

Primary Care Engagement and Osteoporosis Fracture Risk: Findings from a Community Health Fair Screening Initiative

Devon Foster¹

dfost046@fiu.edu

Florida International University

Gabriele Donzella¹

Florida International University

Jonathan Brutti¹

Florida International University

Caden Ray Moenning¹

Florida International University

Aaron Davidson¹

Florida International University

Gabriel Gonzalez¹

Florida International University

Klaudia Greer¹

Florida International University

Albert Sirven

Florida International University

Amalia Landa Galindez¹

Florida International University

Research Article

Keywords: osteoporosis, FRAX, fracture risk, primary care, community screening, health fair

Posted Date: October 8th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11000201/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

Osteoporosis is a chronic skeletal disease characterized by low bone mass and micro-architectural deterioration that leads to increased fracture risk. The economic and social impact of osteoporosis and associated fractures is quite significant, with one in three women as well as one in five men over the age of 50 experiencing an osteoporosis-related fracture. Hip fractures are particularly devastating with significant disability which can be permanent. We aimed to investigate whether community health fairs could provide a unique opportunity to screen individuals in underserved areas, and specifically whether primary care engagement had an impact on an individual's fracture risk based on FRAX-estimated fracture probability.

Methods

This cross-sectional study examined FRAX-estimated 10-year fracture probability among 132 adults aged 45 to 89 years (M = 62.7 years; 91.7% female) recruited voluntarily at community health fairs in South Florida from 2021 through 2026. Volunteers responsible for participant recruitment during health fairs were medical students trained in osteoporosis risk screening/counseling. Participants were asked to complete a structured survey assessing medical history, dietary patterns, supplement use, smoking, alcohol consumption, and primary care visit frequency. Ten-year fracture probabilities for major osteoporotic fracture (MOF) and hip fracture were calculated using the WHO FRAX tool (US reference population). Analyses included one-way ANOVA, independent samples t-tests, and hierarchical linear regression.

Results

Participants seen by a primary care provider every few months had significantly higher FRAX MOF and hip scores than those not seen regularly, a pattern consistent with clinical selection of higher-risk individuals into more frequent care. Hierarchical regression demonstrated that lifestyle and behavioral variables alone explained negligible variance in FRAX scores, while the addition of medical history variables produced significant models explaining 28.1% and 33.5% of variance in hip and MOF outcomes respectively. Osteoporosis history, prior fracture, and cancer history were the strongest positive predictors of fracture risk.

Conclusions

These findings suggest that community health fair screening captures a medically complex, high-risk population, and that individuals without regular primary care contact may represent an underserved

group whose fracture risk is under characterized by self-report alone.

Background

Osteoporosis is a chronic skeletal condition characterized by reduced bone mineral density and structural deterioration, placing affected individuals at significantly elevated risk of fracture. In the United States, an estimated 10 million adults live with osteoporosis, and an additional 44 million have low bone density, collectively representing nearly half of adults aged 50 and older [1]. The prevalence of osteoporosis is particularly concerning in older individuals, with over 77% of women and 46% of men aged 80 and older meeting diagnostic criteria for osteoporosis [2]. Osteoporotic fractures, particularly hip and major osteoporotic fractures (MOF), carry substantial consequences including prolonged hospitalization, loss of functional independence, and increased mortality [3, 4]. Despite the established burden of this disease, osteoporosis remains markedly underdiagnosed and undertreated [5, 6], with a large proportion of at-risk individuals receiving neither screening nor intervention prior to sustaining a fracture. While primary care providers are often trained in the screening and management of osteoporosis, patients do not always have access to preventive care, especially in underserved areas, and providers may not always focus on metabolic bone disease assessment. Several tools are available to facilitate rapid assessment of osteoporosis risk.

The FRAX tool, developed by the World Health Organization, provides a validated estimate of an individual's 10-year probability of hip fracture and major osteoporotic fracture based on a standardized set of clinical risk factors including age, sex, body mass index, prior fracture history, smoking, alcohol use, glucocorticoid exposure, and comorbid conditions [7, 8]. FRAX is widely used in clinical settings to guide decisions about bone density testing and pharmacologic intervention [9]. However, its application at the population level, particularly in community-based settings such as health fairs, remains underexplored.

Primary care providers serve as the frontline of osteoporosis prevention, screening, and management. Regular engagement with a primary care physician (PCP) has been associated with higher rates of bone density testing, appropriate risk stratification, and initiation of calcium, vitamin D, and pharmacologic therapy [10, 11]. Conversely, individuals with limited or no access to primary care may go unscreened for osteoporosis risk, particularly when they are asymptomatic and have not yet experienced a fracture. Community health fairs offer an accessible, low-barrier venue for identifying individuals who may otherwise remain outside the reach of the formal healthcare system [10]. Health fairs also offer the opportunity for education regarding osteoporosis prevention and bring attention to lifestyle modifications that can positively impact bone health and reduce osteoporosis risk. Our team of medical students and providers with high interest in metabolic bone disorders set out to assess whether access to primary care was associated with osteoporosis risk reduction, and whether lifestyle factors could predict fracture risk.

This study examined osteoporosis risk factor data collected through community health fair survey conducted in various underserved South Florida neighborhoods from 2021 through 2026. Participants completed a structured survey capturing information on diet, supplement use, alcohol and tobacco use, comorbid conditions, body mass index, and frequency of primary care engagement, with FRAX-based 10-year fracture probability calculated for each participant. The primary aim was to determine whether frequency of PCP visits was associated with FRAX fracture risk scores. Secondary aims explored the role of medical history and lifestyle factors as predictors of fracture risk in this community-screened population. Findings from this study may inform strategies for identifying and engaging high-risk individuals through community-based screening initiatives.

Methods

Study Design and Setting

This was a cross-sectional survey study conducted at community health fairs held in various underserved neighborhoods across South Florida. These health fairs were open to the general public, and participation at the osteoporosis screening booth was entirely voluntary. Adults who approached the study booth were invited to complete a brief structured survey assessing osteoporosis risk factors. No personally identifiable information was collected, and all surveys were completed anonymously. IRB approval was obtained prior to commencement of this study.

Student Interviewers/Screeners

Each year medical students at the Florida International University Herbert Wertheim College of Medicine are trained via faculty-supervised student-led workshops designed to reinforce classroom education related to osteoporosis pathophysiology and management. The one-hour workshops include distribution and completion of preworkshop surveys, an interactive PowerPoint presentation summarizing osteoporosis principles that include risk assessment, and use of the FRAX tool to estimate an individual's 10-year risk of an osteoporotic fracture. The workshops emphasize the importance of participant counseling with regards to fracture risk, diet, exercise, and lifestyle changes. Post-workshop assessments were obtained to assess readiness for work at community health fairs, including confidence in screening with the FRAX tool and counseling.

