Title
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What role does efficiency play in understanding the relationship between cost and quality in physician organizations?

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Abstract

Background—The belief that there is inefficiency, or the potential to improve patient health at current levels of spending, is driving the push for greater value in health care. Previous studies demonstrate overuse of a narrow set of services, suggesting provider inefficiency, but existing studies neither quantify inefficiency more broadly nor assess its variation across physician organizations (POs).

Methods—We used data on quality of care and total cost of care from 129 California POs participating in a statewide value-based pay-for-performance program. We estimated a production function with quality as the output and cost as the input, using a stochastic frontier model, to develop a measure of relative efficiency for each PO. To validate the efficiency measure, we examined correlations of PO efficiency estimates with indicators representing overuse of services.

Results—The estimated production function showed that PO quality was positively associated with costs, although there were diminishing marginal returns to spending. A certain minimum

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level of spending was associated with high quality even among efficient POs. Most strikingly, however, POs had substantial variation in efficiency, producing widely differing levels of quality for the same cost.

Conclusions—Differences among POs in the efficiency with which they produce quality suggest opportunities for improvements in care delivery that increase quality without increasing spending.

Keywords

Value-based purchasing; health care value; quality of care; health care costs

INTRODUCTION

Public and private sector policy makers have set as a goal improving value in health care. They are deploying an array of policy levers aimed at reducing costs and increasing quality, such as making performance information transparent in the marketplace and paying providers based on performance. The U.S. Department of Health and Human Services recently established value-based payment goals for Medicare to motivate providers to deliver higher-value care, tying payment to quality and value through the use of alternative payment models[1]. The Medicare Access & CHIP Reauthorization Act of 2015[2] established a new value-based framework for paying physicians. Under the Merit-Based Incentive Payment System, physicians will be evaluated and paid differentially based on their performance on a composite measure of quality, resource use, advancing care information (meaningful use of health information technology (HIT)), and clinical practice improvement. Private payers are also adopting value-based performance incentives, as illustrated by the largest private sector value-based pay-for-performance program administered in California by the Integrated Healthcare Association (IHA). Public report cards are evolving to report provider performance on both quality and costs[3].

The push for greater value in health care is based on a belief that there is inefficiency in care delivery -- that quality of care and patient health can be improved at current levels of spending. Figure 1 illustrates the concept of inefficiency. The solid arc represents the highest quality of care achievable at a given cost. For purposes of illustration, we assume for the moment this arc is known without error. In this case, quality increases as cost increases, but with diminishing returns. The open circles represent two providers of quality, q, but with different costs, a and b. The highest quality achievable at costs a and b are represented by vertical dotted lines. For a given cost, one minus the length of the vertical dashed line divided by the length of the vertical dotted line represents the inefficiency, or the difference between the actual level of quality and the maximum quality possible for a given cost. A provider with cost a delivers care more efficiently than one with cost b.

Direct evidence for inefficiency comes from studies that document the overuse of clinical services such as emergency department visits[4], inappropriate antibiotic prescribing[5], or imaging[6]. However, these studies neither quantify the degree of inefficiency more broadly nor assess its variation across physician organizations (POs).

Indirect evidence comes from studies that examine the association between cost and quality. A systematic review concluded that most studies of the association between cost and quality find small-to-moderate associations, both positive and negative[7]. Weak and inconsistent cost-quality relationships indicate variations in provider efficiency. An efficient high-cost provider may deliver higher quality care than an efficient low-cost provider, if the former uses the additional resources to provide evidence-based care that is beneficial to patients, but an inefficient high-cost provider may deliver care of similar quality to a low-cost provider, if the former uses the additional resources to provide largely unnecessary care.

To improve our understanding of the cost-quality relationship, we examined the relative quality efficiency, or the relative efficiency with which POs participating in a statewide value-based pay-for performance and public reporting program produce quality at a given level of cost. These POs aim to deliver high-value care through better coordination across providers and settings of care. Our cost measure reflects care delivered in hospitals, primary and specialty care, pharmacy and ancillary services. Specifically, we used a stochastic frontier model[8–12] to estimate a production function with quality as the output and cost as the input. The estimated production function captures the relationship between cost and quality for maximally efficient POs, and the stochastic frontier approach enables us to assess each PO's efficiency by comparing its observed performance to the production function. Our study addresses two main questions: (1) How does quality of care change as a function of cost along the production function, that is, for maximally efficient POs? (2) Is there variation in quality among POs for a given cost? That is, does the level of efficiency in producing quality vary for a given cost? We assess the validity of our efficiency estimates by examining their association with commonly accepted clinical indicators of excessive healthcare spending and with greater use of health information technology, which has been found to support reductions in spending.

