Practice-Level Variation in Outpatient Cardiac Care and Association With Outcomes

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Background—Utilization of cardiac services varies across regions and hospitals, yet little is known regarding variation in the intensity of outpatient cardiac care across cardiology physician practices or the association with clinical endpoints, an area of potential importance to promote efficient care.

Methods and Results—We included 7 160 732 Medicare beneficiaries who received services from 5635 cardiology practices in 2012. Beneficiaries were assigned to practices providing the plurality of office visits, and practices were ranked and assigned to quartiles using the ratio of observed to predicted annual payments per beneficiary for common cardiac services (outpatient intensity index). The median (interquartile range) outpatient intensity index was 1.00 (0.81−1.24). Mean payments for beneficiaries attributed to practices in the highest (Q4) and lowest (Q1) quartile of outpatient intensity were: all cardiac payments (Q4 $1272 vs Q1 $581; ratio, 2.2); cardiac catheterization (Q4 $215 vs Q1 $64; ratio, 3.4); myocardial perfusion imaging (Q4 $253 vs Q1 $83; ratio, 3.0); and electrophysiology device procedures (Q4 $353 vs Q1 $142; ratio, 2.5). The adjusted odds ratios (95% CI) for 1 incremental quartile of outpatient intensity for each outcome was: cardiac surgical/procedural hospitalization (1.09 [1.09, 1.10]); cardiac medical hospitalization (1.00 [0.99, 1.00]); noncardiac hospitalization (0.99 [0.99, 0.99]); and death at 1 year (1.00 [0.99, 1.00]).

Conclusion—Substantial variation in the intensity of outpatient care exists at the cardiology practice level, and higher intensity is not associated with reduced mortality or hospitalizations. Outpatient cardiac care is a potentially important target for efforts to improve efficiency in the Medicare population. (*J Am Heart Assoc*. 2016;5:e002594 doi: 10.1161/JAHA.115.002594)

Key Words: mortality • physician practice variation • population

Variation in use of services for Medicare beneficiaries has been documented extensively and has been suggested as a useful step toward identifying opportunities to reduce program costs.[1] Experts have recommended focusing on variation at the organizational or provider level to promote high-value care.[2] Increasingly, physicians are the focus of efforts to improve the value of care, with physician practices as a commonly targeted organizational unit for pay-for-performance and alternative payment models.[3–6] Cardiology accounts for one of the highest shares of specialty physician spending[7] and many services commonly performed or ordered by cardiologists have been identified by professional societies as contributing to overuse.[8] Though variation in the delivery of cardiac services has been demonstrated at the regional and hospital level for diagnostic tests and procedures,[9–11] little is known of how the delivery of services vary in the outpatient setting among cardiologists or cardiology physician group practices, or whether a higher intensity of care is associated with better outcomes. An absence of an association of higher intensity with better outcomes would

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provide clinicians with evidence to limit procedures of uncertain clinical benefit and provide support for efforts to promote efficient use of resources.

Several studies have demonstrated substantial variation in the medical management of specific conditions across cardiology practices.[12–14] To date, no study has measured the extent of variation in the delivery of common cardiac services across cardiology practices in the outpatient setting, specific services contributing to variation, or the association between intensity and outcomes. This information is of particular importance given that recent legislation ending the Sustainable Growth Rate as a mechanism for restraining Medicare costs requires the government and professional organizations to develop measures of resource use, particularly for specialty care, to be used for physician performance assessment and alternative payment models.[15] The aim of this study is to quantify variation in the intensity of outpatient cardiac services delivered to a population of Medicare beneficiaries attributed to a cardiology practice and determine the association between practice intensity and outcomes. To determine practice intensity, we used a similar approach used in primary care accountable care models so that cardiology practices are equally compared based on the total outpatient cardiac services delivered to a risk-adjusted population of beneficiaries for whom they provide the plurality of cardiac evaluation and management care. Because most procedures performed in the outpatient setting are intended to diagnose, evaluate, or treat conditions that may lead to death or hospitalization, we determined the association between the intensity of outpatient care and all-cause mortality rates, as well as hospitalizations for cardiac conditions. To further characterize procedure-specific contribution to variation in practice intensity, we measured average payments for individual procedure categories. Finally, to evaluate for possible patient population differences explaining practice variation, we conducted several secondary analyses of practices and the patient populations they served, as well as a falsification endpoint analysis using noncardiac hospitalizations.

Methods

Data Sources and Participants

We used the 100% Medicare fee-for-service Beneficiary Summary, carrier, hospital outpatient, and inpatient claims data in 2012 and the Beneficiary Summary file in 2013. Beneficiaries were eligible for inclusion if they had any outpatient evaluation and management (E&M) visits (procedure codes 99201-5 and 99211-5) to a cardiologist (specialty code "06") during the year. Beneficiaries were excluded if they had missing demographic data (0.3%), less than a full year of

part B eligibility or were enrolled in Medicare Advantage during the year (7.5%), or attributed to practices with fewer than 100 beneficiaries (0.8%). Demographic variables were extracted from the Beneficiary Summary file, and chronic condition variables were extracted from the Chronic Conditions Warehouse categories.[16]

Outcomes

The primary outcome for each practice was the mean cardiac payment for beneficiaries attributed to the practice. All payment data reflect amounts paid by Medicare and were price standardized, which equalizes payments for a service in different regions of the country.[17]