Participants

A convenience sample of 132 adult participants was enrolled across community health fair events in the Miami metropolitan area. Participants were eligible if they were 45 years of age or older; individuals below the age of 45 were excluded, as the FRAX algorithm is validated for use in this age range. The final analytic sample ranged in age from 45 to 89 years (M = 62.7 years). The sample was predominantly

female (n = 121, 91.7%) and racially and ethnically diverse, with the majority of participants identifying as Hispanic/Latino or Black/African American. Participant characteristics are summarized in Table 1.

Survey Instrument

Participants self-completed a structured paper questionnaire at the point of recruitment. The survey captured data across the following domains: medical history, dietary habits, supplement use, smoking/alcohol use, and primary care engagement.

Medical history was assessed by asking participants whether they had ever been diagnosed with cancer, arthritis, osteoporosis, or gastritis, or whether they had a history of prior bone fracture. Each condition was coded as a binary variable (1 = yes, 0 = no).

Dietary patterns were assessed by asking participants to indicate which of the following best described their usual diet: vegan/vegetarian, plenty of meats, plenty of milk/dairy products, or none of the above. Participants could select more than one category, and each was coded as a separate binary indicator variable.

Supplement use was assessed by asking whether participants currently took vitamin D, a multivitamin, and/or calcium supplements, with each supplement coded as a binary yes/no variable.

Smoking status was captured as a binary variable reflecting current smoking status (yes/no), including vaping. Alcohol consumption was captured categorically and coded into three groups: never or rarely, once per week or fewer than four drinks per week, and every day or more than ten drinks per week. For supplementary analyses, alcohol use was recoded as a binary variable (any use vs. none).

Primary care engagement was assessed by asking participants how frequently they visited a primary care provider. Responses were categorized as: every few months (approximately two to three visits per year), once a year, or not regularly. This variable was used as a three-level categorical grouping factor in ANOVA analyses and as a set of dummy-coded binary variables in regression analyses, with 'not seen regularly' as the reference category.

Risk Assessment through FRAX Score Calculation

The 10-year probability of fracture was estimated for each participant using the World Health Organization Fracture Risk Assessment Tool (FRAX), using the United States reference population and adhering to recommendations of the US Preventive Services Task Force. Body Mass Index (BMI) was measured at the time of survey completion and entered into the FRAX calculator along with participant-reported risk factor data. Survey responses were entered manually into the online FRAX calculator (www.sheffield.ac.uk/FRAX) by study team student members. Two outcomes were derived for each participant: the 10-year probability of a major osteoporotic fracture (FRAX MOF) and the 10-year

probability of a hip fracture (FRAX hip), both expressed as percentages. FRAX scores were calculated without bone mineral density data, as dual-energy X-ray absorptiometry (DXA) scanning was not available in the health fair setting.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics. Descriptive statistics were computed for all demographic, clinical, and lifestyle variables. Prior to analysis, free-text survey entries were standardized and coded into binary and categorical variables as described above.

To examine whether FRAX fracture probability differed by primary care visit frequency, one-way analyses of variance (ANOVA) were conducted separately for FRAX MOF and FRAX hip as dependent variables, with PCP visit category as the between-subjects factor. Homogeneity of variance was assessed using Levene's test. Where the assumption of equal variances was violated, Games-Howell post-hoc corrections were applied; where variances were equal, Tukey's HSD procedure was used. Effect sizes were reported as eta-squared (η^2).

To examine bivariate associations between individual medical history and lifestyle variables and FRAX outcomes, independent samples t-tests were conducted for each binary predictor, including cancer, arthritis, osteoporosis, prior fracture, gastritis, vegetarian diet, meat-based diet, dairy-based diet, no special diet, vitamin D supplementation, multivitamin use, calcium supplementation, and smoking status. Alcohol consumption was examined using both one-way ANOVA across three categorical consumption levels and an independent samples t-test using the binary any-versus-none coding. Effect sizes were reported as Cohen's d.

To identify independent predictors of FRAX fracture probability, hierarchical multiple linear regression analyses were conducted separately for FRAX MOF and FRAX hip as outcome variables. Model 1 entered lifestyle and behavioral variables simultaneously, including dietary pattern indicators, supplement use variables, smoking status, binary alcohol use, and PCP visit frequency dummy variables (every few months and once a year, each relative to not seen regularly as the reference group). Model 2 added medical history variables (osteoporosis diagnosis, prior fracture, arthritis, cancer, and gastritis) as a second block, allowing assessment of the incremental variance explained beyond lifestyle factors alone. Model fit was evaluated using R^2 , adjusted R^2 , and the overall F statistic. Multicollinearity was assessed using variance inflation factors (VIF) and tolerance values. Residual independence was evaluated using the Durbin-Watson statistic. Statistical significance was defined as $p < .05$ for all analyses.

Table 1
Health Fair Participant Characteristics (N = 132)

Characteristic	n (%)	M (SD)
Age (years)		62.7 (11.2)
Range		45–89
Female	121 (91.7%)	
Male	11 (8.3%)	
Every few months	67 (50.8%)	
Once a year	51 (38.6%)	
Not regularly	13 (9.8%)	
Osteoporosis	19 (14.4%)	
Prior fracture	19 (14.4%)	
Cancer	12 (9.1%)	
Arthritis	53 (40.2%)	
Gastritis	30 (22.7%)	
Vitamin D	75 (56.8%)	
Calcium	37 (28.0%)	
Multivitamin	63 (47.7%)	
Vegan/Vegetarian	41 (31.1%)	
Meat-based	66 (50.0%)	
<i>Note. SD = standard deviation. MOF = major osteoporotic fracture. Dietary categories were not mutually exclusive; percentages may sum to more than 100%.</i>		

Post-Counseling Assessment

Medical students who participated in the community health-fair screenings were asked to complete post counseling surveys, to assess confidence in screening and providing participants counseling. Questions in the survey included 2 multiple choice questions: 1) Which of the following tools helped prepare you for osteoporosis risk counseling in the community; 2) What have you identified as specific issues that are most significantly impacting the patients you educated during the community health fair with regards to osteoporosis; and two Likert scale questions related to: 1) Confidence in utilizing the FRAX calculator to guide osteoporosis screening as a future provider; 2) Confidence in training received at the student-led

workshop; and 3) Confidence in successfully counseling a patient regarding their bone health and modifiable risks factors for osteoporosis.

