

Process of Care Compliance Is Associated With Fewer Diabetes Complications

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In 2010, the estimated prevalence of diabetes among adults ranged from 5% to 13% across the United States and its territories,¹ accounting for substantial morbidity, mortality, and associated economic costs.^{2,3} Type 2 diabetes mellitus often develops 9 to 12 years before diagnosis⁴ and more than 50% of patients have at least 1 complication by that time.⁵ A significant body of research has established that effective treatments can significantly decrease the development and/or progression of complications.⁶⁻¹⁷

However, diabetes care remains suboptimal and varied in the United States.¹⁸⁻²² In an effort to improve outcomes, The National Diabetes Quality Improvement Project (1997) developed a comprehensive set of process and intermediate outcome measures to assess quality of care for diabetes patients that are now considered standards of care.^{20,23} These measures include annual screenings for lipids and microalbuminuria, at least 2 measurements of glycated hemoglobin (A1C) at least 30 days apart, and annual flu vaccinations, dilated eye exams, and foot examinations.²³

A number of studies^{1,7,18,20-32} have used these performance measures to assess care provided to patients with diabetes. These studies provide evidence of the substantial gaps between national performance measures for diabetes care and actual care received by persons with diabetes in the United States.²⁶

The present study examines 3 process measures of diabetes care: A1C tests, lipid tests, and urine screening tests for microalbuminuria; and their association with 4 subsequent complications of diabetes: coronary artery disease (CAD), stroke, heart failure (HF), and renal disease (RD); in a cohort of employees of a large national manufacturing company. This cohort provides an opportunity to study this issue in a geographically, ethnically, and socioeconomically diverse population with rich and uniform healthcare benefits. This study contributes to the literature by identifying systematic reasons for differences in care among privately insured Americans and examining whether adherence to recommended processes of care is associated with better outcomes.^{26,33}

METHODS

The study setting was a large (approximately 36,000 employees) US-based manufacturing company

Objective: To examine the association between processes measures of diabetes care and time to progression for 4 diabetes complications: coronary artery disease (CAD), stroke, heart failure (HF), and renal disease (RD).

Study Design: This retrospective study followed outcomes from 2003 through 2009 in a cohort of 1797 employees with diabetes who worked for a large US manufacturer and were enrolled in the same health insurance plan.

Methods: Quality of care was measured by consensus standards for testing glycated hemoglobin, lipids, and microalbuminuria. Employees with diabetes who received all 3 measures of care in the baseline year (2003) were compared with those who received less complete testing. Cox proportional hazard regression models were used to assess potential associations between diabetes care and time to complications, controlling for potential confounders.

Results: Observed differences between the 2 groups in time to event were significant for 2 of the 4 complications: HF (hazard ratio [HR] = 0.39, 95% confidence interval [CI], 0.19-0.81; $P = .0117$) and RD (HR = 0.48, 95% CI, 0.24-0.95; $P = .0339$) and any of the 4 complications (HR = 0.66, 95% CI, 0.48-0.91; $P = .0101$). Differences in time to complication for CAD (HR = 0.70, 95% CI, 0.49-1.02; $P = .0635$) and stroke (HR = 0.63, 95% CI, 0.38-1.07; $P = .0891$) showed the same trend but were not significant.

Conclusions: Employees with diabetes who received all 3 quality measures experienced fewer complications, risk-adjusting for other factors. These results provide support for the importance of care quality.

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Take-Away Points

The proportion of patients with diabetes receiving standard processes of care based on systematic reviews is disturbingly low and in our fully insured population is just under 15%.

- The patients in our cohort who received standard processes of care developed fewer complications than those who did not, despite being sicker at the outset.
- Our results provide support for process measures and efforts to promote their application in practice.
- If even a modest portion of outcomes are causally associated with better processes of care, there is great potential for benefit.

with uniform healthcare benefits in 22 states that generated claims data during the years of the study. We examined the relationships between the 3 measures of the quality of diabetes care and the risk of major diabetes complications to determine whether employees with diabetes who received all 3 quality-of-care measures in a baseline year (2003) demonstrated a lower risk for developing any of 4 complications over the 6-year observation period (2004-2009). Baseline characteristics suspected to impact outcome risk and/or likelihood of receiving optimal care included in the multivariate model were age, sex, ethnicity, marital status, income, insulin use, comorbidities, and smoking. Due to data limitations, we were unable to assess the possible confounding roles of obesity and duration of diabetes. Data on annual flu vaccinations, dilated eye exams, and foot examinations were not available; thus, these elements were not included in our model.

Study Design

This was a retrospective cohort study using administrative data on employees collected between January 1, 2001, and December 31, 2009. The majority of the employees held hourly manufacturing jobs; minorities and women were well represented. Although employees could select from a menu of health benefits, only a single preferred provider organization (PPO) network was available to the entire population. Employees who did not opt for this PPO were excluded (3%). The panel was restricted to those employed by the manufacturer for some part of 2001 and 2002, and for all of 2003, the year during which quality of care measures were assessed. Health outcomes were assessed from claims between January 1, 2004, and December 31, 2009.

