

Relationship Between Quality Improvement Processes and Clinical Performance

Cheryl L. Damberg, PhD; Stephen M. Shortell, PhD, MPH, MBA; Kristiana Raube, PhD, MPH; Robin R. Gillies, PhD; Diane Rittenhouse, MD, MPH; Rodney K. McCurdy, MHA; Lawrence P. Casalino, MD, PhD; and John Adams, PhD

The lackluster performance of the US health system^{1,2} has led to several interventions, including provider profiling,³ transparency of performance information,⁴ and pay for performance (P4P),⁵⁻⁷ that are being implemented in an effort to close the quality gap. A key example is the Integrated Healthcare Association (IHA)'s P4P initiative, which is the largest P4P program in the United States, targeting 225 California managed care medical groups and independent practice associations (IPAs). The IHA's P4P program uses financial incentives and public reporting of performance scores to drive improvements in clinical quality, patient experience, and adoption of information technologies.⁸

Although these strategies are intended to stimulate changes by physician organizations (POs), POs face substantial challenges in understanding what investments they could undertake to improve performance scores and achieve success under P4P and public accountability schemes. It is unknown whether investments in chronic care management processes (CMPs), clinical information technology, or quality improvement (QI) activities are associated with better performance. The limited empirical evidence about what factors are associated with better performance hinders providers' investment decision making and our collective ability to close the quality gap.

To address this question, we examined the relationship between the use of organized processes to improve quality and PO clinical performance scores collected in the context of California's P4P program. We examined (1) the use of CMPs, (2) electronic medical record (EMR) capabilities, and (3) participation in externally organized QI initiatives, hypothesizing that greater use of these processes is associated with better clinical performance.

METHODS

Data Sources

We combined IHA clinical data with survey data from the 2nd National Study of Physician Organizations (NSPO2).⁹⁻¹¹ Among 225

unique IHA POs, 180 reported clinical data in 2006 for patients enrolled in commercial health maintenance organization and point-of-service plan products. The IHA's program allows POs the option of being scored using

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Objectives: To examine the association between performance on clinical process measures and intermediate outcomes and the use of chronic care management processes (CMPs), electronic medical record (EMR) capabilities, and participation in external quality improvement (QI) initiatives.

Study Design: Cross-sectional analysis of linked 2006 clinical performance scores from the Integrated Healthcare Association's pay-for-performance program and survey data from the 2nd National Study of Physician Organizations among 108 California physician organizations (POs).

Methods: Controlling for differences in PO size, organization type (medical group or independent practice association), and Medicaid revenue, we used ordinary least squares regression analysis to examine the association between the use of CMPs, EMR capabilities, and external QI initiatives and performance on the following 3 clinical composite measures: diabetes management, processes of care, and intermediate outcomes (diabetes and cardiovascular).

Results: Greater use of CMPs was significantly associated with clinical performance: among POs using more than 5 CMPs, we observed a 3.2-point higher diabetes management score on a performance scale with scores ranging from 0 to 100 ($P < .001$), while for each 1.0-point increase on the CMP index, we observed a 1.0-point gain in intermediate outcomes ($P < .001$). Participation in external QI initiatives was positively associated with improved delivery of clinical processes of care: a 1.0-point increase on the QI index translated into a 1.4-point gain in processes-of-care performance ($P = .02$). No relationship was observed between EMR capabilities and performance.

Conclusion: Greater investments in CMPs and QI interventions may help POs raise clinical performance and achieve success under performance-based accountability schemes.

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For author information and disclosures, see end of text.

Take-Away Points

Physician organizations are being exposed to incentives to drive improvements in quality, yet little is known about which investments may contribute to gains in clinical performance. Findings from this study suggest the following:

- Physician organizations that invest more heavily in care management processes such as patient registries, physician reminders and feedback, patient reminders and education, and case managers may achieve better performance scores.
- The use of organized quality improvement efforts such as participation in a quality improvement demonstration program may be associated with increased delivery of recommended care processes, which in the context of this study translated into better performance on the clinical measures that were rewarded in the pay-for-performance program.
- As performance-based accountability and payment become more prevalent, these study results suggest potential ways for physician organizations to improve the quality of care they deliver.

Analytic Approach

Dependent Variables. We constructed 3 dependent variables (diabetes management, processes of care, and intermediate outcomes) using an opportunities compositing approach, summing all instances in which recommended care was delivered or an outcome was achieved and dividing by the number of times that patients within a PO were eligible for relevant indicators in each composite measure.^{1,12} The mean scores range from 0 to 1 and reflect the percentage of opportunities that were

aggregated health plan encounter data or via audited PO self-reported data; self-reporting groups have higher scores than non-self-reporting groups in large measure because of greater data completeness. To eliminate possible bias due to differential reporting procedures, we used only health plan aggregated data for 14 clinical measures (PO-level numerators and denominators) that existed for all 180 POs.

Control variables included organization type (medical group or IPA), PO size, and percentage of revenue from Medicaid (details are provided in a [Technical eAppendix](#) available at www.ajmc.com). We hypothesize that (1) medical groups will perform better than IPAs because of greater integration of CMPs, (2) larger organizations will outperform smaller organizations owing to economies of scale and availability of resources to support QI, and (3) greater Medicaid revenue will be negatively related to performance because of the effect of lower reimbursement, which hinders investments in organized care processes, and challenges in caring for low-income or disabled patients.

Data on organization characteristics and QI processes were collected in the NSPO2 telephone survey conducted between March 2006 and March 2007 among all US POs that had 20 or more physicians and that treated patients with asthma, diabetes, congestive heart failure, or depression. Of 218 California POs with usable contact information, 20 were classified as ineligible (was out of business, did not treat 1 of the target diseases, or had no contact information). The survey response rate for the remaining 198 POs was 64.1%. We matched 127 California NSPO2 respondents with 180 POs having IHA clinical scores, resulting in a final sample of 108 POs. We found no significant differences between these 108 POs and 72 POs with IHA clinical data and without NSPO2 data in terms of medical group or IPA structure and the number of physicians in the group; however, the 108 POs were more likely to have greater enrollment, have fewer Medicaid enrollees, and be located in northern California. RAND Corporation's Human Subjects Protection Committee approved the study.

The individual measures were constructed using National Committee for Quality Assurance Health Employer Data and Information Set specifications.¹³ The diabetes management composite reflected screening and control measures, the intermediate outcomes composite incorporated outcomes for coronary artery disease and diabetes, and the processes-of-care composite included 11 clinical measures (preventive screens, immunizations, asthma maintenance, and upper respiratory tract infection).

Independent Variables. We included the use of CMPs, EMR capabilities, and participation in external QI initiatives as index variables. The CMP measures, based on the chronic care model by Wagner et al,^{14,15} captured whether the PO used or provided the following: (1) electronic registries or patient lists, (2) guideline-based reminders, (3) feedback data to physicians, (4) patient reminders for follow-up care, (5) nonphysician staff to educate patients about CMPs, and (6) nurse case managers. A process-specific measure was constructed for each of these 6 CMPs (based on whether the PO used or provided the CMPs for diabetes, asthma, and congestive heart failure), resulting in a score ranging from 0 to 3 for each CMP. Construction of the CMP index was tailored to each dependent variable, with a diabetes-specific index ranging from 0 to 6 for the diabetes management composite, an index ranging from 0 to 18 for the processes-of-care composite, and an index ranging from 0 to 6 for the intermediate outcomes composite.

