Examining the Association between Utilization Management and Downstream Cardiovascular Imaging

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Objectives. To examine the association of echocardiography utilization management (EUM) program with downstream cardiac imaging utilization.

Data Sources/Study Setting. Administrative claims data from commercial health plans in Indiana, Ohio, Kentucky, Wisconsin, and Georgia.

Study Design. Patients undergoing index cardiovascular imaging with no imaging in the preceding year were identified ($N = 112,308$). Claims-derived cardiac risk scores were used for one-to-one propensity score matching of patients subject to EUM to patients without EUM ($n = 96,906$). Downstream cardiac imaging utilization for 12–24 months postindex imaging was analyzed using generalized linear models and Cox proportional hazards model.

Principal Findings. Downstream cardiac imaging tests were performed for 10,630 (21.9 percent) and 12,012 (24.8 percent) patients in the EUM and non-EUM groups, respectively. At 12-month follow-up, adjusted utilization was 15.2 (95 percent CI, 7.6–22.5) tests per 1,000 initially tested patients lower in the EUM group ($p < .001$). The likelihood of obtaining downstream cardiac imaging in the EUM group was 7.0 percent lower than the non-EUM group (hazard ratio: 0.930; 95 percent CI, 0.897–0.964, $p < .001$).

Conclusions. Downstream cardiac imaging is relatively common among commercially insured patients. Every 10 initial diagnostic tests yielded two downstream imaging tests in first 24 months. EUM program was associated with lower volumes of downstream imaging.

Key Words. Downstream imaging, cardiovascular disease, utilization management, echocardiography, survival analysis

Echocardiography, a noninvasive cardiac imaging test using ultrasound, is an increasingly common diagnostic tool for diagnosis or exclusion of heart disease. When performed at rest, the test is useful in evaluating structural disease (e.g., the size of the cardiac chambers or function of the heart valves). Stress

echocardiography is focused on the evaluation of patients with suspected or established coronary artery disease. Because echocardiography uses no ionizing radiation and is associated with virtually no adverse risks to the patient, it is commonly used early in the diagnostic process. Ease of use and low risk, however, do not justify indiscriminate utilization of echocardiograms. To promote appropriate use of cardiac imaging tests and to prevent both under- and overutilization, the American College of Cardiology Foundation, the American Society of Echocardiography, and other specialty societies developed Appropriate Use Criteria (AUC) (Douglas et al. 2008, 2011).

Based on the AUC, as many as 20–30 percent of stress echocardiograms are performed for inappropriate reasons (McCully et al. 2009; Mansour et al. 2010; Bhatia et al. 2013; Willens, Nelson, and Hendel 2013). Despite growing recognition of the AUC and educational programs aimed at cardiologists and primary care physicians to reduce inappropriate stress echocardiography, the use of echocardiography for inappropriate indications has persisted (Willens, Nelson, and Hendel 2013).

It is not only inappropriate indications that are a concern with echocardiography but also the frequency of repeat or downstream tests. Although AUC recommend against routine surveillance echocardiography for most clinical scenarios, one-third of Medicare beneficiaries who underwent echocardiography had a repeat test within 1 year (Welch, Hayes, and Frost 2012). While echocardiography is safe, repeat testing is a risk factor for overdiagnosis or detection of clinically insignificant abnormalities (Welch, Hayes, and Frost 2012). Thus, an inappropriate echocardiogram may begin a cascading effect leading to progressively more invasive, riskier, and more costly tests and interventions downstream from the initial test (Mold and Stein 1986; Deyo 2002). Described by Mold and Stein (1986), the cascade is triggered by a seemingly harmless action, such as an unnecessary diagnostic test. Each intervention in the cascade is a direct result of the previous event, and with each step, the process becomes increasingly difficult to interrupt or halt (Mold and Stein 1986; Deyo 2002).

Utilization management (UM) programs are one means to reduce unnecessary or repeat testing and control health care costs (Lee, Rawson, and Wade 2011; Duszak and Berlin 2012a). UM programs have typically focused

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on more invasive or costly interventions; programs addressing echocardiography have been less common. However, ensuring appropriate echocardiography utilization may help prevent unnecessary downstream tests and interventions. This study examined the association of an echocardiography utilization management (EUM) program on downstream imaging. While an EUM program likely affects utilization of the first, or index, test as well, the EUM program in the timeframe of this study only affected the management of downstream imaging. Consequently, this analysis focused on changes in downstream imaging as a result of management of downstream echocardiography tests, computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), and nuclear medicine. We also chose to focus on downstream tests because they are less studied in the literature and they are more likely to be repeated tests with limited incremental value. Therefore, by examining the association between a real-life implementation of EUM program and downstream cardiovascular imaging, this study makes a unique contribution.

