




ORIGINAL RESEARCH

Differences in High- and Low-Value Cardiovascular Testing by Health Insurance Provider

Vinay Kini , MD, MSHP; Bridget Mosley, MPH; Sridharan Raghavan , MD, PhD; Prateeti Khazanie, MD, MPH; Steven M. Bradley , MD, MPH; David J. Magid, MD, MPH; P. Michael Ho, MD, PhD; Frederick A. Masoudi, MD, MSHP

BACKGROUND: Quality of care incentives and reimbursements for cardiovascular testing differ between insurance providers. We hypothesized that there are differences in the use of guideline-concordant testing between Medicaid versus commercial insurance patients <65 years, and between Medicare Advantage versus Medicare fee-for-service patients ≥65 years.

METHODS AND RESULTS: Using data from the Colorado All-Payer Claims Database from 2015 to 2018, we identified patients eligible to receive a high-value test recommended by guidelines: assessment of left ventricular function among patients hospitalized with acute myocardial infarction or incident heart failure, or a low-value test that provides minimal patient benefit: stress testing prior to low-risk surgery or routine stress testing within 2 years of percutaneous coronary intervention or coronary artery bypass graft surgery. Among 145 616 eligible patients, 37% had fee-for-service Medicare, 18% Medicare Advantage, 22% Medicaid, and 23% commercial insurance. Using multilevel logistic regression models adjusted for patient characteristics, Medicaid patients were less likely to receive high-value testing for acute myocardial infarction (odds ratio [OR], 0.84 [0.73–0.98]; $P=0.03$) and heart failure (OR, 0.59 [0.51–0.70]; $P<0.01$) compared with commercially insured patients. Medicare Advantage patients were more likely to receive high-value testing for acute myocardial infarction (OR, 1.35 [1.15–1.59]; $P<0.01$) and less likely to receive low-value testing after percutaneous coronary intervention/ coronary artery bypass graft (OR, 0.63 [0.55–0.72]; $P<0.01$) compared with Medicare fee-for-service patients.

CONCLUSIONS: Guideline-concordant testing was less likely to occur among patients with Medicaid compared with commercial insurance, and more likely to occur among patients with Medicare Advantage compared with fee-for-service Medicare. Insurance plan features may provide valuable targets to improve guideline-concordant testing.

Key Words: health policy ■ imaging ■ quality of care

There is a growing emphasis on providing the right medical care to the right individuals at the right time. Diagnostic cardiovascular tests, such as echocardiography and stress tests, have received particular scrutiny because of regional variation and rapid rises in rates of testing.^{1–3} Clinical practice guidelines explicitly define situations where diagnostic tests are considered high value because they can guide therapy and improve patient outcomes, such as assessment of

left ventricular ejection fraction (LVEF) among patients hospitalized with acute myocardial infarction (AMI).^{4,5} Other practice guidelines, such as the American Board of Internal Medicine's Choosing Wisely program, describe tests that are low value because they are unlikely to provide patient benefit, such as routine stress testing in individuals prior to low-risk noncardiac surgery.⁶

Prior studies have shown differences in use of high- and low-value diagnostic testing based on patient

Correspondence to: Vinay Kini, MD, MSHP, Division of Cardiology, University of Colorado Anschutz Medical Campus, Mail Stop B130, Academic Office One, 12631 E. 17th Ave, Aurora, CO 80045. E-mail: vinay.kini@cuanschutz.edu

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CLINICAL PERSPECTIVE

What Is New?

- A patient's health insurance provider is an independent predictor of whether they will receive diagnostic cardiovascular testing in certain clinical scenarios described in guidelines.
- Compared with commercially insured patients, Medicaid patients were less likely to receive high-value testing to assess left ventricular function when hospitalized for acute myocardial infarction or incident heart failure.
- Compared with Medicare fee-for-service patients, Medicare Advantage patients were more likely to receive high-value testing for acute myocardial infarction and less likely to receive low-value stress testing after percutaneous coronary intervention/coronary artery bypass graft.

What Are the Clinical Implications?

- Overuse and underuse of diagnostic tests can worsen patient outcomes and lead to high healthcare costs.
- Our results suggest that reimbursement and quality incentives may affect use of guideline-concordant testing, and that features of insurance plans could be useful targets to optimize use of testing to improve patient outcomes and reduce healthcare costs.

characteristics such as age and sex, but little is known about the impact of health insurance providers.⁷⁻¹² There is evidence that differences in insurance plan features could lead to differences in the overall volume and quality of healthcare services provided.¹³⁻¹⁵ In particular, differences in reimbursement for testing, such as the typically lower reimbursements for testing provided by Medicaid, or incentives to provide evidence-based care, such as quality incentives provided by Medicare Advantage plans, could lead to significant differences in high- and low-value testing. Therefore, understanding the associations between insurance provider and guideline-concordant testing is important to identify previously unknown disparities in testing, as well as potential new opportunities to improve use of testing.

