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Validity, reliability, and responsiveness to change of the “Osteoporosis and You” knowledge scale

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Abstract

Summary—We studied the Osteoporosis and You knowledge scale in 7749 participants enrolled in a clinical trial. Results confirmed its psychometric properties in a diverse audience. Baseline scores were associated with better recall of bone mineral density test results at follow-up; however, the scale was not responsive to knowledge change.

Introduction—The goal of this study was to confirm the measurement properties of the Osteoporosis and You (*O&Y*) knowledge scale using classic test theory methods in the 7749 men and women participating in the Patient Activation After DXA Result Notification (PAADRN) randomized controlled trial. We hypothesized a simple factor structure that would reflect the four-factor model previously published.

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Authors' contributions Study design: SE, DR, KS, PC, and FW. Study conduct: VN, SE, DR, PC, and FW. Data collection: VN, SE, DR, PC, and FW. Data analysis: VN, YL, and FW. Data interpretation: VN and FW. Drafting manuscript: VN. Revising manuscript and content: VN, SE, YL, DR, PC, and FW. Approving final version of manuscript: VN, SE, YL, DR, KS, PC, and FW. VN takes responsibility for the integrity of the data analysis.

Compliance with ethical standards

Conflicts of interest V Nguyen, S Edmonds, Y Lou, D Roblin, P Cram, and F Wolinsky have no conflicts of interest.

Methods—We conducted psychometric analyses which included item analysis, internal consistency reliability, construct validity using exploratory and confirmatory factor analysis (EFA and CFA), comparing knowledge levels across pre-specified groups, and responsiveness to change.

Results—PAADRN participants were predominantly college educated, White females with low bone density, and a moderate level of 10-year fracture risk. EFA revealed four domains closely matching those in two previous reports. While overall scale reliability was minimally acceptable at 0.68, the reliabilities of the domain subscales were unacceptably low (0.59, 0.64, 0.45, and 0.36 for the *Biological*, *Lifestyle*, *Consequences*, and *Prevention and Treatment* subscales). CFA revealed the data fit the hypothesized model reasonably well with the items loading on their expected latent variable. The scale was not responsive to change, but although not significant, improved knowledge indicated better DXA result recall at 12 and 52 weeks.

Conclusions—In the PAADRN population, the *O&Y* knowledge scale had psychometric properties similar to those previously reported. Over 12 and 52 weeks, participants did not demonstrate significant changes in knowledge, but those with higher knowledge at baseline were more likely to accurately recall their baseline DXA result.

Keywords

DXA; Knowledge; Osteoporosis; Psychometric analysis

Introduction

Low bone density and osteoporosis currently affect 52 million American men and women 50 years of age or older [1]. Consistent with shifting population demographics and population growth, the number and percent of patients with low bone density or osteoporosis will continue to increase, placing more people at risk for fragility fractures [2]. The impact of osteoporosis on morbidity and mortality, especially from fractures and their complications, has prompted efforts for interventions to promote prevention and early identification [3]. Numerous studies have evaluated the impact of behavioral and lifestyle interventions aimed at patients or health care providers to improve bone health [4–7]. While many of these studies have assessed osteoporosis knowledge overall, they have not considered intervention effects on specific knowledge domains like behavioral and lifestyle risk factors, or the consequences of osteoporosis in large, diverse samples of older adults, which is necessary to identify targets for tailored patient education and behavioral or lifestyle modifications.

These knowledge domains are important because the Health Belief Model [8] postulates that patients with greater knowledge, higher self-efficacy, greater perceived susceptibility, and higher perceived severity of health threats from osteoporosis are more likely to take appropriate action. Furthermore, patients with these skills typically demonstrate better function, health, and quality of life [9–11]. Because health-related knowledge is integral to these skills [9, 12] and to treatment compliance, which promote preventative behaviors and decrease the risk of fracture [13, 14], having reliable and valid measures of osteoporosis-related knowledge that are domain specific and sensitive to change over time is crucial to assessing the effects of behavioral and lifestyle interventions. Various independently designed and tested instruments have been developed to assess osteoporosis knowledge, but

the majority of these studies suggest low baseline bone health knowledge with minor increases following educational interventions. These studies have not explored specific domains that inform knowledge such as behaviors or treatment, and none were conducted as part of a large, diverse clinical trial.