DATA AND METHODS

Data

We used 2013 cost and quality data for 129 multi-specialty POs that participated in the California Integrated Healthcare Association's (IHA) Value Based Pay for Performance program and were eligible for the IHA Excellence in Healthcare Award[13], which recognizes POs for strong performance on each of three domains: clinical quality, patient experience, and total cost of care (TCC). The POs are distributed throughout the state and serve more than 2.5 million commercially-insured health maintenance organization (HMO) and point-of-service (POS) patients across 7 health plans. The median (mean) size of the participating POs was 11,580 (19,660) patients, with an interquartile range of 5,570–23,750. The POs represent a mix of medical group and independent practice association types of physician organizations.

Measures of Cost and Quality

PO total cost of care (TCC) measures the average total annual cost to health plans and patients who provide payment to providers who are caring for patients attributed to the PO. This includes care provided by the PO as well as other providers for hospital, ambulatory, prescription drug, and ancillary services. TCC also includes some administrative payments and adjustments like stop loss and capital investments. PO-level TCC is estimated by computing the total cost per patient incurred for each of the plans with which the PO contracts and then aggregating across the plans to generate the average TCC for that PO. The TCC is adjusted to account for differences across POs in patient age, gender, and health status. Patient-level relative risk scores (RRS) are computed using the DxCG Relative Risk software[14]. RRS is normalized so that a RRS of 1.0 represents the average risk across the whole Value Based Pay-for-Performance population. RRS for patients attributed to a PO are combined to calculate PO-level RRS scores. The PO-level TCC is the sum of patient-level observed costs for all patients in the PO divided by the sum of patient-level expected costs for those patients, which is then multiplied by the population average cost, where expected cost for a patient equals the normalized RRS for the patient multiplied by the population average cost, and where the population average cost is the sum of observed costs for all patients in the population divided by the sum of member years enrolled for all patients. TCC is further adjusted for geographic differences in input costs using the Centers for Medicare and Medicaid Services' hospital wage index.

Our quality measure is based on two scores for each PO. The clinical score summarizes performance on 23 clinical measures (Supplementary Digital Content (SDC) Table 1) based on *audited* health plan and PO self-reported data. The patient experience score summarizes six measures (SDC Table 1), based on the national standard CAHPS® Clinician & Group patient experience survey. The overall quality composite score is an equally-weighted average of the clinical and patient experience scores. Measures were included in IHA's program if they addressed clinical priority areas plus met criteria of importance, scientific acceptability, feasibility, usefulness, and alignment with other measurement initiatives. Details about the measures are available elsewhere[14]. We followed IHA's data validity criteria, *i.e.,* for clinical quality a PO's rate is valid if it has a denominator of at least 30 and is not biased (as determined by the auditor); for patient experience, rates are considered usable if they have reliabilities of at least 0.70. Similar to IHA's Value Award, a PO must have valid results available for half or more of the measures used to be in the analysis to generate the summary measure of quality. Consistent with the NCQA HEDIS measure specifications on which the Value Based Pay-for-Performance measures are based, clinical measures were not risk-adjusted for patient characteristics.

Estimating the Production Function

Unlike the solid arc in Figure 1, the actual maximum level of quality achievable for a given cost is unknown, and there could be random factors beyond the control of POs that induce statistical noise in the data.[15] We used a stochastic frontier model to estimate a production function for POs, with quality as the output and TCC as the input. Stochastic frontier modeling[8–12] is a technique for estimating the production frontier, which represents the maximum level of quality achievable for a given TCC. The stochastic frontier model enables us to estimate the shape of the production frontier and the relative efficiency with which each PO delivers quality of care, while allowing for random variation in PO performance relative to the theoretical frontier. Provider efficiency is the quality level achieved divided by the maximum quality possible for a given cost, ranging from 0% (not efficient at all) to 100% (maximally efficient).