Results

Primary Care Visit Frequency and FRAX Fracture Risk

A one-way ANOVA was conducted to examine whether the frequency of primary care visits was associated with FRAX 10-year fracture probability. Participants were categorized into three groups: PCP visits every few months ($n = 67$), PCP visits once a year ($n = 51$), and no regular PCP visits ($n = 13$). Results indicated a significant difference in FRAX major osteoporotic fracture (MOF) probability across groups, $F(2, 128) = 4.31$, $p = .015$, $\eta^2 = .063$. Post-hoc comparisons using the Games-Howell procedure revealed that participants seen every few months had significantly higher FRAX MOF scores ($M = 11.51$) compared to those not seen regularly ($M = 5.64$; $p = .012$). The once-yearly group ($M = 8.85$) did not differ significantly from either group.

Similarly, FRAX hip fracture probability differed significantly by PCP visit frequency, $F(2, 128) = 4.08$, $p = .019$, $\eta^2 = .060$. Games-Howell post-hoc testing indicated that participants seen every few months ($M = 3.40$) and those seen once a year ($M = 1.93$) both had significantly higher hip fracture probability than those not seen regularly ($M = 0.39$; $p < .001$ and $p = .001$, respectively). Effect sizes for both outcomes were small-to-moderate. Given the violation of homogeneity of variances for both outcomes (Levene's test based on mean: FRAX MOF $p = .040$, FRAX hip $p = .002$), Games-Howell corrections were applied throughout. These results are summarized in Table 2 and illustrated in Fig. 1.

Table 2
FRAX Fracture Probability by Primary Care Visit Frequency: One-Way ANOVA Results

PCP Visit Frequency	MOF M	MOF SD	Hip M	Hip SD	Post-hoc (G-H)
Every few months (n = 67)	11.51	8.42	3.40	4.94	a
Once a year (n = 51)	8.85	6.09	1.93	2.82	ab
Not regularly (n = 13)	5.64	5.63	0.39	0.38	b
p	.015*		.019*		
Note. G-H = Games-Howell post-hoc correction. MOF = major osteoporotic fracture. η^2 = eta-squared. Groups sharing the same letter do not differ significantly. * $p < .05$.					

Medical History and Lifestyle Predictors of FRAX Scores

Hierarchical linear regression was conducted separately for FRAX MOF and FRAX hip fracture probability to examine the relative contributions of lifestyle/behavioral factors and medical history.

FRAX Major Osteoporotic Fracture

In Model 1, lifestyle and behavioral variables were entered simultaneously, including dietary pattern, supplement use (vitamin D, calcium, multivitamin), smoking status, alcohol use, and PCP visit frequency dummy variables. Model 1 was not significant, $F(11, 118) = 1.06$, $p = .399$, and explained a negligible proportion of variance ($R^2 = .090$, adjusted $R^2 = .005$). In Model 2, medical history variables were added (history of osteoporosis, prior fracture, arthritis, cancer, and gastritis). Model 2 was significant, $F(16, 113) = 3.56$, $p < .001$, explaining 33.5% of the variance ($R^2 = .335$, adjusted $R^2 = .241$). The addition of the medical history block represented a significant improvement in model fit, $\Delta R^2 = .245$, $\Delta F(5, 113) = 8.32$, $p < .001$.

In the final model, osteoporosis history was the strongest positive predictor of FRAX MOF ($B = 7.32$, 95% CI [3.61, 11.03], $p < .001$), followed by prior fracture history ($B = 3.89$, 95% CI [0.24, 7.54], $p = .037$). Gastritis history was a significant negative predictor ($B = -4.25$, 95% CI [-7.23, -1.28], $p = .006$). No lifestyle or behavioral variables reached significance in the final model. Collinearity was acceptable (all VIFs ≤ 3.66) and the Durbin-Watson statistic was 1.495, indicating no evidence of problematic autocorrelation. The FRAX MOF regression results are presented in Table 3a.

FRAX Hip Fracture

Model 1 including lifestyle and behavioral predictors was not significant, $F(11, 118) = 1.45$, $p = .161$, explaining 11.9% of the variance ($R^2 = .119$, adjusted $R^2 = .037$). Following addition of medical history variables in Model 2, the model became significant, $F(16, 113) = 2.76$, $p < .001$, explaining 28.1% of the variance ($R^2 = .281$, adjusted $R^2 = .179$). Model fit improved significantly with the addition of the medical history block, $\Delta R^2 = .162$, $\Delta F(5, 113) = 5.09$, $p < .001$.

In the final model, osteoporosis history was a significant positive predictor of FRAX hip fracture probability ($B = 4.01$, 95% CI [1.93, 6.09], $p < .001$). Gastritis history was a significant negative predictor ($B = -1.74$, 95% CI [-3.41, -0.07], $p = .041$). Vegetarian diet was also a significant negative predictor in the final model ($B = -2.47$, 95% CI [-4.74, -0.20], $p = .034$). Collinearity was acceptable (all VIFs ≤ 3.66) and the Durbin-Watson statistic was 1.605. The FRAX hip regression results are presented in Table 3b and illustrated in Fig. 2.

Table 3

a. Hierarchical Multiple Linear Regression Predicting FRAX Major Osteoporotic Fracture (MOF) Probability

Predictor	B (M1)	p (M1)	B (M2)	95% CI (M2)	p (M2)	β (M2)
Lifestyle & Behavioral						
Vegetarian diet	—	NS	—	—	NS	—
Meat-based diet	—	NS	—	—	NS	—
Dairy-based diet	—	NS	—	—	NS	—
Vitamin D supp.	—	NS	—	—	NS	—
Calcium supp.	—	NS	—	—	NS	—
Multivitamin	—	NS	—	—	NS	—
Current smoking	—	NS	—	—	NS	—
Any alcohol use	—	NS	—	—	NS	—
Medical History						
Osteoporosis hx	—	—	7.32	[3.61, 11.03]	< .001***	.33
Prior fracture	—	—	3.89	[0.24, 7.54]	.037*	.17
Arthritis hx	—	—	—	—	NS	—
Gastritis hx	—	—	-4.25	[- 7.23, - 1.28]	.006**	-.22
<i>Note.</i> β = standardized coefficient. 95% CI = confidence interval for B. M1 = Model 1 (lifestyle/behavioral only). M2 = Model 2 (+ medical history). — = non-significant or not applicable. * $p < .05$; ** $p < .01$; *** $p < .001$. All VIFs ≤ 3.66. Durbin-Watson = 1.495.						

