ORIGINAL RESEARCH ARTICLE

The Contribution of Patient, Primary Care Physician, and Primary Care Clinic Factors to Good Bone Health Care

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ABSTRACT

Background/Objective: Patient, provider, and system factors can contribute to chronic care management and outcomes. Few studies have examined these multilevel associations with osteoporosis care and outcomes. We examined how key process and structural factors at the patient, primary care physician (PCP), and primary care clinic (PCC) levels were associated with guideline concordant osteoporosis pharmacotherapy, daily calcium intake, vitamin D supplementation, and weekly exercise sessions at 52 weeks following enrollment in a cluster randomized controlled trial.

Methods: We conducted a secondary analysis of observational data from 1 site of the trial. The study sample included 1996 men and women ≥ 50 years of age at the time of recruitment following completion of a dual-energy x-ray absorptiometry (DXA) scan and who had complete data at baseline and 52 weeks. Our primary independent variable was "relationship continuity": the DXA-ordering provider was the patient's PCP. Hierarchical linear and logistic regression accounted for patient, provider, and primary care clinic characteristics.

Results: In multivariable regression analyses, relationship continuity (ie, the PCP ordered the study DXA) was associated with higher average daily calcium intake and likelihood of vitamin D supplementation at 52 weeks. No PCP or primary care clinic factors were associated with osteoporosis care.

Conclusions: The relationship continuity, in which the provider ordering a DXA is the patient's PCP and therefore also presents the results of a DXA, may help to promote patient behaviors associated with good bone health.

INTRODUCTION

In the US health care system, factors at the patient (eg, age, education, literacy, and numeracy), physician (eg, sex, training, and practice experience), or facility (eg, service specialty mix, patient volume) levels may affect patient outcomes. The relative contributions of patient, physician, and facility factors toward patient outcomes can be assessed through multilevel models.[1-6] Most extant studies indicate that patient, but not provider or facility, factors have the strongest associations with patient outcomes. Nevertheless, the general absence of strong associations of patient outcomes with physician or system factors should not dissuade from pursuit of hierarchical analyses because understanding sources of variation in patient outcomes, which have to date primarily focused on cardiometabolic disease, may differ for other less-studied diseases.

Few studies have been conducted to assess the relative contributions of patient, physician, and system factors to variation in patient behaviors and attitudes toward, or healthcare system processes to promote, good bone health.[7,8] The principal objective of the current study was to assess the associations of primary care physician and primary care clinic factors with good bone health care at 52 weeks following enrollment in the Patient Activation after DXA Result Notification (PAADRN) randomized controlled trial. We were particularly interested in understanding whether specific facility (eg, patient volume, specialist colocation) and physician (eg, patient volume, years of experience, sex) factors were associated with good bone health behaviors among older adults independent of the PAADRN intervention effect. If so, this insight might help to improve design of future interventions (eg, attention to workforce composition, organizational culture) that could accelerate the impact of patient-centered interventions, such as the PAADRN intervention, in promoting good bone health behaviors.[1,9,10] A review of the literature suggests some physician and clinic factors that might be relevant.

Both higher volumes and higher specialization at the physician and hospital level have been associated with

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improved patient outcomes for an array of conditions and procedures.[11-14] In outpatient settings, the volume of patients with a specific condition (eg, diabetes or heart failure) has also, but not unequivocally, been associated with process and clinical outcomes.[15-17] The volume-outcome association may occur, in part, because of efficiency of tailoring care to patient needs and values or efficiency in surgical technique accumulates with treating more, and more diverse, patients.

Inclusion of relevant specialist physicians in the care of patients with a specific chronic condition may improve patient outcomes.[9,18] Specialist and primary care providers practicing in the same physical location (ie, "colocation) is one strategy that has been proposed to promote collegial interactions that can improve patient outcomes.[19-26] "Practicing together" can potentially facilitate formal and informal face-to-face interactions that might not otherwise happen among disciplines located remotely from one another.