Beneficiaries were first attributed to the physician practice that had the plurality of payments for outpatient E&M visits with a cardiologist in that year. This attribution methodology is an adaptation of those used in accountable care organization programs.[6] Cardiology practices were defined by the tax identification number listed on the claim, a standard method for identifying physician group practices using administrative claims data.[5,6]

Each beneficiary's annual cardiac payments consisted of the outpatient E&M services billed by the assigned practice and payments for 146 cardiac procedure codes if they were delivered in the outpatient setting, including those delivered by another practice. These procedure codes include the majority of services billed by cardiologists and were grouped into 7 categories: cardiac catheterization (catheterization); electrocardiogram (EKG); echocardiogram (echo); implantable cardioverter defibrillator (ICD) or pacemaker (EP device); other electrophysiology procedures (other EP procedure); myocardial perfusion imaging (MPI); and stress test for further analysis (codes in Table S1). To adjust for outliers, annual cardiac payments were Winsorized at the 1st and 99th percentiles for all values in the sample, meaning values beyond those extremes were recorded as the respective percentile value.

To calculate the association between outpatient practice intensity and inpatient use we included claims for admissions to acute care hospitals. We grouped claims into cardiac if the medical severity diagnosis-related code (MS-DRG) belonged to major diagnostic category 5 and separately analyzed surgical/procedural and medical MS-DRGs (Table S2). Surgical/procedural MS-DRGs include admissions for interventional and electrophysiological procedures. We included noncardiac admissions as a falsification endpoint to assess potential confounding because of unmeasured severity of illness or other factors that may affect utilization of services.[18] Mortality was determined based upon a validated date of death in the Beneficiary Summary file through 2013. We excluded 146 beneficiaries from this analysis who neither died nor were present in the 2013 file.

Statistical Analysis

We divided practices into quartiles based on the ratio of observed to predicted mean cardiac payments. To determine predicted payments, we fit a generalized linear regression model with a log link and gamma distribution with adjustment for clustering at the practice level. The chronic condition variables were selected through clinical review of 21 condition variables in the data set. We included demographic variables and Medicaid eligibility. Predicted values were calculated for each beneficiary using the coefficients from this model. For each practice, we calculated the ((mean observed payments)/ (mean predicted payments)). We divided each practice's observed to predicted ratio by the ratio for the median practice in the sample to calculate the outpatient intensity index so that the median practice in the sample would have an index of 1.

To further understand procedure-specific contribution to variation, we calculated mean payments for each procedure category for all beneficiaries in each quartile, as well as the percentage of beneficiaries with any use of each procedure and mean payments per user.

We conducted several analyses to assess whether characteristics of practices and attributed beneficiaries varied across quartiles, which may have not been accounted for in our risk-adjustment model and could affect the interpretation of our results. We calculated the mean and median number of beneficiaries and unique providers billing for a Medicare service at the practice, including general cardiologists, electrophysiologists, and noncardiologists, identified by specialty code. We also identified the subset of interventional cardiologists as cardiologists who had at least 5 claims for procedure code 92980, the most common billing code for an intracoronary stent placement. We present the distribution of beneficiaries by region and the distribution of primary diagnosis codes for cardiology E&M visits.

To assess for potential differences in patient case mix attributed to regional differences in the propensity for visiting a cardiologist, we calculated the overall proportion of beneficiaries in a hospital referral region visiting a cardiologist (referral rate) and the ratio of observed to predicted proportion (referral index) using a logistic regression model with the same covariates as the above model.

To determine the association between outpatient practice intensity and outcomes, we fit logistic models for each of the outcome variables, including practice quartile as an independent covariate. We determined odds ratios (ORs) for each quartile compared to quartile 1, as well as the ORs associated with each incremental quartile. We used a model with only the practice quartile as an independent predictor and a risk-adjusted model, which included the covariates used above, as well as additional chronic conditions for the mortality analysis. We performed sensitivity analyses including hierarchical condition category

Table 1. Practice Characteristics Across Quartiles of Practice Intensity

Quartile of Spending (Outpatient Intensity Index, Q1=Lowest)	Q1 (<0.81)	Q2 (0.81–1.00)	Q3 (1.00–1.24)	Q4 (>1.24)	Total
No. of practices	1409	1409	1409	1408	5635
Attributed beneficiaries					
Mean*	795	1661	1738	889	1271
Median	353	669	680	467	511
Providers					
General cardiologists					
Mean*	3.4	6.2	6.1	3.0	4.4
Median	1	2	2	1	1
Electrophysiologists					
Mean*	0.2	0.4	0.4	0.1	0.3
Median	0	0	0	0	0
Interventional cardiologists					
Mean*	0.8	2.0	2.2	1.3	1.6
Median	0	1	1	1	1
Noncardiologists					
Mean*	33.5	56.3	60.3	22.6	43.2
Median	0	1	1	0	0

*$P<0.001$ for heterogeneity across quartiles, 1-way ANOVA.

Table 2. Deciles of Mean Cardiac Payments and Outpatient Indices

	Practice Mean Cardiac Payment	Outpatient Intensity Index
Mean (SD)	$795 ($323)	1.06 (0.40)
Decile		
10th	$471	0.66
20th	$562	0.77
30th	$630	0.85
40th	$687	0.93
50th	$744	1.00
60th	$810	1.09
70th	$882	1.18
80th	$976	1.30
90th	$1153	1.51

score, a Medicare comorbidity index used for risk adjustment in many programs, and the referral index calculated above.