Table 3
b. Hierarchical Multiple Linear Regression Predicting FRAX Hip Fracture Probability

Predictor	B (M1)	p (M1)	B (M2)	95% CI (M2)	p (M2)	β (M2)
Lifestyle & Behavioral						
Vegetarian diet	—	NS	-2.47	[- 4.74, - 0.20]	.034*	-.17
Meat-based diet	—	NS	—	—	NS	—
Dairy-based diet	—	NS	—	—	NS	—
Vitamin D supp.	—	NS	—	—	NS	—
Calcium supp.	—	NS	—	—	NS	—
Multivitamin	—	NS	—	—	NS	—
Current smoking	—	NS	—	—	NS	—
Any alcohol use	—	NS	—	—	NS	—
Medical History						
Osteoporosis hx	—	—	4.01	[1.93, 6.09]	< .001***	.37
Prior fracture	—	—	—	—	NS	—
Arthritis hx	—	—	—	—	NS	—
Gastritis hx	—	—	-1.74	[- 3.41, - 0.07]	.041*	-.19
<i>Note.</i> β = standardized coefficient. 95% CI = confidence interval for B. M1 = Model 1 (lifestyle/behavioral only). M2 = Model 2 (+ medical history). Vegetarian diet reached significance only in Model 2. — = non-significant or not applicable. * $p < .05$; *** $p < .001$. All VIFs ≤ 3.66 . Durbin-Watson = 1.605.						

Medical History Comorbidities and FRAX Scores

Independent sample t-tests were conducted to examine differences in FRAX scores between participants with and without specific medical conditions. Participants with a history of osteoporosis had significantly higher FRAX MOF scores ($M = 16.95$) compared to those without ($M = 8.67$), with a large effect size (Cohen's $d = 1.19$). Similarly, osteoporosis history was associated with significantly higher hip fracture probability ($M = 5.80$ vs. $M = 1.97$; Cohen's $d = 1.00$).

Participants with a history of cancer had significantly higher FRAX MOF scores ($M = 16.82$ vs. $M = 9.17$; Cohen's $d = 1.06$) and higher hip fracture probability ($M = 4.80$ vs. $M = 2.29$; Cohen's $d = 0.63$). Those with arthritis history also had significantly higher FRAX scores for both MOF ($M = 11.68$ vs. $M = 8.64$; Cohen's $d = 0.41$) and hip fracture ($M = 3.37$ vs. $M = 1.94$; Cohen's $d = 0.36$). Prior fracture history was associated

with significantly higher FRAX MOF scores ($M = 14.07$ vs. $M = 9.16$; Cohen's $d = 0.67$), though the difference for hip fracture probability did not reach significance ($p > .05$).

Gastritis history was not associated with a significant difference in FRAX scores in bivariate testing, consistent with its emergence only in the multivariate context as a suppressor or confounding variable. The bivariate associations are summarized in Table 4 and illustrated in Fig. 3.

Table 4
Bivariate Associations Between Predictor Variables and FRAX Fracture Probability

Variable	M (Yes)	M (No)	d	M (Yes)	M (No)	d
	MOF	MOF	MOF	Hip	Hip	Hip
Osteoporosis*	16.95	8.67	1.19	5.80	1.97	1.00
Cancer*	16.82	9.17	1.06	4.80	2.29	0.63
Prior fracture*	14.07	9.16	0.67	3.34	2.38	NS
Arthritis*	11.68	8.64	0.41	3.37	1.94	0.36
Gastritis	8.26	10.34	NS	1.65	2.77	NS
Vegetarian diet	8.55	10.45	NS	1.57	2.94	NS†
Meat-based diet	10.32	9.41	NS	2.53	2.51	NS
Dairy-based diet	10.67	9.17	NS	3.08	2.04	NS
Vitamin D supp.	10.50	9.03	NS	2.58	2.43	NS
Calcium supp.	10.71	9.53	NS	3.15	2.27	NS
Multivitamin	10.69	9.11	NS	2.93	2.14	NS
<i>Note. Values shown are group means. d = Cohen's d effect size. "Yes" = participants reporting the condition; "No" = participants not reporting it. NS = not significant ($p > .05$). † = significant in multivariate model only. * = significant bivariate difference ($p < .05$).</i>						

Alcohol, Smoking, Diet, and Supplement Use

Neither alcohol consumption (analyzed both as a three-level categorical variable and as a binary any-versus-none variable) nor smoking status was significantly associated with FRAX MOF or hip fracture probability in bivariate analyses. Among dietary patterns, vegetarian diet was associated with lower mean FRAX scores directionally, though bivariate t-test comparisons did not reach statistical significance for MOF ($p > .05$); the association for hip fracture approached significance in bivariate testing and became significant in the multivariate model. Meat-based diet, dairy consumption, and supplement use (vitamin D, calcium, multivitamin) were not significantly associated with either FRAX outcome in independent samples t-tests.

Medical Student Post-Counseling Assessment

Medical students most frequently responded that the student-led workshop training session was very effective in preparing them for osteoporosis risk counseling, and built upon earlier concepts learned through preclinical courses as well as standardized exam study (NBME or USMLE Step exam). Student listed a variety of issues related to factors impacting participants recruited at the health fairs. Students overwhelmingly responded that they felt increasingly confident in their ability to use the FRAX calculator and provide counseling to participants as a result of this experience.

Discussion

This study examined osteoporosis fracture risk among adults screened at community health fairs in South Florida, with a particular focus on the role of primary care engagement in shaping FRAX-estimated fracture probability. Three key findings emerged from the data. First, participants who reported more frequent primary care visits demonstrated significantly higher FRAX fracture risk scores than those with no regular PCP contact. Second, medical history, particularly osteoporosis diagnosis, prior fracture, and cancer, was a far stronger predictor of FRAX scores than lifestyle or behavioral factors. Third, lifestyle variables including diet, supplement use, alcohol, and smoking did not independently predict fracture risk in this sample. This is particularly surprising given the role of dietary choices that include foods high in calcium and vitamin D, as well as the proven impact of tobacco use on bone density. Together, these findings carry meaningful implications for how community-based screening initiatives can be designed and interpreted.

Medical students have been highly engaged in our osteoporosis screening and counseling project, and over the past five years numerous students have provided continued service at the health fairs, expressing satisfaction in the process of participant screening and counseling.

Primary Care Engagement and Fracture Risk: An Apparent Paradox

The finding that participants seen more frequently by a primary care provider had higher FRAX scores, rather than lower, initially appeared counterintuitive. One might expect that regular primary care engagement would be associated with better managed risk, and therefore lower fracture probability. However, this pattern may be explained by clinical selection: individuals with greater medical complexity, more comorbidities, and higher underlying fracture risk are precisely those who require and seek more frequent primary care contact. The data support this interpretation, participants seen every few months had the highest burden of medical comorbidities, which were in turn the dominant drivers of FRAX scores in the regression models.

This finding aligns with a well-documented phenomenon in health services research sometimes referred to as the 'sick user effect' [10], wherein higher healthcare utilization co-occurs with worse health outcomes not because care is harmful, but because those receiving more care are inherently higher risk. In the context of osteoporosis, it suggests that community health fairs may be capturing a subset of

high-risk individuals who are already engaged with the healthcare system. While this is reassuring from a care-access perspective, it raises an important question about who is not being reached.

