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Authors

Brown, Timothy T
Hurley, Vanessa B
Rodriguez, Hector P

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Timothy T Brown ¹, Vanessa B Hurley ², Hector P Rodriguez¹

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¹Health Policy and Management, University of California Berkeley School of Public Health, Berkeley, California, USA

²Health Systems Administration, Georgetown University, Washington, Columbia, USA

Correspondence to

Dr Timothy T Brown;
timothy.brown@berkeley.edu

ABSTRACT

Objective Musculoskeletal problems like hip and knee osteoarthritis and low-back pain are preference sensitive conditions. Patient engagement strategies (PES), such as shared decision-making and motivational interviewing, can help align patients' preferences with treatment options and potentially reduce spending. We assess the association of physician practice-level adoption of PES with utilisation and spending.

Design Cross-sectional study in which patients were matched across low, moderate and high levels of PES via coarsened exact matching.

Setting Primary and secondary care in 2190 physician practices.

Participants 39 336 hip, 48 362 knee and 67 940 low-back patients who were Medicare beneficiaries were matched to the 2017–2018 National Survey of Healthcare Organizations and Systems.

Primary and secondary outcome measures Total hip replacement (THR), total knee replacement (TKR), 1–2 level posterior lumbar fusion (LF), total annual spending, components of total annual spending.

Results Total annual spending for patients with musculoskeletal problems did not differ for practices with low versus moderate PES, low versus high PES or moderate versus high PES, but spending was significantly lower in some categories for practices with relatively higher PES adoption. For hospital-owned and health system-owned practices, the ORs of receiving LF were 0.632 (95% CI 0.396 to 1.009) for patients attributed to practices with high PES compared with patients attributed to practices with moderate PES. For independent practices, the odds of receiving THR were 1.403 (95% CI 1.035 to 1.902) for patients attributed to practices with moderate PES compared with patients attributed to practices with low PES.

Conclusions Practice-level adoption of PES for patients with musculoskeletal problems was generally not associated with total spending. PES, however, may steer patients toward evidence-based treatments. Opportunities for overall spending reduction exist as indicated by the variation in the subcomponents of total spending by PES adoption.

Strengths and limitations of this study

- The study's research methods advance evidence by linking national US physician practice survey data with national Medicare fee-for-service claims data to examine associations between practice adoption of patient engagement strategies for musculoskeletal conditions with surgical utilisation and spending.
- Coarsened exact matching was used to address selection effects (ie, physician practices with high adoption of patient engagement strategies may attract relatively more complex patients than physician practices with low adoption of patient engagement strategies) when examining the relationships.
- A limitation related to the Medicare fee-for-service claims data is that they do not include measures of patient-reported symptoms or disease severity, which could mediate the relationship between surgical utilisation and spending.
- A limitation related to the use of the National Survey of Healthcare Organizations and Systems physician survey is that it is a single informant survey of physician practice capabilities which may reflect socially desirable responses, but any bias is likely small in magnitude and unlikely to alter conclusions because of the low adoption of the patient engagement strategies overall.

INTRODUCTION

Patient engagement strategies (PES)—which include shared decision-making (SDM) and motivational interviews¹—help align patients' preferences with treatment options for preference sensitive conditions² and can support the provision of patient-centred care.^{3 4} Studies of SDM—particularly randomised controlled trials—find that patients engaged in SDM are more likely to choose conservative treatment options over surgical intervention.^{5 6} However, there is a dearth of research examining the

association of physician practice-level adoption of PES with utilisation and spending.

Although previously associated with reduced health-care costs via lower utilisation of surgical or other invasive treatments,^{7,8} PES may increase rather than decrease spending in the short run because patients may opt for recommended screenings and procedures that increase spending. This effect may be exacerbated by the fact that some decision aids used as part of PES may have been developed by or in conjunction with pharmaceutical or device companies and could potentially reflect a conflict of interest. A similar conflict of interest may occur with respect to systems whose hospitals benefit from providing surgical interventions.^{9,10} One study of hospitalised patients facing surgery choices found that the introduction of SDM increased the number of surgical interventions.¹¹ Similarly, a recent study of patients with hip or knee osteoarthritis within 10 healthcare systems found that hip patients who received decision aids had two and a half times the odds of undergoing surgery and knee patients who received decision aids had nearly twice the odds of surgery compared with propensity score matched comparison groups.¹² These findings highlight that practice-level adoption of PES may be associated with greater spending because upfront financial investments are often needed to support PES whether in the form of materials such as decision aids to enable SDM conversations^{13,14} or process redesigns at the practice level to facilitate capacity—sometimes through additional hiring of clinical support staff.⁴ Even if operational costs increase in the short run with SDM implementation, this may not be undesirable if the ultimate goal of strategies such as SDM is to facilitate patient involvement in treatment decision-making such that the rates of invasive treatment options are reflective of patients' voices in concert with professional judgement.

