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RESEARCH ARTICLE

The Relationships of Physician Practice Characteristics to Quality of Care and Costs

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Background. Medical group practices are central to many of the proposals for health care reform, but little is known about the relationship between practice-level characteristics and the quality and cost of care.

Methods. Practice characteristics from a 2009 national survey of 211 group practices were linked to Medicare claims data for beneficiaries attributed to the practices. Multivariate regression was used to examine the relationship between practice characteristics and claims-computable measures of screening and monitoring, avoidable utilization, risk-adjusted per-beneficiary per-year (PBPY) costs, and the practice's net revenue.

Results. Several characteristics of group practices are predictive of screening and monitoring measures. Those measures, in turn, are predictive of lower values of avoidable utilization measures that contribute to higher PBPY costs. The effects of group practice characteristics on avoidable utilization, cost, and practice net revenue appear to work primarily through improved screening and monitoring.

Conclusions. Practice characteristics influence costs indirectly through a set of statistically significant relationships among screening and monitoring measures and avoidable utilization. However, these relationships are not the only pathways connecting practice characteristics to cost and those additional pathways contain substantial "noise" adding uncertainty to the estimated direct effects. Some of the attributes thought to be important characteristics of accountable care organizations and medical homes appear to be associated with lower quality and no improvement in cost.

Key Words. Medical group practice structures, costs, quality of patient care, health care organizations

Recent proposals for health care reform have highlighted the need for better information about costs and quality of care differences at the medical practice level (Buchmueller 2009; Fendrick and Chernew 2009; Claxton,

DiJulio, and Finder 2010; Sinaiko 2011). This is especially true for medical group practices as physician practices are central to many of the proposals (Merlis 2010; O'Malley, Peikes, and Ginsburg 2010; Wise et al. 2011). It is well known that there is wide variation in physician practice styles and that this variation influences both the costs and quality of care. However, the factors influencing these practice patterns are not well understood, in part, because there are few national datasets that combine information on practice-level characteristics and patient-level encounter or claims data.

Payment methods at both the group practice and physician levels have been shown to influence costs, and several studies have documented regional cost differences and differences across health plans, but the influence of group practice-level organizational attributes on these differences has not been well documented (Kralewski et al. 2005; Dowd et al. 2009; Moore et al. 2010; Zuckerman et al. 2010; Turbyville et al. 2011).

Shortell et al. identified several attributes theoretically important to high-performing medical group practices and surveyed a sample of midsized practices to determine their capabilities as measured against these criteria. While providing important insight into practice structures, the influence of these attributes on the costs and quality of care was not included in the analysis (Shortell et al. 2005; Rittenhouse et al. 2011).

Some smaller studies of specific practice attributes such as use of EHRs on cost and quality provide conflicting findings (Garg et al. 2005; Orzano et al. 2009). As noted by Conrad and Christianson (2004), much remains to be learned about the factors at the group practice level that influence physician practice styles and their ability to employ a cost-effective mix of resources that achieves high quality at low costs.

This study addressed these issues by analyzing differences in the quality and cost of care provided by a 2009 national sample of 211 medical group practices. We examine the variation in quality and cost at the practice level, and then analyze the influence of practice characteristics on these performance measures.

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Analytic Model

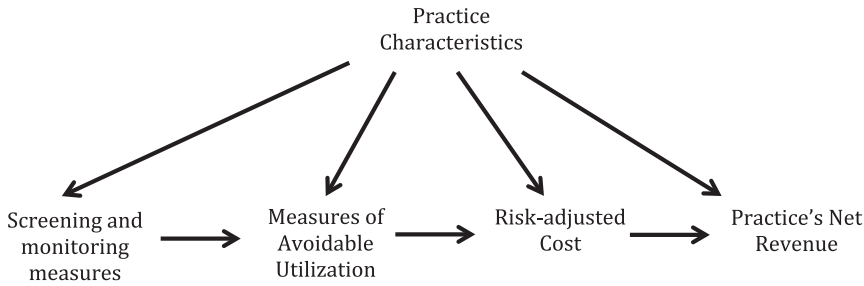
Our analysis is based on the following conceptual model. The horizontal arrows at the bottom of the figure represent relationships that we expect to hold in any model of cost and quality. We hypothesize that higher levels of screening and more frequent monitoring of chronically ill patients could help reduce avoidable utilization of the hospital and emergency department.[1] Such reductions should reduce the practice's risk-adjusted per-member per-year (PBPY) cost. In our data, "cost" refers to cost to the Medicare program. If the practice derives revenue from ACS admissions or avoidable ED visits, then reduced cost to Medicare would imply reduced practice revenue. The effect on the practice's net revenue would depend on the practice's internal cost of the avoidable utilization (Figure 1).