Electronic medical record capabilities were measured on an index ranging from 0 to 5 based on EMR components used by most PO's physicians such as ambulatory care progress notes or electronic prescribing.^{2,16-19} Participation in external QI initiatives was measured using an index ranging from 0 to 2 based on whether the PO participated in QI demonstration programs (eg, Bridges to Excellence,²⁰ Institute for Healthcare Improvement Quality Collaboratives,²¹ Pursuing Perfection,²² Improving Chronic Illness Care,²³ rapid-cycle QI activities²⁴).

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Table 1. Descriptive Statistics of Independent and Dependent Variables Among 108 California Physician Organizations

Variable	Value	Interquartile Range	Minimum, Maximum
Physician organization characteristics			
Medical group, No. (%)	38 (35.2)	—	0, 1 ^a
Physician organization size, mean (SD) [median]	333.26 (400.14) [232.50]	85.50-430.00	20, 2600
Log of physician organization size, mean (SD) [median]	5.22 (1.11) [5.44]	4.45-5.99	3.00, 7.86
% Of revenue from Medicaid, mean (SD) [median]	10.70 (19.87) [1.00]	0.00-10.00	0.00, 85.00
Electronic medical record capabilities scale, mean (SD) [median]	0.91 (1.50) [0.00]	0.00-1.00	0.00, 5.00
Quality improvement index, mean (SD) [median]	0.67 (0.78) [0.00]	0.00-1.00	0.00, 2.00
Diabetes management component, mean (SD) [median]			
Electronic registries or patient lists	0.81 (0.39) [1.00]	1.00-1.00	0.00, 1.00
Guidelines-based reminders	0.46 (0.50) [0.00]	0.00-1.00	0.00, 1.00
Feedback data to physicians	0.76 (0.39) [0.00]	0.00-1.00	0.00, 1.00
Patient reminders for follow-up care	0.48 (0.50) [0.00]	0.00-1.00	0.00, 1.00
Nonphysician staff to educate patients about CMPs	0.58 (0.37) [0.50]	0.50-1.00	0.00, 1.00
Nurse case managers	0.70 (0.46) [1.00]	0.00-1.00	0.00, 1.00
CMP index	3.79 (1.53) [4.00]	3.00-5.00	0.00, 6.00
Processes-of-care component, mean (SD) [median]			
Electronic registries or patient lists	2.33 (1.13) [3.00]	2.00-3.00	0.00, 3.00
Guidelines-based reminders	1.06 (1.28) [0.00]	0.00-2.00	0.00, 3.00
Feedback data to physicians	2.07 (0.99) [2.40]	1.50-2.70	0.00, 3.00
Patient reminders for follow-up care	1.34 (1.09) [1.20]	0.60-2.40	0.00, 3.00
Nonphysician staff to educate patients about CMPs	1.37 (0.96) [1.50]	0.50-2.00	0.00, 3.00
Nurse case managers	1.83 (1.29) [2.00]	0.00-3.00	0.00, 3.00
CMP index	10.04 (4.20) [10.20]	7.40-13.10	0.00, 18.00
Intermediate outcomes component			
CMP index, mean (SD) [median]	3.70 (1.52) [3.75]	3.00-5.00	0.00, 6.00
Dependent variables, mean (SD) [median]			
Diabetes management	0.62 (0.06) [0.62]	0.59-0.66	0.38, 0.72
Processes of care	0.69 (0.08) [0.70]	0.64-0.75	0.43, 0.86
Intermediate outcomes	0.48 (0.04) [0.48]	0.47-0.53	0.19, 0.57

CMP indicates chronic care management process.

^a1 Is medical group, and 0 is independent practice association.

The model controlled for differences in PO size, organization type (medical group or IPA), and percentage of revenue from Medicaid. Because of the skewed nature of PO size, this was specified as the natural logarithm of the number of physicians in the practice. **Table 1** gives descriptive statistics of the independent and dependent variables.

Statistical Analysis

We ran a multivariate ordinary least squares regression model weighted for different sample sizes of the denomina-

tor in the “opportunities” composite dependent variable to address heteroskedasticity that results from using aggregated data. Because the dependent variables are PO means, the equal variance assumption of the regression is violated if the sample sizes across POs are different, which could lead to the treatment of smaller POs as more important than they really are without the correction. We ran a Pearson product moment correlation matrix using a 2-tailed significance test to assess the degree of collinearity among the variables in the model. Weak associations were found between our indepen-

Table 2. Summary of Weighted Least Squares Regression Models

Variable	Diabetes Management Composite				Model 2 Processes-of-Care Composite (n = 108)		Model 3 Intermediate Outcomes Composite (n = 103)	
	Model 1a (n = 106) ^a		Model 1b (n = 106) ^b		Coefficient (SE)	P	Coefficient (SE)	P
	Coefficient (SE)	P	Coefficient (SE)	P				
Constant	0.570 (0.028)	<.001	0.577 (0.025)	.000	0.610 (0.030)	<.001	0.456 (0.013)	<.001
Organization type	0.030 (0.010)	.005	0.032 (0.010)	.001	0.046 (0.011)	<.001	-0.005 (0.005)	.32
Physician organization size	0.005 (0.004)	.29	0.006 (0.004)	.16	0.015 (0.005)	.002	0.002 (0.002)	.45
% Of revenue from Medicaid	-0.001 (0.000)	.15	0.000 (0.000)	.29	-0.001 (0.001)	.10	0.000 (0.000)	.80
Electronic medical record capabilities scale	0.004 (0.003)	.23	0.004 (0.003)	.14	0.005 (0.003)	.13	-0.002 (0.001)	.11
Quality improvement index	0.002 (0.006)	.70	0.001 (0.005)	.91	0.014 (0.006)	.02	-0.005 (0.003)	.06
Diabetes-specific, full CMP set (0-6)	0.006 (0.003)	.10						
Diabetes-specific, CMP (high investment; 1 = .5 to 6.0 CMPs, 0 = 0-5 CMPs) ^a			0.032 (0.009)	.001				
Full CMP set (0-18)					0.0001 (0.001)	.97		
CMP directly related to overall quality outcomes (0-6) ^b							0.006 (0.002)	<.001
F	4.45	.001	6.35	<.001^a	8.10	<.001	4.79	.001
Adjusted R ²	0.17		0.25		0.30		0.18	

CMP indicates chronic care management process; LDL-C, low-density lipoprotein cholesterol.

^aDichotomous specification of CMP variable.

^bIncludes CMP related to LDL-C level (<130 mg/dL) and glycosylated hemoglobin control (<9 g/dL) among patients with diabetes and LDL-C level (<130 mg/dL) among patients with cardiovascular disease.

dent variables (<±0.20) except for size and group structure (value, 0.42) and medical group and EMR capabilities (value, 0.38). Given the small sample, we used the *df*beta statistics in SAS (SAS 9.1; SAS Institute, Cary, NC) to test the sensitivity of our results to possible influential observations.