We estimate the association of physician practice-level adoption of PES for patients with hip osteoarthritis, knee osteoarthritis, or low-back pain on utilisation and spending among Medicare fee-for-service beneficiaries. Total hip replacement (THR) (for treatment of hip osteoarthritis) and total knee replacement (TKR) (for treatment of knee osteoarthritis) are associated with improved long-term clinical outcomes,¹⁵ whereas the evidence supporting the effectiveness of 1–2 level posterior lumbar fusion (LF) (for treatment of low-back pain) is mixed,¹⁶ with one 11-year follow-up study of three randomised controlled trials finding no difference in patient-reported outcomes between LF and exercise therapy.¹⁷

Prior research has also demonstrated that total spending is higher among hospital-owned or health-system owned practices versus independent physician practices.¹⁸ As more independent practices are vertically integrated under hospital or health-system ownership, there are expanded incentives to increase utilisation of services for Medicare beneficiaries because the programme reimburses outpatient care at a higher rate for hospital-based outpatient care compared with free-standing independent

practices.^{19,20} Among health-system owned practices, imaging and medical equipment have been highlighted as two key areas of greater utilisation compared with independent practices.²¹ Given health-system-level incentives for maintaining utilisation and spending, PES may not have an effect on reducing utilisation and spending.

To examine this, we estimate the association of practice ownership with spending and utilisation in the context of practice adoption of PES. In light of evidence demonstrating that THR and TKR tend to result in more positive outcomes compared with LF, we hypothesise that patients attributed to physician practices with relatively high adoption of PES will have greater utilisation of THR and TKR and higher annual spending for hip patients and knee patients compared with patients attributed to practices with lower adoption of PES. In contrast, we hypothesise that patients attributed to physician practices with relatively high adoption of PES will have lower utilisation of LF and lower spending for low-back patients compared with patients attributed to practices with relatively lower adoption of PES.

This study is the first national study to link adoption of PES with claims-derived outcome measures (eg, spending, utilisation). Previous studies of SDM indicate cherry-picking of patients receiving SDM,⁵ resulting in selection bias, or use regression controls versus propensity score weighting to handle potential biases. From a methodological perspective, we advance SDM research through the use of coarsened exact matching as a robust method for handling potential selection bias.

METHODS

Data

We linked anonymised 2017 patient-level Medicare claims data to the 2017/18 National Survey of Healthcare Organizations and Systems (NSHOS)^{22,23} and IQVIA OneKey Data to estimate the association of physician practice-level adoption of PES with spending and utilisation for older adults with hip, knee, and/or low-back problems. We attributed patients to practices using methods similar to those the Centers for Medicare & Medicaid Services (CMS) uses as part of their Medicare Shared Savings Program (MSSP), which is a well-documented and widely accepted method for assigning patients to healthcare providers.²⁴ This method is based on where patients receive the plurality of their primary care. All physician and non-physician providers that bill qualifying evaluation and management (E&M) codes are included in the attribution. Mirroring the MSSP regulations for prioritising attribution to a primary care provider (PCP), we attributed beneficiaries to PCPs in practices that provided the plurality of the beneficiary's qualifying E&M visits. Beneficiaries without qualifying E&M visits to a PCP were then attributed to the specialist providers (non-PCP) with whom they have a plurality of qualifying E&M visits. We attributed patients to practices using the National Provider Identifier (NPI)-OneKey crosswalk. NPIs in

OneKey are directly affiliated with practices, so these NPI-OneKey pairs were the crosswalk between NPIs and OneKey practices. Patients that could not be attributed to an OneKey practice were instead attributed via a tax identification number or CMS certification number.

International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) diagnostic codes were used to define inclusion and exclusion criteria for older adult patients with hip, knee and/or low-back problems (online supplemental appendix 1). The final sample (n=155 638) included 39 336 hip, 48 362 knee and 67 940 low-back patients.

Measures

Outcome variables include both dollar-denominated spending variables and binary indicators of utilisation. Dollar-denominated variables include total allowed payments and relevant component payments for durable medical equipment, imaging, E&M, procedures, testing, facilities, acute care/critical access hospitals, complex post acute-care skilled nursing facilities, skilled nursing/rehabilitation, ordinary home health, complex postacute care home health, hospice and other. Binary outcome variables include utilisation measures of THR, TKR and LF.