Our principal goal in this research, however, concerns the role played by practice-level characteristics. How do practice characteristics enter the model? Do practice characteristics have direct effects on each variable in the model, or do they enter the model only at certain points and not others?

The model has been greatly simplified to address this specific question. Many plausible relationships are omitted from the model. The screening and monitoring measures could exert a direct influence on risk-adjusted cost and the practice's net revenue. The measures of avoidable utilization could affect net revenue directly, as well as through risk-adjusted cost. Although those relationships are not the focus of the analysis, we provide a few tests of those ancillary relationships and report the results in the Results section.

Focusing on risk-adjusted cost as a dependent variable of particular interest, we first test for direct effects of practice characteristics on risk-adjusted cost. Then, we add practice characteristics to the relationships between screening and monitoring measures, avoidable utilization, cost, and net revenue.

Figure 1: Conceptual Model



Data and Methods

Data on practice characteristics were obtained from a survey of practice cost and productivity conducted by the Medical Group Management Association (MGMA) in 2009. Although the data are from a national sample, they are not necessarily representative of all medical practices in the United States. However, the attraction of the data is not their national representativeness, but the fact that the national survey was administered to physician practices, thus creating a unique opportunity to conduct a practice-level analysis that combines both characteristics of the practice and claims-computable measures of quality and cost.

We can verify that our sample is not skewed toward large or small practices in a way that would bias our findings. When compared to a national database on physician practices developed by Welch et al. (2013), 71 percent of our sample have 11–50 physicians compared to 83 percent in the Welch data and 8 percent have more than 100 physicians compared to 7 percent in the Welch data. We are unable to compare the number of practices with fewer than 11 physicians because the Welch dataset includes those with only two physicians in that size category, and they are not considered to be group practices. We have 63 practices in our sample with fewer than 11 physicians.

Our practice-level claims dataset was created by obtaining from MGMA the names and addresses of the medical group practices that completed the MGMA survey. Using data from the National Plan and Provider Enumeration System (NPPES), we collected the National Provider Identifiers (NPIs) for all providers whose practice's name and address in the NPPES data matched the MGMA data. We used the NPIs to link the MGMA survey data to Medicare claims data. Beneficiaries were attributed to practices if they received a plurality of their nonhospital evaluation and management (E&M) visits from the NPIs associated with the practice—the same attribution rule used for Medicare ACOs. We subsequently identified 234 medical group practices that provided care for at least 1,000 attributed Medicare beneficiaries. Twenty-three practices were eliminated due to missing MGMA data, leaving an analytic sample of 211 practices.

Practice Characteristics

The MGMA survey contained data on the following practice characteristics that have been associated with productivity and are of interest in current policy discussions regarding accountable care organizations:

1. Practice type: primary care only versus multispecialty group practices that offer both primary care and specialty care (multispecialty practices are the omitted reference category)
2. Practice ownership: physician owned; hospital or integrated delivery system owned (omitted reference category); or other owners (community health centers, government agencies, private health plans)
3. Practice size: number of FTE physicians[2]
4. Nonphysician providers per physician: number of NPs and PAs divided by number of FTE physicians
5. EHR implementation: practice has an electronic health record (EHR)
6. EHR experience: number of years with EHR
7. The practice's net revenue: net practice revenue after operating expenses divided by total revenue
8. The geographic region in which the practice is located: Northeast (NE), Southeast (SE), Eastern Midwest (EM), Upper Midwest (UM), Lower Midwest (LM), Rocky Mountain (RM), and Far West (FW)
9. Rural: located in a community with 5,000 or fewer population.