METHODS

Intervention Program

The claims-compliant EUM program, which was administered by a large nationwide specialty benefit management company, was launched on October 1, 2010. Under the program, echocardiography management (which required clinical review and preauthorization for any echocardiography tests performed in outpatient settings according to widely accepted clinical guidelines) was added to previously existing management of other cardiac imaging tests, including CT, MRI, PET, and nuclear medicine. As a result, all aforementioned cardiac imaging tests in outpatient settings were subject to UM after October 2010 in the EUM group while the control group had no such management by a company providing an EUM program.

Data Sources and Study Design

Administrative medical claims data were queried from the HealthCore Integrated Research Database (HIRDSM), a repository of fully adjudicated medical, pharmacy, and laboratory claims data for approximately 43 million Blue Cross and Blue Shield health plan members across the United States. Researchers only had access to a limited dataset; strict measures were

observed to preserve patient anonymity and confidentiality and to ensure full compliance with the 1996 Health Insurance Portability and Accountability Act.

This observational cohort study included medical and pharmacy claims from October 1, 2008 through September 30, 2011. The baseline period was from October 1, 2008 through September 30, 2009; the intake period for index cardiovascular imaging tests was from October 1, 2009 through September 30, 2010; and the outcome follow-up period (postindex outpatient cardiovascular imaging utilization) was captured from October 1, 2009 through September 30, 2011.

Inclusion/Exclusion Criteria

The study included patients from Indiana, Kentucky, Missouri, Ohio, and Georgia for two groups: patients with an EUM program and patients without an echocardiography utilization management program (non-EUM).

All patients in both study groups had a cardiac imaging test during the intake period (between October 1, 2009 and September 30, 2010) with no prior cardiac imaging within the previous 12 months. There were no restrictions on place of service for the index cardiac imaging test. The intake period occurred before implementation of the EUM program.

Patients in the EUM group were required to belong to specific employer groups that were subject to the EUM program during the postimplementation period (October 1, 2010 through September 30, 2011). Patients in the non-EUM group had commercial preferred provider organization coverage but did not belong to any of the employer groups that were subject to the EUM program examined in this study. Employer groups typically chose to implement EUM in an effort to reduce inappropriate or unnecessary care for their members. To our knowledge, there are no systematic differences between the groups that purchased EUM and those that did not, nor were there any additional changes in plan characteristics implemented alongside the EUM program. All patients were required to have had commercial health plan coverage and continuous eligibility for at least 24 months of the study period.

Patients were excluded from the study if they had a prior cardiac imaging test within 12 months of the index date to clearly define the initial index test and to identify patients with similar risks of future cardiac testing. Patients without continuous medical eligibility were also excluded. Continuous medical eligibility was necessary to create baseline variables that were used as covariates and to have adequate follow-up of downstream events. Without the

requirement of continuous medical coverage, it would have been difficult to determine whether the lack of an event (e.g., downstream imaging) was due to the true absence of that event or a lack of coverage.

Propensity Score Matching

To minimize group bias, patients in the EUM group were matched using one-to-one propensity score to the nearest non-EUM patients on the basis of their claims-derived cardiac risk scores. The claims-derived cardiac risk scores reflected the probability of cardiovascular hospitalizations in the postimplantation period for each patient and were estimated using predictor variables from the baseline period.

The list of *International Classification of Diseases, Ninth Revision* diagnoses codes for cardiovascular conditions was adapted from the Systematic Coronary Risk Evaluation project (Conroy et al. 2003). The codes for cardiovascular conditions included diagnoses codes 401 through 414 and 426 through 443, with the exception of the codes for nonatherosclerotic causes of hospitalization (codes 426.7, 429.0, 430.0, 432.1, 437.3, 437.4, and 437.5).

Logistic regression was used to calculate the probability of cardiovascular hospitalization; a p -value of .05 was used to retain variables considered good predictors of hospitalizations. The final model included age, history of cardiovascular hospitalization, gender, number of distinct medications, and history of cardiac imaging use as the top five claims-derived predictors with the highest discriminatory power. Using estimated propensity scores for cardiovascular hospitalization, patients in the EUM group were matched with patients in the non-EUM group who had similar predicted probability using greedy nearest neighbor 1:1 matching techniques (Parsons 2001).