During the “lead-in” period (2001-2002), diabetes status was ascertained from the claims data based on *International Classification of Diseases, Ninth Revision (ICD-9)* codes for the condition on a submitted medical claim for at least 1 of the following: a hospitalization, emergency department visit, 2 office visits, or 1 prescription for a diabetes-specific medication. Participants were included in the final data set if they

were between 18 and 64 years old and employed throughout 2003 and for at least 1 month in the observation period (2004-2009). Employees with diabetes who had any 1 of the 4 end point complications coded in a medical claim in 2001 or 2002 and women with a claim containing an ICD-9 code for gestational diabetes were excluded. Those with claims for 1 of the 4 complications in the baseline year (2003) were included in the panel, but were excluded from the analysis for that complication. A total of 1797 subjects were available for analysis.

Process measures of diabetes care (ie, 2 A1C tests at least 30 days apart and at least 1 test each for lipids and microalbuminuria) were assessed in the baseline year (2003).³⁴ Each employee with diabetes was categorized into 1 of 2 mutually exclusive groups: those who received all 3 measures of care in 2003 and those who did not. Cox proportional hazard regression models were used to assess the associations between diabetes care and time to each of the 4 complications (CAD, stroke, HF, and RD) or any of the 4 complications.

The databases available for analysis have been described in detail in previous publications.³⁵ Briefly, health data were obtained from the health insurance plan, extraction of on-site occupational health medical records available for about 40% of the locations, and other linked employer-managed administrative databases. Data included ICD-9 codes from the Chronic Condition Data Warehouse list³⁶ for disease diagnosis and National Drug Codes³⁷ for prescription information. End point complications were identified based on ICD-9 codes during a face-to-face exam or hospitalization. For end point data, the subset of ICD-9 codes from the Chronic Condition Data Warehouse list for causes of kidney disease and heart disease unrelated to diabetes (eg, infectious or genetic etiology) were excluded. Demographic and health behavior data were obtained from the health medical record and human resources databases.

Vision claims were not available. Therefore, claims for routine eye exams and screening for diabetic retinopathy were not usable as measures of quality of diabetes care.

Sightlines DxCG Risk Solutions software (Verisk Analytics, Jersey City, New Jersey) was used to assign risk scores to the cohort during the baseline assessment and capture potential illness-related influences on treatment decisions. This actuarial program uses medical and pharmacy data with proprietary risk-adjustment algorithms to predict future health spending, and its risk scores are comparable to similar scores used by the Centers for Medicare & Medicaid Services and

other insurance bodies for global risk estimates. A score of 1 in 2003 implies an actuarial prediction that an individual would consume the median amount of healthcare for the population in 2004. Databases were linked by an encrypted unique identifier to ensure human subject privacy. This study was approved by the authors' institutional review boards.

Statistical Analysis

Hazard ratios for each outcome (CAD, stroke, HF, RD, and any of the 4 conditions) were calculated for quality of diabetes care (exposures) and covariates. Time to event, defined as the number of months from the start of the observation period (January 1, 2004) to the first medical claim for a complication, was used for all primary analyses. Employees with diabetes who no longer received employer-provided health benefits were censored at the time of their last month of coverage. Records ($n = 901$) were censored during the observation period for the following reasons: retirement, layoff or termination ($n = 647$), change from PPO to health maintenance organization or Consolidated Omnibus Budget Reconciliation Act (COBRA) coverage ($n = 77$), and death or long-term disability ($n = 30$). For 119 subjects, the reason for loss of coverage could not be definitely established from the available records. Differences between the baseline characteristics of censored and uncensored employees were assessed with χ^2 tests. The Kaplan-Meier method was used to identify crude time-to-event models for the associations between the exposure and outcome measures.

Cox proportional hazard models were used to evaluate bivariate and multivariate association, which enabled time-to-outcome assessment with risk adjustment based on socioeconomic and lifestyle risk factors, comorbidities, and severity of diabetes. The base model, calculating time to event as a function of quality of care, was specified with demographic covariates. Covariates including modifiable risks (smoking), clinical characteristics (insulin use and health severity risk score), and socioeconomic status indicators (individual income, job status [hourly or salary], and marital status) were then added to the base model. Finally, the fully adjusted model was used to assess the combined explanatory effects for all measured factors. Hazard ratios (HRs) for primary outcomes were calculated based on Cox proportional hazard analyses stratified by hourly job status, salary, sex, and insulin use. As a sensitivity test, kappa statistics, correlation analyses, and Cox proportional hazard analyses were used to assess outcome differences based on 2 years (2003 and 2004) of continuous high-quality care (leaving 2005-2009 available for outcome observation). Other sensitivity tests included looking at each stratum of sex, job status, and insulin use in the full model. All analyses were conducted using SAS version 9.2 (SAS Institute Inc, Cary, North Carolina).