Years in medical practice is another opportunity for physicians to improve disease management or surgical technique. The literature generally suggests, however, that longer practice tenure is associated with less guideline-concordant care.[27] Recent board certification has been associated with a greater likelihood of providing guideline-concordant care.[28] Younger physicians or physicians new to a practice may demonstrate distinctive styles of medicine compared with older physicians or physicians with an established patient panel.[29,30]

Fenale physicians practice a different style of medicine than male physicians, tending to provide more preventive service (particularly with respect to female preventive services), engaging in more partnership building and question asking and providing positive talk and information.[31-34] Historically, osteoporosis has been considered primarily a "women's disease," given the increased risk of major bone fracture among postmenopausal women. The osteoporosis literature shows consistent practice differences between female and male physicians, with male physicians tending to underscreen, diagnose, and treat osteoporosis compared with female physicians.[7,9,35]

"Relationship continuity" expresses the concept that when patients have developed a pattern of trust and psychosocial security with a health care provider, adherence to recommended care will be likely.[36-39] Relationship continuity improves the likelihood of adherence behaviors.[40-43] In the case of a laboratory or radiology service, when the patient's PCP is the ordering provider, a discussion with the patient will have occurred that will typically present the rationale for the procedure, probably including framing of expectations about results. With this background of trust and framed expectations, and to some extent the presence of the PCP as a peer whom many patients will try to please (or appease) by demonstrating adherence to recommendations, continuity will promote a greater likelihood of adherence.

METHODS

Study Population

Men and women ≥ 50 years old presenting for dual-energy x-ray absorptiometry (DXA) between February 2012 and August 2014 at the University of Iowa (the study-coordinating center), University of Alabama at Birmingham, and Kaiser Permanente of Georgia (KPGA) were invited to participate.[44] Patients were excluded if they were unable to read, speak, or understand English; were prisoners or unable to provide informed consent due to perceived cognitive disabilities; or did not have telephone access.

This analysis focuses exclusively on Kaiser Permanente of Georgia (KPGA) participants because it was the only site where PCP and PCC measures could be collected and linked to other PAADRN study records. PAADRN's protocol was reviewed, approved, and monitored by the institutional review boards at each of the participating institutions.

PAADRN Study Overview

The PAADRN study was a double-blinded, cluster-randomized trial in which patients were randomly assigned to an intervention or usual-care group according to the DXA-ordering provider. PAADRN's intervention consisted of a 1-page direct-to-patient letter accompanied by an educational brochure that was mailed 4 weeks post-DXA. The letter presented results in text and a graph of the 10-year risk of an osteoporotic fracture (calculated by FRAX, available at https://www.shef.ac.uk/FRAX/).

Recruitment was open from February 2012 to August 2014. Recruitment primarily occurred prior to a DXA appointment by mail and phone outreach queries of patients on DXA appointment schedules. "Same day" recruitment was facilitated by waiting room posters and brochures and referral to research by the DXA technologist.

Eligible patients who consented to participate completed a post-DXA baseline survey administered by the research assistants at each site. The baseline survey collected information related to participant sociodemographic characteristics (eg, age, race/ethnicity, education); factors affecting fracture risk (eg, height and weight for computation of body mass index); comorbidities; and osteoporosis-related knowledge, attitudes, and behaviors. The survey, except for a few baseline items (eg, sociodemographic variables), was repeated at 12 and 52 weeks. Follow-up surveys were conducted by telephone by trained data collectors at the University of Iowa Social Science Research Center. Follow-up data collectors were also blinded to treatment allocation. Data collection ended August 2015.

Data Sources

The primary data sources were the PAADRN surveys at baseline and 52 weeks, a KPGA provider credentialing

database, and several KPGA electronic medical record (EMR) databases. Records could be linked between the PAADRN and KPGA data by a unique study identifier and within the KPGA credentialing and EMR data by PCP and PCC identifiers. The KPGA credentialing database was the source of PCP age, sex, years working at KPGA, and board certification. The KPGA EMR was the source of numbers of patients with osteopenia and osteoporosis at the PCP and PCC levels and PCC colocation of endocrinology and rheumatology (ie, endocrinologists and/or rheumatologists were in the same facility as the PCP). PCP and PCC measures were associated with patients as of the PAADRN enrollment date.