Risk Group Stratification

Recognizing that the need for diagnostic imaging varies with cardiac risk status, the EUM program systematically gathers clinical data for each health plan member for whom a cardiac imaging test was requested to calculate a cardiac risk score, categorizing members into low-, medium-, or high-risk groups, and serving as a critical input into the clinical review process. Included in the EUM program stratification model are clinical data such as smoking status, systolic blood pressure, total cholesterol, and diabetes, as well as age and gender. The availability of such clinically based risk categorization presented an opportunity to compare our claims-derived risk scores against clinical data

from the subset of the population that requested cardiac imaging and were subject to the EUM program. To evaluate the performance of the claims-based risk model, average claims-based risk scores (reflecting the probability of cardiac hospitalization) were calculated for patients in each EUM program-defined risk group (low, medium, and high) for the subset of patients for whom the EUM program provided clinically based risk group identification. This comparison demonstrated that the average claims-based risk score (probability of cardiac hospitalization) was 1.31, 2.55, and 3.66 percent for low, medium, and high EUM program-defined risk subgroups, respectively. The claims-derived risk scores reflected consistently higher risk from low- to high-risk cohorts in the clinically determined categorization used by the EUM program. Patients with a greater than 5 percent chance of cardiac hospitalization were classified as high risk (5 percent being about five times the population average), medium risk was represented by a 2–5 percent probability, and low risk as less than 2 percent probability. For the purposes of this study, the risk group classification was used as a control variable in regression modeling.

Outcome Measure

The outcome measured in this study was the difference in downstream cardiac imaging utilization in the matched study population comparing patients subject to the EUM program with those not subject to the EUM program. The intervention studied here was the addition of EUM in the postimplementation period (October 1, 2010 through September 30, 2011), which was absent in the non-EUM group. In the follow-up period, we studied the impact of the EUM intervention on echocardiography utilization as well as other types of cardiac imaging. We used this inclusive approach in measuring follow-up tests because echocardiography is a common precursor to the other cardiac imaging modalities and we also wanted to incorporate the impact of any substitution effects, should they occur. Therefore, a downstream test was defined as any postindex cardiac imaging test (resting echocardiography, stress echocardiography, CT, MRI, PET, or nuclear medicine). In addition, the downstream test was required to be performed in an outpatient setting (outpatient hospital, physician office, or freestanding facility), where imaging utilization can be considered discretionary. Inpatient imaging services are not managed by UM programs and are thus not in scope for the study.

As a secondary analysis, we reported utilization rates in the emergency departments (ED) during visits that did not result with inpatient admissions. Although imaging in ED was not subject to the EUM, it might be somehow

discretionary and therefore potentially influenced by the EUM if patients shifted to ED to avoid constraints of the preauthorization process, offsetting the reductions from the settings subject to the EUM.

Statistical Analysis

Descriptive statistics including means ($\pm$ standard deviation) and relative frequencies were reported for continuous and categorical data, respectively. Differences in descriptive characteristics between the EUM and non-EUM groups during the baseline period were assessed with Pearson's χ^2 tests for categorical data; student's *t*-tests or nonparametric analysis were used for numeric data whenever appropriate. Inferential analyses were conducted with two methods. In the first method, downstream imaging utilization within 12 months postindex was analyzed. Generalized linear models (GLMs) were used to analyze downstream utilization differences net of other covariates. Negative binomial distribution with log link was used to model downstream imaging utilization. Exponentiated coefficients and corresponding confidence intervals (CIs) are presented and are interpreted as incident rate ratios (RRs) between groups. In addition, the predicted values from the generalized linear model were used to calculate covariate adjusted mean difference (tests per 1,000 index-tested patients) to simplify interpretation of the results. However, because some patients could have up to 24 months follow-up available for observation and the occurrence of downstream imaging is subject to censoring, the second method—stratified survival analyses using Cox proportional hazard model—was fitted. The number of days until the first occurrence of a downstream cardiac test was modeled. Exponentiated coefficients and corresponding confidence intervals are presented and are interpreted as hazard ratios between groups. Incidence rate difference was obtained by using log of person-years as an offset in regression modeling. All statistical analyses were conducted with SAS 9.2 software for Windows. Alpha was set at 0.05 for each test.