RESULTS

The signs on all coefficients were as hypothesized (Table 2), and the models achieved moderate predictive power (R² range, 0.17-0.30). The CMP index demonstrated significant positive associations with performance on 2 of the composite measures, namely, diabetes management and intermediate outcomes. Higher performance in diabetes management (3.2 points higher on a 0-100 performance scale) was associated with substantial investments in CMPs (>5 CMPs on a 0-6 scale); each 1.0-point increase on the CMP index translated into a 1.0-point gain for the intermediate outcomes composite (P <.001). Higher engagement in external QI initiatives was significantly positively associated with the processes-of-care component; a 1.0-point increase on the

QI index translated into a 1.4-point gain on the CMP index (P = .02). The results were robust to the removal of influential observations.

Among the control variables, medical group organization type was significantly associated with higher performance for 2 of the composite measures (3.0-4.6 points higher for medical groups compared with IPAs). Physician organization size was positively associated with higher performance on the processes-of-care composite (1.5 points) (P = .002). The median PO size was 168 physicians (minimum of 8 and maximum of 2207); therefore, the net effect of increasing the number of physicians within a PO from 10 to 100 physicians on the log scale would translate into a 3.5-point gain for the processes-of-care composite, with an effect size of 1.5 (Table 2). We observed no relationship between Medicaid revenue and performance.

DISCUSSION

Enhancing our understanding of the types of investments that will yield positive gains in performance is essential to en-

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abling POs and their physicians to improve care for patients. Although causality in a cross-sectional design cannot be established, the associations we observed in this broad sample of physician group practices suggest a positive relationship between clinical performance and the use of CMPs and involvement in external QI initiatives. A positive association was observed between the use of CMPs and clinical performance (approximately 1.0-3.2 points higher) for 2 of 3 composite clinical outcomes measured in this study. We assumed that the component parts of our CMP measure are equally valued; in other words, adding a patient registry has the same positive relationship with performance as providing patient feedback. A larger study could help to discern whether the differential contributions of specific CMPs such as disease registries or performance feedback to physicians are more important for improving clinical performance or whether the broader set of CMPs is required.

To a lesser extent, we found that involvement in external QI initiatives was associated with higher performance on the processes-of-care composite; each 1.0-point increase on the QI index translated into a 1.4-point gain in the processes-of-care composite score (score range, 0-100 points) ($P = .02$). Greater use of EMR capabilities was not associated with improved performance possibly because for many POs, EMR capabilities remain in their early phases of adoption and were not being readily applied for QI purposes at the time of this study. Other studies^{22,23} have found no relationship between EMR use and CMPs.

Among the control variables, large PO size seems to confer performance advantages, which is consistent with recent research suggesting that integrated and larger POs perform better on technical quality²⁴ and patient experience^{25,26} measures. Large-scale operations may signal a greater ability to bring resources to bear on QI and to invest in care management “capabilities” and systems support.

The study findings should be considered in light of several limitations. Although the relationship was tested in one of the largest measurement and improvement projects in the United States, the study focuses on the experiences of California POs. The replicability of these results may be influenced by differences in PO structures and market characteristics. In addition, the cross-sectional nature of this study precludes the ability to demonstrate a causal relationship between performance and the use of CMPs or external QI initiatives. The small sample size of POs among which to detect differences also limited the study; therefore, it will be important to replicate this work in other settings with a larger sample of provider practices. Moreover, the composite measures may act as a proxy for unmeasured attributes such as organizational culture²⁷ of groups that choose to invest in

more CMPs. Finally, it is possible that POs with particular patient mixes (eg, better educated and higher income) perform better. Because we did not have access to patient-level data, we were unable to assess this relationship.

Although the present findings suggest that the use of CMPs and, to a lesser extent, participation in external QI initiatives are associated with better clinical performance, the gains are modest. A stronger and broader set of interventions such as redesigned care structures and processes may be needed to achieve greater gains. The continuing evolution toward performance-based payment and other forms of accountability underscores the importance of physician practices developing the capabilities needed to successfully respond to the incentives.

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Author Affiliations: From RAND Corporation (CLD, JA), Santa Monica, CA; University of California, Berkeley (SMS, KR, RRG, RKM), Berkeley, CA; University of California, San Francisco (DR), San Francisco, CA; and Department of Public Health (LPC), Weill Cornell Medical College, New York, NY.

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Address correspondence to: Cheryl L. Damberg, PhD, RAND Corporation, 1776 Main St, PO Box 2138, Santa Monica, CA 90407-2138. E-mail: damberg@rand.org.

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TECHNICAL APPENDIX

Development of Control and Independent Variables

Table A1: Control Variables

Concept (Variable Name)	NSPO2 Survey Question(s) On Which Measure Is Based	Computation
Medical Group (mg1)	A1. Which of the following best describes your physician organization? 1 'Medical group' 2 'Medical group that owns or manages an independent practice' 3 'IPA' 4 'IPA that owns or manages a medical group' 5 'Academic general internal medicine clinic' 6 'Academic family practice clinic' 7 'Academic general pediatrics clinic' 8 'Community clinic' 9 'Other (Specify)	If A1 = 1,2,5,6,7,8,9, mg1=1 If A1 = 3,4, mg1=0.
Log of Number of Physicians. (log_size)	A2. At the present point in time, what is the total number of physicians practicing in your medical group across all its locations?	log_size=ln(A2).
% revenues Medicaid (f3)	F3. Approximately what percent of your annual revenues for patient care come from each of the following major sources of insurance coverage? % Medicaid	F3: % Medicaid
EMR Use, 0-5 (EMR_Use)	Are the majority of your physicians using the electronic record for ... B2. ambulatory care progress notes, 0='No' 1='Yes' B10. automatic alerts of potential drug interactions, 0='No' 1='Yes' B12. prompts and reminders at the time the physician is seeing the patient, 0='No' 1='Yes' B14. alerts on abnormal test results at the time they are received, 0='No' 1='Yes' B29. Does the majority of your physicians have the ability to transmit prescriptions via computer or PDA to pharmacies, 0='No' 1='Yes'	B2: if B2 = yes, 1 point B10: if B10 = yes, 1 point B12: if B12 = yes, 1 point B14: if B14 = yes, 1 point B29: if B29 = yes, 1 point EMR_Use=B2+B10+B12+B14+B29
Quality Improvement Index, 0-2 (QI_Index)	At present or within the past year, has your group participated in any of the following quality demonstration programs? E13. Bridges to Excellence, 0='No' 1='Yes' E14. A Institute for Healthcare Improvement (IHI) Quality Collaborative, 0='No' 1='Yes' E15. Pursuing Perfection, 0='No' 1='Yes'	QI_Program: If (E13=yes) or (E14=yes) or (E15=yes) or (E16=yes) or (E17=yes), QI_Program, 1 point C54: if C54 = yes, 1 point Compute QI_Index =

Concept (Variable Name)	NSPO2 Survey Question(s) On Which Measure Is Based	Computation
	<p>E16. Improving Chronic Illness Care (ICIC), 0='No' 1='Yes'</p> <p>E17. Does your group participate in any other quality demonstration programs with any organization external to yours? 0='No' 1='Yes'</p> <p>C54 Does your group use the rapid cycle quality improvement strategy? 0='No' 1='Yes'</p>	<p>QI_Program+C54 (range=0-2)</p>