RESULTS

Baseline Characteristics

A total of 1797 patients met criteria for inclusion. The cohort consisted primarily of white (69.2%), male (83.1%), married (74.2%), hourly employees (75.7%), a significant number of whom earned less than \$35,423 per year (27.2%). More than half (55.1%) were between the ages of 18 and 51 years. The mean age for the total population was 49.0 years (standard deviation = 8.4). Smoking data were reported as never (14.4%), past/current (17.3%), and unknown (68.3%). The unknown group represents primarily locations for which health medical record data were unavailable. As a measure of diabetes severity, 20.1% of the population had insulin prescriptions during the baseline year. Health severity risk scores were also used to assess comorbidities, with 75.1% of the cohort receiving a score of 2.1 or lower (1 = average health risk spending probability, 2 = risk likelihood of double the average health expenditures). Regarding the quality of diabetes care process measures, a majority of patients received at least 1 A1C test (67.6%) and lipid testing (61.8%) in the baseline year. Other measures of care were less common: 43% of patients had at least 2 tests for A1C and only 24.0% were tested for microalbuminuria in the baseline year.

Characteristics of the baseline sample are shown in **Table 1**; the same subjects stratified by treatment status are shown in **Table 2**. At baseline, the group receiving all 3 process measures was smaller ($n = 267$) than the comparison group ($n = 1530$). Differences between the 2 groups were assessed with 2-tailed t tests for independent samples. Despite the sample size differences, there were no statistically significant differences between the 2 groups during the baseline period (2003) for demographic, socioeconomic status, or modifiable risk variables. However, there was evidence that the group receiving all 3 process measures was sicker at baseline. They were significantly more likely to be receiving insulin than the comparison group (27.7% vs 18.8%; $P = .0007$) and were also more likely to fall into the higher quartiles of health severity risk score ($P = .043$).

Table 3 shows the characteristics of those who were censored compared with those who remained in employment throughout the follow-up period. Although workers who left were older and less well paid on average at baseline, differences between censored employees and noncensored employees were not significant for race, marital status, occupational group (salary or hourly), insulin use, health severity risk score, and importantly, likelihood of receiving the treatment.

In total, 366 persons with diabetes (20%, $n = 1797$) had medical claims for at least 1 of the 4 complications with a mean time to complication of 29.1 months. The most fre-

■ **Table 1.** Demographic Characteristics of a Cohort of Employees With Diabetes of a Large US Manufacturing Company in the Baseline Year (2003)

Characteristics	Employees With Diabetes (N = 1797)	
	No.	Percent
Age, y		
18-45	522	29.0
46-51	469	26.1
52-56	469	26.1
57-64	337	18.8
Sex		
Male	1494	83.1
Female	303	16.9
Race		
White	1244	69.2
Black	346	19.3
Hispanic	166	9.2
Other	41	2.3
Marital status/dependents^a		
Married (spouse on health insurance)	1333	74.2
Compensation		
Hourly	1361	75.7
Salary	436	24.3
Wage		
Quartile 1 (<\$35,423)	488	27.2
Quartile 2 (\$35,424-\$44,743)	435	24.2
Quartile 3 (\$44,744-\$56,903)	444	24.7
Quartile 4 (>\$56,903)	430	23.9
Smoking		
Never	258	14.4
Past/current	311	17.3
Unknown	1228	68.3
Insulin		
	361	20.1
Health severity risk score		
Quartile 1 (≤ 1.0)	451	25.1
Quartile 2 ($> 1.0-1.4$)	448	24.9
Quartile 3 ($> 1.4-2.0$)	451	25.1
Quartile 4 (≥ 2.1)	447	24.9
Quality of care measures		
A1C (1 tests)	1214	67.6
A1C (2 tests)	773	43.0
Microalbuminuria	431	24.0
Lipids	1110	61.8
A1C indicates glycated hemoglobin.		
^a Determined from health insurance eligibility file.		