We measure PES using a composite measure of nine NSHOS questions assessing adoption and extent of implementation of motivational interviewing and SDM. The main independent variable is a PES composite (range: 0–9) measure. To derive the measure, numerical scores assigned to the answers to nine questions were summed: (1) does your practice have clinicians/staff formally trained in motivational interviewing (0=none, 1=clinicians only, 2=staff only, 3=clinicians and staff); (2) do physicians and/or staff in your practice routinely use motivational interviewing to aid with behaviour change for weight loss/diet (0=no, 1=yes); (3) do physicians and/or staff in your practice routinely use motivational interviewing to aid with behaviour change for increase in physical activity (0=no, 1=yes); (4) do physicians and/or staff in your practice routinely use motivational interviewing to aid with behaviour change for medication adherence (0=no, 1=yes); (5) considering the physicians and staff in your practice, how many are formally trained in SDM (0=none, 1=some, 2=most, 3=all); (6) considering the physicians and staff in your practice, how many routinely engage in SDM (0=none, 1=some, 2=most, 3=all); (7) considering the physicians and staff in your practice, how many routinely use decision aids (0=none, 1=some, 2=most, 3=all); (8) considering the physicians and staff in your practice, how many follow-up on patients' treatment decisions after initial discussion of treatment tradeoffs (0=none, 1=some, 2=most, 3=all); and (9) how many eligible patients receive decision aids before making a decision about osteoarthritis (*hip or knee replacement*) treatment (0=none, 1=some, 2=most, 3=all)? Scores were divided into low (0%–25%), medium (26%–75%) and high (>75%) categories based on the resulting

percentile distribution of the PES scores. Alternatively, scores were also divided into low (0%–33%), medium (34%–66%) and high (>67%) categories for sensitivity analysis purposes.

Statistical methods

We employed coarsened exact matching.^{25 26} When using coarsened exact matching,²⁶ continuous variables are converted into meaningful segments. All relevant variables are then matched, such that only the treatment variable varies across the matched groups. A simple comparison of means between the treatment and comparison groups was conducted using a two-variable regression model, which provides an estimate of the average treatment association. This approach limits the extent to which the average treatment association is model dependent²⁷ and balances all linear and nonlinear relationships as well as all interactions between variables.²⁵ Moreover, this approach limits the sample to data that are on the common support and is approximately invariant to measurement error.²⁵

A key assumption in matching approaches, including coarsened exact matching, is that treatment assignment is ignorable conditional on included covariates or in our case, the set of variables we are matching on. The methodology assumes there are no unmeasured confounders or omitted variables such that treatment assignment is independent of potential outcomes.^{25 26} To the extent there are important variables that are both not available to match on and also correlate with both PES and outcomes; bias may still occur. In this study, we do not have access to clinical information on the severity of a given musculoskeletal condition. This could result in bias if, for example, more clinically severe patients are more likely to have surgery or are more costly to treat and also are more likely to be established patients in high PES practices. Since PES is measured at the practice level, if more clinically severe patients are more likely to be treated in hospital-owned/system-owned practices relative to independent practices, we would expect PES to have larger associations with the probability of surgical intervention and total expenditures at hospital-owned/system-owned practices relative to independent practices, other things equal. There is no clear prediction regarding the components of total expenditures.

Available matching variables were chosen to include the following categories known to be associated with variation in medical decision making²⁸: demographics, medical conditions (different patients have different medical care preferences),^{29 30} geographical area³¹ and physician practice characteristics (physician preferences affect medical care).²⁹ We matched on sex, age category (65–69, 70–74, 75–79, 80–84, 85 or greater), race/ethnicity (white, black, Hispanic, other), at or below the federal poverty level, dual eligible, disabled, more than three hierarchical condition categories, congestive heart failure, coronary artery disease, diabetes, cancer, chronic obstructive pulmonary disease, end-stage renal disease, mental illness, population density (suburban, large town, small town, isolated

**Table 1** Surgical utilisation outcomes

Variables	(1)	(2)	(3)
	Hip	Knee	Low
	Replacement	Replacement	Back
	Surgery	Surgery	Surgery
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Hospital/health-system owned practices			
High versus low PES	1.063 (0.885 to 1.523)	1.013 (0.771 to 1.331)	0.826 (0.451 to 1.513)
Observations	4857	6189	8975
High versus mod PES	0.817 (0.617 to 1.082)	0.997 (0.829 to 1.199)	0.632 (0.396 to 1.009)
Observations	8032	9705	13 794
Mod versus low PES	1.016 (0.806 to 1.281)	1.09 (0.915 to 1.298)	0.869 (0.608 to 1.241)
Observations	10 260	11 832	17 414
Independent practices			
High versus low PES	0.91 (0.600 to 1.379)	0.985 (0.759 to 1.278)	1.366 (0.794 to 2.350)
Observations	3643	4541	6173
High versus mod PES	1.174 (0.835 to 1.650)	1.064 (0.853 to 1.327)	0.789 (0.501 to 1.243)
Observations	5674	7476	10 392
Mod versus low PES	1.403 (1.035 to 1.902)	0.978 (0.786 to 1.217)	1.278 (0.842 to 1.940)
Observations	6870	8619	11 192

Bold denotes statistically significant relationship ($p \leq 0.05$).