These variables are included in our analysis because they have been found to influence the performance of health care organizations and are included in many of the proposals for health care reform such as Accountable Care Organizations and Medical Homes (Fendrick and Chernew 2009; Wise et al. 2011; Burns and Pauly 2012). Medical practice ownership is a central issue. Hospital ownership provides access to more resources and can create integrated patient care system, but the influence on medical practice performance is still uncertain (Friedberg et al. 2009; O'Malley, Bond, and Berenson 2011). Medical practice size and the inclusion of specialists as well as primary care physicians have been found to improve patient care access and quality in some studies but also often results in higher costs (Friedberg et al. 2009; Town, Feldman, and Kralewski 2011; McWilliams et al. 2013).

Inclusion of the use of EHRs has sound theoretical grounding in that it improves the clinical information available for physicians at the patient care site and provides medical prompts for needed care as well as care management guidelines. However, the influence of EHRs on costs and quality of care has been mixed and in some studies has been found to increase patient-level costs (Garg et al. 2005).

The employment of nonphysician providers such as nurse practitioners and physician assistants has been found to improve access to patient care and

improve medical practice performance (Moody, Smith, and Glenn 1999). Consequently, we include the ratio of these providers to physicians in the practices.

As higher patient-level costs increase practice revenue, while higher quality might reduce the net profit on that revenue, we include net revenue after operating costs as a measure to assess that relationship. Net revenue after operating costs represents the profit level of the practice before physician compensation. It also is a measure of the efficiency of the practice in producing units of services. Holding total revenue constant, higher net revenue indicates that services are being provided at lower practice-level costs. We also include geographic and urban/rural location in our analysis to control for differences in geographic practice norms.

Risk-Adjusted Cost

Risk-adjusted costs to the Medicare program were computed from Medicare claims data at the individual beneficiary level by regressing the beneficiary's annual Medicare payments (allowable charges) adjusted for Medicare's geographic practice cost index (GPCI)[3] on the patient's age, gender, and Medicare hierarchical condition categories. The residuals from this regression were summed for the patients attributed to each practice.

Screening and Monitoring Measures

Quality measures include diabetes care rates, LDL screens for beneficiaries with cardiovascular conditions, and colon cancer screening rates for the at-risk population.[4] The diabetic, cancer, and cardiovascular quality of care measures are calculated using the algorithms available from the Generating Medicare Physician Quality Performance Measurement Results (GEM) project 2007 specifications (Center for Medicare and Medicaid Services 2011). The numbers represent fractions of beneficiaries receiving a service. The numerators (those who received a service) and denominators (those who were eligible for the service, adjusted for the Medicare population) were defined for each parameter as in the GEM Functional Specification Document.

Measures of Avoidable Utilization

Emergency Department Visits. Inappropriate emergency department (ED) visits were calculated using the ED classification algorithm developed by Billings,

Parikh, and Mijanovich (2000). This algorithm was adapted to use at the individual physician level as described in Dowd et al. (2013). The algorithm assigns 640 diagnoses to the following categories:

1. Nonemergent: indicating medical care was not needed within 12 hours.
2. Emergent, but primary care treatable: indicating treatment was required within 12 hours but could have been treated in a primary care office.
3. Emergent, but preventable/avoidable: indicating ED care was needed, but the visit could have been prevented with timely and effective primary care.
4. Truly emergent: ED care was needed and the visit was not preventable/avoidable.

In the case of multiple diagnoses for an ED visit, we chose the diagnosis that gave the physician the maximum probability of the ED visit being appropriate. The probabilities for "nonemergent" and "emergent, but primary care treatable" were summed across all ED visits for the practice, and then divided by the number of beneficiaries attributed to the practice to obtain average scores for this analysis.