Accordingly, we used a large all-payer administrative claims database from the state of Colorado to examine variations in use of diagnostic testing in 2 high-value clinical scenarios: (1) assessment of LVEF after hospitalization for AMI and (2) assessment of LVEF after hospitalization for incident heart failure (HF); and 2 low-value clinical scenarios: (1) preoperative stress testing prior to low-risk surgery and (2) routine stress testing within 2 years after percutaneous coronary intervention (PCI) or coronary artery

bypass graft surgery (CABG). Hereafter, we refer to the use of testing in these scenarios as high-value and low-value testing. Consistent with prior studies, we separately examined Medicaid versus commercial insurance patients <65 years, and fee-for-service Medicare versus Medicare Advantage patients ≥65 years.^{16,17} We hypothesized that insurance provider would be independently associated with use of high- and low-value testing after adjustment for patient characteristics.

METHODS

Data Source and Study Population

We used data from the Colorado All-Payer Claims Database, which is a comprehensive administrative data set that includes inpatient, outpatient, physician, and facility claims on nearly all patients who received care in the state. Reporting is required for all insurance companies and plans, with the exception of federal health facilities (e.g., Veterans Health Administration hospitals) and self-insured group health plans. Thus, it is not a voluntary effort that could lead to reporting bias. The Colorado All-Payer Claims Database also includes beneficiary demographics including age and sex, insurance carrier, and hospital identifiers, but does not include reliable data on race/ethnicity. These data are made available for purchase by researchers. Because of the sensitive nature of the data collected for this study, requests to access the data set from qualified researchers trained in human subject confidentiality protocols may be sent to the Center for Improving Value in Healthcare at info@civhc.org.

For this study, we included patients aged 18 to 95 years between 2015 and 2018 in the Colorado All-Payer Claims Database. We excluded patients without at least 1 year of enrollment in insurance prior to an index testing event. We excluded critical access hospitals and hospitals with fewer than 40 hospitalizations for AMI or HF during the study period. *International Classification of Diseases, Ninth Revision (ICD-9) and Tenth Revision (ICD-10) codes and Current Procedural Technology codes used are provided in Table S1: PCI, CABG surgery, and diagnostic cardiovascular tests; Table S2: low-risk surgeries; and Table S3: hospitalizations for AMI and HF. Comorbid conditions were identified using algorithms provided by the Centers for Medicare and Medicaid Services Chronic Conditions Warehouse,¹⁸ and were assessed based on claims filed in the year prior to eligibility for high- or low-value testing. The study was approved by the University of Colorado Institutional Review Board. Because this was a retrospective study using administrative claims, it was deemed low risk and thus exempt from the need for informed consent. Dr Kini had full access to all of the data in the study and takes responsibility for their integrity and the data analysis.*

Identification of High- and Low-Value Cardiovascular Tests

Overview

We identified use of 2 high-value tests, assessment of LVEF after hospitalization for AMI or incident HF, and 2 low-value tests, preoperative stress testing prior to low-risk surgery and routine stress testing within 2 years after coronary revascularization with PCI or CABG surgery, using the methods described below.

High-Value Assessment of LVEF Among Patients Hospitalized With AMI

Using methods previously validated by Miller et al.,¹¹ we identified all patients discharged with a primary diagnosis of AMI, and excluded those in whom LVEF assessment may not have been indicated according to clinical practice guidelines^{19,20}: (1) patients who died during hospitalization or were discharged to hospice, and (2) patients readmitted with myocardial infarction within 90 days of a prior hospitalization, because readmission may have been related to the initial event and would not necessarily require another assessment (Figure 1A). If the same patient had another AMI hospitalization beyond 90 days following a prior AMI hospitalization, they were considered eligible for LVEF assessment again. To define the

completion of testing, we included any test of LVEF (i.e., echocardiography, nuclear single photon emission computed tomography, left ventriculography, cardiac positron emission tomography, cardiac computed tomography angiography, or cardiac magnetic resonance imaging) billed between the day of admission for the index hospitalization for AMI and the 60 days following discharge.

High-Value Assessment of LVEF Among Patients Hospitalized With HF

Using methods similar to those previously validated by Curtis et al.¹² and Farmer et al.,¹⁰ we identified all patients discharged with a new primary diagnosis of HF (i.e., incident HF, patients without a primary diagnosis of HF on an inpatient claim or 2 outpatient claims in the 2 years prior to hospitalization). We excluded patients who died during their hospitalization or were discharged to hospice (Figure 1B). Patients were unique (i.e., could only be included in the cohort once because only patients with incident HF were considered eligible for testing). To define the completion of testing, we included any test to assess LVEF (i.e., echocardiography, nuclear single photon emission computed tomography, left heart catheterization with left ventriculography, or cardiac positron emission tomography/cardiac computed tomography angiography/magnetic resonance imaging) between 30 days prior