We modeled the PO quality as a function of TCC and number of PO enrollees. To estimate the production frontier, we used a standard Bayesian frontier modeling approach,[9] regressing the natural logarithm of quality on the natural logarithm of TCC and the natural logarithm of PO enrollment:

$$\ln(Q_i)=\beta_0+\beta_1\ln(C_i)-\beta_2\ln(n_i)-u_i+\varepsilon_i,$$

where Q_i is average quality of care delivered to patients by provider i, C_i is the average TCC, n_i is enrollment, u_i and ε_i are the two components of the error term (see below), and β_0, β_1, and β_2 are coefficients to be estimated. β_1, captures how quality of care changes with cost along the production function, holding enrollment constant. A positive coefficient indicates that quality increases with TCC, and a coefficient between 0 and 1 indicates diminishing returns to additional spending. Similarly, β_2, captures how quality changes with PO enrollment, holding cost constant. A positive coefficient indicates that, for a fixed amount of spending per patient, quality improves as enrollment grows, consistent with economies of scale. Given recent recommendations to consider adjustment of cost and quality measures for patient socioeconomic status (SES),[16] sensitivity analysis included adding a measure of average neighborhood SES[17] of PO enrollees as an adjustment variable to assess whether it meaningfully changed inefficiency estimates.

The stochastic frontier model error term is decomposed into two components. One component, ε_i, is modeled as normally distributed with mean zero and captures random error. The other term, u_i, is modeled as truncated normal, restricted to be positive, and captures inefficiency, i.e., the distance between a PO's actual level of quality and the estimated production frontier.

Details of the model, computations, and sensitivity analyses are described in the SDC.

Validating the Inefficiency Estimates

To validate the frontier-based PO efficiency estimates we examined their correlations with five commonly agreed to indicators of excess healthcare spending representing the overuse of services such as inappropriate care or avoidable events: inappropriate prescribing of antibiotic treatment for acute bronchitis[5]; overuse of imaging studies for low back pain[18]; inappropriate antibiotic prescribing for treatment of children with upper respiratory infection[19]; all-cause readmissions[20]; and emergency department (ED) visits[4]. We expected negative correlations between PO efficiency and these measures. We correlated PO efficiency with meaningful use of health information technology (HIT), which some studies have found to be associated with reduced spending[21–23]. We expected a positive correlation between PO efficiency and meaningful use of HIT.

RESULTS

Descriptive statistics—TCC ranged $2472–$5824 across POs. Quality composite scores ranged 0.50–0.74 (on a 0–1 scale) (Table 1), with clinical and patient experience sub-composites having similar ranges (0.61–0.76 and 0.64–0.74, respectively). Summary statistics for the individual measures of the quality composite are shown in SDC Table 1.

How does quality of care change with cost along the production function, that is, for maximally efficient POs?

The estimated coefficient of TCC in the production function was β_1=0.175 (95% probability interval, 0.081–0.266), indicating that quality increases with TCC but with diminishing returns to additional spending. The estimated coefficient of enrollment was β_2=0.030 (95% interval, 0.017–0.044), suggesting that POs enjoy economies of scale - that is, quality improves as enrollment grows, holding spending per patient constant. Figure 2 displays an estimate of the maximally efficient production frontier by PO enrollment. The maximum level of quality a PO can produce for a given cost increases with PO enrollment.

Is there variation in quality among POs for a given level of cost?

Figure 3 shows a range of quality for given levels of spending, which is most clearly seen for TCC between $3500 and $4000. Corresponding to the variation in quality for given spending levels, our efficiency estimates ranged from 77% to 98% *(mean=89%)* across the 129 POs in the study.

Providing the highest quality of care required both a minimum level of spending well above the lowest TCC in the data and high efficiency. The 11 POs with quality scores exceeding 0.70 had a TCC of at least $3691 (range, $3691–$5237) and efficiencies of at least 95%. Conversely, no PO with TCC lower than $3600 had a quality score above 0.68.

