			
Female	55.1 (1.2)	52.8 (1.4)	52.7 (1.4)
Race/ethnicity			
White/European American	77.1 (2.4)	77.4 (2.6)	77.4 (2.6)
Black/African American	8.6 (1.4)	8.0 (1.4)	8.0 (1.4)
Another race/ethnicity	14.3 (1.6)	14.7 (1.8)	14.6 (1.8)
Insurance			
Medicare only	38.1 (2.5)	36.6 (2.5)	36.6 (2.5)
Private insurance only	14.4 (1.6)	17.5 (2.0)	17.6 (2.0)
Medicare and private	47.6 (2.5)	45.8 (2.8)	45.9 (2.8)
Osteoporosis diagnosis based on DXA scans			
Yes		6.0 (1.0)	6.0 (1.0)
No		94.0 (1.0)	94.0 (1.0)
Osteoporosis diagnosis by doctor (2013–14)[a]			
No	292	264	248
Yes	30	7	22
Osteoporosis diagnosis by doctor (2017–18)[a]			
No	1038	896	802
Yes	246	72	160

[a]Counts of respondents reporting an osteoporosis diagnosis.

six times more likely to be diagnosed with osteoporosis than those without (Model 3). After controlling for BMD scan, having both insurance types generated lower odds of an osteoporosis diagnosis. BMD scan, then, was an effect mediator, rather than modifier.

In Models 4 (which included the hip fracture variable) and 5 (which dropped the BMD scan variable), having a hip fracture was not related to higher odds of osteoporosis diagnosis, indicating it was not an important factor, or mediator, for osteoporosis diagnosis when insurance type was held constant. Race/ethnicity was not significant in Model 4, but was in Model 5 without the BMD scan variable, which is consistent with the realized racial/ethnic disparities in Models 1 and 2. In Model 4, respondents with combination insurance experienced 19% lower odds of an osteoporosis diagnosis; this combination was protective. The McFadden's R^2 was excellent for Model 4 (0.21) and very good (0.17) for Model 5.

In the NHANES sample, approximately 18% reported being diagnosed with osteoporosis by a doctor, and about 6% as having osteoporosis from femoral *T*-score (Table 3). Approximately 55% of this sample identified as female, 77% as White/European American, 9% as Black/African American (as in the HRS), and 14% as another race or ethnicity. Medicare coverage levels were lower in NHANES (83–86%) than nationally (94%), and dual-insurance coverage (47%) was underrepresented (52% nationally) (Administration for Community Living, 2021). The McFadden's pseudo R^2 for Models 6 and 7 were 0.19 (very good) and 0.09 (poor), while the McFadden's pseudo R^2 for Model 8 was 0.20 (excellent). In Model 6 (Table 4), where health insurance type was used to predict doctor diagnosis of osteoporosis, the odds of receiving an osteoporosis diagnosis were 90% lower for those with private insurance compared to Medicare, but 1.5 times higher for those with Medicare and private insurance (vs. Medicare only). Using objectively measured osteoporosis (Model 7; Table 4), the odds of osteoporosis diagnosis for those with private insurance were around 92% lower than for those with Medicare, while the odds for those with combination insurance did not differ from Medicare alone. Finally, in Model 8 (Table 4), private insurance had 87% lower odds of osteoporosis diagnosis, holding objectively measured osteoporosis constant. Having objectively measured osteoporosis had four times the odds of an osteoporosis diagnosis from a doctor. Individuals identifying as female had higher odds of osteoporosis than those identifying as male across both outcomes, though the gap was smaller for objectively measured osteoporosis. Additionally, identifying as Black/African American was linked with lower odds of an

Table 4. Logistic Regression with Osteoporosis Diagnosis as the Outcome Variable for Models 6–8 from National Health and Nutrition Examination Survey.

	Model 6		Model 7		Model 8	
	(*N* = 1606)		(*N* = 1239)		(*N* =1238)	
Variable	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Intercept	0.02 (0.01–0.05)	<.001***	0.01 (>0.00–0.09)	<.001***	0.03 (0.01–0.09)	<.001***
Sex						
Female	13.18 (7.44–23.35)	<.001***	3.95 (2.06–7.57)	<.001***	9.26 (5.14–16.68)	<.001***
Race/Ethnicity						
Black/African American	0.55 (0.34–0.91)	.02*	0.59 (0.28–1.26)	.17	0.67 (0.43–1.04)	.08
Another race/ethnicity	1.19 (0.72–1.96)	.49	0.71 (0.37–1.37)	.30	1.53 (0.79–2.96)	.19
Type of health insurance						
Private only	0.10 (0.03–0.38)	.001**	0.08 (0.02–0.36)	.001**	0.13 (0.03–0.52)	.01*
Medicare and private	1.51 (1.04–2.19)	.03*	0.95 (0.49–1.83)	.87	1.53 (0.89–2.63)	.12
Osteoporosis from bone mineral density scan						
Yes					4.18 (1.86–9.43)	.001**
Wave	1.41 (0.81–2.46)	.21	1.68 (0.61–4.66)	.31	1.04 (0.60–1.81)	.88

*$p < .05$.
**$p < .01$.
***$p < .001$.

osteoporosis diagnosis from a doctor (compared to identifying as White/European Americans), but diagnosis from objectively measured BMD did not vary by race/ethnicity, nor did doctor diagnosis vary after accounting for objectively measured osteoporosis. VIFs for all models did not exceed 5.