Critically, the group reporting a lack of regular primary care provider contact had the lowest mean FRAX scores in this sample. This could reflect genuinely lower fracture risk in that group, or it may reflect systematic underdiagnosis, individuals without regular PCP contact may have undetected osteoporosis, unrecorded fracture history, and unmanaged comorbidities that would otherwise elevate their FRAX scores. The FRAX tool relies on self-reported and clinically documented risk factors, meaning that individuals who are not regularly seen by a provider may underreport or be unaware of conditions that would increase their calculated risk. This interpretive ambiguity is important: health fair screening of individuals without regular primary care may paradoxically underestimate their true fracture risk.

Medical History as the Dominant Predictor

The hierarchical regression analyses in this investigation demonstrated that lifestyle and behavioral variables alone accounted for a negligible proportion of variance in FRAX scores, while the addition of medical history variables produced significant, meaningful models explaining approximately 28 to 34 percent of variance in hip and MOF outcomes respectively. This pattern was consistent across both FRAX outcomes and reinforces the well-established clinical literature indicating that fracture risk is driven primarily by skeletal and systemic disease burden [6, 7] rather than modifiable lifestyle behaviors in isolation.

Osteoporosis history emerged as the single strongest predictor of both FRAX MOF and hip fracture probability, which is expected given that an existing osteoporosis diagnosis is itself a primary input into the FRAX algorithm. More clinically informative was the independent contribution of prior fracture history to FRAX MOF scores, even after controlling for osteoporosis diagnosis and other comorbidities. This is consistent with the established concept of the 'fracture cascade' [12], in which an initial fracture substantially increases the probability of subsequent fractures through a combination of skeletal fragility, fall risk, and reduced functional reserve. The presence of prior fracture as an independent predictor in this community-screened sample underscores the importance of capturing fracture history during health fair screening, even when bone density data are unavailable.

The association between cancer history and higher FRAX scores is similarly consistent with the broader literature. Several mechanisms may account for this relationship, including direct skeletal effects of malignancy, bone-toxic effects of cancer therapies such as aromatase inhibitors and androgen deprivation therapy, treatment-related hypogonadism, and reduced physical activity and nutritional status during and following cancer treatment [13]. The magnitude of the effect observed here, with cancer-history participants showing mean FRAX MOF scores nearly twice those of cancer-free participants, suggests that oncology history warrants particular attention in community screening contexts.

Arthritis history was also associated with significantly higher FRAX scores in bivariate analyses and approached significance in the multivariate model. This association likely reflects multiple overlapping

mechanisms including systemic inflammation, corticosteroid use for disease management [14, 15], and reduced physical activity, all of which are established contributors to bone loss and fracture risk.

The Gastritis Finding

Among the more unexpected findings was the emergence of gastritis history as a significant negative predictor of FRAX scores in both regression models, that is, participants reporting a history of gastritis had lower predicted FRAX scores after controlling for other variables, despite no significant difference being observed in bivariate comparisons. This pattern is characteristic of a suppressor effect in regression, wherein a variable exerts influence on the outcome only in the context of other predictors with which it is correlated.

A purely protective effect of gastritis on fracture risk is biologically implausible. Gastritis, particularly when treated with proton pump inhibitors, has in fact been associated with increased fracture risk in the literature [16], as impaired gastric acid production can reduce calcium absorption. One possible explanation is that gastritis in this sample was correlated with other variables, perhaps dietary patterns or supplement use, that themselves were associated with higher FRAX scores, such that controlling for those variables revealed an apparent negative relationship. Another possibility is that this reflects a sample size limitation, as the gastritis group ($n = 30$) was relatively small. This finding should be interpreted with caution and not taken to suggest a clinically protective effect of gastritis on bone health. Future research with larger samples and more detailed medication data, particularly proton pump inhibitor use, would help clarify this relationship.

Lifestyle Factors: Null Findings and Their Implications

The absence of significant associations between lifestyle variables, including diet, supplement use, alcohol, and smoking, and FRAX scores in this sample warrants careful interpretation. These null findings do not necessarily indicate that lifestyle factors are unimportant in osteoporosis risk, as the established literature consistently supports the role of calcium and vitamin D intake, physical activity, smoking cessation, and alcohol moderation in bone health [6, 17]. Rather, they likely reflect several features of this study's design and sample.

First, the FRAX algorithm itself does not incorporate dietary or supplement data as inputs [7, 8], meaning that lifestyle variables could only influence FRAX scores indirectly through their effects on bone density or fracture history, effects that may not be detectable in a cross-sectional survey design without longitudinal follow-up. Second, variability in lifestyle exposures may have been insufficient to detect associations in a sample of this size. Notably, the vast majority of participants reported never or rarely consuming alcohol, and only a small number were current smokers, leaving limited statistical power to detect differences across these groups. Third, many lifestyle effects on bone health accumulate over decades and would not necessarily manifest in a single cross-sectional FRAX estimate captured at a health fair.

The directional finding that vegetarian diet was associated with lower FRAX hip fracture probability in the multivariate model is noteworthy, though it should be interpreted cautiously given that it did not reach significance in bivariate testing. Plant-based diets have been associated with lower body weight in some populations [18, 19], which could reduce FRAX scores through its effect on BMI, though lower body weight is itself a risk factor for osteoporosis. The relationship between vegetarian diet and fracture risk in the broader literature is complex and context-dependent, and the finding here is best treated as hypothesis-generating rather than conclusive.

Health Fairs as a Screening Venue: Implications and Limitations

Community health fairs represent an important opportunity to reach individuals who may not otherwise engage with formal healthcare. This study suggests that health fair attendees span a range of risk profiles, from individuals already engaged in regular primary care with documented medical complexity, to those with no regular provider contact whose true risk may be undercharacterized. A well-designed health fair osteoporosis screening protocol should therefore do more than calculate a FRAX score, it should actively assess primary care engagement, facilitate referrals for individuals without a regular provider, and flag those with high-risk comorbidity profiles for follow-up bone density testing. Medical students throughout the United States regularly participate in community health fairs, and these experiences provide valuable opportunities for the clinical application of knowledge and the development of interpersonal counseling skills, all essential to the formation of a successful practitioner, with opportunities for development of empathy and increased professionalism.