Primary Endpoints

Guideline-Concordant Pharmacotherapy

Guideline-concordant pharmacological treatment at 52 weeks was based on the 2010 National Osteoporosis Foundation guidelines in effect at the time of this study, along with FRAX estimates from the baseline DXA results and survey data obtained at baseline and 52 weeks.[45] An algorithm assigns patients to 4 groups: appropriately on osteoporosis medication, appropriately not on osteoporosis medication, inappropriately on osteoporosis medication, and inappropriately not on osteoporosis medication. The first 2 classes were considered guideline concordant; the latter 2 classes were considered not guideline concordant.

Daily calcium intake (mg/d), at baseline and 52 weeks, was estimated from responses to food sources (4 items), calcium supplements (1 item), and daily multiple vitamins (1 item).[46] Daily calcium intake was retained as a continuous variable, with a lower bound of 0.

Vitamin D supplementation was assessed by the item regarding multiple vitamin use, assuming all multiple vitamins have vitamin D. The use of supplemental vitamin D at baseline and 52 weeks was binary coded.[46]

Weekly exercise sessions at baseline and at 52 weeks were assessed from 2 items: "In the past 30 days, how many times per week were you engaged in aerobic activity?" and "In the past 30 days, how many times per week were you engaged in strength training?" Examples of aerobic activity and strength training were provided. Responses from each of these items were combined into an estimate of the number of weekly exercise sessions, ranging from 0 to 10.[46]

Independent Variables

PCC Measures

"Volume" was measured as the proportions of adults with osteoporosis or osteopenia who were empaneled to the participant's PCC at the time of the baseline interview. The numerators for these proportions were counts of the PCC's empaneled adults ≥ 50 years as of the baseline interview date with osteoporosis or osteopenia (t-score for wrist, hip, pelvis, or spine ≤ 2.5 or > −2.5 and ≤ −1.0, respectively, from a DXA on or before this date). The denominator was the count of the PCC's empaneled adults ≥ 50 years as of the baseline interview date. For each participant, the proportions were computed as the numerators divided by the denominator. To fix these proportions at the PCC level, the median of these proportions was obtained for all PAADRN participants empaneled at the PCC at the time of enrollment. Colocation of endocrinologists and rheumatologists was defined as location of either or both of these medical subspecialties at the participant's PCC. Colocation did not vary over the study period and was fixed the PCC level.

PCP Measures

"Volume" was measured as the proportions of adults with osteoporosis or osteopenia who were empaneled to the participant's PCP at the time of the baseline interview. These proportions were computed and fixed at the PCP level in the same manner as described for the PCC level. PCP age and duration of employment at KPGA were initially computed for each empaneled participant as of the baseline interview date; then, the median of the ages or years of tenure were obtained for all PAADRN participants empaneled with the PCP at the time of enrollment. PCP race was not available, and board certification was not used because > 95% of the PCPs were board certified.

"Relationship continuity" was a patient-level variable and defined as whether or not the patient's PCP ordered the DXA.

Patient Covariates

Other variables included in the multivariable models were: whether or not the patient was in the PAADRN intervention or usual care group, age, sex, race/ethnicity, education, literacy and numeracy, several comorbid conditions, prior fracture, prior DXA, smoking status, self-reported health, study DXA results, and FRAX risk category.[45,46]

Statistical Analysis

We initially examined equivalence between PAADRN intervention and PAADRN control participants for each of the PCP/PCC level measures, relationship continuity, and patient covariates at the time of enrollment. Comparisons were made using a Student t-test, χ^2 test, or Wilcoxon test depending on the measure's distribution.

Multivariable hierarchical regression models were estimated using a logistic or linear specification as appropriate to the distribution of the dependent variable. Patients were nested within PCPs who were nested within PCCs. Models were first estimated initially as unconditional (no independent variables) models to obtain intraclass correlation coefficients and then as conditional models to gauge the relative

significance of the independent variables to the dependent variables. The modeling strategy was a complete-case analysis of KPGA patients who had information at baseline and 52 weeks. Because of the cluster randomized design, an ordering provider random effect was included to account for the correlation (due to unobserved confounders at the ordering provider level) among patients with the same ordering providers.