The correlation of TCC and the quality composite was 0.27 (p=0.002). However, among the 61 POs with efficiencies of 90% or greater – those closest to the production frontier – the correlation of quality and TCC was 0.58 (p<.0001).

Are PO efficiency estimates associated with indicators of inappropriate care and use of HIT?

Of five measures previously found to be associated with inappropriate care or overuse of care, four were significantly negatively correlated with our efficiency estimates (Table 2). The exception was all-cause readmissions, a measure that is limited in its applicability to the 4.7% of the commercially-insured population with hospitalizations. PO efficiency was significantly positively correlated with meaningful use of HIT.

Sensitivity Analyses

We compared our results to those from a translog production function specification, which allows for a more flexible functional form than the specification we used[24]. Goodness-of-fit, assessed using deviance statistics, was essentially identical for both models. The efficiency estimates from the two models were very highly correlated (r=0.98) and essentially equal.

Thus, the additional complexity of the translog model is unwarranted. We repeated our analyses using a half-normal distribution, rather than a truncated normal, for u_i. Goodness-of-fit was better for the truncated normal model. When adjusting for PO average patient SES, efficiency estimates were similar to those when SES was not included in the model (correlation=0.92). More details provided in the SDC.

DISCUSSION

We examined the relationships among cost, quality, and efficiency of health care delivery for POs in California that are being incentivized to reduce costs and improve quality. Similar to other studies, our first key finding is that the correlation between cost and quality across all POs was positive, but only weak to moderate in strength. The correlation is low (0.27) when all POs are included in the analysis and much higher (0.58) for highly efficient POs. This illustrates that findings for the association between quality and cost can be misleading when efficiency is not taken into account. We also found that the benefit of additional spending diminishes with each additional dollar. Our estimates of the production frontier suggest that gains in quality are possible for all cost levels observed in the study.

Our second key finding is that POs vary widely in the quality of care they provide for the same cost. POs providing the highest quality care had relatively high efficiencies and at least $3500 average annual per-patient spending. No POs with costs below this level are among those with the highest quality scores. These findings suggest that there is a level of annual per patient spending below which delivering the highest quality of care is difficult irrespective of the level of efficiency attained by a PO. Many measures included in the composite quality score are prevention and screening measures; however, the literature is mixed on demonstrating that preventive care saves money in the near[25]- or long-term[26]. Our findings are consistent with the subset of quality-cost relationships found in other contexts that are positive[7].

Several indicators of overuse of services were negatively associated with efficiency. Additionally, meaningful use of HIT to reduce unnecessary care and smooth patient transitions was positively associated with efficiency. The correlation of efficiency and delivery of treatments widely regarded as indicative of wasteful care demonstrates the validity and potential usefulness of our efficiency measure.

Our study is the first to apply stochastic frontier modeling to examine efficiency for POs. Our focus differs from the traditional frontier modeling that has predominately been applied to examine efficiency[8,27] of hospitals[28], where the objective is to understand the relationship between the number and types of patients treated by hospitals and hospital costs. The efficiency estimates we generated can help to better understand how efficiency, cost, and quality relate to one another and may be useful in accountability applications that aim to encourage better care coordination across providers and care settings. Valid efficiency measures would be valuable for stakeholders, such as an administrator for a pay-for-performance program, who might wish to summarize succinctly cost and quality measures and understand how PO efficiency varies within a market.

Similarly, patients are increasingly responsible for larger shares of the cost of care through increased premium contributions and rapid growth in high-deductible health plans. A well-designed public report card can help patients identify higher-value providers[29]. An efficiency metric could encourage cost-constrained patients to choose the most efficient providers within their choice set. It could also guide health plans to strategically expand coverage by choosing providers with the highest efficiency for a given level of cost. However, efficiency reporting alone should not supplant cost and quality information, as demonstrated by our findings that no POs with relatively low costs are among those with the highest quality scores.

Our study has several limitations. First, stochastic frontier estimation works best when the output in the production function is homogeneous[11]. Heterogeneity of output across POs may arise due to differences in the types of patients treated by different POs, so that it is more difficult for some POs than for others to provide high quality. To the degree these differences are not captured by the adjustment for patient mix in the TCC measure, our efficiency measure may be biased.