We considered a 2-sided $P<0.05$ as statistically significant. Chi-square tests were used for categorical variables and 1–

Table 3. Characteristics of Beneficiaries Attributed to Practices by Quartile of Practice Intensity*

Quartile of Spending (Outpatient Intensity Index, Q1=Lowest)	Q1 (<0.81)	Q2 (0.81–1.00)	Q3 (1.00–1.24)	Q4 (>1.24)	Total
Beneficiaries	1 120 423	2 339 812	2 449 313	1 251 184	7 160 732
Age (mean), y	75.8	75.3	75.0	74.2	75.1
≤65 (%)	9.3	9.7	10.2	12.5	9.3
66 to 70 (%)	18.7	19.6	20.2	20.8	18.7
71 to 75 (%)	19.9	20.7	21.2	21.3	19.9
76 to 80 (%)	19.0	19.2	19.2	18.7	19.0
81 to 85 (%)	17.2	16.5	15.9	14.7	17.2
>85 (%)	15.9	14.3	13.3	12.0	15.9
Male (%)	48.7	49.8	50.0	48.5	49.5
Race (%)					
White	82.4	85.3	85.6	81.3	84.3
Black	7.4	7.3	6.9	9.3	7.5
Asian	2.6	1.8	2.0	2.3	2.1
Hispanic	6.5	4.7	4.5	6.0	5.1
Dual eligibility (%)	13.1	11.4	10.9	14.5	12.0
Comorbidities (% prevalence or current year where specified)					
Atrial fibrillation	31.4	32.6	32.3	30.4	31.9
MI (current year)	2.0	2.1	2.2	2.3	2.1
Congestive heart failure	46.3	46.3	46.1	48.5	46.6
Chronic kidney disease	31.9	33.2	33.7	34.4	33.4
COPD	33.1	34.3	34.6	37.1	34.7
Depression	30.9	32.2	32.5	34.0	32.4
Diabetes	47.9	45.8	45.1	47.6	46.2
Coronary artery disease	79.7	81.5	82.0	84.2	81.9
Stroke (current year)	5.9	6.2	6.2	6.6	6.2
Alzheimer's disease	5.0	4.7	4.6	4.9	4.8
Breast cancer	5.7	5.5	5.3	5.1	5.4
Colon cancer	3.7	3.5	3.3	3.3	3.4
Lung cancer	1.9	1.9	1.8	1.8	1.8
HCC	1.44	1.45	1.45	1.51	1.46
Census tract region (%)					
Midwest	15.0	24.7	20.3	19.0	20.8
Northeast	45.0	23.7	13.4	10.2	21.3
South	23.2	35.8	47.3	47.4	40.1
West	14.9	15.5	18.0	23.4	17.8
Urban	94.9	92.1	91.1	88.6	91.6
Mean regional referral rate	24.7	24.4	24.4	24.6	24.5
Mean referral index[†]	1.04	1.03	1.02	1.03	1.03

COPD indicates chronic obstructive pulmonary disease; HCC, hierarchical condition score; MI, myocardial infarction.

*P<0.001 for heterogeneity across quartiles using chi-square test for proportions and 1-way ANOVA for continuous variables.

[†]Referral index=observed/predicted regional rate of referral to cardiologists calculated by hospital referral regions.

way ANOVA for continuous variables. The Wald chi-square tests were used to determine statistical significance for ORs.

Given the large sample size, our interpretation focuses on the clinical significance of findings. All analyses were conducted using SAS Enterprise Guide (Version 5.1; SAS Institute Inc., Cary, NC). The analysis was conducted by Centers for Medicare and Medicaid Services employees in accord with institutional policies governing research activities.

Results

Practice Characteristics

We included 5635 practices and 7 160 129 beneficiaries. Table 1 provides practice-level statistics. The median

(interquartile range) practice mean payment, SE, and outpatient intensity index were $744 ($603–$928), $51 ($35–$74), and 1.00 (0.81–1.24), respectively (Table 2 lists means and deciles). The practices had a mean and median of 1271 and 511 patients, 4.4 and 1 general cardiologist, 0.3 and 0 electrophysiologists, 1.6 and 1 interventional cardiologists, and 43.2 and 0 noncardiologists, respectively. Practices in the middle 2 quartiles (Q2 and Q3) of outpatient intensity were larger than the lowest and highest quartiles (Q1 and Q4) for all measures, though they were highly skewed in size with both single and multispecialty practices in all quartiles. On average, Q4 practices had a higher average of interventional cardiologists compared to Q1 (1.3 vs 0.8). A substantial proportion of practices in both quartiles had no interventional cardiologists (68% in Q1 and 39% in Q4).

Table 4. Parameter Estimates for Generalized Linear Model for Predicting Cardiac Payments*