Knowledge assessment can be a valuable clinical tool used by health care providers to quickly identify osteoporosis knowledge deficits that can be targeted and used to frame customized care plans for improving patient understanding and susceptibility and thus stimulate and enhance behavioral change and treatment adherence. While there have been mixed results in the effects of targeted interventions, most patients with greater perceived susceptibility were more responsive to change than to generic interventions designed to target a wide audience [15–18]. Susceptibility can be identified through knowledge deficits and can easily be screened with a brief, valid osteoporosis knowledge scale quickly and inexpensively. This has the potential to result in improved clinical recommendations for significant and effective patient behavioral and treatment adherence. However, many of the validated osteoporosis knowledge scales were designed for research purposes and do not target specific domains that health care providers and patients can emphasize for clinical interventions. The exception is the *O&Y* scale, which is composed of multiple domains and can quickly be administered and scored in the clinical setting, but its psychometric properties have not yet been fully established for this purpose.

The 10-item *Osteoporosis and You* (*O&Y*) instrument assesses osteoporosis knowledge and is said to be appropriate for use among older adults due to its brevity, simplicity, and varied knowledge domains [19, 20]. It was, however, developed and validated using a 20-item version among women 20 years old or older [19]. The psychometric properties of the 10-item version have only been assessed using a cross-sectional sample of Canadian women 65 years old or older, and its responsiveness to change has not been established [20]. Moreover, the generalizability, reliability, validity, and responsiveness to change of the 10-item *O&Y* instrument have not been established for men or for the US population.

Therefore, we used data from the Patient Activation After DXA Result Notification (PAADRN) randomized controlled trial to assess the validity, reliability, multidimensionality, and responsiveness to change of the *O&Y* instrument. We used classic test theory methods including item analysis, exploratory and confirmatory factor analysis (EFA and CFA) to establish construct validity, internal consistency reliability, comparisons of knowledge levels across pre-specified groups, and responsiveness to change by contrasting those newly diagnosed with low bone density or osteoporosis from their study DXA to those with no prior and no current diagnoses and those with prior experience in DXA or osteoporosis-related pharmacotherapy patients at baseline, 12 and 52 weeks.

Methods

Study population

PAADRN participants were drawn from the bone density testing centers during March 2012 to August 2014 at three health care sites in the U.S. (University of Iowa, University of Alabama at Birmingham, and Kaiser Permanente of Georgia). Patients who were unable to

speak or read English, were incarcerated, or had significant mental, visual, or hearing impairments were excluded. Baseline interviews were conducted either in person or by telephone using trained on-site research assistants and web-based computer-assisted interviewing (CAI) software (REDCap™) [21]. All follow-up interviews were conducted by trained telephone interviewers from the Iowa Social Science Research Center (ISRC) using locally resident CAI software (WinCATI 4.2 and 5.0). Details of the original study protocol are available elsewhere [22]. For the EFA, CFA, and reliability analyses, we use data on all 7749 patients who completed baseline interviews. For the responsiveness to change analysis, we use data available for participants who completed the 12 and 52 week follow-up interviews. Information collected at baseline included demographics, health histories, health habits, and the *O&Y* scale.

The O&Y instrument

Brenneman et al. developed the *O&Y* instrument using a convenience sample of 500 women who were equally distributed across five age groups (20–39, 40–49, 50–59, 60–69, and 70) [19]. After a qualitative evaluation for readability and understanding of items from previously used but not validated instruments, 20 items were chosen with a five-point Likert response set ranging from 1 (“strongly disagree”) to 5 (“strongly agree”). Brenneman et al. hypothesized that these 20 items would tap three domains among women—osteoporosis knowledge, attitudes, and behaviors—which they confirmed using CFA. Internal consistency reliability of the overall scale was 0.75 [19].