RESULTS

Patient Population

After matching, a total of 96,906 patients were included in the study, 48,453 in both the EUM and non-EUM groups (Table 1). Approximately half were women (50 percent in the EUM group and 52.7 percent in the non-EUM group) and mean age was 47.2 ± 14.9 years in the EUM group and

Table 1: Baseline* Patient Characteristics

	<i>EUM</i> <i>n</i> = 48,453 <i>N</i> / <i>Mean</i> (<i>%</i> / <i>SD</i>)	<i>Non-EUM</i> <i>n</i> = 48,453 <i>N</i> / <i>Mean</i> (<i>%</i> / <i>SD</i>)	<i>p</i> - <i>Value</i>
Age, years			
0–17	3,218 (6.6)	3,221 (6.7)	<.0001
18–44	12,914 (26.7)	12,273 (25.3)	
45–64	29,634 (61.2)	26,836 (55.4)	
≥65	2,687 (5.6)	6,123 (12.6)	
Mean	47.19 (14.9)	48.95 (16.3)	<.0001
Female	24,204 (50.0)	25,511 (52.7)	<.0001
DCI score [†] (mean)	1.43 (2.0)	1.69 (2.3)	<.0001
Heart procedures [‡]	478 (1.0)	440 (0.9)	.208
Comorbidities			
Dyslipidemia	18,515 (38.2)	17,358 (35.8)	<.0001
Hypertension	18,143 (37.4)	18,663 (38.5)	.001
Coronary heart disease	6,648 (13.7)	6,912 (14.3)	.015
Diabetes mellitus	6,296 (13.0)	7,315 (15.1)	<.0001
Cardiac arrhythmia	3,943 (8.1)	4,234 (8.7)	.001
Cardiac valvular disease	2,452 (5.1)	2,538 (5.2)	.211
Congestive heart failure	1,011 (2.1)	1,199 (2.5)	<.0001
Myocardial infarction	813 (1.7)	782 (1.6)	.434
Carotid artery disease	683 (1.4)	829 (1.7)	.0002
Number of unique prescription drugs (mean)	6.41 (5.7)	5.94 (5.6)	<.0001
Census region (patient state of residence)			
Midwest	26,986 (55.7)	20,165 (41.6)	<.0001
South	18,998 (39.2)	13,719 (28.3)	
Northeast	334 (0.7)	3,238 (6.7)	
West	262 (0.5)	2,166 (4.5)	
Unknown	1,873 (3.9)	9,165 (18.9)	
Census rural/urban (using patient ZIP code)			
Urban	32,546 (67.2)	28,370 (58.6)	<.0001
Rural	13,829 (28.5)	10,918 (22.5)	
Unknown	2,078 (4.3)	9,165 (18.9)	

*Baseline period was October 1, 2008 through September 30, 2009.

[†]Deyo-Charlson ICD-9 codes were updated based on Agency for Healthcare Research and Quality Elixhauser codes (version 3.6).

[‡]Heart procedures include coronary artery bypass graft, percutaneous coronary intervention, and diagnostic cardiac catheterizations.

49.0 ± 16.3 years in the non-EUM group. At baseline, patients in the EUM group had a lower comorbidity burden, as measured by the Deyo-Charlson Comorbidity Index (DCI) score (Deyo, Cherkin, and Ciol 1992). While statistically significant differences were found between the two groups for most comorbid conditions, these differences were not clinically meaningful (Table 1).

Downstream Cardiac Imaging

Overall, 17.8 percent of all patients had downstream cardiac imaging during the 12 months following the initial test (Table 2). By 24 months, 23.4 percent of all patients who had an initial diagnostic test had downstream cardiac imaging. Cardiac imaging utilization was lower among patients in the EUM group at both the 12-month (16.8 percent) and 24-month follow-up (21.9 percent) compared with those in the non-EUM group (18.9 percent at 12 months and 24.8 percent at 24 months). At 12 months, the downstream cardiac imaging rate was 222 tests per 1,000 patients in the EUM group, compared with 251 tests per 1,000 patients in the non-EUM group. Patients in the EUM group had a longer interval between index imaging test and the first occurrence of a downstream cardiac imaging test (mean 466.3 ± 194.4 days) compared with the non-EUM group (mean 456.4 ± 199.8 days).

Outpatient downstream imaging tests were mostly composed of resting echocardiography and nuclear medicine (Table 2). Using the rates for up to 24 months of follow-up, 54.9 percent were resting echocardiography, whereas 34.7 percent were nuclear medicine. Advanced cardiac imaging (CT scan, MRI, or PET) downstream to an index test was used less frequently in relation to other modalities.

Patients in the EUM group had a 6.8 percent lower rate of downstream cardiac imaging test within 12 months of the initial test, compared with the non-EUM group ($p < .0001$; RR = 0.932; 95 percent CI, 0.899–0.966; Table 3). This translated to an adjusted mean difference of 15.19 (95 percent CI, 7.59–22.50) tests per 1,000 tested patients between the EUM and non-EUM groups.