Discussion

The United States Preventative Services Task Force (USPSTF) (2018) called for more research to be conducted on men and fracture outcomes, which we aimed to do across hypotheses. Further, Noel et al. (2021) requested more research examining osteoporosis care, which was accomplished with H2. Osteoporosis diagnoses, without considering BMD scans, were similar across insurance types in the HRS, but there were differences in rates of diagnosis across sex and among those identifying as White/European American versus those identifying as Black/African American. Therefore, our first hypothesis (H1), that in the absence of a BMD scan, all insurance types will perform similarly to diagnose osteoporosis but evidence of structural racism and sexism will be detectable, is supported. Interestingly, our second hypothesis, that private insurance will be better for diagnosing osteoporosis prior to a hip fracture using a BMD scan, although it may introduce health inequities, was negated in the HRS; private insurance performed similarly to Medicare (Models 1–2, 5), and a combination of insurance was best as regards access to BMD scans (Models 3, 4). All HRS models performed similarly in the presence of fractures. In the NHANES data, H2 was supported; private insurance was associated with lower odds of diagnosis. Individuals with private insurance were about 90% less likely to have a doctor's diagnosis or objectively measured osteoporosis compared to Medicare beneficiaries.

While it may initially appear the results from NHANES contradict the HRS findings, they are complimentary and support the generalizability of this study to the greater United States for these ages. The average ages for individuals with private insurance in NHANES are 9 and 11 years younger than the Medicare-only and combination insurance groups. They are likely still working and have experienced fewer age-related health changes. Further, HRS's private insurance-only sample is much smaller compared to NHANES (3% vs. 14%).

Identifying as Black/African American in HRS (Models 1, 5) and NHANES (Model 6) led to lower odds of an osteoporosis diagnosis in models without the BMD scan variable, but when it was added, race/ethnicity was no longer significant. This may result from underdiagnosis due to lack of access to adequate providers or practitioner bias (e.g., Burgess et al., 2004). The literature documents how the intersectional identities of woman and Black/African American are linked with negative interactions with the health care system. Women identifying as Black/African American receive less care (Miller et al., 2005; Mudano et al., 2003), screening (Gillespie & Morin, 2017; Hamrick et al., 2006; Miller et al., 2005; Mudano et al., 2003; Neuner et al., 2007), treatment (Miller et al., 2005), and referrals pre-fracture for low BMD than women identifying as White/European American (Miller et al., 2005; Mudano et al., 2003), even after fracture and in the presence of risk factors (Mudano et al., 2003). Physicians may use race/ethnicity in decision-making for preventative screening (Miller et al., 2005;

Wilkins & Goldfeder, 2004), which reduces testing in women identifying as Black/African American, compared to women identifying as White/European American, and is improper given their similar risk factors. Further, women identifying as Black/African American have increased difficulties accessing similar health care to women identifying as White/European American post hip fracture (Graham et al., 2008; Hamrick et al., 2006; Jacobsen et al., 1992; Miller et al., 2005). Indeed, only 38% of HRS respondents identifying as Black/African American reported having a BMD scan, which is far lower than the 50% reported by participants identifying as White/European American, a gap that remains despite the time that has passed since the original identification of this trend. However, our tests of intersectionality were not significant, indicating a similar experience across people who identify as Black/African American women or men (Appendix Section A4, Online Supplementary Tables 3 and 4).