Parameter	Full Cohort	Sample	Estimate	SE	Payment Ratio	*P* Value
Intercept			6.15	0.01		<0.0001
Atrial fibrillation	31.9%	31.8%	0.22	0.01	1.25	<0.0001
Myocardial infarction (current year only)	2.1%	2.1%	0.12	0.02	1.13	<0.0001
Congestive heart failure	46.6%	46.5%	0.23	0.01	1.26	<0.0001
Chronic kidney disease	33.4%	33.5%	0.03	0.01	1.03	<0.0001
Chronic obstructive pulmonary disease	34.7%	34.7%	0.04	0.01	1.04	<0.0001
Depression	32.4%	32.4%	0.04	0.01	1.05	<0.0001
Diabetes	46.2%	46.2%	0.03	0.01	1.03	<0.0001
Coronary artery disease	81.9%	82.0%	0.31	0.01	1.37	<0.0001
Stroke (current year only)	6.2%	6.3%	0.05	0.01	1.05	<0.0001
Medicaid enrollment	12.0%	12.1%	−0.01	0.01	0.99	0.1381
White (reference)	84.3%	84.2%				
Black	7.5%	7.6%	0.01	0.01	1.01	0.5158
Other	0.7%	0.7%	−0.04	0.03	0.96	0.1661
Asian	2.1%	2.1%	−0.01	0.02	0.99	0.7663
Hispanic	5.1%	5.1%	−0.02	0.01	0.98	0.0515
North American Native	0.3%	0.3%	−0.01	0.05	0.99	0.9199
Female (reference)	50.5%	50.6%				
Male	49.5%	49.4%	0.04	0.00	1.04	<0.0001
≤65 y	10.3%	10.3%	0.16	0.01	1.18	<0.0001
66 to 70 y	19.9%	19.9%	0.11	0.01	1.11	<0.0001
71 to 75 y	20.9%	20.9%	0.05	0.01	1.05	<0.0001
76 to 80 y	19.1%	19.0%	0.00	0.01	1.00	0.8126
81 to 85 y	16.1%	16.2%	−0.06	0.01	0.94	<0.0001
>85 y (reference)	13.8%	13.8%				

*Because of computer memory constraints, the model was fit on a random sample of 500 000 beneficiaries stratified by practice. The proportion of the population in the full cohort and the random sample are displayed below. Each beneficiary's predicted payments were equal to the exponential value for the estimate generated using the equation below. A modified Park test was performed with an intercept of 2.01 supporting the use of a gamma distribution.

Beneficiary Characteristics

Table 3 shows characteristics of beneficiaries attributed to practices within each quartile, and Table 4 provides parameter estimates for the generalized linear model predicting annual cardiac payments. Average age was 75.1 years (range from 74.2 to 75.8). The percent of males was 49.5% (range from 48.5% to 50.0%), and the percent of black patients was 7.5% (range from 6.9% to 9.3%). The percent of beneficiaries enrolled in Medicaid was 12.0% (range from 10.9% to 14.5%). The prevalence of chronic conditions and occurrence of myocardial infarction or stroke were similar across quartiles, with the proportion of beneficiaries never exceeding a 2.3% difference from the national average.

Relative to Q1, beneficiaries in Q4 were less likely to reside in the Northeast (10.2% vs 45.0%) or in an urban location (88.6% vs 94.9%) and more likely to reside in the South (47.4% vs 23.2%), Midwest (19.0% vs 15.0%), and West (23.4% vs 14.9%). The mean regional referral rate (range 24.4–24.7%) and mean referral index (range 1.02–1.04) were similar across quartiles. Table 5 lists parameter estimates for the logistic model used to determine the referral index.

Table 6 lists the mean number of outpatient visits to cardiologists, the proportion to the assigned practice, and the distribution of primary diagnosis codes for cardiology visits. The proportion of visits to the assigned practice ranged from 94.1% to 95.8%. Compared to Q1, beneficiaries in Q4 had more total visits (2.85 vs 2.51), a lower proportion of visits for hypertension (10.0% vs 12.8%), and a greater proportion of visits for acute respiratory and chest symptoms (10.2% vs 6.8%).

Procedure Contribution to Variation

Figure illustrates the contribution for individual procedures to variation across quartiles. Mean cardiac payments ranged from $583 in Q1 to $1272 in Q4. E&M payments to the same practice were 1.25-fold higher in Q4 relative to Q1. Mean procedure payments were $433 and $1085 in Q1 and Q4, respectively, a 2.50-fold difference. Compared with Q1, beneficiaries attributed to Q4 practices had higher average payments for all procedure categories, most significantly cardiac catheterization (Q4 $215 vs Q1 $64; ratio, 3.4), myocardial perfusion imaging (Q4 $253 vs Q1 $83; ratio, 3.0), and electrophysiology device procedures (Q4 $353 vs Q1 $142; ratio, 2.5). Table 7 includes the full data as well as a delineation of variation in the number of users for each procedure as well as the average payment per user. Most variation was explained by differences in the proportion of users of each procedure.

Table 5. Parameter Estimates for Logistic Model Predicting Visit to a Cardiologist*

Parameter	Odds Ratio	95% Wald Lower Limit	95% Wald Upper Limit
Atrial fibrillation	3.40	3.37	3.43
Myocardial infarction (current year)	2.55	2.47	2.64
Congestive heart failure	1.83	1.82	1.84
Chronic kidney disease	1.12	1.11	1.13
Chronic obstructive pulmonary disease	0.99	0.98	0.99
Depression	0.82	0.81	0.82
Diabetes	1.10	1.09	1.11
Coronary artery disease	7.29	7.23	7.35
Stroke (current year)	1.19	1.17	1.21
Medicaid enrollment	0.51	0.51	0.52
White (reference)	1.59	1.51	1.68
Black	0.77	0.76	0.78
Other	0.92	0.88	0.95
Asian	1.00	0.98	1.02
Hispanic	0.92	0.91	0.93
North American Native	0.65	0.62	0.69
Female (reference)			
Male	1.08	1.07	1.09
≤65 y	0.77	0.76	0.78
66 to 70 y (reference)			
71 to 75 y	0.92	0.91	0.93
76 to 80 y	0.82	0.81	0.83
81 to 85 y	0.72	0.71	0.72
>85 y	0.45	0.45	0.46

*This model was developed using a random sample of 2 878 028 Medicare beneficiaries. Area under the curve=0.82.