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■ Table 2. Characteristics of Employees Who Received All 3 Quality-of-Care Measures Versus Those Who Received Fewer Than 3 During the Baseline Period (January 1, 2003–December 31, 2003)

Characteristics of Employees With Diabetes (N = 1797)	All 3 QOCMs (n = 267)		Fewer Than 3 QOCMs (n = 1530)		P
	No.	Percent	No.	Percent	
Age, y					.2973
18-45	75	28.1	447	29.2	
46-51	74	27.7	395	25.8	
52-56	70	26.2	399	26.1	
57-64	48	18.0	289	18.9	
Sex					.2137
Male	229	85.8	1265	82.7	
Female	38	14.2	265	17.3	
Race					.1525
White	170	63.7	1074	70.2	
Black	59	22.1	287	18.8	
Hispanic	32	12.0	134	8.8	
Other	6	2.2	35	2.3	
Marital status^a					
Married	204	76.4	1129	73.8	.3679
Compensation					.3679
Hourly	186	69.7	1175	76.8	
Salary	81	30.3	355	23.2	
Wage					.864
Quartile 1 (<\$35,423)	67	25.1	421	27.5	
Quartile 2 (\$35,424-\$44,743)	65	24.3	370	24.2	
Quartile 3 (\$44,744-\$56,903)	69	25.8	375	24.5	
Quartile 4 (>\$56,903)	66	24.7	364	23.8	
Smoking					.2495
Never	32	12.0	226	14.8	
Past/current	41	15.4	270	17.6	
Unknown	194	72.7	1034	67.6	
Insulin	74	27.7	287	18.8	.0007
Health severity risk score					.0429
Quartile 1 (≤1.0)	50	18.7	401	26.2	
Quartile 2 (>1.0-1.4)	67	25.1	381	24.9	
Quartile 3 (>1.4-2.0)	71	26.6	380	24.8	
Quartile 4 (≥2.1)	79	29.6	368	24.1	

QOCM indicates quality-of-care measure.

^aDetermined from health insurance eligibility files.

quent complication in the cohort was CAD (16.9%) with a mean time to complication of 26.6 months, followed by stroke (8.7%, 33.1 months), HF (5.8%, 29.7 months), and RD (4.9%, 38.1 months). Those getting all 3 process measures of care fared better for all end points. Hazard ratios for 2 of the 4 complications were significant: HF (HR = 0.39, 95% confidence interval [CI], 0.19-0.81; *P* = .012) and RD (HR =

0.48, 95% CI, 0.24-0.95; *P* = .034). The HRs for CAD (HR = 0.70, 95% CI, 0.49-1.02; *P* = .064) and stroke (HR = 0.63, 95% CI, 0.38-1.07; *P* = .089) showed the same trend but were not significant. Hazard ratios with CIs for each and any of the 4 end points are summarized in **Table 4**.

The HR for submitting a medical claim for any of the 4 complications was significantly lower for those receiving all

■ **Table 3.** Comparison at Baseline of Characteristics of Those Who Remained in Employment to the End of Follow-up and Those Who Were Censored Because They Left Employment

Characteristic	Censored (n = 901)		Not Censored (n = 625)		P
	No.	Percent	No.	Percent	
Age, y					<.0001
18-45	322	35.7	165	26.4	
46-51	205	22.8	202	32.3	
52-56	207	23.0	163	26.1	
57-64	167	18.5	95	15.2	
Sex					.3267
Male	738	81.9	524	83.8	
Female	163	18.1	101	16.2	
Race					.4363
White	603	66.9	433	69.3	
Black	190	21.1	111	17.8	
Hispanic	85	9.4	65	10.4	
Other	23	2.6	16	2.6	
Marital status^a					
Married	644	71.5	468	74.9	.1414
Compensation					.514
Hourly	673	74.7	476	76.2	
Salary	228	25.3	149	23.8	
Wage					<.0001
Quartile 1 (<\$35,423)	283	31.4	127	20.3	
Quartile 2 (\$35,424-\$44,743)	229	25.4	144	23.0	
Quartile 3 (\$44,744-\$56,903)	188	20.9	189	30.2	
Quartile 4 (>\$56,903)	201	22.3	165	26.4	
Smoking					<.0001
Never	111	12.3	117	18.7	
Past/current	117	13.0	138	22.1	
Unknown	673	74.7	370	59.2	
Insulin	167	18.5	133	21.3	.1846
Health severity risk score					.1161
Quartile 1 (≤1.0)	261	29.0	174	27.8	
Quartile 2 (>1.0-1.4)	267	29.6	156	25.0	
Quartile 3 (>1.4-2.0)	216	24.0	171	27.4	
Quartile 4 (≥2.1)	157	17.4	124	19.8	
Quality-of-care measures					
A1C (1 tests)	592	65.7	429	68.6	.2308
A1C (2 tests)	375	41.6	274	43.8	.3884
Microalbuminuria	222	24.6	160	25.6	.6701
Lipids	532	59.0	387	61.9	.2592

A1C indicates glycated hemoglobin.

^aDetermined from health insurance eligibility file.