Ambulatory Care Sensitive (ACS) Admissions. The Agency for Healthcare Quality and Research (AHRQ) defines ACS admissions as "conditions for which good outpatient care can potentially prevent the need for hospitalization, or for which early intervention can prevent complications or more severe disease" (AHRQ 2001). Medicare Part A claims were used to identify ACS admissions using the algorithm available from the Agency for Health Research and Quality (AHRQ 2013). The algorithm uses the primary and the secondary diagnoses to identify ACS admissions. The ACS measure is the number of ACS admissions by beneficiaries attributable to a practice divided by the total number of beneficiaries attributed to the practice.

Methods

Because our dependent variables all are continuous variables, we use multivariate regression models to analyze the relationships in the model. All standard errors are computed using White's heteroscedastic-consistent variance-covariance estimator.

As in many analyses of organizational characteristics, virtually all the characteristics of the practice represent endogenous choices by the practice, and thus, in the absence of valid instruments, we cannot claim that the estimated relationships are causal. However, it is important to distinguish two questions that analysts or policy makers might pose regarding the cost and quality of care. First, analysts or policy makers might ask, "If we were able to alter the characteristics of a specific practice, would we expect to see the effects suggested by the results in this analysis?" That question would require a valid causal model. Second, analysts or policy makers might ask, "If we wished to reward practices that have certain characteristics, what characteristics would those be?" Here, the causal relationships are less important. The true underlying causal mechanisms may not be empirically verifiable, but as long as they remain reasonably stable, policy makers can choose practices to reward for their current level of performance. Our analysis addresses the second question, but our findings suggest that neither of these approaches may be the optimal way to improve the cost and quality of care.

RESULTS

Descriptive Statistics

Descriptive statistics are shown in Table 1. The practices range in size from 5 to 148 physicians and employ one nonphysician provider for every four physicians, on average. Forty-six percent have an EHR in place and those with an EHR had had it in place for 2.14 years.[5]

Thirty-four percent of the practices are owned by hospitals; 61 percent are owned by physicians; and 5 percent are owned by CHCs, government agencies, or health plans (the other category). Forty percent of practices provide only primary care as opposed to multispecialty group practices. Thirty-four percent of the practices are in rural areas.

An important point is that the practice characteristics are not highly correlated with each other, as shown in Table 2. Thus, even if some practice characteristics were found to be associated with better performance on the outcome measures, it is unlikely that there will be large clusters of practices that share all those desirable characteristics.

The screening rates are 1-year rates computed from claims data and thus do not represent adherence to screening guidelines unless they are adjusted for the recommended frequency of the test. The practices average approximately 0.14 ACS admissions per beneficiary, 0.04 primary care-preventable

Table 1: Descriptive Statistics

Variable	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
FTE physicians	31.53	31.50	5.00	147.94
Nonphysician providers per physician	0.24	0.22	0.00	1.70
Electronic health record (EHR)	0.46	0.50	0.00	1.00
Years of EHR	2.14	3.41	0.00	15.00
Hospital owned (omitted reference category)	0.34	0.48	0.00	1.00
Physician owned	0.61	0.49	0.00	1.00
Other owned	0.05	0.21	0.00	1.00
Primary care only	0.40	0.49	0.00	1.00
Rural	0.34	0.47	0.00	1.00
Upper Midwest (omitted reference category)	0.13	0.33	0.00	1.00
Eastern Midwest	0.22	0.41	0.00	1.00
Far West	0.13	0.34	0.00	1.00
Lower Midwest	0.19	0.39	0.00	1.00
Northeast	0.15	0.36	0.00	1.00
Rocky Mountains	0.05	0.22	0.00	1.00
Southeast	0.13	0.33	0.00	1.00
HbA1c	0.71	0.25	0.03	1.00
CVD-LDL	0.67	0.09	0.41	0.92
Colon cancer screening	0.15	0.05	0.06	0.48
ACS admission rate	0.14	0.09	0.04	0.71
Emergent, primary care treatable ED visits per beneficiary	0.04	0.01	0.02	0.10
Nonemergent ED visits per beneficiary	0.05	0.02	0.02	0.14
Total PBPY cost	6,764.19	3,165.16	2,817.42	24,645.10
Risk-adjusted PBPY cost (regression residual)	42.99	1,181.81	−7,620.12	5,086.39
Net revenue	0.38	0.12	0.02	0.73

ED visits per beneficiary, and 0.05 nonemergent ED visits per beneficiary. Table 1 shows that there is considerable variation in the screening and monitoring measures and the measures of avoidable utilization.