In a subsequent study of 869 community-dwelling Canadian women 65–89 years old, Cadarette et al. tested the 10 knowledge items from the *O&Y* instrument [20]. In addition, they changed the middle response option from “no opinion” to “neutral” to be consistent with the other instruments in their study. Cadarette et al. hypothesized that these ten items (shown in the footnotes to Table 1) would reflect four knowledge domains—*Biological* risk factors, *Lifestyle* risk factors, *Consequences*, and *Prevention and Treatment*. These domains were characterized by grouping items with high inter-item correlations and standardized residuals and were validated using EFA and CFA, although item 10 did not load principally on any of the four domains [20]. Internal consistency reliability of the 10-item scale was low (Cronbach’s alpha = 0.60) and generally lower among the domain subscales (0.48 for *Biological* risk factors, 0.51 for *Lifestyle* risk factors, 0.37 for *Consequences*, and 0.67 for *Prevention and Treatment*).

For PAADRN, we used Cadarette et al.’s version of the *O&Y* instrument. Because PAADRN included both men and women, however, we modified item 2 to read “For women, the risk of having osteoporosis is higher after menopause;” additionally, “father” was added to item 3 and “man” was included in items 7 and 8 [22, 23]. Similar to Cadarette et al., items were scored as correct for true statements when the participant chose the “agree” or “strongly agree” response options while reverse-scored items 6 and 9 were scored as correct when the participant chose “disagree” or “strongly disagree.” In constructing the overall and domain-specific scale scores, the percentage of correct answers was used.

Analyses

The technical details of our analysis may be found in the supplemental materials (Technical Details of the Analyses). Simply put, we imputed missing data at the item level using the fully conditional specification (FCS) approach [8, 22, 24] assuming that any missingness was random and that the response mechanism was ignorable. Then, we conducted item analyses to summarize the response distributions for each item. Internal consistency was then assessed using Cronbach's alpha. We used EFA to investigate the underlying structure of the *O&Y* scale assuming a simple factor structure with each item loading principally (factor loading = 0.50) when a one-factor solution was specified for the overall scale. Because we assumed that the four subscales were correlated, oblique rotation was used for the four-factor solution. We used CFA to determine whether Cadarette et al.'s measurement model was replicated in the PAADRN data [20]. Measurement invariance was tested across subgroups defined by age, sex, race, education, prior DXA history, DXA diagnosis, study site, and osteoporosis-related pharmacotherapy.

Responsiveness to change was evaluated by comparing three distinct groups. Group 1 included patients with no prior history of DXA, no prior diagnoses of osteopenia or osteoporosis, and no osteoporosis-related pharmacotherapy at baseline although their study DXA indicated a need for pharmacotherapy per National Osteoporosis Foundation guidelines. Group 2 included patients with the same criteria as Group 1 but whose study DXA was normal. Group 3 included patients with any prior history of DXA, osteopenia or osteoporosis diagnoses, or osteoporosis-related pharmacotherapy use at baseline and whose study DXA indicated osteoporosis. We compared these groups using logistic regression where the outcome was the correct identification of the baseline study DXA result, adjusting for age, sex, BMI, race, ethnicity, site, marital and insurance status, education, smoking and drinking behaviors, FRAX® score, and self-reported prior fracture, low bone density, or osteoporosis diagnoses.

Results

Table 2 shows selected demographic characteristics for the PAADRN participants included in the analyses. There were 7749 enrolled patients at baseline. The majority of PAADRN participants were White women with approximately 75% having had some college education. Most participants were former smokers or had never smoked, and about half reported current alcohol intake. Two-thirds of participants had undergone bone density testing prior to PAADRN, and nearly 45% reported a previous history of osteoporosis-related pharmacotherapy. Baseline study DXA results for 53% of the participants indicated low bone mineral density, and the overall 10-year fracture risk in the study population was 12% (SD = 9.2), which is in the low end of the Moderate Risk category.