3 process measures (HR = 0.66, 95% CI, 0.48-0.91; $P = .01$). Covariates associated with increased risk included increasing age 46-51 years (HR = 1.88, 95% CI, 1.36-2.61; $P = .0001$), 52-56 years (HR = 2.06, 95% CI, 1.47-2.89; $P < .0001$), and 57-64 years (HR = 3.09, 95% CI, 2.15-4.46; $P < .0001$); health severity risk scores of 2.1 or higher (HR = 1.91, 95% CI, 1.36-2.68; $P = .0002$); and smoking (HR = 1.44, 95% CI, 1.01-2.07; $P = .047$). Differences in all other covariates were not statistically significant. The Kaplan-Meier estimates of cumulative hazards for all end points are depicted in **Figures 1** through **5**.

We conducted 2 sensitivity analyses. The first used 2 years (2003 and 2004) of continuous process of care measures to reduce the likelihood of random misclassification. Results showed the same trends and similar point estimates (data not shown), although with shorter follow-up (2005-2009) these results were no longer significant. Likewise we tested for robustness within strata by sex, hourly versus salaried job status, and initial insulin use. Results revealed comparable point estimates for all strata with the exception of the women, in whom HR estimates for each complication hovered around 1. In general, the point estimates within strata were similar to those found for the full cohort, but with wider CIs.

DISCUSSION

This study compared 2 groups of employees with diabetes to assess how differences in process measures of care might have affected the onset of complications associated with diabetes. Significant differences in time to complication were observed between the 2 groups for 2 of the 4 complications (HF and RD) and for any of the 4 complications. Remarkably, those employees getting optimal process scores were, on average, sicker at the outset based on greater insulin use and increased risk severity scores; hence, they would have been expected a priori to have worse outcomes.

Many studies have assessed whether interventions at the provider level improve processes of care and intermediate outcomes, but the effect of such process improvements on complications remains less clear because the outcomes themselves are rarely assessed.³⁸ This study estimates the impact of process measures of quality care by analyzing data in a national sample across multiple physician groups administering diabetes care within the same health insurance plan structure. This study is the first to our knowledge confirming, in practice, the expectations for benefit from compliance with recommended process measures of care in which follow-up was long enough to observe the major clinical end points of interest.

That said, there remain significant limitations to our methods and our ability to draw causal inference from the results. We relied on claims data for recognition of our population with diabetes, for ascertainment of complications, and for assessment of the critical covariate of interest—execution of all of the quality of care diagnostic measures in the baseline year. Each step entails opportunity for misclassification. Although the diagnosis of diabetes is readily inferred from claims with high sensitivity and specificity,³⁹ comparable data comparing claims with verifiable sources such as medical records or examinations do not exist for any of the major complications with the exception of RD,⁴⁰ which has been found to be identified with high specificity but less sensitivity than diabetes. That would not, however, bias our findings for patients who had been identified as having RD. Thus, it is possible that the end points misclassified cohort members in both directions and that some with complications already evident were not appropriately excluded. The impact of such misclassifications, assuming they were random, would likely drive our result toward the null, but there is no assurance that such errors were random.

Another concern is the impact on our conclusions of unobserved variables (eg, body mass index, duration of diabetes) as noted above. Although there is no strong prior reason to suspect that such variables were distributed in such a way as to confound our result, more obese subjects might have received consistently poorer care and, independently, had a higher risk of bad outcomes. The impact of censorship may also have resulted in possible bias, as those faring most poorly might be expected to leave prematurely more often. It is reassuring that censorship was not associated with baseline characteristics of disease severity nor with treatment group, but the size of loss—more than half of the cohort—introduces concern for unmeasured bias.

The employees in this study may not represent a generalizable population, as they work for a stable employer with rich and uniform benefits in the heavy manufacturing sector, both less common features than a generation ago. Our study panel requirements demanded a group stably employed during a period of years, further rendering it less representative of the larger workforce.

Perhaps most difficult to fully address is the possibility of endogenous differences among persons with diabetes leading some to *both* seek better care for their disease—picking better qualified doctors and/or advising them what tests to order—and take better care of themselves in other ways, collectively resulting in better outcomes. Nonetheless, it is noteworthy that in the primary test of the hypothesis, the baseline characteristics created an uneven playing field, with

Table 4. Multivariate Associations With Hazard Ratios, Confidence Intervals, and *P* Values for Developing Each of the 4 Complications (Coronary Artery Disease, Stroke, Heart Failure, or Renal Disease) During the 6-Year Observation Period (January 1, 2004–December 31, 2009)