Logistic regression using coarsened exact matching.

PES, patient engagement strategies.

rural area), census region (west, midwest, northeast, south), organisation (physician-owned, federally qualified health centre, nursing facility, other organisation), number of physicians in organisation (0–7, 8–12, 13–19, 20–99, 100 or more), percentage of physicians engaged in primary care (0%–32%, 33%–99%, 100%), percentage of patient care revenue from Medicaid (0, 1%–29%, 30% or greater), and accountable care organisation affiliation. Matching was performed separately for each class of patients (hip, knee, low back) within two categories of organizations (independent versus hospital-owned or health-system owned). Cut-points for the percentage of physicians engaged in primary care follows earlier work that uses 33%–99% to designate multispecialty practices and 100% to designate primary care practices,³² and cut-points for the percentage of patient care revenue from Medicaid also follows earlier work.³³ After matching, patients thus only varied with respect to their practice PES index level. All combinations of the practice-level PES index were compared: low to moderate, moderate to high and high to low. When using coarsened exact matching,²³ continuous variables are converted into meaningful segments. This approach limits the extent to which the average treatment effect is model dependent.²⁴ and balances all linear and nonlinear relationships as well as all interactions between variables.²² Moreover, this approach limits the sample to data that are on the

common support and is approximately invariant to measurement error.²²

Using these matched data, we applied logistic regression to determine the ORs for binary outcomes and generalised linear regression with a log link and a gamma distribution of dollar-denominated outcomes to determine marginal associations. The latter was used to examine total spending and components of spending to assess whether specific spending categories are more strongly associated with higher PES. All regressions include robust standard errors and were performed using Stata V.15.

Patient and public involvement

No patient involved.

RESULTS

Descriptive statistics are presented in online supplemental appendix 1 and are presented by hospital-owned and health-system owned practices, and independent practices for each pairwise comparison of PES: high versus low PES, high versus moderate PES, and moderate versus low PES. These statistics only present matched observations and are on the common support.

Two statistically significant differences are found with regard to receiving surgery. Among practices owned by hospitals or health systems, the odds of patients receiving

Table 2 Total spending and durable medical equipment, imaging and evaluation and management spending components