As expected, age, comorbidity burden (expressed by both DCI score and number of distinct medications), prior history of cardiovascular hospitalization, and the presence of cardiac arrhythmia at baseline were associated with a higher rate of downstream cardiac imaging utilization (Table 3). Medium-to-high cardiac risk for postindex hospitalization as a variable did not add further to the model as an adjustor of downstream utilization. That should not be surprising as cardiac risk scores were already used for matching EUM and non-EUM groups. In contrast, female gender, having had either stress or resting echocardiography as the index test, and having had nuclear medicine as an index test were associated with a lower rate of downstream imaging utilization rates.

A Cox proportional hazard regression model was used to estimate the effect of EUM program implementation on downstream cardiac imaging

Table 2: Descriptive Statistics for Downstream Cardiac Imaging Utilization in Outpatient Setting (Excluding Emergency Departments)

	12-Month Rate			12- to 24-Month Rate		
	All N = 96,906	EUM n = 48,453	Non-EUM n = 48,453	All N = 96,906	EUM n = 48,453	Non-EUM n = 48,453
Downstream cardiac imaging utilization rate per 1,000 tested patients	236.7	222.4	251.0	337.6	314.0	361.2
Echocardiography						
Resting	122.6	117.8	127.5	185.2	173.8	196.6
Stress	19.7	18.8	20.7	26.5	24.9	28.1
Nuclear medicine	87.4	79.7	95.1	117.2	107.6	126.9
MRI	2.8	3.1	2.6	3.8	4.1	3.5
CT scan	2.6	1.5	3.7	3.0	1.8	4.2
PET	1.5	1.5	1.5	2.0	1.9	2.0
Patients with downstream cardiac imaging, n (%)	17,260 (17.8)	8,129 (16.8)	9,131 (18.9)	22,642 (23.4)	10,630 (21.9)	12,012 (24.8)
0 tests	79,646 (82.2)	40,324 (83.2)	39,322 (81.2)	74,264 (76.6)	37,823 (78.1)	36,441 (75.2)
1 test	13,019 (13.4)	6,159 (12.7)	6,860 (14.2)	15,619 (16.1)	7,426 (15.3)	8,193 (16.9)
2 tests	3,268 (3.4)	1,515 (3.1)	1,753 (3.6)	5,068 (5.2)	2,320 (4.8)	2,748 (5.7)
≥3 tests	973 (1.0)	455 (0.9)	518 (1.1)	1,955 (2.0)	884 (1.8)	1,071 (2.2)
Days to first downstream cardiac imaging test, n (%)						
Mean (SD)				461.4 (197.2)	466.3 (194.4)	456.4 (199.8)
Median (range)				498 (1–729)	501 (1–729)	493 (1–729)

CT, computed tomography; EUM, echocardiography utilization management; non-EUM, without echocardiography utilization management; MRI, magnetic resonance imaging; PET, positron emission tomography.

Table 3: Generalized Linear Model Adjusted Results for Patients with Twelve-Month Follow-up*

	<i>Parameter Estimate</i>	<i>95% Confidence Interval</i>	<i>p-Value</i>
Intercept	0.159	0.145–0.175	<.0001
EUM group [†]	0.932	0.899–0.966	.0001
Age	1.009	1.008–1.010	<.0001
Female	0.867	0.840–0.895	<.0001
DCI	1.135	1.127–1.143	<.0001
Distinct medication count	1.002	0.999–1.005	.2567
Index imaging test—echocardiogram	0.893	0.847–0.940	<.0001
Index imaging test—nuclear medicine	0.593	0.567–0.621	<.0001
Prior cardiovascular hospitalization	1.056	1.008–1.107	.0211
High or medium cardiac risk group (claims-derived) [‡]	0.954	0.904–1.005	.0786
Baseline coronary heart disease	1.014	0.967–1.063	.5699
Baseline cardiac arrhythmia	1.161	1.101–1.224	<.0001
Region			
Midwest	0.850	0.635–1.136	.272
South	0.919	0.688–1.227	.5653
Northeast	0.921	0.683–1.241	.5884
West	0.864	0.638–1.170	.3439
Urban	1.085	0.814–1.445	.5788
Rural	1.140	0.855–1.519	.3732

*Generalized linear model analysis conducted using negative binomial distribution and log link function. All coefficients presented in exponentiated form and interpreted as incident rate ratios.

[†]EUM group: 1 for EUM group and 0 for non-EUM group.

[‡]Compared with low-risk group (claims-derived).