There also is significant variation in risk-adjusted cost. Remembering that the risk-adjusted PBPY cost is a regression residual, the range is from −$7,620.12 to $5,086.39, or approximately $12,700.[6] The practice's net revenue as a percent of total revenue averages approximately 38 percent.

Direct Effects of Practice Characteristics on Risk-Adjusted Cost. Because cost to the Medicare program and other payers is of particular interest, we first test for a direct relationship between cost and the practice characteristics alone. The results are shown in Table 3. Among the practice characteristics, only "other"

Table 2: Correlations of Practice Characteristics

	FTE Physicians	*Nonphysician Providers per Physician*	*Electronic Health Record (EHR)*	*Years of EHR*	*Physician Owned*	*Other Owned*	*Primary Care Only*
FTE physicians	1.000						
Nonphysician providers per physician	0.022	1.000					
Electronic health record (EHR)	0.039	0.135	1.000				
Years of EHR	0.022	0.061	0.677	1.000			
Physician owned	0.183	0.019	0.216	0.085	1.000		
Other owned	−0.001	0.327	0.061	0.043	−0.280	1.000	
Primary care only	−0.485	−0.057	−0.009	0.034	−0.336	0.090	1.000

owned, and three of the geographic variables—Rural, Far West, and Southeast—are statistically significant. All except the rural variable have negative coefficients indicating that they have lower costs. Rural practices have higher costs. Physician-owned practices and those with EHRs have negative coefficients, but they are not statistically significant in this analysis of direct influence on

Table 3: Direct Effects of Practice Characteristics on Risk-Adjusted Cost

Variable	*Coefficient*
FTE physicians	2.33
Nonphysician providers per physician	448.52
Electronic health record (EHR)	−153.97
Years of EHR	1.23
Physician owned†	−280.87
Other owned†	−913.60***
Primary care only‡	−109.36
Rural	376.26**
Eastern Midwest§	−371.43
Far West‡	−927.49***
Lower Midwest§	401.86
Northeast§	−217.24
Rocky Mountain§	−269.03
Southeast§	−586.07***
Constant	311.38
R-squared	0.129

†Practices owned by hospitals or integrated delivery systems are the omitted reference category.
‡Multispecialty practices are the omitted reference category.
§The Upper Midwest is the omitted regional reference category.
Statistical significance: *$p < .1$, **$p < .05$, ***$p < .01$.

PBPY costs. These data suggest that attempting to identify practices with low costs and high quality is very difficult as costs and quality are not related and the quality measures have considerable variation.

Our next analysis seeks to gain insights into the indirect influence of these practice attributes on costs through care coordination and management pathways.

Screening and Monitoring Measures. Our first analysis focuses on the association of practice characteristics with measures of screening and monitoring. As shown in Table 4, physician-owned practices have significantly better scores on all three screening and monitoring measures at the 0.10 level of significance minimally, compared to hospital-owned practices. "Other" owned practices also outperform hospital-owned practices on two of the three screening and monitoring measures. EHRs are associated with better HbA1c measures, but not CVD-LDL or colon cancer screening. Practices

Table 4: Screening and Monitoring Measures

Variable	*HBA1C Rate Parameter Estimate*	*CVD-LDL Rate Parameter Estimate*	*Colon Cancer Screening Rate Parameter Estimate*
FTE physicians	−0.0004	−0.0003	0.00002
Nonphysician providers per physician	−0.0451	−0.0362	−0.0235
Electronic health record (EHR)	0.1310***	0.0068	0.0114
Years of EHR	−0.0072	0.0028	−0.0003
Physician owned†	0.2186***	0.0311**	0.0144*
Other owned†	0.1783*	0.0348	0.0391**
Primary care only‡	−0.0208	−0.0049	−0.0189**
Rural	−0.0678*	−0.0506***	−0.0142*
Eastern Midwest§	−0.0044	0.0527***	0.0264**
Far West‡	0.0762	0.0384**	0.02178*
Lower Midwest§	0.0989*	0.0495**	0.0325***
Northeast§	−0.1404**	0.0704***	0.0574***
Rocky Mountain§	−0.1057	−0.0581**	0.0116
Southeast§	0.1181**	0.0984***	0.0629***
Constant	0.5640***	0.6270***	0.1208***
R-squared	0.288	0.213	0.147