Development of Control and Independent Variables (Continued)

Table A2: Independent Variables – Care Management Processes

Care Management Process (CMP)	NSPO2 Survey Question(s) On Which Measure Is Based	Computation of CMP components for diabetes care (scale 0-6)	Computation of CMP components for overall quality process (scale 0-18)	Computation of CMP components for overall quality outcomes (scale 0-6)
1. Registries	Does your group (or IPA/PHO) maintain an electronic registry or list of patients for: C1. asthma, 0='No' 1='Yes' C2. CHF, 0='No' 1='Yes' C4. diabetes, 0='No' 1='Yes'	C4: if C4 = yes, 1 point (range 0-1)	C1: if C1 = yes, 1 point C2: if C2 = yes, 1 point C4: if C4 = yes, 1 point Total registries score = C1+C2+C4 (range 0-3)	C4: if C4 = yes, 1 point (range 0-1)
2. Physician guideline-based reminders	We would like to know whether your group (or IPA/PHO) provides the majority of your physicians with guideline-based reminders for services the patient should receive for use at the time of seeing the patient. Does this happen for the group's patients with... C5. asthma, 0='No' 1='Yes' C6. CHF, 0='No' 1='Yes' C8. diabetes, 0='No' 1='Yes'	C8: if C8 = yes, 1 point (range 0-1)	C5: if C5 = yes, 1 point C6: if C6 = yes, 1 point C8: if C8 = yes, 1 point Total physician reminders score = C5+C6+C8 (range 0-3)	C8: if C8 = yes, 1 point (range 0-1)
3. Physician Feedback	C10. Does your group (or IPA/PHO) provide data to your physicians on the quality of their care for patients with CHF, 0='No' 1='Yes' Does your group provide physician-specific performance reports that you distribute to individual	I14: if I14 = yes, 1 point I15: if I15 = yes, 1 point Total physician feedback score= $[(I14+I15)/2]$ (range 0-1)	C10: if C10 = yes, 1 point I8: if I8 = yes, 1 point I9: if I9 = yes, 1 point I10: if I10 = yes, 1 point I11: if I11 = yes, 1 point I12: if I12 = yes, 1 point I13: if I13 = yes, 1 point I14: if I14 = yes, 1 point	I12: if I12 = yes, 1 point I13: if I13 = yes, 1 point I14: if I14 = yes, 1 point I15: if I15 = yes, 1 point Total physician feedback score= $[(I12+I13+I14+I15)/4]$

Care Management Process (CMP)	NSPO2 Survey Question(s) On Which Measure Is Based	Computation of CMP components for diabetes care (scale 0-6)	Computation of CMP components for overall quality process (scale 0-18)	Computation of CMP components for overall quality outcomes (scale 0-6)
	<p>physicians for ...?</p> <p>I8. Percent of eligible patients who received childhood immunizations, 0='No' 1='Yes'</p> <p>I9. Percent of eligible patients who received cervical cancer screening (PAP smear), 0='No' 1='Yes'</p> <p>I10. Percent of eligible patients who received breast cancer screening (mammography), 0='No' 1='Yes'</p> <p>I11. Percent of patients with persistent asthma that were prescribed appropriate medication, 0='No' 1='Yes'</p> <p>I12. Percent of patients who received an LDL screening test after an acute cardiovascular event, 0='No' 1='Yes'</p> <p>I13. Percent of patients who had an acute cardiovascular event whose LDL level was below specified thresholds, 0='No' 1='Yes'</p> <p>I14. Percent of patients with diabetes who had a hemoglobin A1c test, 0='No' 1='Yes'</p> <p>I15. Percent of patients with diabetes that is poorly controlled indicated by a hemoglobin A1c that is greater than 9, 0='No' 1='Yes'</p> <p>I16. Percent of women 16-25 years of age (identified as sexually active) who had at least one test for Chlamydia, 0='No' 1='Yes'</p>		<p>I15: if I15 = yes, 1 point I16: if I16 = yes, 1 point</p> <p>Total physician feedback score=</p> <p>$[(C10+I8+I9+I10+I11+I12+I13 + I14+I15+I16)/3.33]$</p> <p>(range 0-3)</p>	<p>(range 0-1)</p>

Care Management Process (CMP)	NSPO2 Survey Question(s) On Which Measure Is Based	Computation of CMP components for diabetes care (scale 0-6)	Computation of CMP components for overall quality process (scale 0-18)	Computation of CMP components for overall quality outcomes (scale 0-6)
4. Reminders to Patients	<p>Does your group (or IPA/PHO) routinely send reminders for preventive or follow-up care directly to a majority of patients with... C17. asthma, 0='No' 1='Yes' C18. CHF, 0='No' 1='Yes' C20. diabetes, 0='No' 1='Yes'</p> <p>Does your medical group routinely send reminders directly to... G4. women over the age of 50 regarding mammograms, 0='No' 1='Yes' G5. high risk patients regarding flu shots, 0='No' 1='Yes'</p>	<p>C20: if C20 = yes, 1 point (range 0-1)</p>	<p>C17: if C17 = yes, 1 point C18: if C18 = yes, 1 point C20: if C20 = yes, 1 point G4: if G4 = yes, 1 point G5: if G5 = yes, 1 point</p> <p>Total reminders to patients score= $[(C17+C18+C20+G4+G5)*0.6]$ (range 0-3)</p>	<p>C20: if C20 = yes, 1 point (range 0-1)</p>
5. Patient Education	<p>Does your group (or IPA/PHO) make available non-physician staff that are specially trained and designated to educate patients in managing their illness to your patients with... C25. asthma, 0='No' 1='Yes' C26. CHF, 0='No' 1='Yes' C28. diabetes, 0='No' 1='Yes'</p> <p>Does your medical group offer patients an ongoing and systematic health promotion program in... G8. weight loss or management, 0='No' 1='Yes' G10. STD prevention, 0='No' 1='Yes' G11. smoking cessation, 0='No' 1='Yes'</p>	<p>C28: if C28 = yes, 1 point G8: if G8 = yes, 1 point</p> <p>Total patient education score= $[(C28+G8)/2]$ (range 0-1)</p>	<p>C25: if C25 = yes, 1 point C26: if C26 = yes, 1 point C28: if C28 = yes, 1 point G8: if G8 = yes, 1 point G10 if G10 = yes, 1 point G11: if G11 = yes, 1 point</p> <p>Total patient education score= $[(C25+C26+C28+G8+G10+G11)/2]$ (range 0-3)</p>	<p>C28: if C28 = yes, 1 point G8: if G8 = yes, 1 point</p> <p>Total patient education score= $[(C28+G8)/2]$ (range 0-1)</p>