All data management and analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

RESULTS

Sample Description

At KPGA, 2984 patients consented to participate in the PAADRN study and completed the baseline survey (see Figure S1 in the Supplemental Material at www.thepermanentejournal.org/files/2020/20.095.supp.pdf). Among participants, 48.3% were randomized to the intervention group and 51.7% to the usual-care group. Of these, 94.2% in the intervention group and 94.0% in the usual-care group had both a valid PCC (n = 27) and PCP (n = 130) assignment. Reasons for nonassignment were a participant receiving care through an out-of-area (ie, not within the Atlanta metropolitan area) network provider or a patient who had not been assigned a PCP at the time of enrollment into the PAADRN study. PCC or PCP measures were unavailable for these participants. Of those with complete PCC and PCP information, 72.4% of intervention participants and 69.8% of usual care participants completed the 52-week survey.

Participants were not randomized to intervention and usual-care groups based on their PCP or PCC. Nevertheless, the groups were relatively well balanced on PCP and PCC measures (Table 1). Patients in the usual-care group were empaneled to PCPs with slightly higher proportions of patients with osteoporosis (0.068 vs 0.065, p = 0.006) or osteopenia (0.133 vs 0.127, p = 0.012) compared with the intervention group. A slightly higher proportion of patients in the usual-care group were empaneled to a female PCP compared with the intervention group (0.592 vs 0.548, p = 0.021). The 2 study groups had similar proportions of PCPs who ordered the study DXA (0.762 in the intervention group, 0.751 in the usual care group; p = 0.500).

At the patient level, there were no statistically significant differences at baseline between PAADRN intervention participants and usual-care participants (see Table S1 in the Supplemental Material at www.thepermanentejournal.org/files/2020/20.095.supp.pdf). This was also the case in the PAADRN intervention study where 3 recruitment sites were involved.[45]

Clustering of Primary Endpoints by PCP and PCC

Clustering of primary endpoints by PCP and PCC was low, with intraclass correlation coefficients indicating < 1% of variance in an endpoint associated with PCP or PCC being typical (Tables 2-5). Daily calcium intake exhibited the most clustering by PCC or PCC (approximately 3.5% of variance; Table 3), and, when nesting of PCP within PCC was taken into account, most of the PCC-level variation was due to PCP-level variation.

Proportion of Participants with Guideline Concordant Pharmacotherapy at 52 Weeks

In the multivariable logistic regression (Table 2), none of the PCC or PCP level variables was associated with patient receipt of guideline-concordant pharmacotherapy at 52 weeks. Several patient-level variables were associated with lower odds of guideline-concordant pharmacotherapy (older age, male sex, non-white race, prior hip fracture, moderate or high FRAX score), and former smoking status was associated with higher odds (data not shown, available on request).

Average Daily Calcium Intake at 52 Weeks

In the multivariable linear regression (Table 3), participants empaneled to receive primary care at a clinic where endocrinology and/or rheumatology were located had 31.15 mg/d (p = 0.038) higher calcium intake than participants empaneled to receive primary care at a clinic where neither of these specialty physician services was offered. Participants whose PCP ordered the study DXA had 40.86 mg/d (p = 0.005) higher calcium intake than participants whose DXA was not ordered by their PCP. At the patient level, the strongest association of daily calcium intake at 52 weeks was with daily calcium intake at baseline, with participants having higher baseline intake also having higher 52-week intake, and vice versa (β = 0.5221, p < 0.001). Other patient variables were associated with lower daily calcium intake (male sex, non-white race), and both low and high DXA t-scores (vs moderate scores) were associated with higher average daily calcium intake (data not shown, available on request).

Proportion with Vitamin D Supplementation at 52 Weeks

In the multivariable logistic regression (Table 4), none of the PCC- or PCP-level variables was associated with whether or not the participant was taking vitamin D supplementation at 52 weeks. Participants whose PCP ordered the study DXA were 1.327 times more likely (p = 0.045) to take vitamin D supplementation at 52 weeks than participants for whom another provider ordered the DXA. At the patient level, the strongest association of vitamin D supplementation at 52 weeks was with vitamin D supplementation at baseline (adjusted odds ratio = 20.513; p < 0.001). No other patient-level variables were associated with vitamin D supplementation at 52 weeks.