DCI, Deyo-Charlson Comorbidity Index score; EUM, echocardiography utilization management.

utilization across the EUM and non-EUM groups. The EUM group experienced a statistically significantly lower (7.0 percent; RR = 0.930; 95 percent CI, 0.897–0.964) likelihood of incurring downstream cardiac imaging utilization compared with the non-EUM group, while controlling for covariates and accounting for censoring and variable follow-up time (Table 4). The downstream cardiac imaging incidence rate per 1,000 person-years was 284 for the EUM group versus 332 for the non-EUM group, with a statistically significant incidence rate difference of 48.7 ($p < .0001$; 95 percent CI, 45.2–93.4) in favor of the EUM group.

As expected, imaging utilization in the ED setting was much lower compared with other outpatient settings (Table 5). At 12 months, the rates were 6.5 and 5.7 for the EUM and the non-EUM groups, respectively; during the

Table 4: Stratified Survival Analyses Adjusted Results for Patients with up to Twenty-Four Months Follow-up*

Cohort	N	Person-Years	Number of First Events	Incidence Rate per 1,000 Person-Years	Incidence Rate Difference per 1,000 Person-Years		
					Incidence Rate Difference	95% Confidence Interval	p-Value
EUM group [†]	48,453	37,490	10,630	284	48.72	45.19–93.44	<.0001
Non-EUM group	48,453	36,152	12,012	332	Hazard Ratio	95% Confidence Interval	p-Value
Df		Parameter Estimate	Standard Error	χ^2			
EUM group [†]	1	–0.0731	0.01838	15.818	0.930	0.897–0.964	<.0001

*Analysis conducted through stratified survival analyses using the Cox proportional hazard model. Primary coefficient of interest (EUM group) presented in exponentiated form and interpreted as hazard ratios. Analyses was stratified for cardiac risk group (claims-derived, compared with low-risk group), prior cardiovascular hospitalization, index test echocardiography, index test nuclear medicine, Devo-Charlson Comorbidity Index score category, and number of distinct medications category. Event time is measured as number of days until the first downstream cardiac imaging or censor date or end of study period.

[†]EUM-group: 1 for EUM group and 0 for non-EUM group.

EUM, echocardiography utilization management; non-EUM, without echocardiography utilization management.

Table 5: Descriptive Statistics for Downstream Cardiac Imaging Utilization in Emergency Departments

	12-Month Rate			12- to 24-Month Rate		
	All N = 96,906	EUM n = 48,453	Non-EUM n = 48,453	All N = 96,906	EUM n = 48,453	Non-EUM n = 48,453
Downstream cardiac imaging utilization rate per 1,000 tested patients	6.1	6.5	5.7	10.0	10.4	9.6
Echocardiography						
Resting	1.8	1.9	1.7	3.2	3.4	2.9
Stress	2.1	2.3	1.9	3.4	3.7	3.2
Nuclear medicine	2.2	2.3	2.1	3.5	3.4	3.5
MRI	0.1	0.1	0.1	0.1	0.1	0.2
CTscan	0.00	0.00	0.00	0.01	0.00	0.02
PET	0.02	0.02	0.02	0.02	0.02	0.02

CT, computed tomography; EUM, echocardiography utilization management; non-EUM, without echocardiography utilization management; MRI, magnetic resonance imaging; PET, positron emission tomography.

24 months follow-up, the rates were 10.0 and 9.6 for the EUM and the non-EUM groups, respectively. The apparently higher ED imaging use in the EUM group is inconsequential to our primary finding—the differences amount to less than 1 test per 1,000 tested patients at each timeframe compared with a difference of 15.2 and 48.7 outpatient tests per 1,000 in favor of the EUM group at 12 and 24 months, respectively.

DISCUSSION

This study examined the association between an EUM program and downstream outpatient cardiac imaging in commercially insured patients. The relationship between EUM and the incidence of downstream cardiac imaging has not been evaluated in commercially insured patient cohorts. In light of the continued growth of echocardiography testing (Chen et al. 2011) and reported increase in downstream testing following echocardiography (Welch, Hayes, and Frost 2012), this study contributes to our understanding of the emerging practice of EUM programs. This is one of the first studies to our knowledge to quantify the relationship between an EUM program and a lower rate of downstream imaging in commercially insured patients. Unlike prior studies (Welch, Hayes, and Frost 2012), we accounted for censoring and variable follow-up time in addition to the common practice of adjusting for covariates.