Second, in typical production function studies the inputs used are the various types of inputs hired by the entities under study. In an analysis of POs these might include physicians and other staff, office space, different types of equipment, etc. Although these inputs would be appropriate for a typical production function study of POs, our study is different in two ways: the output we consider is a measure of clinical quality of care, and we are interested in the relationship between the payments POs and their referred providers receive to treat patients and the quality of care patients receive. Using TCC, which is a weighted metric of the average payments received by a PO and its referred providers in treating its patients, is an appropriate aggregate input for this type of study.

Third, we could only estimate PO efficiency relative to the most efficient POs based on the data. We have no way of determining whether all POs in the data fell short of a theoretically possible but unobserved maximum performance level. Consequently, we provide estimates of relative rather than absolute efficiency.

Fourth, our quality measure was constructed using 23 clinical and 6 patient experience measures. There are other important areas of health care that are not included in our measure, such as risk-adjusted mortality rates. For other applications, alternative weightings of the measures from what was presented here might be more desirable, such as greater weight on clinical measures, or larger relative weights on specific individual measures. Some measures were omitted from different PO composites if the PO did not have the minimum number of patients required for that measure, which would also lead to differential weighting of measures relative to POs eligible for reporting on all measures.

Fifth, our ability to assess the validity of our efficiency measure was limited by available measures of overuse, inappropriate use, and meaningful HIT use. These measures are monitored by IHA as part of their program and used to determine shared savings with POs.

Finally, our findings are limited to POs in commercial HMO and POS plans in California.

To summarize, we observed differences among POs in the efficiency with which they produce quality. While either lowering costs while maintaining quality or increasing quality without increasing spending would increase value, the approaches used to encourage providers to increase value must be sharp enough to improve efficiency rather than reducing both necessary and unnecessary care. Thus the focus should be on identifying the sources of inefficiency and targeting these areas for improvement. Additional research on where efficiencies exist and features of POs associated with efficiency would help in developing and targeting strategies to improve value. Our study does not address the question of the "right" cost-quality combination on the production frontier where an efficient PO should aim to operate. This can only be answered by determining how much Americans are willing to spend for increments in the quality of health care.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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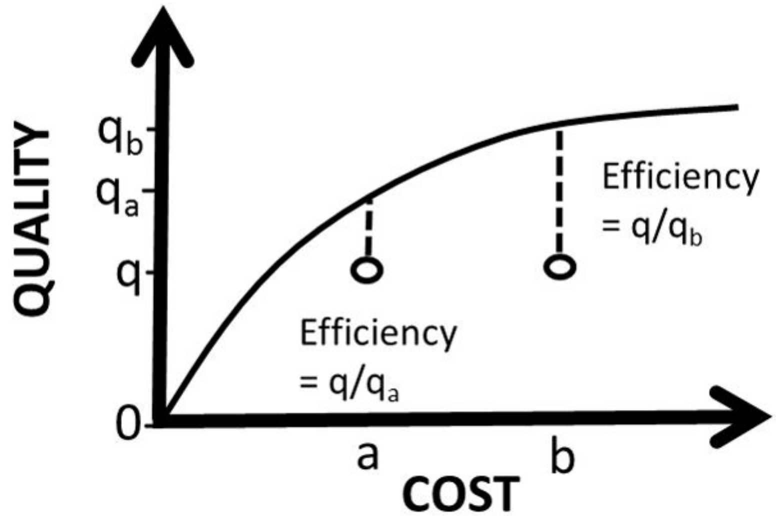

Figure 1.

Illustration of inefficiency. Solid curved line represents the highest quality of care, q, achievable for a given cost. Open circles represent two providers with different costs, a and b, but having the same quality, q. The relative length of the dashed line versus the dotted line for each cost represents the inefficiency of providing quality q at the given cost