†Practices owned by hospitals or integrated delivery systems are the omitted reference category.
‡Multispecialty practices are the omitted reference category.
§The Upper Midwest is the omitted regional reference category.
Statistical significance: *$p < .1$, **$p < .05$, ***$p < .01$.

limited to primary care have lower colon cancer screening rates but do not differ from other practices on the other screening rates. Practices located in rural areas have significantly lower rates for all three screening and monitoring measures.

Neither the number of FTE physicians nor the use of nonphysician providers is associated with any of the screening or monitoring measures. The regional effects are mixed, although the lower Midwest and Southeast are higher on all three measures than the upper Midwest (reference category).

Avoidable Utilization. In contrast to the screening and monitoring measures, practice ownership has little effect on avoidable utilization, once the effects of the screening and monitoring measures are included in the model (Table 5).

Table 5: Avoidable Utilization

Variable	*Ambulatory Care Sensitive Hospitalization Rate Parameter Estimate*	*Emergent-Primary Care Treatable ED Rate Parameter Estimate*	*Nonemergent ED Rate Parameter Estimate*
FTE physicians	0.0003	−0.00002	0.00001
Nonphysician providers per physician	0.0140	0.0056	0.0048
Electronic health record (EHR)	−0.0158*	−0.0041***	−0.0046**
Years of EHR	0.0004	0.0006***	0.0007***
Physician owned†	−0.0143	0.0007	0.0016
Other owned†	−0.0432	0.0022	0.0008
Primary care only‡	−0.0026	0.0006	0.0010
Rural	0.0080	0.0052***	0.0059***
Eastern Midwest§	0.0535***	0.0022	0.0034
Far West‡	−0.0069	0.0008	0.0033
Lower Midwest§	0.0455**	0.0030	0.0037
Northeast§	0.0597**	0.0006	0.0013
Rocky Mountain§	−0.0243	−0.0009	0.0024
Southeast§	0.0319	−0.0013	−0.0021
HbA1c	−0.0585***	−0.0116***	−0.0351***
CVD-LDL	−0.3268***	−0.0253**	−0.0351***
Colon cancer screening	0.2217**	0.0435***	0.0582***
Constant	0.3355***	0.0553***	0.0864***
R-squared	0.252	0.198	0.414

†Practices owned by hospitals or integrated delivery systems are the omitted reference category.
‡Multispecialty practices are the omitted reference category.
§The Upper Midwest is the omitted regional reference category.
Statistical significance: *$p < .1$, **$p < .05$, ***$p < .01$.

Table 6: Risk-Adjusted Cost and Practice Net Revenue

Variable	*Risk-Adjusted Cost Parameter Estimate*	*Net Revenue Parameter Estimate*
FTE physicians	−0.001	−0.00000007
Nonphysician providers per physician	279.46	−0.0594
Electronic health record (EHR)	21.97	−0.0110
Years of EHR	−2.83	.00614**
Physician owned†	−59.10	0.0212
Other owned†	−576.47	0.0347
Primary care only‡	−90.58	−0.0130
Rural	182.58	0.0275
Eastern Midwest§	−623.96**	−0.0336
Far West‡	−823.29***	−0.0231
Lower Midwest§	224.17	−0.0260
Northeast§	−567.69**	0.0004
Rocky Mountain§	−314.71	0.0034
Southeast§	−594.19**	−.10182***
ACS admission rate	5,538.40***	–
Emergent, primary care treatable ED visits	3,708.29	–
Nonemergent ED visits	2,848.83	–
Risk-adjusted cost	–	0.000005
Constant	−677.63	0.4001***
R-squared	0.297	0.161