The item analyses in Table 1 show the response frequencies and distributions for the 10 *O&Y* items. Higher numbers indicate greater agreement, although items 6 and 9 had to be reverse-coded. The proportion of correct answers was > 70% for the items that did not need reverse coding (range = 71.6 to 92.2%), but was much lower for the reverse-coded items (49.9 and 47.9%) due to a larger proportion of neutral responses. Few items were robustly correlated with each other ($r < 0.50$, data not shown). The highest correlations were between

items 4 and 5 (eating calcium and daily exercise, $r = 0.47$), which comprise the *Lifestyle* risk factor domain.

Exploratory factor analysis

A more complete presentation of the technical details surrounding our EFA results may be found in the supplemental materials (Technical Details of the “Results” section). Table 3 contains the results of the EFA and internal consistency reliability analyses for the 10-item single factor model (Full Scale), the 9-item single factor model, and the 9-item four-factor imposed model (Subscales) tested by Cadarette et al. The Kaiser-Mayer-Olkin and Bartlett’s sphericity test results show that using EFA on these data was appropriate, although the amount of variance explained was low (only 36.6% in the 9-item four-factor model). The individual factor loadings were adequate (> 0.30) for our large sample size [25] except for the reverse-coded items. The individual items loaded onto their respective factors from the Cadarette et al. model, although the factor loadings were weak (range = 0.36–0.92, data not shown). Cronbach’s alpha for the 10-item overall instrument was 0.68 with the reliability coefficients for the domain subscales all being lower.

Confirmatory factor analysis

A more complete presentation of the technical details surrounding our CFA results may also be found in the supplemental materials (Technical Details of the “Results” section). We tested each of the factor domains and their respective items using CFA as depicted in Fig. 1, which shows how the items in the scale relate to one another in relation to the knowledge domains that they comprise. Several goodness-of-fit test statistics indicated that overall, the model reasonably fit the data well, although the three pairs of error terms for Age Related and No Osteoporosis Prevention (e3 and e9), Diet and Thin bones (e5 and e8), and Diet and No Osteoporosis Prevention (e5 and e9) were correlated. After incorporating those correlated error terms into the model, the fit was slightly improved. The comparative fit index (CFI) and the Tucker-Lewis Index (TLI), both of which range from 0 to 1, were close to 1 indicating that the model fit the data well (CFI = 0.996; TLI = 0.992), as did the root mean square error of approximation (RMSEA = 0.017) which corrects for parsimony [26] and was below the 0.05 threshold designating that the model was a good fit. The correlations between the factors ranged from a low of 0.23 between *Consequences* and *Prevention and Treatment* to a high of 0.73 between *Biological* and *Consequences*, signifying that each item was measuring a distinct component. Each item significantly loaded on its respective latent variables with values ranging from 0.44 to 0.74, or poor to excellent (data not shown) [27].

Measurement invariance

Measurement invariance was examined by testing for structural or configural invariance across age, sex, education, history of prior DXA, baseline study DXA result, site, and pharmacotherapy groups. These results are shown in Table 4. The fit indices of each subgroup for the unconstrained models all met the desirable respective thresholds (RMSEA < 0.05 , CFI > 0.95 , NFI > 0.95 , TLI > 0.95). We also tested for weak invariance by constraining the factor loadings to be equal in each subgroup and obtained similar results except for the diagnosis subgroups which indicated weak invariance. For all of the other subgroups, the model fit indices indicate at least configural invariance.

Responsiveness to change

A more complete presentation of the technical details surrounding our responsiveness to change results may also be found in the supplemental materials (Technical Details of the “Results” section). Improvements in knowledge of 0.50 standard deviations or more were reported among 14.7% ($N = 1137$) of participants at 12 weeks and 17.7% ($N = 1375$) at 52 weeks. There was a statistically significant difference in the scale scores at 12 and 52 weeks among those who improved versus those who did not improve relative to baseline ($p < 0.001$). The logistic regression models for correctly identifying the results of their baseline study DXA scan are shown in Table 5. Models 1 and 3 included as the predictor variables the change score and whether or not the score improved at follow-up for 12 and 52 weeks, respectively. Models 2 and 4 further adjusted for the baseline knowledge score for 12 and 52 weeks, respectively. In Model 4, there were no significant differences in the odds of patients correctly recalling their DXA results between normal bone density patients, newly diagnosed patients, or patients with a prior history of osteoporosis, indicating that the *O&Y* scale was not responsive to change.