Several limitations of this study should be acknowledged. The cross-sectional design precludes causal inference, and the reliance on self-reported data introduces the possibility of recall bias and underreporting, particularly for conditions such as prior fracture and osteoporosis diagnosis in individuals without regular care. The sample was drawn from health fair attendees in South Florida, who may not be representative of the broader at-risk population nationally. Individuals who attend health fairs may differ systematically in health literacy, motivation, and access from those who do not. The sample of participants was also predominantly female and Hispanic/Latino or Black/African American, which limits generalizability to other demographic groups, though it reflects the population of South Florida and highlights the importance of osteoporosis screening in these communities. The relatively small sample size, particularly in subgroups such as regular smokers and heavy alcohol users, limited statistical power to detect associations for some exposures. Additionally, FRAX scores were calculated without bone mineral density data, which would typically strengthen the precision of fracture risk estimates.

Conclusions

This study found that primary care engagement was positively associated with FRAX-estimated fracture risk among community health fair participants in South Florida, a pattern most plausibly explained by clinical selection of higher-risk individuals into more frequent care. Medical history, particularly

osteoporosis diagnosis, prior fracture, and cancer, was the dominant predictor of fracture risk in this sample, while lifestyle and behavioral factors did not independently predict FRAX scores. These findings suggest that community health fair screening may be well-positioned to identify high-risk individuals, but that individuals without regular primary care contact may represent an underserved population whose fracture risk is underestimated by self-report alone. Future research should examine whether health fair screening followed by structured referral pathways can improve downstream osteoporosis diagnosis and treatment rates in community-dwelling adults, with particular attention to populations with limited primary care access. This research consortium provides valuable opportunities for learners, enabling students to positively impact the community and enhance interpersonal skills and professionalism.

Abbreviations

ANOVA: Analysis of variance

BMI: Body mass index

CI: Confidence interval

DXA: Dual-energy X-ray absorptiometry

FIU: Florida International University

FRAX: Fracture Risk Assessment Tool

G-H: Games–Howell

MOF: Major osteoporotic fracture

NS: Not significant

PCP: Primary care provider

SD: Standard deviation

SPSS: Statistical Package for the Social Sciences

VIF: Variance inflation factor

WHO: World Health Organization

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical standards of the Florida International University Institutional Review Board and with the 1964 Helsinki Declaration and its later amendments. Informed consent was obtained from all individual participants included in the study. Clinical trial number: not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare no conflicts of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Authors' contributions

D.F., G.D., J.B., A.L.G.: Conceptualization. D.F., G.D., J.B., C.R.M., A.D., G.G., K.G.: Data curation. D.F., C.R.M., A.D., G.G.: Formal analysis. D.F., G.D., J.B., C.R.M., A.D., G.G., K.G., A.L.G.: Investigation. D.F., G.D., J.B.: Methodology. A.L.G.: Supervision. D.F., G.D., J.B., C.R.M., A.D., G.G., K.G., A.S.: Writing – original draft. D.F., A.L.G.: Writing – review & editing. All authors reviewed the manuscript.

Acknowledgements

The authors thank the participants of the FIU Herbert Wertheim College of Medicine NeighborhoodHELP community health fair screening initiative, as well as the faculty and staff who supported data collection.

References

1. Wright NC, Looker AC, Saag KG, Curtis JR, Delzell ES, Randall S, et al. The recent prevalence of osteoporosis and low bone mass in the United States based on bone mineral density at the femoral neck or lumbar spine. *J Bone Min Res*. 2014;29(11):2520–6. <https://doi.org/10.1002/jbmr.2269>.
2. Sabri S, Chavarria J, Ackert-Bicknell C, Swanson C, Burger E. Osteoporosis: an update on screening, diagnosis, evaluation, and treatment. *Orthopedics*. 2023;46(1):e20–6. <https://doi.org/10.3928/01477447-20220719-03>.

3. Cauley JA. Public health impact of osteoporosis. *J Gerontol Biol Sci Med Sci*. 2013;68(10):1243–51. <https://doi.org/10.1093/gerona/glt093>.
4. Schroeder JD, Turner SP, Buck E. Hip fractures: diagnosis and management. *Am Fam Physician*. 2022;106(6):675–83.
5. Åkesson KE, McGuigan FEA. Closing the osteoporosis care gap. *Curr Osteoporos Rep*. 2021;19(1):58–65. <https://doi.org/10.1007/s11914-020-00644-w>.
6. Lane NE. Epidemiology, etiology, and diagnosis of osteoporosis. *Am J Obstet Gynecol*. 2006;194(2 Suppl):S3–11. <https://doi.org/10.1016/j.ajog.2005.08.047>.
7. Kanis JA, Johnell O, Oden A, Johansson H, McCloskey E. FRAX and the assessment of fracture probability in men and women from the UK. *Osteoporos Int*. 2008;19(4):385–97. <https://doi.org/10.1007/s00198-007-0543-5>.
8. Kanis JA, Johansson H, Oden A, McCloskey EV. Assessment of fracture risk. *Eur J Radiol*. 2009;71(3):392–7. <https://doi.org/10.1016/j.ejrad.2008.04.061>.
9. Yedavally-Yellayi S, Ho AM, Patalinghug EM. Update on osteoporosis. *Prim Care*. 2019;46(1):175–90. <https://doi.org/10.1016/j.pop.2018.10.013>.
10. Singer AJ, Sharma A, Deignan C, Borgermans L. Closing the gap in osteoporosis management: the critical role of primary care in bone health. *Curr Med Res Opin*. 2023;39(3):387–98. <https://doi.org/10.1080/03007995.2022.2141483>.
11. Viswanathan M, Reddy S, Berkman N, Cullen K, Middleton JC, Nicholson WK, et al. Screening to prevent osteoporotic fractures: updated evidence report and systematic review for the US Preventive Services Task Force. *JAMA*. 2018;319(24):2532–51. <https://doi.org/10.1001/jama.2018.6537>.
12. Kanis JA, Johansson H, Harvey NC, Lorentzon M, Liu E, Vandenput L, et al. Previous fracture and subsequent fracture risk: a meta-analysis to update FRAX. *Osteoporos Int*. 2023;34(12):2027–45. <https://doi.org/10.1007/s00198-023-05885-w>.
13. Khan MI. Management of bone loss due to endocrine therapy during cancer treatment. *Osteoporos Int*. 2023;34(4):671–80. <https://doi.org/10.1007/s00198-023-06672-3>.
14. Wysham KD, Baker JF, Shoback DM. Osteoporosis and fractures in rheumatoid arthritis. *Curr Opin Rheumatol*. 2021;33(3):270–6. <https://doi.org/10.1097/BOR.0000000000000789>.
15. Briot K, Roux C. Glucocorticoid-induced osteoporosis. *RMD Open*. 2015;1(1):e000014. <https://doi.org/10.1136/rmdopen-2014-000014>.
16. Ngamruengphong S, Leontiadis GI, Radhi S, Dentino A, Nugent K. Proton pump inhibitors and risk of fracture: a systematic review and meta-analysis of observational studies. *Am J Gastroenterol*. 2011;106(7):1209–18. <https://doi.org/10.1038/ajg.2011.113>.
17. Capozzi A, Scambia G, Lello S. Calcium, vitamin D, vitamin K2, and magnesium supplementation and skeletal health. *Maturitas*. 2020;140:55–63. <https://doi.org/10.1016/j.maturitas.2020.05.020>.
18. Galchenko A, Gapparova K, Sidorova E. The influence of vegetarian and vegan diets on the state of bone mineral density in humans. *Crit Rev Food Sci Nutr*. 2021;63(7):845–61.