Care Management Process (CMP)	NSPO2 Survey Question(s) On Which Measure Is Based	Computation of CMP components for diabetes care (scale 0-6)	Computation of CMP components for overall quality process (scale 0-18)	Computation of CMP components for overall quality outcomes (scale 0-6)
6. Nurse Care Managers	<p>Does your group (or IPA/PHO) provide nurse care managers for patients with severe...</p> <p>C41. asthma, 0='No' 1='Yes'</p> <p>C42. CHF, 0='No' 1='Yes'</p> <p>C44. diabetes, 0='No' 1='Yes'</p>	<p>C44: if C44 = yes, 1 point</p> <p>(range 0-1)</p>	<p>C41: if C41 = yes, 1 point</p> <p>C42: if C42 = yes, 1 point</p> <p>C44: if C44 = yes, 1 point</p> <p>Total nurse care manager score= C41+C42+C44</p> <p>(range 0-3)</p>	<p>C44: if C44 = yes, 1 point</p> <p>(range 0-1)</p>
CMP Scale		<p>Sum of the above 6 (0-1) components.</p> <p>i.e.,</p> <p>CMP diabetes care= Registries + Physician reminders + Physician feedback + Reminders to patients + Patient education + Nurse care managers</p> <p>(Scale range 0-6)</p>	<p>Sum of the above 6 (0-3) components</p> <p>(Scale range 0-18)</p> <p>i.e.,</p> <p>CMP overall quality process= Total registries + Total physician reminders + Total physician feedback + Total reminders to patients + Total patient education + Total nurse care managers</p>	<p>Sum of the above 6 (0-1) components</p> <p>i.e.,</p> <p>CMP overall quality outcomes= Registries + Physician reminders + Physician feedback + Reminders to patients + Patient education + Nurse care managers</p> <p>(Scale range 0-6)</p>

Development of Dependent Variables

Table A3 shows the individual clinical measures that were used to construct each composite.

Table A3: Clinical Measures Used to Construct Composite Dependent Variables

Variable Label	Dependent Variable Composite Measures		
	Diabetes Care	Overall Quality Process	Overall Quality Outcomes
Cardiovascular Mgt LDL Control < 130			x
Diabetes LDL Control < 130	x		x
HbA1c Control (<9)	x		x
Diabetes LDL Screening (1-yr look-back)	x	x	
HbA1c Screening	x	x	
Nephropathy Monitoring	x	x	
Asthma Maintenance All Ages		x	
Breast Cancer Screening Ages 52-69		x	
Cardiovascular Mgt LDL Screening		x	
Cervical Cancer Screening Ages 21-64		x	
Chlamydia Screening All Ages		x	
Childhood Immunization MMR		x	
Childhood Immunization VZV		x	
Upper Respiratory Infection		x	
N	106	108	103

Note: The number of POs included for analysis varies on these different composite measures because a PO was required to have a minimum of 30 patients in the denominator for each individual measure within a composite to be scored on the composite.

To be eligible for an incentive payment, POs needed to meet the minimum annual encounter submission threshold of 2.5 encounters per member per year, with each of the seven participating plans. They also had to have a minimum of 30 patients in the denominator to be eligible for payment on a specific measure. Of the 225 targeted POs, 180 met the thresholds noted.

Table A4 below shows how we constructed the opportunities composite variable for each of the three outcome measures.

Table A4: Opportunities Composite Construction

Dependent Variable (variable name)	P4P Original Measures	Computation
Diabetes Care (DiabCare_hpr)	<p>Each scale component consists of two variables (numerator and denominator) Numerator=Number of patients satisfying criteria Denominator=Number of patients eligible</p> <p><u>Components:</u> Diabetes LDL Control < 130 (DLDL130) HbA1c Control (<9) (HGBA1CLT9) Diabetes LDL Screening (1-yr look-back) (DLDLSCR) Nephropathy Monitoring (NEPHSCR) HbA1c Screening (HBASCR)</p>	<p>Sum of the numerators divided by the sum of the denominators</p> <p>i.e., (Sum of Numerators for DLDL130, HGBA1CLT9, DLDLSCR, NEPHSCR, HBASCR) / (Sum of Denominators for DLDL130, HGBA1CLT9, DLDLSCR, NEPHSCR, HBASCR)</p>
Overall quality process (Qualprocess_hpr)	<p>Each scale component consists of two variables (numerator and denominator) Numerator=Number of patients satisfying criteria Denominator=Number of patients eligible</p> <p><u>Components:</u> 1. Diabetes LDL Screening (1-yr look-back) (DLDLSCR) 2. Nephropathy Monitoring (NEPHSCR) 3. HbA1c Screening (HBASCR) 4. Asthma Maintenance All Ages (ASMOV) 5. Upper Respiratory Infection (URI) 6. Cardiovascular Mgt LDL Screening (CMCSCR) 7. Breast Cancer Screening Ages 52-69 (BCS52) 8. Cervical Cancer Screening Ages 21-64 (CCS) 9. Chlamydia Screening All Ages (CHLAMSCR) 10. Childhood Immunization MMR (CISMMR) 11. Childhood Immunization VZV (CISVZV)</p>	<p>Sum of the numerators divided by the sum of the denominators</p> <p>i.e., (Sum of Numerators for DLDLSCR, NEPHSCR, HBASCR, ASMOV, URI, CMCSCR, BCS52, CCS, CHLAMSCR, CISMMR, CISVZV) / (Sum of Denominators for DLDLSCR, NEPHSCR, HBASCR, ASMOV, URI, CMCSCR, BCS52, CCS, CHLAMSCR, CISMMR, CISVZV)</p>
Overall quality outcome (Qualoutcome_hpr)	<p>Each scale component consists of two variables (numerator and denominator) Numerator=Number of patients satisfying criteria Denominator=Number of patients eligible</p> <p><u>Components:</u> 1. Diabetes LDL Control < 130 (DLDL130) 2. HbA1c Control (<9) (HGBA1CLT9) 3. Cardiovascular Mgt LDL Control < 130 (CMC130)</p>	<p>Sum of the numerators divided by the sum of the denominators</p> <p>i.e., (Sum of Numerators for DLDL130, HGBA1CLT9, CMC130) / (Sum of Denominators for DLDL130, HGBA1CLT9, CMC130)</p>

Table A5: Correlation Matrix

Correlation Matrix--Independent and Dependent Variables

NBR	Medical Group	Log Nbr of MDs	% Annual Revenue Medicaid	EMR use Scale	QI Scale	Diabetes CMP set (0-6)	CMP full Set (0-18)	CMP Set Related to Outcomes (0-6)
mg1 Medical Group	1							
log_size Log of Nbr of MDs	-0.42***	1						
f3r '% [PO]s annual revenue-Medicaid'	-0.16	0.08	1					
EMR_Use EMR Use scale (0-5)	0.38***	-0.03	-0.05	1				
QI_index Quality Index (0-2)	0.15	0.12	0.14	0.29**	1			
P4P_Clin_selfrpt PO self reports clinical P4P items	0.25**	0.04	-0.25*	0.25*	0.28**			
CMP Diabetes-Specific Set (0-6)	0.14	0.13	-0.09	0.20*	0.34***	1		
Diabetes composite (outcome variable)	0.36***	0.04	-0.27**	0.27**	0.28**	0.34***		
CMP Full Set (0-18)	0.03	0.12	-0.12	0.17	0.32**	0.31**	1	
Process of care composite (outcome variable)	0.43***	0.14	-0.27**	0.33***	0.34***	0.72***		
CMP Set Related to Quality Outcomes (0-6)	0.14	0.14	-0.13	0.21*	0.33***	0.43***		1
Outcomes composite (outcome variable)	0.35***	0.18	-0.19	0.30**	0.26**	0.69***		

*p<.05; **p<.01; ***p<.001

Table A6 shows how physician groups, out of the universe of groups (n=180) eligible for payments in the IHA Pay-for-Performance (P4P) program compared on key structural features among those that responded to the NSPO II survey and those that did not.