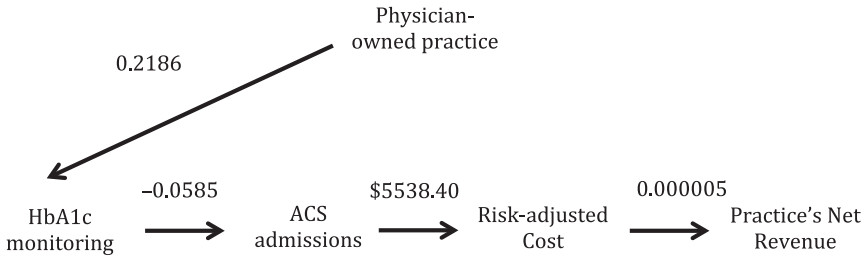
†Practices owned by hospitals or integrated delivery systems are the omitted reference category.
‡Multispecialty practices are the omitted reference category.
§The Upper Midwest is the omitted regional reference category.
*$p < .1$, **$p < .05$, ***$p < .01$.

However, the presence of an EHR is now statistically and negatively associated with all three measures of avoidable utilization, possibly resulting from better management of diabetic patients. But among practices with EHRs, the years of experience with the EHR is *positively* associated with avoidable ED visits. Beneficiaries attributed to rural practices have more avoidable ED visits.

All of the screening and monitoring measures are significantly associated with avoidable utilization.[7] Better HbA1c and CVD-LDL monitoring are associated with lower levels of avoidable utilization, but higher rates of colon cancer screening are *positively* associated with all three measures of avoidable utilization.

Risk-Adjusted Cost and Net Revenue. None of the practice characteristics except the geographic variables are directly associated with PBPY Medicare costs

Figure 2: The Indirect of Effect of Physician-Owned Practices on Costs



once effects of the avoidable utilization measures are controlled (Table 6). An ACS admission adds approximately $5,538 to PBPY costs. Avoidable ED visits also add to cost, but the effects are not statistically significant.[8]

Although some of the increase in risk-adjusted cost to the Medicare program could represent revenue to the practice, risk-adjusted costs are not significantly associated with the practice's net revenue. Practices with more years of experience with EHRs have higher net revenue, possible because they tend to have higher levels of avoidable utilization.

DISCUSSION

We examine the relationship between characteristics of physician practices and measures of quality and cost, as well as the practice's net revenue. We find that practice characteristics affect mainly screening and monitoring measures, with subsequent indirect effects on avoidable utilization and cost.

The wide variation in average PBPY costs in our data indicates the potential for substantial cost savings and quality improvement. Neither identifying nor "producing" high-quality, low-cost practices is likely to be easy, however. Although we find that a number of practice characteristics are associated with better screening and monitoring measures, those practice characteristics are not highly correlated among themselves, nor are they especially helpful in direct identification of practices with lower levels of avoidable utilization or lower risk-adjusted cost. Instead, the effects of practice characteristics on risk-adjusted costs appear to work their way through a series of mediating relationships.

Consider, for example, the effect of physician-owned practices on risk-adjusted costs, operating through the effect of HbA1 monitoring on ACS

admissions—one of the strongest pathways in the model. The corresponding regression coefficients are shown in Figure 2.

The regression coefficients are partial derivatives and so the effect of this (partial) pathway, controlling for the effect of other variables, indicates that PBPY costs in physician-owned practices are \$71 ($(0.2186 \times -0.0585 \times \$5538.40 = \$71)$ less expensive to Medicare than in hospital-owned practices. The effect of physician ownership on the practice's net revenue is negligible, due to the small coefficient linking risk-adjusted cost to net revenue (0.000005).

A similar calculation for CVD-LDL monitoring produces an estimated reduction of \$56 PBPY for physician-owned practices, while increased colon cancer screening results in an *increase* of \$40 PBPY in Medicare costs due to the positive relationship between colon cancer screening and ACS admissions. Thus, the estimated difference in risk-adjusted cost for physician-owned practices versus hospital-owned practices (limited to statistically significant regression coefficients) is $\$71 + \$56 - \$40 = \$87$.