Association of Outpatient Intensity With Inpatient Use and Mortality

Table 8 lists the proportion of beneficiaries with an inpatient admission for each admission type and both unadjusted and adjusted ORs by quartile. The proportion of beneficiaries with a noncardiac admission and a cardiac medical admission were similar across quartiles. The adjusted odds ratio (C-statistic) for each incremental quartile was 0.99 [0.99, 0.99] *P*<0.001 (0.73) and 1.00 [0.99, 1.00] *P*=0.001 (0.78) for noncardiac and cardiac medical admissions, respectively.

Compared to Q1 (4.2% [4.2%, 4.2%], the proportion of beneficiaries with a surgical/procedural admission increased with outpatient intensity: Q2 (4.9% [4.9%, 5.0%], adjusted OR

Table 6. Description of Cardiology Outpatient Visits for Beneficiaries Attributed to Practices by Quartile of Intensity*

Quartile of Spending (Outpatient Intensity Index, Q1=Lowest)	Q1 (<0.81)	Q2 (0.81–1.00)	Q3 (1.00–1.24)	Q4 (>1.24)	Total
Beneficiaries	1 120 423	2 339 812	2 449 313	1 251 184	7 160 732
Mean cardiology outpatient visits	2.51	2.45	2.57	2.85	2.57
Proportion to assigned practice (%)	94.1	95.7	95.8	95.4	95.4
Primary diagnoses for most frequent cardiology outpatient visits (% total)†					
Disorders of lipoid metabolism (272.xx)	3.3	3.3	3.1	2.4	3.1
Essential hypertension (401.xx)	12.8	10.8	9.9	10.0	10.7
Hypertensive heart disease (402.xx)	3.2	1.9	1.6	1.9	2.0
Angina pectoris (413.xx)	1.6	1.6	1.7	3.0	1.9
Chronic ischemic heart disease (414.xx)	21.5	24.4	24.3	24.6	24.0
Other diseases of endocardium (424.xx)	4.3	4.2	4.0	3.4	4.0
Cardiomyopathy (425.xx)	2.1	2.3	2.2	2.1	2.2
Cardiac dysrhythmias (427.xx)	19.6	21.4	21.9	17.9	20.6
Heart failure (428.xx)	3.7	3.7	3.4	3.4	3.5
General symptoms (780.xx)	1.7	1.8	2.0	2.2	1.9
Cardiovascular symptoms (785.xx)	1.7	1.8	1.9	2.0	1.9
Respiratory and chest symptoms (786.xx)	6.8	7.2	8.0	10.2	8.0

*$P<0.001$ for heterogeneity across quartiles for all variables using chi-square for proportions and 1-way ANOVA for continuous variables.
†International Classification of Diseases, Ninth Revision, Clinical Modification codes.

1.14 [1.13, 1.15], $P<0.001$); Q3 (5.3% [5.3%, 5.3%], adjusted OR 1.22 [1.21, 1.24], $P<0.001$); and Q4 (5.9% [5.8%, 5.9%], adjusted OR 1.32 [1.31, 1.34], $P<0.001$). The adjusted odds ratio (C-statistic) for each incremental quartile was 1.09 [1.09, 1.10], $P<0.001$ (0.76).

Compared to Q1 (6.3% [6.2%, 6.3%], mortality rates were similar across quartiles: Q2 (6.3% [6.3%, 6.3%], adjusted OR 1.01 [1.00, 1.02], $P=0.011$); Q3 (6.2% [6.2%, 6.2%], adjusted OR 1.01 [1.00, 1.02], $P=0.026$); and Q4 (6.2% [6.1%, 6.2%], adjusted OR 0.99 [0.98, 1.00], $P<0.001$). The adjusted odds ratio (C-statistic) for each incremental quartile was 1.00 [0.99, 1.00], $P=0.028$ (0.79).

Sensitivity analyses were conducted for all outcome variables incorporating the regional referral index with and without HCC score, with similar results and C-statistics with inclusion of these variables (Table 9).
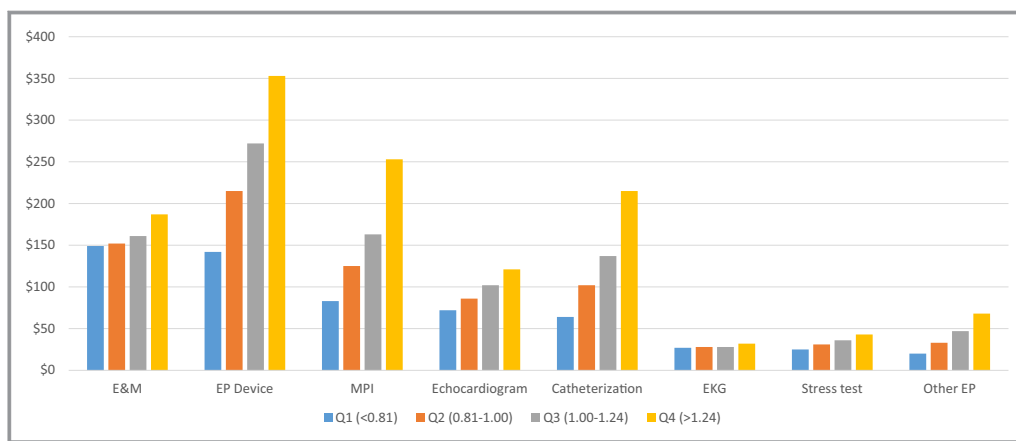

Figure. Procedure-specific contribution to payment variation. Each bar represents the average payment for the indicated procedure for all beneficiaries attributed to practices in the respective quartile of intensity. Payments are adjusted for regional price differences. E&M indicates outpatient evaluation and management visits; EKG, electrocardiogram; EP, electrophysiology; MPI, myocardial perfusion imaging.