Characteristic	Coronary Artery Disease			Stroke		
	HR	95% CI	<i>P</i>	HR	95% CI	<i>P</i>
Age, y						
18-45	1.00	Reference		1.00	Reference	
46-51	1.81	1.24-2.64	.0020	1.53	0.85-2.75	.1545
52-56	1.85	1.25-2.74	.0020	2.95	1.69-5.15	.0001
57-64	2.61	1.70-4.00	<.001	4.65	2.57-8.44	<.0001
Sex						
Male	1.72	1.15-2.56	.0080	0.77	0.50-1.21	.2609
Race						
White	1.00	Reference		1.00	Reference	
Black	0.92	0.66-1.27	.6014	0.81	0.52-1.25	.3304
Hispanic	0.87	0.57-1.33	.5195	0.55	0.28-1.08	.0833
Other	1.14	0.53-2.45	.7290	0.23	0.03-1.66	.1452
Marital status						
Married	0.92	0.69-1.24	.5921	0.88	0.60-1.31	.5430
Compensation						
Hourly	1.24	0.88-1.73	.2173	1.27	0.81-1.98	.2988
Wage						
Quartile 1 (<\$35,423)	1.00	Reference		1.00	Reference	
Quartile 2 (\$35,424-\$44,743)	1.19	0.83-1.70	.3552	0.85	0.52-1.41	.5351
Quartile 3 (\$44,744-\$56,903)	0.97	0.66-1.42	.8778	1.15	0.70-1.89	.5907
Quartile 4 (>\$56,903)	0.96	0.63-1.46	.8999	1.28	0.74-2.21	.3713
Smoking						
Never	1.00	Reference		1.00	Reference	
Past/current	1.47	0.97-2.21	.0676	1.35	0.76-2.38	.3043
Unknown	1.19	0.82-1.71	.3669	1.39	0.83-2.32	.2171
Insulin						
	1.14	0.84-1.54	.3430	1.04	0.69-1.57	.8559
Health severity risk score						
Quartile 1 (≤1.0)	1.00	Reference		1.00	Reference	
Quartile 2 (>1.0-1.4)	1.17	0.79-1.72	.4260	0.94	0.52-1.69	.8221
Quartile 3 (>1.4-2.0)	1.28	0.87-1.89	.2134	1.46	0.85-2.51	.1704
Quartile 4 (≥2.1)	2.17	1.47-3.19	<.0001	2.04	1.18-3.52	.0105
Quality-of-care measures (2003)						
All 3 measures ^a	0.70	0.49-1.02	.0635	0.63	0.38-1.07	.0891

CI indicates confidence interval; HR, hazard ratio.

^aThere were 2 A1C measurements, 1 microalbuminuria test, and 1 lipid test in 2003.

more ostensibly sick patients having a higher rate of better care; thus, the deck was stacked against those with better care having better outcomes, an effect that began to be visually apparent in the third observation year (see Figure 5). It is also reassuring that our result survived the various sen-

sitivity tests. We are exploring instrumental variables and other approaches to examine the causal pathway further, including assessment of the relationships between the process measures and intermediate outcomes such as medication change, adherence, frequency of exams, and the like.

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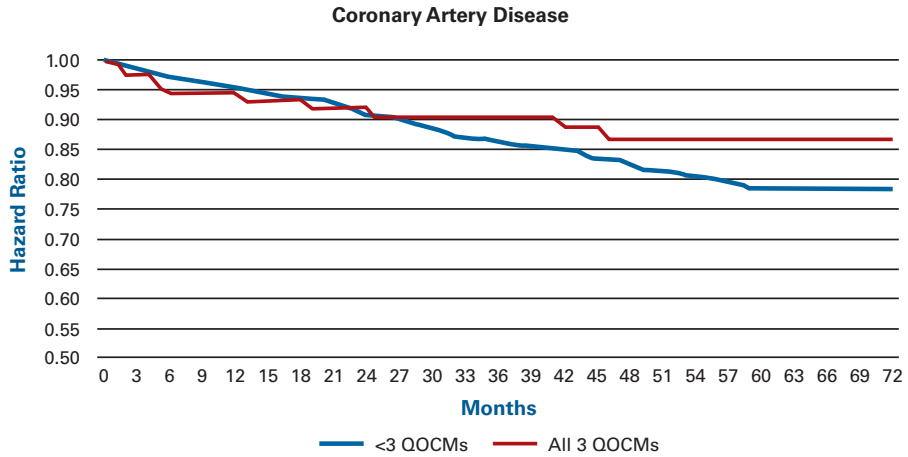
Heart Failure			Renal Disease			Any of the 4 Conditions		
HR	95% CI	P	HR	95% CI	P	HR	95% CI	P
1.00	Reference		1.00	Reference		1.00	Reference	
2.15	1.00-4.65	.0513	1.70	0.80-3.58	.1657	1.88	1.36-2.61	.0001
3.42	1.61-7.25	.0013	2.71	1.31-5.62	.0073	2.06	1.47-2.89	<.0001
6.44	2.96-14.01	<.0001	4.19	1.89-9.26	.0004	3.09	2.15-4.46	<.0001
1.01	0.57-1.79	.9641	1.22	0.65-2.29	.5447	1.18	0.87-1.61	.2867
1.00	Reference		1.00	Reference		1.00	Reference	
1.50	0.93-2.41	.0961	1.77	1.06-2.97	.0295	1.05	0.80-1.36	.7457
1.14	0.58-2.25	.6966	1.60	0.82-3.11	.1693	0.86	0.60-1.25	.4369
0.45	0.06-3.28	.4317	0.00	0.00-0.00	.9791	0.83	0.39-1.77	.6282
1.05	0.64-1.73	.8529	1.27	0.71-2.27	.4209	0.99	0.77-1.28	.9475
1.19	0.68-2.07	.5503	0.76	0.44-1.33	.3395	1.09	0.82-1.44	.5436
1.00	Reference		1.00	Reference		1.00	Reference	
1.22	0.69-2.18	.4952	0.99	0.52-1.87	.9687	1.00	0.73-1.36	.9988
1.01	0.54-1.90	.9682	1.19	0.62-2.28	.6063	0.96	0.70-1.32	.8029
1.05	0.53-2.07	.8913	0.84	0.40-1.76	.6515	0.98	0.69-1.39	.9029
1.00	Reference		1.00	Reference		1.00	Reference	
2.21	1.06-4.62	.0353	2.01	0.86-4.69	.1074	1.44	1.01-2.07	.0468
1.65	0.82-3.31	.1576	2.22	1.03-4.77	.0411	1.30	0.94-1.79	.1118
1.54	0.96-2.46	.0707	2.52	1.58-4.03	.0001	1.20	0.92-1.55	.1797
1.00	Reference		1.00	Reference		1.00	Reference	
1.16	0.58-2.35	.6729	0.95	0.44-2.05	.8966	1.20	0.87-1.66	.2731
1.14	0.57-2.29	.7075	0.82	0.38-1.79	.6243	1.38	0.99-1.91	.0541
2.05	1.04-4.03	.0380	2.16	1.06-4.41	.0349	1.91	1.36-2.68	.0002
0.39	0.19-0.81	.0117	0.48	0.24-0.95	.0339	0.66	0.48-0.91	.0101