Table A6: Comparison of P4P Physician Groups with NSPOII Survey Responses (n=108) vs. those without NSPOII Survey Responses (n=72)

	P4P Medical Groups with NSPO II Data (n=108)		P4P Medical Groups without NSPO II Data (n=72)		p-value
	Number or %	(SD)	Number or %	(SD)	
Organizational Structure (%)					
IPA	59%	(63)	54%	(51)	0.63
Region, No. (%)					
Southern California	75%	(43)	94%	(22)	0.001
Size, Mean (SD)					
# of MDs	281	(320)	253	(266)	.59
# of practice sites	135	(206)	122	(162)	.74
Total member enrollment	36,209	(44,862)	16,545	(16,546)	.0002
Payer Mix, Mean percent annual revenue (SD)					
Medi-Cal	5.9	(14.4)	31.1	(36.7)	.0005

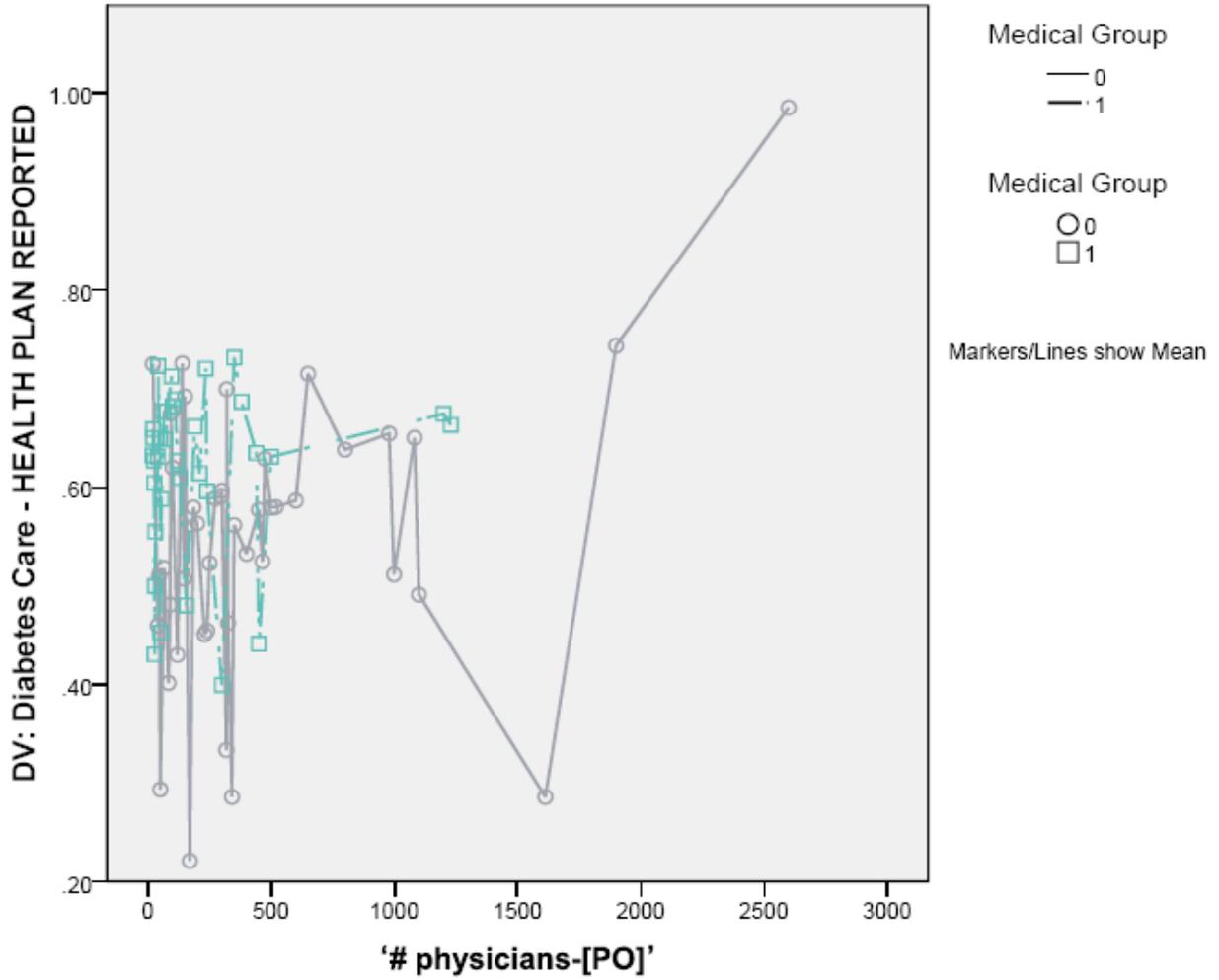
The table below compares:the p values in our regressions with the t-test p values comparing mean independent variable values of the top dependent variable quartile to the bottom dependent variable quartile, for each of the three independent variables of interest: CMP, EMR, and QI Index.

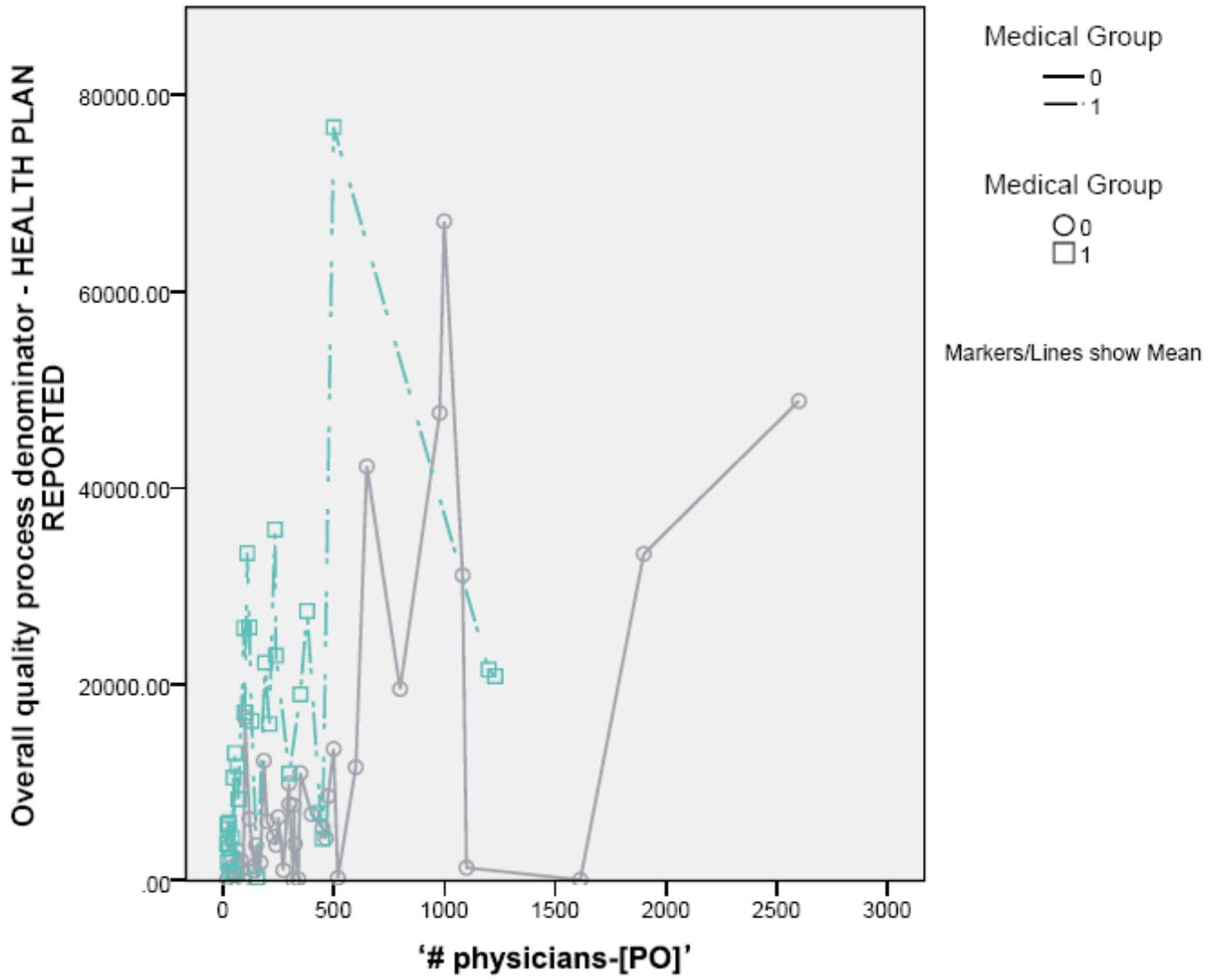
The results presented are significance levels, and they show that for the model 6A (quality processes of care) the regression coefficients were not significant but if one looked only at the bottom/top 25% they are significant. Otherwise there was no difference between including all groups vs. just looking at the top and bottom performers and the relationship between use of CMPs, EMRs, and QI and performance on the outcome variables.