Table 7. Mean Cardiac and Procedure Specific Payments and Users for Beneficiaries Attributed to Practices by Quartile of Intensity*

	Q1 (<0.81)	Q2 (0.81–1.00)	Q3 (1.00–1.24)	Q4 (>1.24)	Difference Q4−Q1	Ratio Q4:Q1
Beneficiaries	1 120 423	2 339 812	2 449 313	1 251 184		
Mean cardiac payments	583	771	946	1272	689	2.18
Mean E&M payments	149	152	161	187	38	1.26
Mean procedure payments	433	619	785	1085	651	2.50
Procedure variation						
Mean catheterization payments	64	102	137	215	151	3.38
% users	3.1	4.8	6.4	9.8		3.18
Mean payment per user	2062	2130	2151	2193		1.06
Mean EKG payments	27	28	28	32	5	1.18
% users	76.3	75.3	75.7	78.0		1.02
Mean payment per user	36	37	37	41		1.15
Mean other EP procedure payments	20	33	47	68	48	3.39
% users	0.6	0.8	1.2	1.5		2.72
Mean payment per user	3581	3855	4062	4474		1.25
Mean echo payments	72	86	102	121	49	1.68
% users	33.8	37.3	43.0	53.6		1.59
Mean payment per user	214	230	238	227		1.06
Mean ICD/pacemaker payments	142	215	272	353	210	2.48
% users	1.2	1.7	2.1	2.7		2.22
Mean payment per user	11 689	12 501	12 784	13 056		1.12
Mean MPI payments	83	125	163	253	170	3.04
% users	14.6	20.2	25.1	36.4		2.49
Mean payment per user	569	622	649	696		1.22
Mean stress test payments	25	31	36	43	18	1.74
% users	18.6	23.4	28.1	38.8		2.09
Mean payment per user	133	134	128	110		0.83

Payments are in dollars. echo indicates echocardiogram; EKG, electrocardiogram; EP, electrophysiology; E&M, evaluation and management; ICD, implantable cardioverter defibrillator; MPI, myocardial perfusion imaging.

*$P<0.001$ for heterogeneity across quartiles for all variables using chi-square for proportions and 1-way ANOVA for continuous variables.

Discussion

Our study demonstrates substantial variation in Medicare payments for outpatient services at the cardiology practice level. Because prices were standardized, the variation reflects differences in utilization. Increasing utilization of outpatient services was not associated with a meaningful decrease in the odds of death or a medical hospitalization, but was associated with a meaningful increase in the odds of a cardiac surgical/procedural admission. These findings are important because they suggest that higher levels of intensity of outpatient care may not be delivering value.

Quantifying variation at the cardiology practice level is important because practice-level variation is highly actionable, both by patients and referring physicians who may use this information to guide selection, and payers who may use various contracting mechanisms to encourage high-value care. Although measuring a comprehensive set of services at the practice level likely underestimates variation for individual procedures and physicians, this mitigates risk of identifying variation attributed to specialization in a field of cardiology and still demonstrated clinically and financially meaningful variation. Our approach to first attributing beneficiaries to practices and then including all cardiac procedures regardless of billing practice allows for comparison across practices that

Table 8. Inpatient Use and Mortality Across Quartiles*

Quartile of Spending (Outpatient Intensity Index, Q1=Lowest)	Q1 (<0.81)	Q2 (0.81–1.00)	Q3 (1.00–1.24)	Q4 (>1.24)	Odds Ratio Per Incremental Quartile
Inpatient use					
Noncardiac					
Actual users (%)	19.7 [19.6, 19.8]	20.3 [20.2, 20.3]	20.1 [20.0, 20.1]	20.7 [20.6, 20.8]	
Unadjusted odds ratio	Reference	1.04 [1.03, 1.04]	1.03 [1.02, 1.03]	1.06 [1.06, 1.07]	1.02 [1.01, 1.02]
Adjusted odds ratio	Reference	1.01 [1.00, 1.01]	0.99 [0.99, 1.00]	0.98 [0.97, 0.99]	0.99 [0.99, 0.99]
Cardiac medical					
Actual users (%)	7.9 [7.9, 8.0]	8.3 [8.3, 8.4]	8.2 [8.2, 8.2]	8.5 [8.5, 8.6]	
Unadjusted odds ratio	Reference	1.05 [1.04, 1.06]	1.03 [1.03, 1.04]	1.09 [1.08, 1.10]	1.02 [1.02, 1.02]
Adjusted odds ratio	Reference	1.02 [1.01, 1.03]	1.00 [0.99, 1.01]	1.00 [0.99, 1.01]	1.00 [0.99, 1.00]
Cardiac surgical/procedural					
Actual users (%)	4.2 [4.2, 4.2]	4.9 [4.9, 5.0]	5.3 [5.3, 5.3]	5.9 [5.8, 5.9]	
Unadjusted odds ratio	Reference	1.18 [1.17, 1.19]	1.28 [1.26, 1.29]	1.42 [1.40, 1.44]	1.11 [1.11, 1.12]
Adjusted odds ratio	Reference	1.14 [1.13, 1.15]	1.22 [1.21, 1.24]	1.32 [1.31, 1.34]	1.09 [1.09, 1.10]
Mortality rate (1-year)					
Actual (%)	6.3 [6.2, 6.3]	6.3 [6.3, 6.3]	6.2 [6.2, 6.2]	6.2 [6.1, 6.2]	
Unadjusted odds ratio	Reference	1.01 [1.00, 1.021	0.99 [0.98, 1.00]	0.98 [0.97, 0.99]	0.99 [0.99, 0.99]
Adjusted odds ratio	Reference	1.01 [1.00, 1.02]	1.01 [1.00, 1.02]	0.99 [0.98, 1.00]	1.00 [0.99, 1.00]