CONCLUSION

Limitations notwithstanding, these results provide further support for process measures and efforts to promote their application in practice, starting with the obvious; the proportion

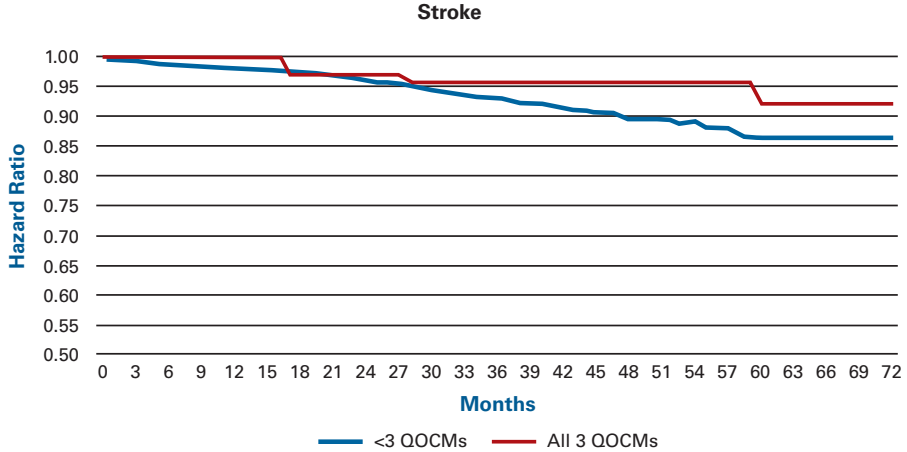
of employees with diabetes getting the standard of care based on systematic reviews^{1,38} was disturbingly low (just under 15%) in our fully insured population. If even a modest portion of the association with outcome is causal, there is a considerable opportunity for benefit from driving better processes of care.

■ **Figure 1.** Kaplan-Meier Estimates of Adjusted Cumulative Hazard Ratios and Aggregate Data: Coronary Artery Disease^a



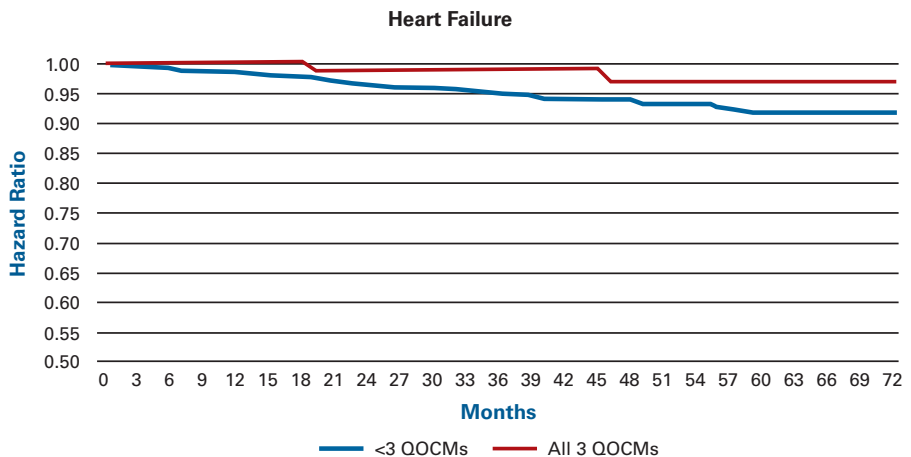
QOCM indicates quality of care measure.
^aCoronary artery disease (n = 1580, hazard ratio = .70, 95% confidence interval, .49-1.02; P = .0635).