19. Hsu E. Plant-based diets and bone health: sorting through the evidence. *Curr Opin Endocrinol Diabetes Obes.* 2020;27(4):248–52. <https://doi.org/10.1097/MED.0000000000000552>.

Figures

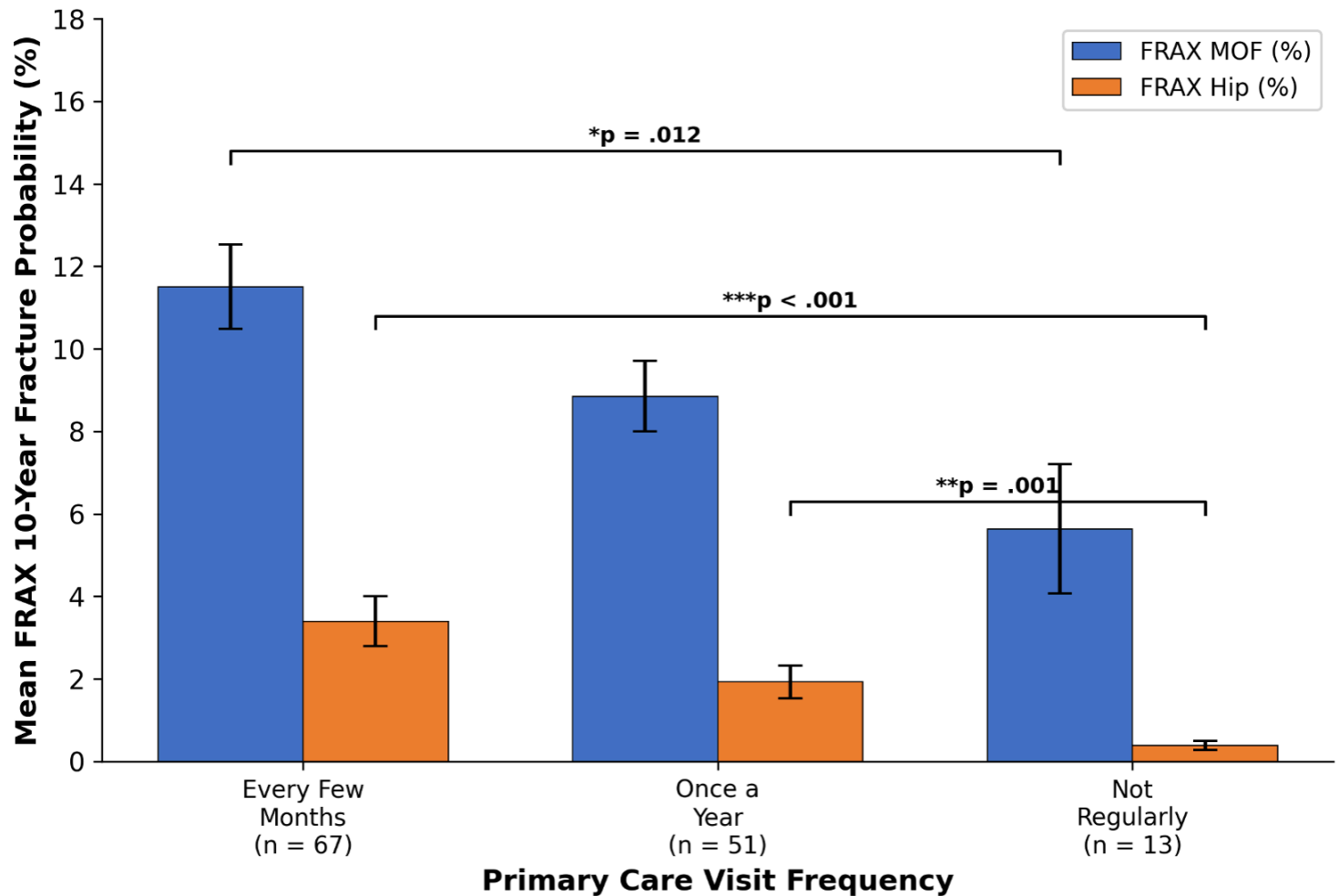


Figure 1

Mean FRAX Fracture Probability by Primary Care Visit Frequency.

Note. Error bars represent ± 1 standard error. * $p < .05$; ** $p = .001$; *** $p < .001$ (Games-Howell post-hoc).
MOF = major osteoporotic fracture.