*Reported values are proportion or odds ratio and 95% CI. Users indicate the proportion of beneficiaries in each quartile that experienced the respective outcome.

may not offer all services. The similar distribution of encounter diagnoses and subspecialists provides further evidence that practices in each quartile were managing comparable populations.

The association between a higher intensity of outpatient care and procedural inpatient admissions are consistent with studies demonstrating greater use of downstream interventions with an increased performance of diagnostic procedures.[9,10,19] This also provides evidence that lower outpatient intensity was not associated with a shift to performing procedures in the inpatient setting. Little is known regarding the association between the intensity of outpatient care and mortality or medical inpatient use, and our results suggest that there is very minimal association, no larger than the association with noncardiac admissions. In the mortality models, the direction and magnitude for clinical variables, particularly age and the presence of chronic kidney disease or chronic obstructive pulmonary disease, were comparable to models predicting mortality using registry data, and C-statistics were high for all models.[20–22]

Myocardial perfusion imaging and cardiac catheterization accounted for approximately half of the procedural variation between the highest and lowest quartiles of practices. Several studies have documented high rates of inappropriate use based on published appropriate use criteria for these

procedures in contemporary practice.[23–29] Large, community-based studies have documented inappropriate use rates of 45.5% for MPI[23] and 34.6% for stress tests with imaging.[28] Among 8996 patients undergoing diagnostic catheterization in New York, 24.9% were considered inappropriate with rates ranging from 8.6% to 48.8% across hospitals.[26] Variation in adherence to appropriate use criteria may occur because cardiologists are unaware or disagree with the criteria[30] or are influenced by nonclinical factors, such as perceived malpractice risk or expectations from patients or referring providers.[31] Though we cannot determine whether individual procedures are inappropriate, increased inappropriate use among higher-intensity practices potentially explains some variation.

Documented rates of inappropriate use alone could not account for 3-fold differences in utilization, even though rates of inappropriate use may be higher among practices that do not participate in studies or registries. Variation without an associated improvement in outcomes could also occur because of an increase in procedures that meet appropriate use criteria or are of uncertain appropriateness, for example because of differences in interpretation of clinical findings. Many outpatient procedures confer limited benefit in many situations,[32–35] and suboptimal communication of expected risks and benefits for elective cardiac procedures has been