Model 5, showing respondents identifying as Black/African American in the HRS have lower odds of reporting an osteoporosis diagnosis and a fracture, is also consistent with reports of women identifying as Black/African American having fewer BMD scans post-fracture than women identifying as White/European American (Neuner et al., 2007). However, when an objective measure, a BMD scan, is included in the models, respondents in the HRS who identify as Black/African American have similar odds of osteoporosis diagnosis and a fracture. In other words, access to a BMD scan reduces health inequities among respondents in the HRS who identify as Black/African American, irrespective of hip fracture, and a similar result is seen with NHANES (Appendix Section A5, Online Supplementary Figures 1–3). However, standards for osteoporosis screening and diagnosis are based on samples derived from patients identifying as Non-Hispanic White, and *T*-score cutoffs may not reflect the full continuum of human variation (Noel et al., 2021). Bone health among those identifying as Black/African American is impacted by standards of measuring and treating vitamin D deficiencies developed on individuals identifying as Non-Hispanic White, which led to unnecessary supplementation recommendations in persons with adequate BMD (Brown et al., 2018; Powe et al., 2013). A lack of understanding of how human variation and its underlying genetics affects various biomarkers led to inappropriate standards being developed and applied to people identifying as Black/African American (Brown et al., 2018), an issue which may extend to additional racial/ethnic identities and be an erroneous belief about risks to bone health (see Burt et al., 2019; LeBoff et al., 2020). Our results agree with others and suggest race/ethnicity should not play a role in a provider's decision to screen for osteoporosis; instead, risk factors and USPSTF and Bone Health and Osteoporosis Foundation (BHOF) recommendations should be considered so health inequities stemming from racial/ethnic identification can be reduced. Health inequities between individuals identifying as White/European American and those identifying as Black/African Americans from structural racism are known in the HRS dataset; they were empirically quantified using Black felony disenfranchisement for depression and functional/mobility limitations (Homan & Brown, 2022). Our results align with Homan and Brown (2022); differences in diagnosis without a BMD scan demonstrated in this paper may also be attributable to structural racism and poorer quality of care afforded those identifying as Black/African American.

We detected that persons identifying as female had dramatically higher odds (6.7 times) of being diagnosed with osteoporosis than those identifying as male in HRS models without the BMD scan variable (Models 1, 5): with a scan odds were only 2.6-fold higher (Models 2–4). Similarly, in NHANES, people identifying as female were 13 times more likely to report doctor diagnosis than those identifying as male but only 4 times more likely to have objectively measured osteoporosis. This may partly speak to the better-understood screening of women for osteoporosis than men and the relative lack of information on risk factors for men pre-fracture (e.g., US Preventive Services Task Force, 2018), although BHOF makes recommendations for men based on age and risk factors (Bone Health & Osteoporosis Foundation, 2021). However, osteoporosis in males is not rare, accounting for approximately one-third of hip fractures (Khosla et al., 2008), and they experience increased mortality post-fracture (Jiang et al., 2005). Limited research exists on causes, risk factors, prevalence, and outcomes (Khosla et al., 2008). Macro-level structural sexism may be a factor, as it is linked to poorer physical functioning, particularly in married men (Homan, 2019).

Understanding remaining inequities is important, but the same level of inequity by insurance type is not apparent. The performance of Medicare in comparison to other insurances is important for health inequities among certain types of workers (e.g., those who retire without private insurance) and immigrants navigating U.S. social programs (Cobian et al., 2020). Although political rhetoric may portray Medicare in a poor light (e.g., Wallace et al., 2019), we present evidence that it is on par with private insurance as relates to osteoporosis diagnosis, helping reduce health inequities through access to detection of osteoporosis and preventative fracture care.

This paper has limitations, including recall bias, the inability to differentiate between Medicare products, and Medicare's policy for DXA scan reimbursement changing during the period examined, which may have introduced heterogeneity into our results. Similarly, because of question wording, osteoporosis diagnoses may have been received 20–30 years earlier. Further, sample sizes precluded us from separating the race/ethnicity variable into more groups, which limits generalizability. Moreover, the HRS question on sex only captures binary biological sex, which does not reflect its underlying continuum. Eating disorders can also impact bone health, but this information is not available in the HRS, so we could not include it. Finally, standards for osteoporosis

diagnosis reflect the underlying bias of having been derived predominantly from participants identifying as Non-Hispanic White.

Conclusions

A combination of insurance types (private, Medicare) provides increased access to BMD scans for osteoporosis diagnoses, which appears to reduce race and sex inequities in osteoporosis diagnosis among older adults in the United States, regardless of fracture presence. Medicare performed similarly to private insurance, and both individually underperformed in relation to having a combination of insurances. When paired with the detected inequities in accessing BMD scans, this underscores the need to invest in access to BMD scans across insurance types to facilitate reductions in health inequities due to racial/ethnic and sex bias, deriving, in part, from structural racism and sexism.

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Author Contributions

Margaret Gough Courtney: Conceptualization (equal); formal analysis (supporting); funding acquisition (equal); methodology (equal); project administration (equal); supervision (equal); writing—original draft (lead); writing—reviewing and editing (equal); final approval of manuscript (equal). Josephine Roberts: Conceptualization (supporting); formal analysis (supporting); funding acquisition (none); methodology (none); project administration (supporting); supervision (none); writing—original draft (supporting); writing—reviewing and editing (supporting); final approval of manuscript (equal). Kanya Godde: Conceptualization (equal); formal analysis (lead); funding acquisition (equal); methodology (equal); project administration (equal); supervision (equal); writing—original draft (supporting); writing—reviewing and editing (equal); final approval of manuscript (equal).

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Ethical Approval

This study was determined to be exempt by the University of La Verne's Institutional Review Board (IRB), La Verne IRB. The protocol number is 2019-13-CAS.

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Supplemental Material

Supplemental material for this article is available online.

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