	Total allowed payments		Durable medical equipment payments		Imaging payments		Evaluation and management payments	
	95% CI	95% CI	95% CI	95% CI	95% CI	95% CI	95% CI	95% CI
Hip patients—spending (hospital/system-owned practices)								
High versus low PES	0.024	-0.103 to 0.152	-0.554	-1.126 to 0.018	-0.042	-0.157 to 0.074	0.02	-0.072 to 0.111
Observations	4857		4857		4857		4857	
High versus moderate PES	0.027	-0.085 to 0.139	-0.136	-0.45 to 0.178	0.225	0.142 to 0.308	0.109	0.027 to 0.191
Observations	8032		8032		8032		8032	
Moderate versus low PES	-0.019	-0.103 to 0.065	-0.335	-0.87 to 0.2	-0.035	-0.099 to 0.029	-0.043	-0.104 to 0.018
Observations	10 260		10 260		10 260		10 260	
Knee patients—spending (hospital/system-owned practices)								
High versus low PES	0.009	-0.095 to 0.112	-0.003	-0.269 to 0.264	0.017	-0.079 to 0.114	0.032	-0.043 to 0.106
Observations	6189		6189		6189		6189	
High versus moderate PES	0.043	-0.04 to 0.127	0.008	-0.204 to 0.219	0.183	0.114 to 0.252	0.04	-0.035 to 0.114
Observations	9705		9705		9705		9705	
Moderate versus low PES	0.018	-0.055 to 0.091	0.003	-0.191 to 0.196	0.023	-0.043 to 0.089	0.042	-0.036 to 0.12
Observations	11 832		11 832		11 832		11 832	
Low-back patients—spending (hospital/system-owned practices)								
High versus low PES	0.028	-0.07 to 0.126	0.094	-0.223 to 0.412	0.036	-0.033 to 0.106	0.01	-0.057 to 0.078
Observations	8975		8975		8975		8975	
High versus moderate PES	0.08	-0.005 to 0.165	0.276	0.068 to 0.484	0.199	0.142 to 0.256	0.07	0.008 to 0.133
Observations	13 794		13 794		13 794		13 794	
Moderate versus low PES	-0.01	-0.074 to 0.053	0.021	-0.166 to 0.208	-0.01	-0.058 to 0.038	-0.008	-0.059 to 0.043
Observations	17 414		17 414		17 414		17 414	
Hip patients—spending (independent practices)								
High versus low PES	0.018	-0.153 to 0.189	0.028	-0.462 to 0.518	-0.018	-0.132 to 0.096	-0.04	-0.136 to 0.056
Observations	3643		3643		3643		3643	
High versus moderate PES	0.103	-0.03 to 0.236	-0.148	-0.477 to 0.181	0.035	-0.067 to 0.138	0.046	-0.052 to 0.144
Observations	5674		5674		5674		5674	
Moderate versus low PES	-0.008	-0.122 to 0.107	0.074	-0.206 to 0.354	0.072	-0.02 to 0.164	-0.002	-0.081 to 0.077
Observations	6870		6870		6870		6870	
Knee patients—spending (independent practices)								
High versus low PES	-0.054	-0.192 to 0.085	-0.257	-0.624 to 0.11	0.03	-0.067 to 0.127	-0.057	-0.14 to 0.026
Observations	4541		4541		4541		4541	
High versus moderate PES	0.003	-0.098 to 0.103	-0.04	-0.297 to 0.217	0.085	0.001 to 0.169	0.018	-0.062 to 0.098
Observations	7476		7476		7476		7476	

Continued

Table 2 Continued

	Total allowed payments		Durable medical equipment payments		Imaging payments		Evaluation and management payments	
	95% CI		95% CI		95% CI		95% CI	
Moderate versus low PES	-0.065	-0.148 to 0.019	-0.195	-0.487 to 0.097	-0.003	-0.076 to 0.071	-0.007	-0.058 to 0.045
Observations	8619		8619		8619		8619	
Low-back patients—spending (independent practices)								
High versus low PES	-0.025	-0.15 to 0.1	-0.206	-0.59 to 0.178	0.014	-0.07 to 0.098	-0.013	-0.083 to 0.057
Observations	6173		6173		6173		6173	
High versus moderate PES	-0.017	-0.106 to 0.073	0.009	-0.279 to 0.297	0.029	-0.044 to 0.102	0.052	-0.009 to 0.112
Observations	10 392		10 392		10 392		10 392	
Moderate versus low PES	0.029	-0.052 to 0.109	-0.108	-0.351 to 0.135	0.015	-0.048 to 0.078	0.011	-0.048 to 0.069
Observations	11 192		11 192		11 192		11 192	

Bold denotes statistically significant relationship ($p \leq 0.05$).
Generalised linear model using coarsened exact matching.
PES, patient engagement strategies.

LF surgery are 36.8% lower for patients attributed to practices with high PES relative to patients attributed to practices with moderate PES. Among patients attributed to independent practices, the odds of receiving THR are 40.3% higher for patients attributed to practices with moderate PES compared with patients attributed to practices with low PES. No other statistical differences in the odds of receiving versus not receiving surgery were found across the various pairwise comparisons of PES for THR, TKR and LF (table 1). However, there is no statistical difference in total spending across patients with hip problems, knee problems, or low-back problems when we compare low-to-moderate PES, low-to-high PES or moderate-to-high PES (table 2).

In spite of no overall spending differences, we find that the *components* of spending varied significantly by practice-level adoption of PES for musculoskeletal problems. The major spending categories are as follows: durable medical equipment, imaging, procedures, E&M, testing, facilities and home health (tables 2–4).

Durable medical equipment only varied statistically for low-back patients attributed to hospital-owned and health-system owned practices, where high versus moderate PES levels were associated with 27.6% higher payments. No association was found when varying levels of PES for either hip or knee patients in hospital-owned or health-system owned practices or for any patient category attributed to independent practices. See table 2.

With regard to imaging payments for patients attributed to hospital-owned or health-system owned practices, higher PES levels were significantly and positively associated with higher payments (18.3%–22.5%) for all three patient types when comparing high versus moderate PES levels. This pattern was only present for knee patients attributed to independent practices (8.5%). See table 2.