The \$87 estimate is far below the statistically insignificant point estimate of the direct effect of physician ownership \$281 in Table 3. Comparison of those two estimates suggests that there are additional ways in which physician ownership affects risk-adjusted cost, but those additional ways contain substantial statistical noise, adding considerable uncertainty to the estimated direct effect.

Rural practices have higher PBPY cost in Table 2, but these differences are no longer significant when ACS hospital admissions are accounted for in Table 6. It appears that ACS hospital admissions accounts for much of the rural cost differences. However, *regional* cost differences remain after ACS admissions and inappropriate ED visits are accounted for, suggesting that these differences result from pathways other than coordination and management of care. Moreover, these differences are significant, even though the data are risk adjusted.

Our results suggest caution in specifying desirable practice characteristics. The ACO program in Medicare, for example, appears to embed the assumption that large multispecialty organizations centered on hospitals will be best positioned to devise and implement improved care delivery systems. Our results, in contrast, suggest that physician-owned and "other"-owned practices are associated with better screening and quality measures than hospital-owned practices.

We find no evidence that the size of the practice, measured either in terms of FTE physicians or number of beneficiaries attributed to the practice,

is associated with better quality or lower cost. Nor are there substantial differences between multispecialty practices and primary care–only practices except for colon cancer screening rates.

In our data, increased use of nonphysician providers is not associated with better screening or monitoring measures, reduced levels of avoidable utilization, increased Medicare revenue (risk-adjusted cost), or improvements in net revenue. Initiatives that do not have a positive return on investment for the practice may be short-lived or limited in their adoption. It would be helpful to know more about the return on investment for nonphysician providers in the commercial insurance sector and the ways in which physicians use these clinicians in their practices.

If policy makers want to encourage higher performance among physician practices, then incentive payments may be helpful, but our results suggest that rather than rewarding the acquisition of particular practice characteristics such as larger size, use of EHRs, multispecialty organization, or use of nonphysician providers, it might be better simply to reward physicians directly for better screening and monitoring, lower levels of avoidable utilization, and lower risk-adjusted cost.

Our study has several important limitations. Although our sample provides a unique link between practice-level variables and Medicare claims, the sample of practices is not necessarily nationally representative. Second, our practice-level variables were limited to those collected by MGMA as part of their ongoing surveys of physician practices. These limitations underscore the need for a national sample of data on physician practices that links practice characteristics to claims data for both publicly and privately insured patients. Third, as noted earlier, many of the practice-level characteristics represent endogenous choices by the practices. This is a common problem in organizational research and limits our ability to make statements about the causal effect of changing a practice characteristic from one value to another.

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NOTES

1. The particular screening and monitoring measures we chose are those that are computable from claims data. Our hypothesis is not that these specific screening and monitoring measures are associated with specific types of avoidable utilization. Instead, the screening and monitoring measures are taken to be indicators of a practice's general propensity to provide preventive and maintenance care.
2. We also computed the number of beneficiaries attributed to the practice. We found that it, like the number of FTE physicians, was insignificant in all regressions.
3. The GPCI adjusts Medicare payments for factors that are beyond the practice's control.
4. We tested a measure of breast cancer screening but found that it generally was insignificant.
5. The 2.14 figure in Table 1 refers to years the EHR has been in place across all practices, including zeros for those without an EHR.
6. Had we not aggregated costs to the practice level and eliminated practices with missing data, the mean of the risk-adjusted cost variable, being a regression residual, would be zero.
7. The coefficients in Table 5 represent the effect of a one unit change in the screening and monitoring measures, for example, from 0.00 to 1.00 or "none" to "all" of the eligible beneficiaries receiving the test.
8. We tested for a direct effect of the screening and monitoring measures on risk-adjusted cost and found no effect for HbA1c. However, CVD-LDL tested was negatively and significantly associated with risk-adjusted cost, and colon cancer screening was positively and significantly associated with risk-adjusted cost. Neither the screening and monitoring measures nor the measures of avoidable utilization had statistically significant association with the practice's net revenue.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.