Table 1. Sample characteristics by primary care clinic and primary care physician levels

Level of analysis	Variable	All participants	Treatment group		p value intervention vs usual care
			Intervention	Usual care	
N at baseline		2984	1440	1544	–
N with valid values on PCC and PCP level		2809	1357	1452	–
Primary Care Clinic (PCC)	Unique N of PCCs represented	27	27	27	–
	Proportion of patients at PCCs with colocated RHE or END	0.363	0.355	0.371	0.378[a]
	Average of median proportion of osteoporosis patients at PCCs, mean (SD)	0.061 (0.019)	0.062 (0.019)	0.06 (0.018)	0.350[b]
	Average of median proportion of osteopenia patients at PCCs, mean (SD)	0.120 (0.031)	0.121 (0.032)	0.120 (0.030)	0.856[b]
Primary Care Physician (PCP)	Unique N of PCPs represented	130	120	115	–
	Average of median proportion of osteoporosis patients on panel, mean (SD)	0.067 (0.032)	0.065 (0.031)	0.068 (0.033)	**0.006**[b]
	Average of median proportion of osteopenia patients on panel, mean (SD)	0.130 (0.055)	0.127 (0.054)	0.133 (0.057)	**0.012**[b]
	Average age of PCPs, mean (SD)	47.44 (8.74)	47.32 (9.05)	47.56 (8.44)	0.472[c]
	Average KPGA tenure of PCPs, mean (SD)	8.37 (6.63)	8.23 (6.66)	8.50 (6.61)	0.273[c]
	Proportion of female PCPs	0.571	0.548	0.592	**0.021**[a]
Patient	PCP the provider who ordered the DXA	0.756	0.762	0.751	0.500[a]

Bold indicates significance at $p \leq 0.05$.
[a] Pearson χ^2 test.
[b] Wilcoxon rank-sum test.
[c] Two-sample Student t-test.
DXA = dual-energy x-ray absorptiometry; END = endocrinology; KPGA = Kaiser Permanente of Georgia; PCC = primary care clinic; PCP = primary care physician; RHE = rheumatology; SD = standard deviation.

Table 2. Adjusted odds ratios for effects of primary care clinic, primary care physician, and patient factors on guideline concordant pharmacotherapy at 52-weeks

Level of analysis	Variable	Effect estimate (aOR)	95% CI	p value
Primary Care Clinic (PCC)	Proportion of participants at PCCs with colocated RHE or END	1.113	0.784-1.580	0.535
	Median proportion of osteoporosis patients at PCCs	1.010	0.605-1.685	0.968
	Median proportion of osteopenia patients at PCCs	0.797	0.486-1.309	0.355
Primary Care Physician (PCP)	Median proportion of osteoporosis patients on panel	0.903	0.593-1.374	0.633
	Median proportion of osteopenia patients on panel	1.306	0.858-1.989	0.213
	Age	0.999	0.838-1.192	0.994
	Years at KPGA	0.899	0.726-1.114	0.331
	Female	0.758	0.549-1.046	0.091
Patient	Intervention vs usual care	0.963	0.761-1.218	0.750
	PCP ordered the DXA	1.022	0.773-1.351	0.880
Intraclass correlation coefficient	PCCs	0.004	–	–
	PCPs	0.011	–	–

Bold indicates significance at $p \leq 0.05$. Patient covariates are included in the model specification but not displayed (available on request).
aOR = adjusted odds ratio; CI = confidence interval; DXA = dual-energy x-ray absorptiometry; END = endocrinology; KPGA = Kaiser Permanente of Georgia; PCC = primary care clinic; PCP = primary care physician; RHE = rheumatology.