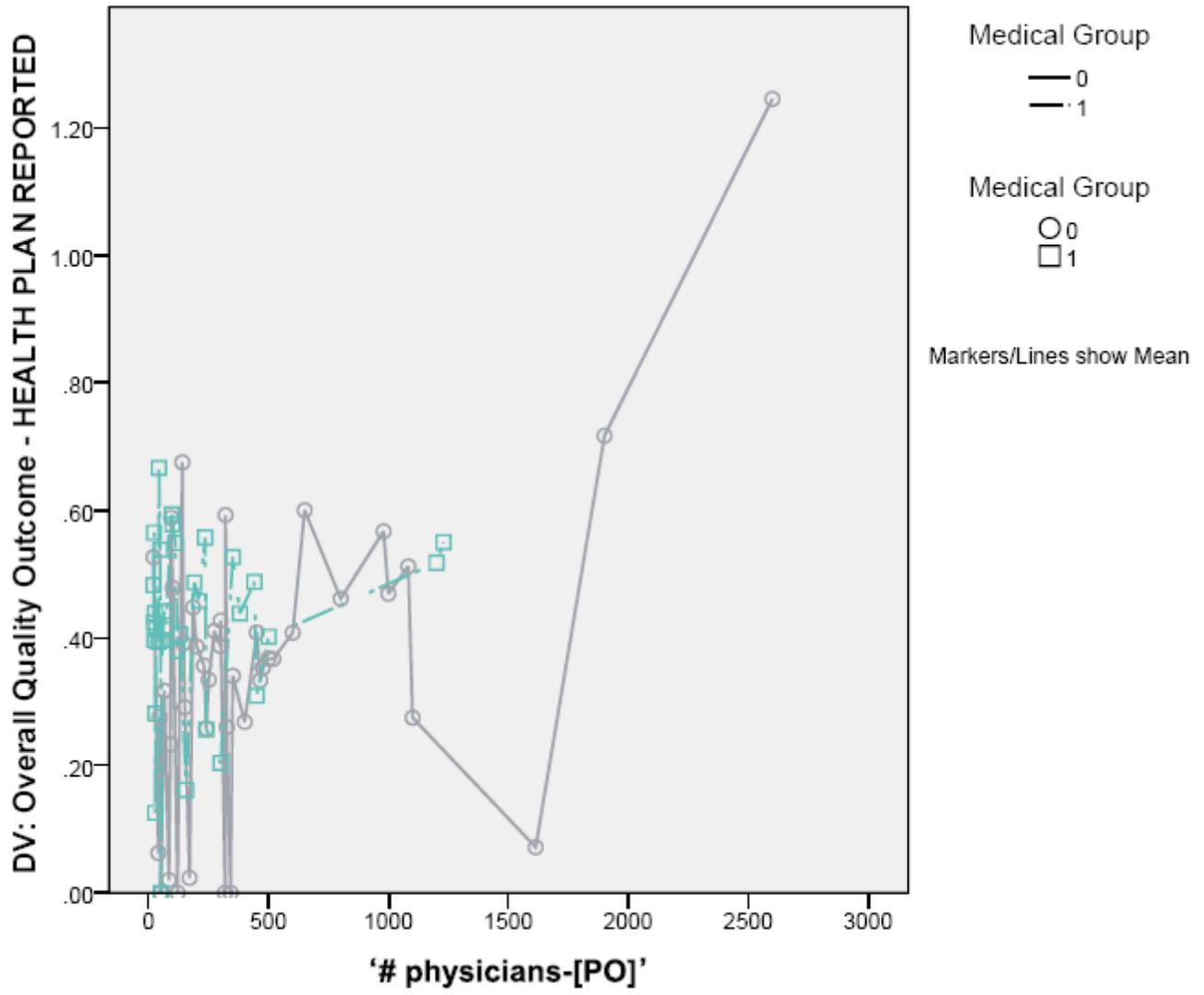
Table A7: Relationship between Lowest and Highest Performing POs and CMPs, EMR and QI

DV's	P Values	
	Regression	Top Quartile vs Bottom Quartile
DiabCare_hpr (4A)		
Diab_Full	0.002	0.012
EMR_Use	0.411	0.224
QI_Index	0.466	0.461
Qualprocess_hpr (6A)		
CMP_Full	0.969	0.006
EMR_Use	0.129	0.012
QI_Index	0.021	0.001
Qualoutcome_hpr (7A)		
DV7_Full	0.001	0.010
EMR_Use	0.904	0.480
QI_Index	0.613	0.819

Figure 1: Relationship between Group Size (# of physicians) and Physician Organization Structure







Calculation of Reliabilities

We took two approaches to calculating reliabilities, neither of which is perfect due to the dichotomous nature of the data and the different sample sizes by measure within and between groups. The dichotomous nature of the data makes traditional statistics like Cronbach’s alpha pessimistic. Cronbach’s alpha is more or less the average of the correlations between the individual measures in a composite. The different sample sizes make alpha unduly influenced by the smaller groups. There is no commonly available fix for this problem.

A second approach is to take the point of view that regardless of how the components load in the scale, the real issue is how reliable the scale is at the end of construction. This suggests that a different kind of reliability should be calculated.