With regard to E&M payments, in hospital-owned and health-system owned practices, higher levels of PES were significantly and positively associated with higher payments for hip patients (10.9%) and low-back patients (7.1%) when comparing high versus moderate PES levels. There were no statistically measurable associations in independent practices. See table 2.

For procedure payments among patients attributed to system-owned or independent practices, there is a significant positive association with higher payments for low-back patients. Among patients attributed to system-owned practices, this occurs for high versus moderate PES levels (10.6%). Among patients attributed to independent practices, this occurs for moderate versus low PES levels (11%). See table 3.

For testing payments for patients attributed to independent practices, high versus moderate levels of PES are positively and significantly associated with higher payments (hospital-owned or health-system owned: 8.3%–9.3%; Independent practices: 11.5%–16.8%). The only exception to this is that for patients attributed to independent practices, high versus low levels of PES are also positively

Table 3 Procedure, testing, facilities and hospital spending components

	Procedure payments		Testing payments		Facilities payments		Acute care/critical access hospital payments	
	95% CI		95% CI		95% CI		95% CI	
Hip patients—spending (hospital/system-owned practices)								
High versus low PES	0.08	-0.034 to 0.194	-0.034	-0.136 to 0.068	0.24	0.067 to 0.413	0.189	-0.056 to 0.434
Observations	4857		4857		4857		4857	
High versus moderate PES	0.007	-0.092 to 0.106	0.093	0 to 0.185	0.319	0.167 to 0.471	-0.041	-0.243 to 0.161
Observations	8032		8032		8032		8032	
Moderate versus low PES	-0.015	-0.092 to 0.063	-0.029	-0.099 to 0.041	0.106	-0.054 to 0.266	0.097	-0.062 to 0.255
Observations	10 260		10 260		10 260		10 260	
Knee patients—spending (hospital/system-owned practices)								
High versus low PES	0.0158	-0.091 to 0.123	-0.012	-0.095 to 0.071	0.348	0.167 to 0.529	0.035	-0.198 to 0.269
Observations	6189		6189		6189		6189	
High versus moderate PES	0.047	-0.035 to 0.129	0.083	0.011 to 0.155	0.449	0.325 to 0.573	0.063	-0.1 to 0.225
Observations	9705		9705		9705		9705	
Moderate versus low PES	0.0431	-0.023 to 0.11	-0.013	-0.07 to 0.045	0.203	0.084 to 0.322	0.019	-0.123 to 0.161
Observations	11 832		11 832		11 832		11 832	
Low-back patients—spending (hospital/system-owned practices)								
High versus low PES	0.022	-0.069 to 0.112	0.05	-0.029 to 0.128	0.309	0.163 to 0.455	0.005	-0.279 to 0.289
Observations	8975		8975		8975		8975	
High versus moderate PES	0.106	0.038 to 0.174	0.086	0.023 to 0.148	0.391	0.294 to 0.488	-0.062	-0.313 to 0.189
Observations	13 794		13 794		13 794		13 794	
Moderate versus low PES	-0.054	-0.125 to 0.017	-0.046	-0.098 to 0.006	0.086	-0.003 to 0.175	-0.055	-0.225 to 0.114
Observations	17 414		17 414		17 414		17 414	
Hip patients—spending (independent practices)								
High versus low PES	0.007	-0.123 to 0.137	0.181	0.037 to 0.325	-0.302	-0.574 to -0.03	-0.091	-0.35 to 0.168
Observations	3643		3643		3643		3643	
High versus moderate PES	0.048	-0.064 to 0.161	0.168	0.046 to 0.29	0.015	-0.179 to 0.209	0.162	-0.071 to 0.395
Observations	5674		5674		5674		5674	
Moderate versus low PES	-0.017	-0.157 to 0.124	-0.076	-0.25 to 0.099	-0.064	-0.262 to 0.134	0.15	-0.077 to 0.377
Observations	6870		6870		6870		6870	
Knee patients—spending (independent practices)								
High versus low PES	0.045	-0.051 to 0.142	0.086	-0.028 to 0.2	-0.208	-0.422 to 0.006	-0.068	-0.294 to 0.157
Observations	4541		4541		4541		4541	