Discussion

While knowledge of osteoporosis has been evaluated by various scales that have been widely used and are well characterized, the complexity of their administration precluded using them in the PAADRN study. We elected to use the *O&Y* scale for its brevity and simplicity and examined its psychometric properties. The Health Belief Model, similar to several other behavioral models, is predicated on knowledge as a driving factor for susceptibility and treatment adherence. Assessing osteoporosis knowledge is essential in order to understand a patient’s risk perception and is a prerequisite for prevention. Comparable studies assessing osteoporosis knowledge have used the Facts on Osteoporosis Quiz (FOOQ) [13], the Osteoporosis Knowledge Test (OKT) [28], the Osteoporosis Questionnaire (OPQ) [29], the Osteoporosis Knowledge Assessment Tool (OKAT) [30], or other independently designed and tested instruments. While many of these instruments have sufficient to good internal consistency reliability, the majority were developed without a conceptual framework [6]. The results of those studies generally indicate low knowledge with some evidence that educational interventions increase knowledge and behavioral intentions [15, 31–39]. None of those studies, however, were randomized controlled trials nor did they examine specific behavioral outcomes such as those measured in PAADRN.

The *O&Y* scale performed reasonably well in PAADRN. Items in the exploratory factor analysis clustered with their anticipated domains, and the data fit the model well in confirmatory factor analysis. The low to moderate correlations between domains were expected because they are not independent yet they do reflect unique constructs. Furthermore, the model exhibited at least configural invariance across age, sex, race, education, DXA history, site, and history of osteoporosis-related pharmacotherapy. This is notable considering the study design and population composition of PAADRN was different from the cross-sectional design used by Cadarette et al. The similarities of the psychometric properties in spite of the study designs suggests that the *O&Y* knowledge scale appears to be measuring similar constructs and domains across varied populations.

The Cronbach's alphas for the subscales exceeded those obtained by Cadarette et al., except for the reverse-coded items comprising the *Prevention and Treatment* domain. The wording of these items performed poorly in our study population. These items were worded in simple present negative tense, which may have made these items more difficult to understand. The poor discrimination of these items is noticeable due to the large proportion of neutral responses relative to other items. Furthermore, the use of reverse-coded questions is typically recommended to assess unengaged responses rather than discrimination [40], and it has been shown that participants tend to answer differently to positive- and negative-worded items and as such, they may not necessarily measure the same domain [41].

Osteoporosis knowledge was relatively high based on the response distributions in PAADRN and trended similarly to the response distributions and frequencies reported by Cadarette et al. [20]. Notably, increased knowledge by 0.50 standard deviations was demonstrated at 52 weeks by one in five study participants. The significance of improved scores at 12 weeks in Group 3, the previously diagnosed or DXA- or treatment-experienced patients, may be due to increased awareness of bone health and preventative behaviors following the baseline interview. This was not, however, significant after the baseline knowledge score was included in Model 2 at 12 weeks or in either Models 3 and 4 at 52 weeks. Comparable studies to ours found osteoporosis-related knowledge to be relatively low [30, 42–45], but the participants in PAADRN scored markedly better. The exception occurs for the reverse-coded items in the *Prevention and Treatment* domain.

There was also no significant evidence of responsiveness to change after adjusting for baseline knowledge and change score, but baseline knowledge scores were a strong indicator of correctly recalling one's bone density scan result. The average change score at 52 weeks was an increase of 0.07, which is considerable since knowledge at 12 weeks had dropped by 0.10. The indicator variable for having an improved score 0.50 standard deviations was not significant after adjusting for the baseline knowledge score but non-significantly increased the correct identification of DXA results at 12 and 52 weeks. Improvements were seen for each of the three groups, but the largest increases occurred in Group 2 which were the normal bone density patients. This may be due to the ease of recall of a "normal" bone density result versus a specific bone disease diagnosis. The relatively poorer recall in Group 3 is surprising; however, this can be explained by a plateau of knowledge due to repeated familiarity with low bone density or osteoporosis preventative literature and/or pharmacotherapy experience over time.