The most common way to make reliability an implementable quantity is to characterize it as a function of the components of a simple hierarchical model (HLM).¹ A simple 2-level HLM separates the observed variability in group scores into two components, variability between groups and variability within group. The definition of reliability from this framework is:

$$reliability = \frac{\sigma_{group-to-group}^2}{\sigma_{group-to-group}^2 + \sigma_{group-specific-error}^2}$$

With different sample sizes this formula produces a different reliability for each group. Smaller sample size groups typically have smaller reliabilities.

Measure	Mean Reliability	Chronbach’s Alpha
Diabetes Management	0.98	0.66
Process of Care	0.93	0.77
Intermediate Outcomes	0.99	0.55

In summary, the Chronbach’s alpha statistics for the 3 composites ranged from 0.55 (Outcome) to 0.66 (Process.) The underlying data are dichotomous data and of varying sample sizes so lower values than those seen in other settings are expected. Directly calculated mean reliabilities for the scales ranged from 0.93 (Process) to 0.98 (Diabetes). These high reliabilities are a consequence of the large sample sizes at the group level.

¹ Raudenbush, SW, Bryk, AS. *Hierarchical Linear Models. Applications and Data Analysis Methods*. Newbury Park, CA: Sage, 2nd ed., 2002.

Results of the non-Linear Regression Models

Model 1: Diabetes

The LOGISTIC Procedure

Model Information

Data Set	WORK.TEST	
Response Variable (Events)	DIABCARENUM_HPR	Diabetes Care Numerator - HEALTH PLAN REPORTED
Response Variable (Trials)	DIABCAREDEN_HPR	Diabetes Care Denominator - HEALTH PLAN REPORTED
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	106
Number of Observations Used	100
Sum of Frequencies Read	505110
Sum of Frequencies Used	495200

Response Profile

Ordered Value	Binary Outcome	Total Frequency
1	Event	310062
2	Nonevent	185138

NOTE: 6 observations were deleted due to missing values for the response or explanatory variables.

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	654637.34	652043.33
SC	654648.45	652121.12
-2 Log L	654635.34	652029.33

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	2606.0102	6	<.0001
Score	2626.7241	6	<.0001
Wald	2603.5239	6	<.0001

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The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	0.0179	0.0202	0.7888	0.3745
MG1	1	0.0984	0.00718	187.7457	<.0001
LOG_SIZE	1	0.0332	0.00314	111.2175	<.0001
F3R	1	-0.00682	0.000329	429.9499	<.0001
EMR_USE	1	0.0278	0.00213	169.1530	<.0001
QI_INDEX	1	-0.0430	0.00390	121.8970	<.0001
DIAB_FULL	1	0.0680	0.00229	878.2304	<.0001

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
MG1	1.103	1.088	1.119
LOG_SIZE	1.034	1.027	1.040
F3R	0.993	0.993	0.994
EMR_USE	1.028	1.024	1.032
QI_INDEX	0.958	0.951	0.965
DIAB_FULLL	1.070	1.066	1.075

Association of Predicted Probabilities and Observed Responses

Percent Concordant	52.3	Somers' D	0.084
Percent Discordant	43.8	Gamma	0.088
Percent Tied	3.9	Tau-a	0.039
Pairs	57404258556	c	0.542

Model 2: Quality Processes

The LOGISTIC Procedure

Model Information

Data Set	WORK.TEMP
Response Variable (Events)	QUALPROCESSNUM_HPR
Response Variable (Trials)	QUALPROCESSDEN_HPR
Model	binary logit
Optimization Technique	Fisher's scoring

Model Information

Overall quality process numerator - HEALTH PLAN REPORTED
 Overall quality process denominator - HEALTH PLAN REPORTED

Number of Observations Read	108
Number of Observations Used	101
Sum of Frequencies Read	1225966
Sum of Frequencies Used	1199067

Response Profile

Ordered Value	Binary Outcome	Total Frequency
1	Event	876788
2	Nonevent	322279

NOTE: 7 observations were deleted due to missing values for the response or explanatory variables.

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	1395803.3	1389447.4
SC	1395815.3	1389531.4
-2 Log L	1395801.3	1389433.4

The LOGISTIC Procedure

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	6367.9265	6	<.0001
Score	6398.6960	6	<.0001
Wald	6363.7826	6	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	0.3771	0.0137	761.5006	<.0001
MG1	1	0.2340	0.00507	2130.6655	<.0001
LOG_SIZE	1	0.0798	0.00218	1343.7506	<.0001
F3R	1	-0.00555	0.000244	517.5318	<.0001
EMR_USE	1	0.0311	0.00154	407.5237	<.0001
QI_INDEX	1	0.0650	0.00283	528.1355	<.0001
CMP_FULL	1	-0.00025	0.000622	0.1660	0.6837

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
MG1	1.264	1.251	1.276
LOG_SIZE	1.083	1.078	1.088
F3R	0.994	0.994	0.995
EMR_USE	1.032	1.028	1.035
QI_INDEX	1.067	1.061	1.073
CMP_FULL	1.000	0.999	1.001

Association of Predicted Probabilities and Observed Responses

Percent Concordant	53.0	Somers' D	0.096
Percent Discordant	43.5	Gamma	0.099
Percent Tied	3.5	Tau-a	0.038
Pairs	282570359852	c	0.548

The LOGISTIC Procedure

Model 3: Intermediate Outcomes

Model Information

Data Set	WORK.TEMP
Response Variable (Events)	QUALOUTCOMENUM_HPR
Response Variable (Trials)	QUALOUTCOMEDEN_HPR
Model	binary logit
Optimization Technique	Fisher's scoring

Model Information

Overall Quality Outcome numerator - HEALTH PLAN REPORTED
 Overall Quality Outcome denominator - HEALTH PLAN REPORTED

Number of Observations Read	107
Number of Observations Used	100
Sum of Frequencies Read	214557
Sum of Frequencies Used	210327

Response Profile

Ordered Value	Binary Outcome	Total Frequency
1	Event	96809
2	Nonevent	113518

NOTE: 7 observations were deleted due to missing values for the response or explanatory variables.

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	290248.32	287562.59
SC	290258.58	287634.39
-2 Log L	290246.32	287548.59

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The LOGISTIC Procedure

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	2697.7311	6	<.0001
Score	2660.7614	6	<.0001
Wald	2617.4436	6	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-0.8421	0.0304	769.1510	<.0001
MG1	1	-0.0783	0.0107	54.0438	<.0001
LOG_SIZE	1	0.0437	0.00471	86.2963	<.0001
F3R	1	-0.00954	0.000529	325.0703	<.0001
EMR_USE	1	0.0132	0.00318	17.2732	<.0001
QI_INDEX	1	-0.1211	0.00588	424.4639	<.0001
DV7_FULL	1	0.1351	0.00354	1459.1811	<.0001

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
MG1	0.925	0.906	0.944
LOG_SIZE	1.045	1.035	1.054
F3R	0.991	0.989	0.992
EMR_USE	1.013	1.007	1.020
QI_INDEX	0.886	0.876	0.896
DV7_FULL	1.145	1.137	1.153

Association of Predicted Probabilities and Observed Responses

Percent Concordant	54.6	Somers' D	0.122
Percent Discordant	42.4	Gamma	0.126
Percent Tied	3.1	Tau-a	0.061
Pairs	10989564062	c	0.561