Average Exercise (Weight Bearing and Strengthening) Sessions per Week at 52 Weeks

In the multivariable linear regression (Table 5), participants empaneled to a PCP with a higher proportion of osteoporosis patients on the panel or to a female PCP had lower average weekly exercise sessions (−0.409, p = 0.016 and −0.285, p = 0.057, respectively). No PCC-level variables were associated with weekly exercise sessions at 52 weeks. At the patient level, the strongest association of weekly exercise sessions at 52 weeks was with weekly

Table 3. Mean effects of primary care clinic, primary care physician, and patient factors on daily calcium intake at 52 weeks

Level of analysis	Variable	Effect estimate	95% CI	p value
Primary Care Clinic (PCC)	Proportion of participants at PCCs with colocated RHE or END	31.145	1.938 to 60.352	**0.038**
	Median proportion of osteoporosis patients at PCCs	14.345	−33.193 to 61,884	0.535
	Median proportion of osteopenia patients at PCCs	4.433	−41.713 to 50.580	0.843
Primary Care Physician (PCP)	Median proportion of osteoporosis patients on panel	16.742	−20.316 to 53.800	0.376
	Median proportion of osteopenia patients on panel	−21.745	−58.326 to 14.835	0.244
	Age	−4.668	−22.584 to 13.249	0.610
	Years at KPGA	3.292	−18.566 to 25.150	0.768
	Female	2.745	−29.879 to 35.370	0.869
Patient	Intervention vs usual care	−0.265	−24.486 to 23.956	0.983
	PCP ordered the DXA	40.860	12.205 to 69.515	**0.005**
Intraclass correlation coefficient	PCCs	0.034	–	–
	PCPs	0.035	–	–

Bold indicates significance at $p \leq 0.05$. Patient covariates are included in the model specification but not displayed (available on request).
CI = confidence interval; DXA = dual-energy x-ray absorptiometry; END = endocrinology; KPGA = Kaiser Permanente of Georgia; PCC = primary care clinic; PCP = primary care physician; RHE = rheumatology.

Table 4. Adjusted odds ratios for effects of primary care clinic, primary care physician, and patient factors on vitamin D supplementation at 52 weeks

Level of analysis	Variable	Effect estimate (aOR)	95% CI	p value
Primary Care Clinic (PCC)	Proportion of participants at PCCs with colocated RHE or END	1.262	0.948-1.680	0.106
	Median proportion of osteoporosis patients at PCCs	1.321	0.842-2.073	0.214
	Median proportion of osteopenia patients at PCCs	0.769	0.497-1.188	0.224
Primary Care Physician (PCP)	Median proportion of osteoporosis patients on panel	1.247	0.889-1.750	0.201
	Median proportion of osteopenia patients on panel	0.746	0.538-1.034	0.078
	Age	1.021	0.856-1.218	0.819
	Years at KPGA	1.007	0.812-1.250	0.948
	Female	1.101	0.800-1.515	0.555
Patient	Intervention vs usual care	0.942	0.743-1.194	0.621
	PCP ordered the DXA	1.327	1.006-1.750	**0.045**
Intraclass correlation coefficient	PCCs	0.006	–	–
	PCPs	0.008	–	–

Bold indicates significance at $p \leq .05$. Patient covariates are included in the model specification but not displayed (available on request).
aOR = adjusted odds ratio; DXA = dual-energy x-ray absorptiometry; END = endocrinology; KPGA = Kaiser Permanente of Georgia; PCC = primary care clinic; PCP = primary care physician; RHE = rheumatology.

exercise sessions at baseline, with participants having higher baseline sessions having higher average sessions at 52 weeks, and vice versa ($\beta = 0.4948$, $p < 0.001$). Other patient-level variables were associated with lower weekly exercise sessions (older age, poor health status, comorbid depression), and male sex, prior DXA history, and low bone mineral density result on the study DXA were associated with higher average weekly exercise sessions (data not shown, available on request).

DISCUSSION

In this analysis of the association of patient, PCP, and PCC factors with osteoporosis care, only relationship continuity (which, in this study, was defined as whether or not the patient's PCP ordered the study) was associated with any of the 4 primary endpoints. The association with both increased daily calcium intake and vitamin D supplementation likely has 2 explanations. A clinical explanation is that, for purposes of bone health, both are necessary, so it would make little clinical sense to promote an increase in one without an increase in the other, on average. A second explanation is that these 2 measures are linked by the way in which questions about vitamin supplementation were asked. In the case of multivitamins, an affirmative answer resulted in assignment of calcium and vitamin D intake, under the assumption that

Table 5. Mean effects of primary care clinic, primary care physician, and patient factors on weekly exercise sessions at 52 weeks