Table 9. Sensitivity Analyses for Mortality and Inpatient Use*

	Inpatient									Mortality		
	Noncardiac			Cardiac Medical			Cardiac Surgical			Mortality Rate		
	Current	+Referral Index	+HCC/ Referral Index	Current	+Referral Index	+HCC/ Referral Index	Current	+Referral Index	+HCC/ Referral Index	Current	+Referral Index	+HCC/ Referral Index
C-statistic	0.73	0.73	0.73	0.78	0.78	0.78	0.76	0.76	0.76	0.79	0.79	0.80
Quartile (ref=Quartile 1)												
Quartile 2	1.01	1.01	1.00	1.02	1.01	1.01	1.14	1.13	1.13	1.01	1.01	1.01
Quartile 3	0.99	0.99	0.99	1.00	0.99	0.99	1.22	1.21	1.21	1.01	1.00	1.00
Quartile 4	0.98	0.98	0.98	1.00	0.99	0.99	1.32	1.31	1.32	0.99	0.99	0.99
Race (ref=White)												
Black	1.01	1.01	0.95	1.46	1.49	1.44	0.95	0.97	0.94	1.00	1.01	0.89
Other	0.81	0.81	0.79	0.91	0.91	0.91	0.90	0.90	0.90	0.80	0.80	0.78
Asian	0.66	0.66	0.65	0.74	0.75	0.74	0.74	0.75	0.74	0.71	0.71	0.69
Hispanic	0.85	0.85	0.82	0.98	1.00	0.98	0.89	0.90	0.89	0.73	0.74	0.69
Native American	1.09	1.08	1.05	1.25	1.21	1.18	1.15	1.10	1.09	1.15	1.15	1.08
Male	0.89	0.89	0.88	0.85	0.85	0.84	1.38	1.38	1.37	1.35	1.35	1.32
Afib	1.26	1.26	1.21	2.47	2.47	2.43	1.36	1.35	1.33	1.49	1.49	1.42
MI	1.92	1.91	1.93	11.84	11.73	11.83	29.95	29.67	29.88	2.05	2.05	2.05
CHF	1.40	1.39	1.30	2.23	2.22	2.15	1.49	1.48	1.44	2.12	2.12	1.92
CKD	2.19	2.19	1.97	1.84	1.84	1.74	1.47	1.47	1.40	1.97	1.96	1.69
COPD	1.76	1.76	1.69	1.46	1.46	1.43	1.17	1.17	1.15	1.61	1.61	1.52
Depression	1.56	1.56	1.53	1.27	1.27	1.25	1.00	1.00	0.99	1.25	1.25	1.21
Diabetes	1.14	1.14	1.09	1.09	1.10	1.07	1.07	1.07	1.05	1.10	1.10	1.02
CAD	0.98	0.98	0.96	1.28	1.28	1.27	2.85	2.85	2.83	1.02	1.02	0.99
Stroke	3.89	3.89	3.85	1.51	1.52	1.51	1.39	1.39	1.38	1.49	1.49	1.45
Medicaid	1.17	1.17	1.13	1.15	1.14	1.12	0.94	0.94	0.92	1.30	1.30	1.23
Age (ref=66–70)												
≤65 y	1.19	1.19	1.12	1.25	1.25	1.20	1.06	1.06	1.03	1.01	1.01	0.87
71 to 75 y	0.92	0.92	0.92	0.84	0.84	0.84	0.83	0.83	0.83	1.04	1.04	1.06
76 to 80 y	0.91	0.91	0.92	0.80	0.81	0.81	0.75	0.75	0.75	1.26	1.26	1.32
81 to 85 y	0.94	0.94	0.95	0.84	0.84	0.85	0.66	0.66	0.66	1.72	1.72	1.82
>85 y	1.02	1.02	1.03	0.95	0.95	0.96	0.47	0.47	0.48	3.14	3.14	3.33
Referral index	—	0.91	0.90	—	0.63	0.62	—	0.57	0.57	—	0.93	0.92
HCC score	—	—	1.13	—	—	1.06	—	—	1.05	—	—	1.17
Alzheimer's	—	—	—	—	—	—	—	—	—	1.87	1.87	1.88
Breast cancer	—	—	—	—	—	—	—	—	—	1.15	1.15	1.12
Lung cancer	—	—	—	—	—	—	—	—	—	3.70	3.70	3.41
Colon cancer	—	—	—	—	—	—	—	—	—	1.31	1.31	1.27

Afib indicates atrial fibrillation; CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; HCC, hierarchical condition score; MI, myocardial infarction.

*All values are odds ratios using the actual model and models incrementally adding referral index and hierarchical condition score. For each outcome, the table includes results from the risk model used in the study, as well as sequential addition of referral index and HCC score. Addition of these variables had minimal impact on overall model performance as measured by the C-statistic or quartile-specific effects.

well documented, so that variation in approaches to shared decision making could result in different choices among patients.[36–38]

Approximately one third of variation was attributable to electrophysiology device procedures. Al-Khatib et al. found that as many as 22.5% of primary ICD placements may not be evidence based, with significant variation in rates across sites.[39] Beyond inappropriate use, the absence of an improvement in mortality for practices with higher use of these procedures could be attributed to an undetected benefit for the small proportion of the population that received these procedures or a lack of benefit for indications that are considered appropriate based on expert opinion, but may not improve mortality.[40] Studies have suggested that primary ICD placement is associated with reduced mortality and underutilized in the Medicare population, though observational data may be subject to selection bias.[41,42] Our study also includes generator or lead replacements, for which limited evidence or guidelines exist, and may be particularly susceptible to differences in cardiologists' approach to shared decision making.[43] The high cost, variable use, and uncertain benefit of these procedures in the Medicare population suggests a critical need for further study.

There was a notable difference in the distribution of practices nationally, with a much lower than expected percentage of beneficiaries attributed to higher quartile practices in the Northeast and urban regions. These differences were not explained by regional differences in the propensity to refer to a cardiologist or prevalence of disease and may reflect different practice norms or other market factors. Though these trends are important, all regions of the country contained high- and low-utilization practices, emphasizing the importance of measuring variation at the practice level.

Limitations of the study include residual differences in patient populations following claims-based risk adjustment. We found a similar distribution of conditions, encounter diagnoses, and encounter frequencies in each quartile, though we did find a lower mean number of interventional cardiologists in the lowest quartile. It is possible that the lower intensity partially reflects a lower-acuity patient population, but also a reduced tendency to recommend procedures of limited benefit that would require referral to another practice. We could not determine whether outpatient intensity was associated with other dimensions of quality, including symptom relief and patient satisfaction with the experience of care. Although our study was of sufficient sample size to detect very small changes in mortality, it is possible that differences would emerge over a longer time frame. It is possible that other attribution methodologies would have yielded different results; however, we selected a methodology that is typical of value-based payment programs.[6] Finally, these results are only applicable to Medicare fee-for-service beneficiaries.

Conclusions

These findings demonstrate that significant opportunities to improve the value of cardiac care in the outpatient setting likely exist. Further research to identify the underlying factors driving differences in outpatient intensity, association with additional outcomes, and effective solutions to optimize value is needed. Professional organizations, physicians, and patients commonly must make recommendations or decisions with uncertain evidence, and these findings provide important contextual information, suggesting that, in many cases, a lower intensity of care may not sacrifice outcomes. The cardiology profession has been a leader in developing evidence-based standards of care and promoting dissemination into practice.[25,44,45] The amount of variation presents a new challenge to eliminate waste, ensure that any differences are justified, and test strategies to improve the efficiency of practice without diminishing outcomes.

Disclosures

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