■ **Figure 2.** Kaplan-Meier Estimates of Adjusted Cumulative Hazard Ratios and Aggregate Data: Stroke^a



QOCM indicates quality of care measure.
^aStroke (n = 1751, hazard ratio = 0.63, 95% confidence interval, 0.38-1.07; P = .0891).

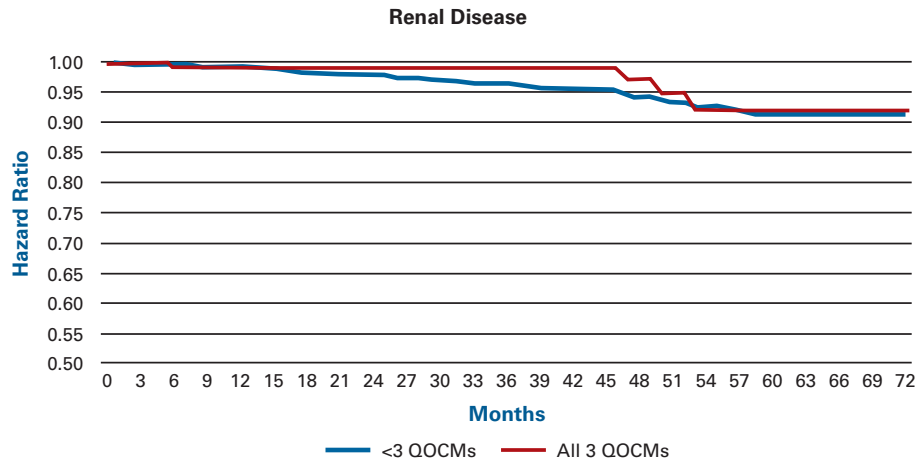
■ **Figure 3.** Kaplan-Meier Estimates of Adjusted Cumulative Hazard Ratios and Aggregate Data: Congestive Heart Failure^a



QOCM indicates quality of care measure.
^aHeart failure (n = 1765, hazard ratio = 0.39, 95% confidence interval, 0.19-0.81; P = .0117).

Process of Care Compliance

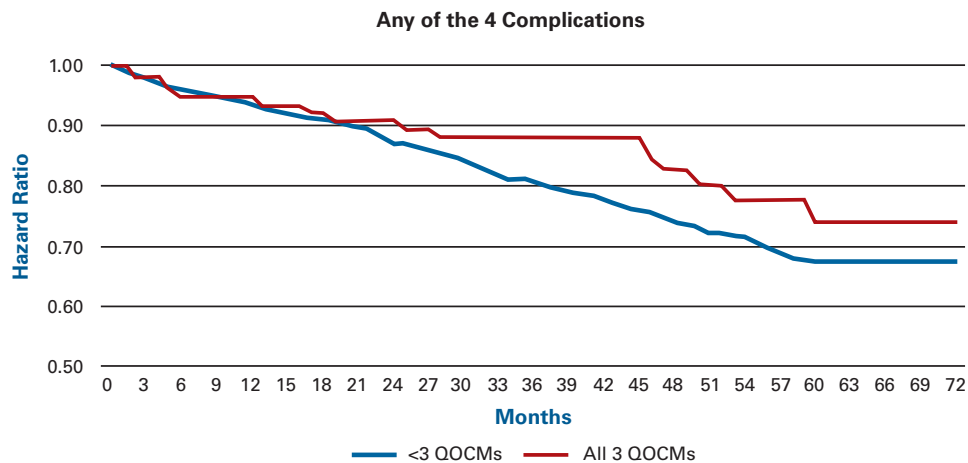
■ **Figure 4.** Kaplan-Meier Estimates of Adjusted Cumulative Hazard Ratios and Aggregate Data: Renal Disease^a



QOCM indicates quality of care measure.

^aRenal disease (n = 1785, hazard ratio = 0.48, 95% confidence interval, 0.24-0.95; P = .0339).

■ **Figure 5.** Kaplan-Meier Estimates of Adjusted Cumulative Hazard Ratios and Aggregate Data: Any of the 4 Complications^a



QOCM indicates quality of care measure.

^aAny of the 4 complications (n = 1797, hazard ratio = 0.66, 95% confidence interval, 0.48-0.92; P = .0101).

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