Our study is not without limitations. While the scale is composed of multiple domains that comprise osteoporosis knowledge, each domain has only two to three items. The poor discrimination in each domain targeted by the scale items was not fully addressed by the PAADRN letter or educational brochure sent to intervention participants, making responsiveness to change difficult to assess. The overall *O&Y* scale was only marginally acceptable with a Cronbach's alpha of 0.68. The loss of significance for the dummy variable for improved knowledge may be due to collinearity because Models 2 and 4 looked at improved knowledge, baseline knowledge score, and change score, which the indicator for improved knowledge was predicated upon; however, upon examining collinearity diagnostics using linear regression, this was not a major concern. The lowest tolerance

observed ($TOL = 0.36$) was on the threshold of the collinearity cut point of $TOL > 0.36$ for the change score in Model 4 for Group 1, but the variance inflation factor ($VIF = 2.81$) did not exceed 10, which would have supported multicollinearity. Additionally, our results are consistent with our previous findings where improvements in knowledge among intervention and control patients were not significant [23]. Lastly, a weakness of all randomized controlled trials, the PAADRN population may not be representative of the at-risk U.S. population that is over 50 years of age.

Our study is, nevertheless, notable for its large and diverse population that was derived from three health systems. It is also the first study to measure and psychometrically assess the *O&Y* instrument among older men and women. We corroborated the underlying model structure and item loadings across the knowledge domains hypothesized by Cadarette et al. and demonstrated its configural invariance across important subgroups. This confirms the acceptability of the *O&Y* scale for use in examining osteoporosis knowledge within specific risk and preventative factors, namely, the *Biological*, *Lifestyle*, *Consequences*, and *Prevention and Treatment* domains identified by Cadarette et al. The simple 10-item scale could be administered during patient wait times or prior to health care visits through online health record portals. Scoring could be automated and would allow clinicians to customize education and care plans to increase patient susceptibility recognition and increase knowledge. This could improve communication and lead to patient activation for achieving specific health goals such as retention of or increasing bone mineral density through uptake of preventative behaviors such as exercise or consumption of calcium-fortified foods.

In conclusion, our analyses show that improved osteoporosis knowledge may increase ability to correctly identify baseline study DXA result. This may contribute to greater awareness of susceptibility and severity of bone diseases, which may lead to health-specific behavior change culminating in improved wellness, health maintenance, and patient engagement. Future studies are needed to examine whether information or behavioral changes occur within the domains measured by the *O&Y* scale. Our study suggests that building a foundation for bone health knowledge before the onset of low bone density or osteoporosis is favorable to diagnostic recall, which may help to reduce future morbidity and lifetime health-related expenditures due to debilitating conditions such as fractures.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Fig. 1. Osteoporosis and You knowledge scale factor model with standardized factor loadings. *OP* osteoporosis