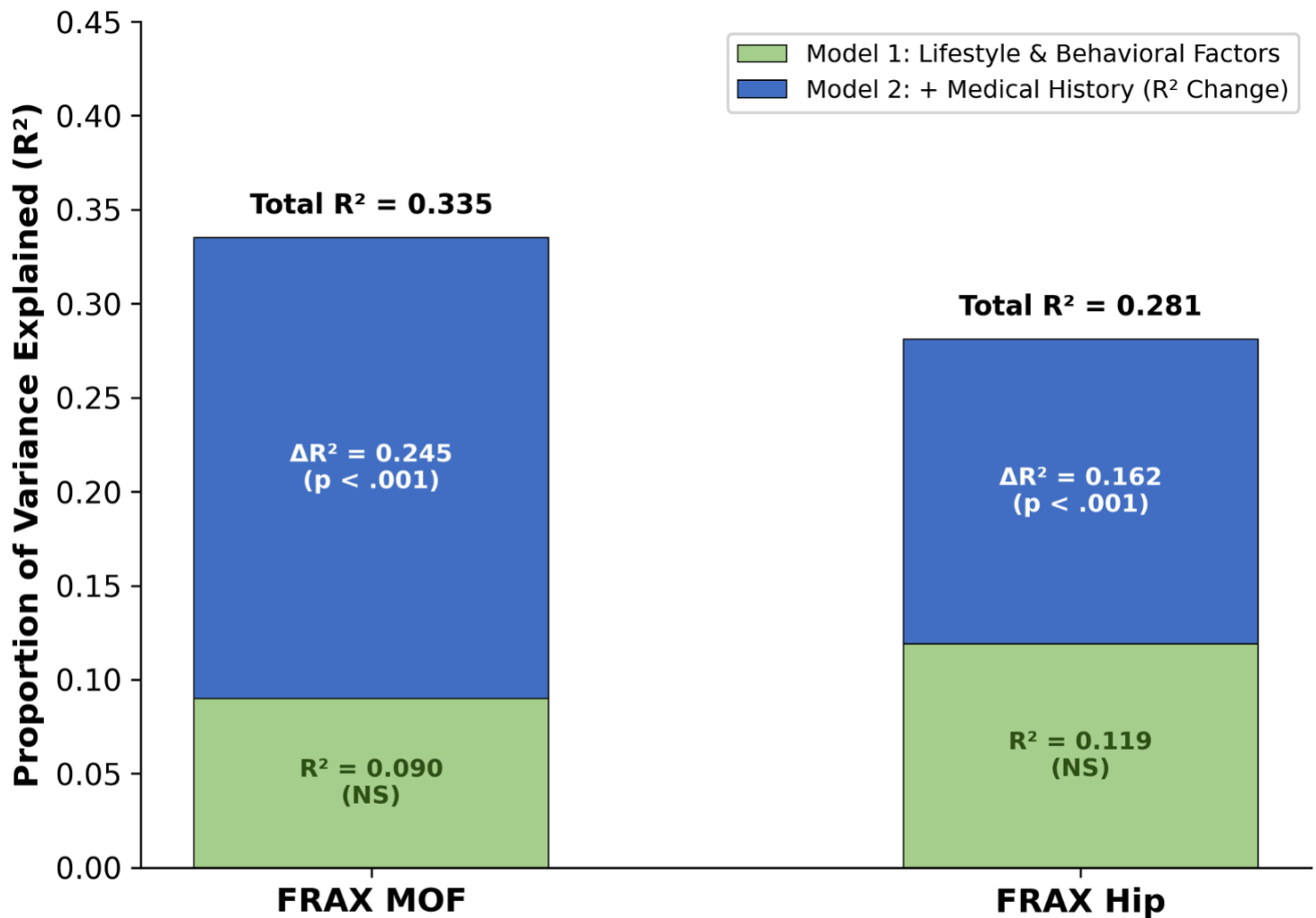


Figure 2

Incremental Variance Explained by Medical History Variables Beyond Lifestyle and Behavioral Factors in Hierarchical Regression.

Note. Green bars represent R^2 from Model 1 (lifestyle and behavioral variables only; both non-significant). Blue bars represent the ΔR^2 contributed by the addition of medical history variables in Model 2 (both $p < .001$). MOF = major osteoporotic fracture. NS = non-significant model.

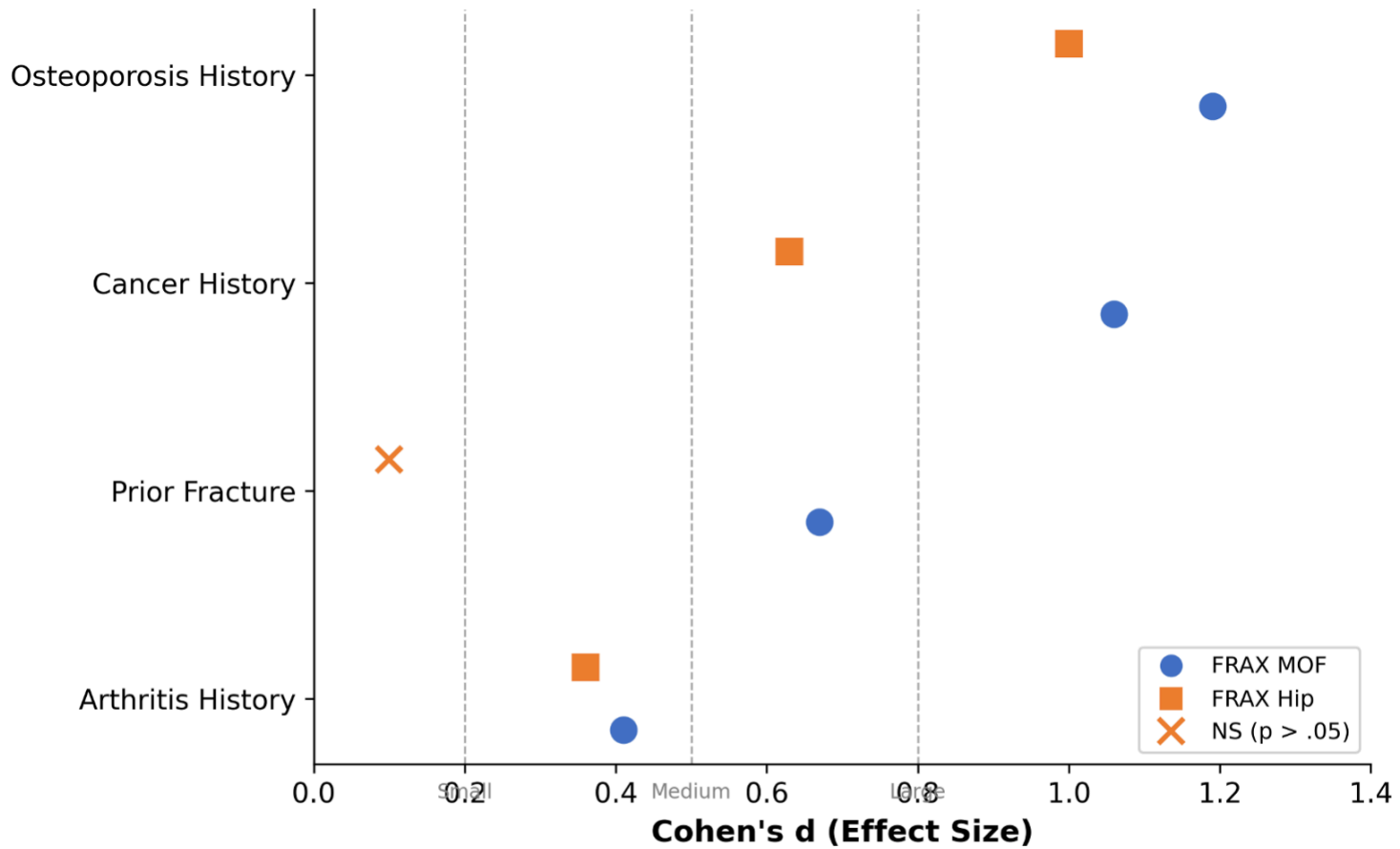


Figure 3

Effect Sizes (Cohen's d) for Medical History Variables and FRAX Fracture Probability.

Note. MOF = major osteoporotic fracture. × indicates non-significant bivariate association ($p > .05$). All significant effects represent higher FRAX scores in the affected group. Dashed vertical lines indicate conventional benchmarks (small = 0.2, medium = 0.5, large = 0.8).