The results of this retrospective analysis demonstrated that downstream cardiac imaging occurs frequently within the commercially insured population. Overall, we found 21.9 percent of patients in the EUM group had a downstream imaging test within 2 years, or about 2.2 additional cardiac imaging tests for every 10 initial diagnostic tests performed. In contrast, the rate of downstream imaging in the non-EUM group was 24.8 percent, which translates to approximately 2.5 additional cardiac tests for every 10 initial diagnostic tests. The between-group difference was a statistically significant drop of 3 downstream tests per 100 index tests in favor of the EUM group. Previous studies among fee-for-service Medicare beneficiaries found 55 percent of patients with echocardiography tests obtained downstream imaging within 3 years (Welch, Hayes, and Frost 2012). It is not surprising that imaging rates would be higher for patients enrolled in Medicare than for a commercially insured population. Commercially insured patients tend to be younger and healthier than those enrolled in Medicare and generally require less imaging.

The secondary comparison of imaging use in ED indicated that the difference between the EUM and non-EUM groups was less than 1 test per

1,000 index-tested patients, confirming the absence of significant shift in cardiac imaging services from outpatient settings to ED.

The apparently modest between-group difference in downstream imaging tests may have several explanations. By focusing on downstream imaging and not including index tests, our analyses reflected only a partial impact of the EUM program. A separate population-level evaluation of the overall impact of the EUM program included all outpatient imaging tests (both index and downstream) as outcome measures. In that broader analysis, the EUM program was associated with a utilization reduction of up to 20 percent (DeVries et al. 2013). Furthermore, in a commercially insured population, it is difficult to identify a truly nonmanaged group given the ubiquitous nature of UM programs. Although EUM programs were uncommon during our study period, other cardiac imaging tests in the non-EUM group could have been subject to utilization management. There is also a spill-over effect favorable to the non-EUM group. Since the patients in both groups most likely shared the same provider network, providers could have transferred their learning from complying with the EUM program to their treatment of patients not subject to EUM requirements. Additionally, while the downstream imaging follow-up period started as early as October 2009, the EUM program was not in full effect until October 2010.

We analyzed the association between EUM and downstream cardiovascular imaging through two distinct statistical methods. The first method was fitted with GLM, which among other things offers the key advantage of providing predictions on the scale of the response variable. An added benefit is the interpretation of adjusted group differences on metrics of interest (in our case, per 1,000 index-tested patients). Using the GLM method, the EUM program was associated with a statistically significant reduction of about 15 downstream cardiac tests per 1,000 tested patients. However, two key limitations of GLM prompted the need to re-examine the results through an alternative method. The follow-up period might have ended before a downstream cardiac imaging event was observed, and such censoring of data could bias study results. Another limitation was that GLM requires a fixed follow-up, which often results in exclusion of data points if patients have shorter or longer follow-up times.

In the second method, we fitted the Cox proportional hazard model using the same set of control variables as were used in the GLM. Covariates that did not meet the proportionality hazard assumption were used as stratifying variables. A stratified survival analysis is most natural when a covariate takes on only a few distinct values and when the effect of the stratifying

variable is not of direct interest. Since our main interest was the relationship between the EUM program and downstream imaging, stratified survival analyses was preferred. Using this method, patients in the EUM group were 7.0 percent less likely to have had a downstream test within 24 months after the initial diagnostic test compared with patients in non-EUM group. Therefore, even when accounting for right censoring and variable follow-up time, the EUM program was still associated with lower incidence of downstream imaging.

Overall, the results of both statistical methods consistently indicated a significant negative association between EUM and downstream imaging, whereby the presence of the EUM program was related to lower rates of downstream cardiovascular imaging. Given the significant association of the imaging utilization program with reduced downstream imaging utilization, studying the cost-saving aspects of such programs is a useful area for future study. The cost reduction for commercial cardiac imaging spend was about \$1 per member per month not including UM program costs and the cost of compliance on the provider side. The potential cost-saving implications could drive continued and increased use of imaging UM programs.

Diagnostic imaging utilization programs are prevalent among health plans with commercially insured members. But until recently, conventional cardiac imaging UM programs did not include echocardiography tests. In the early 2000s, large health insurers such as UnitedHealth and Humana had operated without imaging UM programs that contained a prior authorization component (Bernardy et al. 2009). However, the current industry trend indicates a shift back to reinstating imaging UM programs wherever they had been dropped and the expansion of existing UM programs to incorporate less invasive tests, such as echocardiography (Allen et al. 2011). UnitedHealthcare, for example, reinstated outpatient diagnostic imaging UM programs in 2012 (UnitedHealthcareOnline 2012). Similarly, Humana began requiring preauthorization for outpatient stress echocardiography in 2011 (Humana 2011).