Table 1

Response distribution and frequencies for the *O&Y* instrument

Variable	Domain	Response distribution					Response frequency				
		Mean	SD	Median	Min	Max	Correct (%)	Incorrect (%)	Disagree (%)	Neutral (%)	Agree (%)
Item 1	Biological risk factors	3.73	0.84	4	1	5	5568 (71.9)	2181 (28.1)	859 (11.1)	1322 (17.1)	5568 (71.9)
Item 2	Biological risk factors	4.02	0.65	4	1	5	6649 (85.8)	1100 (14.2)	228 (2.9)	872 (11.3)	6649 (85.8)
Item 3	Biological risk factors	3.78	0.80	4	1	5	5696 (73.5)	2053 (26.5)	699 (9.0)	1354 (17.5)	5696 (73.5)
Item 4	Lifestyle risk factors	4.06	0.58	4	1	5	7033 (90.8)	716 (9.2)	174 (2.2)	542 (7.0)	7033 (90.8)
Item 5	Lifestyle risk factors	4.12	0.61	4	1	5	7147 (92.2)	602 (7.8)	192 (2.5)	410 (5.3)	7147 (92.2)
Item 6 ^a	Prevention and treatment	3.33	0.90	3	1	5	3863 (49.9)	3886 (50.1)	3863 (49.9)	2236 (28.9)	1650 (21.3)
Item 7	Consequences	3.94	0.62	4	1	5	6758 (87.2)	991 (12.8)	365 (4.7)	626 (8.1)	6758 (87.2)
Item 8	Consequences	3.79	0.69	4	1	5	6046 (78.0)	1703 (22.0)	537 (6.9)	1166 (15.0)	6046 (78.0)
Item 9 ^a	Prevention and treatment	3.28	0.85	3	1	5	3708 (47.9)	4041 (52.1)	3708 (47.9)	2358 (30.4)	1683 (21.7)
Item 10	–	3.69	0.77	4	1	5	5545 (71.6)	2204 (28.4)	791 (10.2)	1413 (18.2)	5545 (71.6)

Item 1 = “Age-related height loss is a symptom of osteoporosis,” Item 2 = “For women, the risk of having osteoporosis is higher after menopause,” Item 3 = “I have a greater chance of having osteoporosis if my mother or father has/had it,” Item 4 = “Eating foods high in calcium and vitamin D can help slow the rate of bone loss,” Item 5 = “Exercising everyday can help slow the rate of bone loss,” Item 6 = “There is no way to prevent osteoporosis,” Item 7 = “A woman/man may have osteoporosis for years but not know this until she/he breaks a bone,” Item 8 = “If a woman/man has osteoporosis, something as simple as lifting a bag of groceries can break a bone,” Item 9 = “Bones cannot be rebuilt once they thin from osteoporosis,” Item 10 = “The health problems caused by osteoporosis can be life-threatening”

^aReverse-coded

Table 2

Baseline characteristics of PAADRN participants ($N = 7749$)

	Number	Percentage
Sociodemographics		
Age, mean (SD)	66.6 (8.3)	-
Women	6489	83.7
Race/Ethnicity		
White	5935	76.6
Non-White	1811	23.4
Education		
High school diploma or less	1956	25.5
Some college or higher	5731	74.6
Health habits		
Current smoker	590	7.6
Past smoker	2866	37.0
Current alcohol user	3576	46.1
Bone health		
Prior DXA	5196	67.1
Self-reported history of osteoporosis	1703	22.0
Self-reported current osteoporosis pharmacotherapy	1435	18.5
Self-reported history of osteoporosis pharmacotherapy	3456	44.6
Study DXA results		
Normal	2123	27.4
Low BMD	4118	53.1
Osteoporosis	1508	19.5
10-year Fracture Risk (FRAX), mean (SD)	12.1 (9.2)	-

Table 3

Individual factor loadings and reliability

Subscale	Item	Individual factor loadings	Cronbach's alpha		
			Full scale	9-item model	Subscales
Biological	1	0.45	0.68	0.66	0.59
	2	0.65			
	3	0.51			
Lifestyle	4	0.55			0.64
	5	0.59			
Consequences	7	0.45			0.45
	8	0.44			
Prevention and treatment	6 ^a	0.18			0.36
	9 ^a	0.19			
N/A	10	0.43			

^aReverse-coded

Table 4
Measurement invariance testing for education, prior to DXA, diagnosis, and pharmacotherapy