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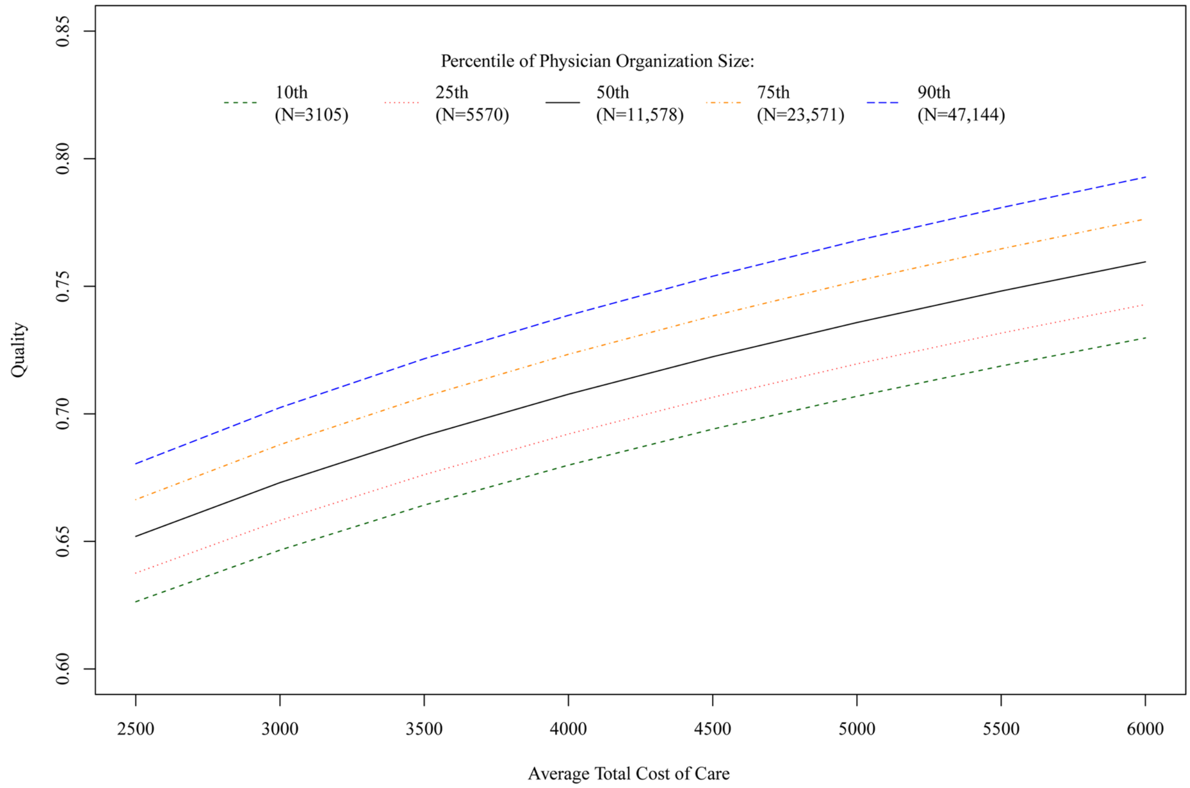

Figure 2.