Because echocardiography is a relatively inexpensive and noninvasive test, the inclusion of this modality in radiology UM programs may seem surprising (Duszak and Berlin 2012b). However, echocardiography may serve as a “gateway test” leading to increasingly costly and invasive downstream tests (Mold and Stein 1986; Deyo 2002). Consequently, more imaging UM programs are adding echocardiography. Additional reasons for managing echocardiography include the following: echocardiography is one of the fastest growing imaging modalities in Medicare Part B claims (Andrus and Welch

2012); the availability of appropriate use criteria alone does not reduce inappropriate use even when combined with educational programs (Willens, Nelson, and Hendel 2013); and the rate of inappropriate use substantially decreases when ordering providers are required to justify stress echocardiography requests using society guidelines (Picano et al. 2007). This study is one of the first systematic evaluations of a real-life implementation of a programmatic intervention demonstrating utilization gains resulting from an EUM program.

Despite the growing recognition of EUM programs, implementation (as with other UM programs) faces challenges, one of which is the need for provider acceptance. The EUM program evaluated here was one of the first such programs. Since the end of the study period (October 2009 to September 2011), similar programs have been launched in the US health care market. Although other programs may be similar, the EUM program described here was based on clinical guidelines that are consistent with specialty societies' recommendations and focused on prospective provider education.

EUM programs benefit from an association with clinical guidelines that are consistent with medical society recommendations in gaining acceptance with providers. However, provider acceptance alone is insufficient to ensure program success; administrative costs associated with EUM programs present another challenge. Reviews of imaging orders for clinical appropriateness necessitate documentation and reporting of clinical data that add to staffing and related administrative costs shouldered by providers. Some of the administrative burden of the EUM program was reduced through real-time, online clinical review tools that are used by the majority of participating physician offices. It is therefore important to strike a balance between the costs saved by reducing unnecessary imaging and the expenses of administering a UM program. The utilization trends described in the current study can provide the platform for additional research that further explores the costs and savings associated with UM programs.

Limitations

There were several limitations in our study. The first year of the study was designated as the index imaging period, with the post-EUM implementation period following in the second year. Some patients in the EUM program who had downstream tests performed in the initial year of the study or, in other words, before implementation of the EUM program, did not experience the full effect of the EUM program during the follow-up period. The likely effect of this

aspect of the study design would be to lessen our ability to measure the influence of the EUM program.

Secondly, the nonexperimental research design cannot rule out other possible influences on the association between the EUM program and downstream imaging, for example, systematic provider practice pattern differences could exist between the EUM and non-EUM groups. Since the patients in both groups most likely shared the same network of providers, we would anticipate provider practice differences to be less of a factor although our study findings cannot rule out such differences, including self-referral patterns.

Concerns have been raised that UM programs such as this one merely shift services from one setting to another. This analysis focused on services performed in an outpatient setting. However, to address the issue of shifting site of service, we carried out a secondary analysis examining imaging that occurred in the ED setting. We observed inconsequential small differences for both groups, reducing the likelihood that a shift to the ED is a significant issue for this population.

Although we attempted to be inclusive in the spectrum of the diagnostic tests we incorporated in the analysis, it is important to acknowledge that during the cardiac disease diagnostic process the testing can often progress toward more invasive evaluations not examined in this study, such as cardiac catheterizations. Examination of such invasive testing was beyond the scope of this study but would be a worthy area of further research, contributing to a more complete understanding of the treatment pathways.

Lastly, the results were limited by inherent issues associated with claims-based analyses. Claims list only the test performed, not the reason for the test, so we were unable to determine the appropriateness of the index and downstream imaging tests. Clinical outcomes were not assessed, nor the effect of the imaging tests on treatment decisions. The database used for the study contained claims for patients enrolled in major US commercial health plans, and the results may not be generalizable to individuals outside of that population.

CONCLUSIONS

Echocardiography, which is a relatively inexpensive, noninvasive test often used early in the patient evaluation cascade, has not traditionally been included in UM programs. This study demonstrated that downstream cardiac imaging is relatively common among commercially insured patients. In

addition, implementation EUM program was associated with reduced volumes of downstream cardiac imaging tests. Using widely accepted clinical guidelines as the basis for assessing the appropriateness of imaging tests, echocardiography management programs such as the one evaluated in this study may serve as effective tools to decrease overutilization and avoid a diagnostic cascade.

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SUPPORTING INFORMATION

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

Appendix SA1: Author Matrix.