Continued

Table 3 Continued

	Procedure payments		Testing payments		Facilities payments		Acute care/critical access hospital payments	
	95% CI		95% CI		95% CI		95% CI	
High versus moderate PES	0.058	-0.024 to 0.14	0.132	0.043 to 0.221	0.138	-0.036 to 0.312	0.027	-0.175 to 0.228
Observations	7476		7476		7476		7476	
Moderate versus low PES	0.012	-0.073 to 0.096	0.033	-0.041 to 0.107	-0.037	-0.21 to 0.137	-0.018	-0.19 to 0.154
Observations	8619		8619		8619		8619	
Low-back atients – spending (independent practices)								
High versus low PES	-0.041	-0.133 to 0.052	0.03	-0.053 to 0.112	-0.152	-0.32 to 0.016	-0.081	-0.357 to 0.196
Observations	6173		6173		6173		6173	
High versus moderate PES	-0.02	-0.112 to 0.071	0.115	0.046 to 0.184	-0.082	-0.23 to 0.066	-0.164	-0.397 to 0.069
Observations	10 392		10 392		10 392		10 392	
Moderate versus low PES	0.11	0.033 to 0.187	0.046	-0.014 to 0.107	0.033	-0.102 to 0.169	-0.043	-0.267 to 0.18
Observations	11 192		11 192		11 192		11 192	

Bold denotes statistically significant relationship ($p \leq 0.05$).
Generalised linear model using coarsened exact matching.
PES, patient engagement strategies.

Table 4 Home health spending components

	Home health agency	95% CI
Hip patients—spending (hospital/system-owned practices)		
High versus low PES	-0.125	-0.542 to 0.292
Observations	4857	
High versus moderate PES	0.017	-0.254 to 0.287
Observations	8032	
Moderate versus low PES	-0.027	-0.262 to 0.208
Observations	10 260	
Knee patients—spending (hospital/system-owned practices)		
High versus low PES	-0.139	-0.423 to 0.145
Observations	6189	
High versus moderate PES	-0.013	-0.234 to 0.209
Observations	9705	
Moderate versus low PES	0.021	-0.171 to 0.213
Observations	11 832	
Low-back patients—spending (hospital/system-owned practices)		
High versus low PES	0.007	-0.34 to 0.354
Observations	8975	
High versus moderate PES	-0.06	-0.342 to 0.222
Observations	13 794	
Moderate versus low PES	0.14	-0.08 to 0.36
Observations	17 414	
Hip patients—spending (independent practices)		
High versus low PES	-0.079	-0.496 to 0.339
Observations	3643	
High versus moderate PES	0.064	-0.334 to 0.461
Observations	5674	
Moderate versus low PES	-0.409	-0.842 to 0.024
Observations	6870	
Knee patients—spending (independent practices)		
High versus low PES	-0.179	-0.498 to 0.14
Observations	4541	
High versus moderate PES	0.051	-0.223 to 0.326
Observations	7476	
Moderate versus low PES	-0.614	-0.971 to -0.257
Observations	8619	
Low-back patients—spending (independent practices)		
High versus low PES	0.21	-0.157 to 0.577
Observations	6173	
High versus moderate PES	0.043	-0.289 to 0.374
Observations	10 392	
Moderate versus low PES	0.003	-0.306 to 0.313
Observations	11 192	

Continued

Table 4 Continued

	Home health agency	95% CI
Generalized linear model using coarsened exact matching. PES, patient engagement strategies.		

and significantly associated with higher payments for hip patients (18.1%). See [table 3](#).

For facilities payments, hospital-owned and system-owned practices had significantly higher spending only for knee-patients for all comparisons of PES levels (20.3%–44.9%). There was no variation in spending by PES for independent practices.

Finally, home health agency payments only varied in independent practices for knee patients, where moderate versus low levels of PES were associated with 61.4% lower payments. There were no other measurable PES associations. See [table 4](#).

Sensitivity analysis

In online supplemental appendix 2, we perform the same analysis as above using alternative PES cut-points of low (0%–33%), moderate (34%–66%) and high (>67%), rather than the original PES cut-points of low (0%–25%), moderate (26%–75%) and high (>75%). By definition, the alternative PES levels are, on average, closer together. In other words, the comparisons across levels are examining the association of outcomes with smaller differences in PES. In addition, the matched sample sizes will differ when using the alternative PES levels. Thus, we expect to find differences in magnitude of the measured relationships due to variation in the average differences being measured and variation in statistical significance due to differences in matched sample sizes. Overall, this is what we find: if a relationship is statistically significant using one set of PES cut-points, the analogous relationship using the other set of PES cut-points always has the same sign (the relationship remains positive or negative) although the magnitude of the relationship may be altered, and the relationship may become more or less precise (gain or lose statistical significance). There is one minor exception to this rule. See online supplemental appendix 2.

DISCUSSION

Practice-level adoption of PES has limited association with surgical interventions for hip, knee and low-back problems in the USA. For beneficiaries attributed to hospital-owned or health-system owned physician practices, the ORs for receiving LF is 36.8% lower for patients of practices with high PES relative to patients of practices with moderate PES. For independent practices, the ORs of patients receiving THR surgery is 40.2% higher for beneficiaries attributed to practices with moderate PES relative to beneficiaries attributed to practices with low PES.