Subgroup	RMSEA (95% CI)	CFI	NFI	TLI	χ^2 (df)	Model comparison	χ^2 (df)	p value
Age								
Unconstrained	0.011 (0.007, 0.014)	0.994	0.988	0.989	100.861 (54)	–		< 0.0001
Equal factors	0.012 (0.009, 0.015)	0.992	0.984	0.986	135.041 (64)	34.18 (10)		< 0.0001
Sex								
Unconstrained	0.012 (0.008, 0.015)	0.996	0.992	0.992	73.533 (36)	–		< 0.0001
Equal factors	0.012 (0.008, 0.015)	0.995	0.991	0.991	85.161 (41)	11.63 (5)		0.04
Race								
Unconstrained	0.013 (0.009, 0.016)	0.995	0.990	0.989	80.403 (36)	–		< 0.0001
Equal factors	0.015 (0.012, 0.018)	0.992	0.987	0.985	111.528 (41)	31.13 (5)		< 0.0001
Education								
Unconstrained	0.009 (0.006, 0.011)	0.994	0.983	0.987	141.325 (90)			< 0.0001
Equal factors	0.010 (0.007, 0.012)	0.990	0.977	0.984	187.575 (110)	40.25 (20)		0.001
Prior DXA								
Unconstrained	0.015 (0.011, 0.018)	0.993	0.989	0.987	94.735 (36)			< 0.0001
Equal factors	0.015 (0.012, 0.018)	0.992	0.988	0.986	111.275 (41)	16.54 (5)		0.005
Diagnosis								
Unconstrained	0.011 (0.008, 0.014)	0.995	0.989	0.989	103.930 (54)			< 0.0001
Equal factors	0.0113 (0.008, 0.013)	0.994	0.987	0.990	118.901 (64)	14.97 (10)		0.133
Site								
Unconstrained	0.009 (0.005, 0.012)	0.996	0.990	0.993	87.520 (54)			0.003
Equal factors	0.010 (0.007, 0.013)	0.994	0.987	0.990	115.600 (64)	28.08 (10)		0.002
Pharmacotherapy								
Unconstrained	0.012 (0.008, 0.016)	0.996	0.992	0.991	76.506 (36)			< 0.0001
Equal factors	0.012 (0.008, 0.015)	0.995	0.991	0.991	86.305 (41)	9.80 (5)		0.081

Table 5

Responsiveness to change from baseline to 12 and 52 week regression models with odds ratios, p values, and 95% confidence intervals controlling for confounders^a

Variable	Group	Model 1			Model 2 ^b			Model 3			Model 4 ^c		
		OR	p value	95% CI	OR	p value	95% CI	OR	p value	95% CI	OR	p value	95% CI
Change score	1	0.91	0.12	0.82, 1.02	0.83	0.004	0.73, 0.94	0.88	0.04	0.78, 1.00	0.81	0.003	0.70, 0.93
	2	0.85	0.007	0.75, 0.96	0.76	<0.001	0.66, 0.87	0.82	0.005	0.72, 0.94	0.74	<0.001	0.64, 0.86
	3	0.99	0.74	0.93, 1.06	0.89	0.002	0.82, 0.96	0.97	0.35	0.91, 1.03	0.88	0.001	0.82, 0.95
Improved	1	0.99	0.99	0.56, 1.78	1.03	0.93	0.57, 1.86	1.27	0.40	0.73, 2.22	1.51	0.16	0.84, 2.69
	2	0.82	0.52	0.46, 1.49	0.98	0.93	0.53, 1.77	1.35	0.34	0.73, 2.49	1.53	0.18	0.82, 2.84
	3	0.70	0.012	0.52, 0.92	0.83	0.20	0.62, 1.11	0.97	0.83	0.73, 1.28	1.13	0.40	0.85, 1.51
Baseline score	1	–	–	–	1.17	0.004	1.05, 1.29	–	–	–	1.14	0.014	1.03, 1.27
	2	–	–	–	1.20	0.001	1.08, 1.33	–	–	–	1.20	0.001	1.08, 1.33
	3	–	–	–	1.17	<0.001	1.11, 1.24	–	–	–	1.16	<0.001	1.10, 1.23

Group 1 = Newly diagnosed patients, Group 2 = normal bone density patients, Group 3 = DXA, osteoporosis- and/or pharmacotherapy-experienced patients

^a Age, sex, BMI, race, ethnicity, site, marital status, FRAX, education, smoking, drinking, insurance, history of fracture, and history of low bone density or osteoporosis

^b Model at 12 week follow-up including variables in Model 1 while controlling for baseline score

^c Model 52 week follow-up including variables in Model 3 while controlling for baseline score