Level of analysis	Variable	Effect estimate	95% CI	p value
PCC	Proportion of participants at PCCs with colocated RHE or END	−0.070	−0.332 to 0.193	0.586
	Median proportion of osteoporosis patients at PCCs	0.373	−0.054 to 0.800	0.083
	Median proportion of osteopenia patients at PCCs	−0.267	−0.682 to 0.147	0.193
PCP	Median proportion of osteoporosis patients on panel	−0.409	−0.742 to −0.076	**0.016**
	Median proportion of osteopenia patients on panel	0.155	−0.173 to 0.484	0.354
	Age	−0.099	−0.261 to 0.062	0.227
	Years at KPGA	0.153	−0.043 to 0.350	0.127
	Female	−0.285	−0.578 to 0.009	0.057
Patient	Intervention vs usual care	0.135	−0.083 to 0.352	0.226
	PCP ordered the DXA	−0.161	−0.419 to 0.096	0.219
Intraclass correlation coefficient	PCCs	0.019	–	–
	PCPs	0.009	–	–

Bold indicates significance at $p \leq 0.05$. Patient covariates are included in the model specification but not displayed (available on request).
aOR = adjusted odds ratio; CI = confidence interval; DXA = dual-energy x-ray absorptiometry; END = endocrinology; KPGA = Kaiser Permanente of Georgia; PCC = primary care clinic; PCP = primary care physician; RHE = rheumatology.

most multivitamins have some minimum calcium and vitamin D components.

Among the PCP measures, we found no statistically significant associations with the 4 primary endpoints. The absence of KPGA tenure or PCP age effects is consistent with literature examining whether these physician factors were associated with DXA use rates and postfracture osteoporosis management.[8,35] We found no effect of physician sex on osteoporosis care, whereas other studies have found patients at risk for a fragility fracture who are provided care by female physicians compared with male physicians are more likely to receive guideline concordant care.[7,8]

At both the PCP and PCC levels, the proportion of a panel's or clinic's patients, respectively, with previously identified osteoporosis or osteopenia had no association with the 4 primary endpoints. Although a volume-outcome relationship is relatively well established among acutely ill patients, a volume-outcome relationship in outpatient settings is less well established. The number of postmenopausal women on a physician panel has been associated with increased likelihood of a DXA scan in 1 study.[35] Among adults with diabetes, the number of those patients on a physician panel may[15] or may not[4] be associated with better processes of care and outcomes. Finally, at the PCC level, colocation of endocrinologists and rheumatologists had no association on osteoporosis outcomes.

Our study has limitations. It was conducted within the context of one managed care organization (MCO), which was necessary because of the availability of unique data needed for estimation of multilevel models and appropriate nesting of patients within PCP and within PCC. Although most patients are treated by the PCP or PCC to which they are empaneled, they may obtain care for osteoporosis or osteopenia elsewhere within the MCO; this could diminish the "volume-outcome" effect. Patients may change PCPs or PCPs over the course of a year; however, we fixed the associations of patient with PCP and PCC to simplify analyses. We could not study the effect of board certification, which elsewhere has been shown to be associated with chronic care outcomes, because virtually all PCPs in this MCO were board certified. Our measure of PCP practice duration is limited to duration of practice within the MCO.

In conclusion, we found that relationship continuity (ie, the patient's PCP ordered the study DXA) was associated with higher average daily calcium intake and likelihood of vitamin D supplementation at 52 weeks following a DXA. This finding suggests that productive interactions in chronic care management[47] are supported by continuity of care, in which patient expectations and preparation for behavior change related to good bone health can be framed by the PCP at the time of a DXA order and then reinforced by the PCP when test results are obtained. ❖

Disclosure Statement

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Role of the Sponsor

The NIA, NIAMS, and NIH had no role in the 1) design and conduct of the study, 2) collection, management, analysis, and interpretation of the data, 3) preparation, review, or approval of the manuscript, or 4) decision to submit the manuscript for publication.

Trial Registration

The Patient Activation after DXA Result Notification (PAADRN) Study is registered at ClinicalTrials.Gov: NCT01507662, https://clinicaltrials.gov/ct2/show/NCT01507662.

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