These findings provide partial support for our hypothesis that patients attributed to hospital or health system-owned practices with higher adoption of PES have greater utilisation of THR but lower utilisation of LF compared with patients attributed to practices with relatively lower adoption of PES. We did not, however, find greater utilisation for TKR among patients in hospital-owned or health-system owned practices with high use of PES. This suggests that any conflicts of interest regarding those who prepare decision aids used as part of PES may not be resulting in much or any association with outcomes. Since the evidence base for LF is weaker than for THR and TKR, it may be that practices with higher use of PES may be steering patients toward evidence-based care differently than in low PES practices.^{34 35} Although we did not find greater utilisation of TKR for patients with knee osteoarthritis among practices with higher PES, a recent randomised controlled trial of SDM and decision aids in the context of management of knee osteoarthritis found that while shared decision making implementation positively impacted patients' experiences and decision quality, it had no impact on rates of TKR.³⁶

In light of prior research demonstrating the existence of system-level incentives for maintaining spending, we also hypothesised that the use of PES may not necessarily translate to reduced spending associated with low-back pain, knee problems, or hip problems. Although we found no differences in overall spending similar to other analyses of practice associations,^{37 38} our analyses revealed that certain components of spending did vary by PES level and hospital-owned and health-system owned versus independent practices. For example, hospital-owned and health-system owned practices with high PES levels had greater spending on imaging across all three surgical interventions relative to hospital-owned and health-system owned practices with moderate PES levels. Additionally, payments associated with durable medical equipment were higher for patients attributed to hospital-owned or health system-owned practices with high versus moderate PES levels. Notably, this was only true for patients treated for low-back pain rather than patients with hip or knee osteoarthritis. These findings are consistent with previous evidence that spending for patients treated in hospital-owned or health-system owned versus independent practices was higher by almost 6 percentage points and significantly higher spending across the categories of medical equipment and imaging alongside unclassified services.²¹ Our study examines spending in the context of higher versus lower physician practice-level adoption of PES and notes similarly higher spending for hospital-owned or health-system owned practices.

Although we find evidence of systematic associations of relative levels of PES with *components* of spending, there is no measurable association of PES with total annual spending. The ability to detect statistically significant associations in spending components but not in aggregate spending is likely because large differences in small spending components translate into smaller changes in

the aggregate measure. This indicates that while PES do not appear to be associated with total spending, it likely affects treatment choices in ways that may be important to patient satisfaction and other patient-reported outcomes,^{3 4} including pain management, mental health, and disability. If true, this would make PES cost-effective even if practices with high PES adoption do not have lower overall spending.

Our results should be considered in light of limitations. First, we are unable to establish causal relationships given the cross-sectional study design. However, we used coarsened exact matching,^{25 39} which is a robust method for handling potential selection bias.

Second, the assessment of PES was based on a single informant survey, which may be subject to social desirability response bias. This could result in a compression of the distribution of PES if organisations with a lower PES report a higher PES than is actually the case, whereas organisations with higher PES would report more accurately. The larger any such compression, the more likely the association of PES with outcomes could be understated in our analyses. In addition, to the extent social desirability varies by whether a practice is independently-owned relative to hospital-owned/system-owned, other things equal, there could be different findings on the association of PES with overall costs and the probability of surgical intervention across these two categories of practices. The reported levels of PES, however, indicate that such strategies were used by less than half of practices, indicating that social desirability biases are unlikely to have a large effect on our results.

Third, we are unable to assess the role of patient preferences in treatment decisions to the extent preferences are not accounted for by patient demographics. Quasi-experimental research of PES implementation in routine settings should examine the extent to which patient preferences help explain some of the differential utilisation of surgery by practice-level adoption of PES.

CONCLUSION

In conclusion, practice-level adoption of PES may not reduce total spending for older adults with musculoskeletal problems but may steer them toward evidence-based treatments. The existence of variation in the components of total spending for low-back patients, hip patients, and knee patients suggests that process changes could result in reduced total spending if each component of cost is systematically analysed and appropriately modified.⁴⁰ Differences in spending components across hospital-owned and health-system owned versus independent practices within each PES comparison suggest that potentially unnecessary activities may be occurring in the testing, imaging, procedure, E&M, and durable medical equipment categories that should be examined in future research.

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ORCID iDs

Timothy T Brown <http://orcid.org/0000-0002-5334-0768>

Vanessa B Hurley <http://orcid.org/0000-0002-3901-291X>

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