Efficient frontier for physician organizations, by physician organization size

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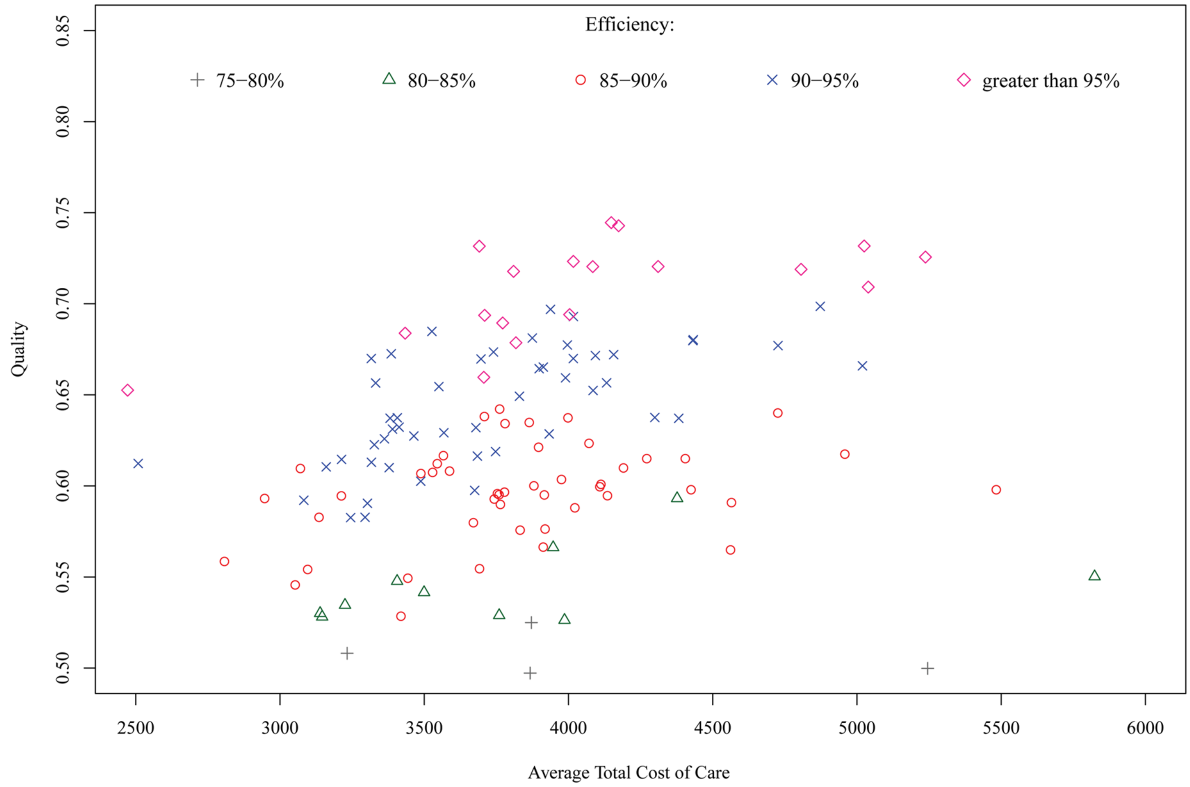

Figure 3.
Association of quality (vertical axis), cost (horizontal axis) and physician organization efficiency (plotting symbols)

Table 1

Cost, quality, and efficient care measures for N=129 physician organizations (P.O.s)

Measure*	N P.O.s	Mean	Standard deviation	Minimum	25th percentile	75th percentile	Maximum
Risk- and geography-adjusted total cost of care ($)	129	$3,837	$568	$2,472	$3,434	$4,085	$5,824
Quality composite score	129	0.624	0.056	0.497	0.593	0.666	0.745
Clinical score	129	0.609	0.082	0.359	0.560	0.672	0.765
Patient experience score	129	0.639	0.044	0.515	0.607	0.670	0.741
Inappropriate Use or Overuse of Care Measures^							
Inappropriate Antibiotic Treatment for Adults With Acute Bronchitis	118	0.535	0.163	0.180	0.429	0.640	0.908
Overuse of Imaging Studies for Low Back Pain	122	0.208	0.061	0.034	0.162	0.250	0.409
Inappropriate Treatment for Children with Upper Respiratory Infection	116	0.084	0.072	0.000	0.033	0.105	0.475
Emergency Department Visits (Observed-to-Expected Ratio)^	128	1.083	0.239	0.492	0.915	1.207	1.934
All-Cause Readmissions (Observed-to-Expected Ratio)^	129	0.775	0.327	0.000	0.621	0.912	2.059
Meaningful Use of Health Information Technology	119	0.691	0.253	0.000	0.500	0.938	1.000

* Measures reported on 0–1 scale unless otherwise noted;

^ Lower scores are better for these measures.

Source: Authors' analysis of 2013 data from the Integrated Healthcare Association.

Table 2

Correlations of efficiency measures with measures of inappropriate use or meaningful use of health information technology

Measure	N P.O.s	Correlation
Inappropriate Use or Overuse of Care Measures^		
Inappropriate Antibiotic Treatment for Adults With Acute Bronchitis	118	−0.21 *
Overuse of Imaging Studies for Low Back Pain	122	−0.32 ***
Inappropriate treatment of children with upper respiratory infection	116	−0.54 ****
All-cause Readmissions	129	0.13
Emergency department visits	128	−0.57 ****
Meaningful use of health information technology	119	0.39 ****

^ Lower scores are better for these measures.

* p<.05,

** p<.01,

*** p<.001,

**** p<.0001

Source: Authors' analysis of 2013 data from the Integrated Healthcare Association