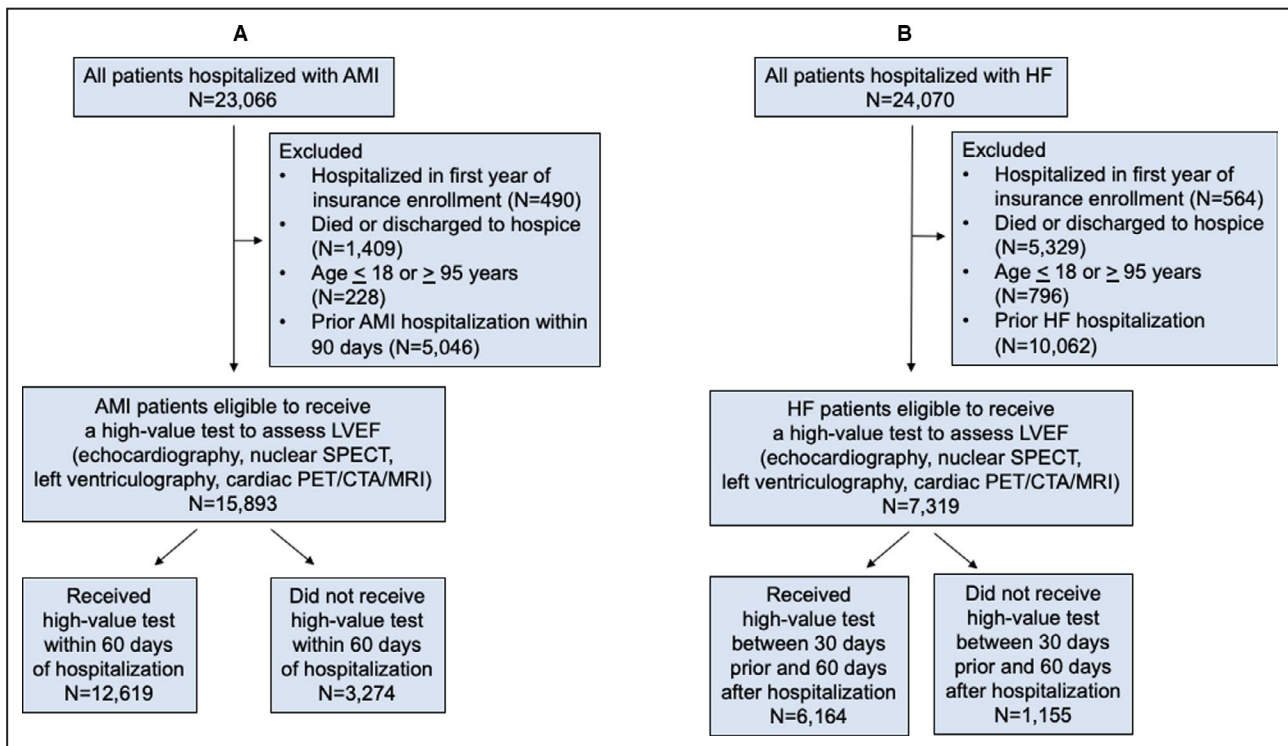


Figure 1. Flow diagrams for creation of high-value testing cohorts.

Patients hospitalized with acute myocardial infarction (AMI) (A) and heart failure (HF) (B). CTA indicates computed tomography angiography; LVEF, left ventricular ejection fraction; MRI, magnetic resonance imaging; PET, positron emission tomography; and SPECT, single photon emission computed tomography).

to the day of admission of the index hospitalization for HF to capture tests that may have prompted hospitalization and 60 days after the day of discharge.

Among both the AMI and HF cohorts, we performed the following sensitivity analyses: (1) increasing the time interval for testing from 60 to 90 days following discharge, and (2) excluding 2 safety-net hospitals that provide care for the largest proportion of Medicaid patients in the state.

Low-Value Preoperative Stress Testing Among Patients Undergoing Low-Risk Surgery

Among all patients undergoing low-risk surgery (e.g., knee or shoulder arthroscopy, cataract surgery, laparoscopic cholecystectomy, inguinal hernia repair, mastectomy, hysterectomy, or transurethral prostatectomy), we identified patients for whom stress testing was likely to be low value based on Appropriate Use Criteria and Choosing Wisely (Figure 2A).^{5,6} We used methods previously validated by Kerr et al.²¹ and Schwartz et al.²² We treated as low value any stress test performed in the 60 days prior to the low-risk surgery. We excluded surgeries that occurred within

1 year after a prior surgery. If the same patient had another low-risk surgery at least 1 year after a prior surgery, they were assessed for low-value stress testing again. We excluded tests that were billed during an acute care visit to an emergency department or during another hospitalization, as these may have been performed for appropriate clinical indications.

Low-Value Routine Stress Testing Within 2 Years After PCI or CABG

For patients who underwent PCI or CABG, we identified patients for whom stress testing was likely to be low value based on Appropriate Use Criteria and Choosing Wisely (Figure 2B).^{6,7} We used methods similar to those used by Shah et al.²³ and Bradley et al.²⁴ We identified all patients who underwent an initial index PCI or CABG. We excluded subsequent PCI and CABG procedures performed on the same patient (i.e., patients were assessed for low-value stress testing only once). We identified whether patients received a cardiac stress test between 60 days 2 years after the index procedure. We excluded stress tests within the first 60 days after the index procedure because these tests may have been performed to

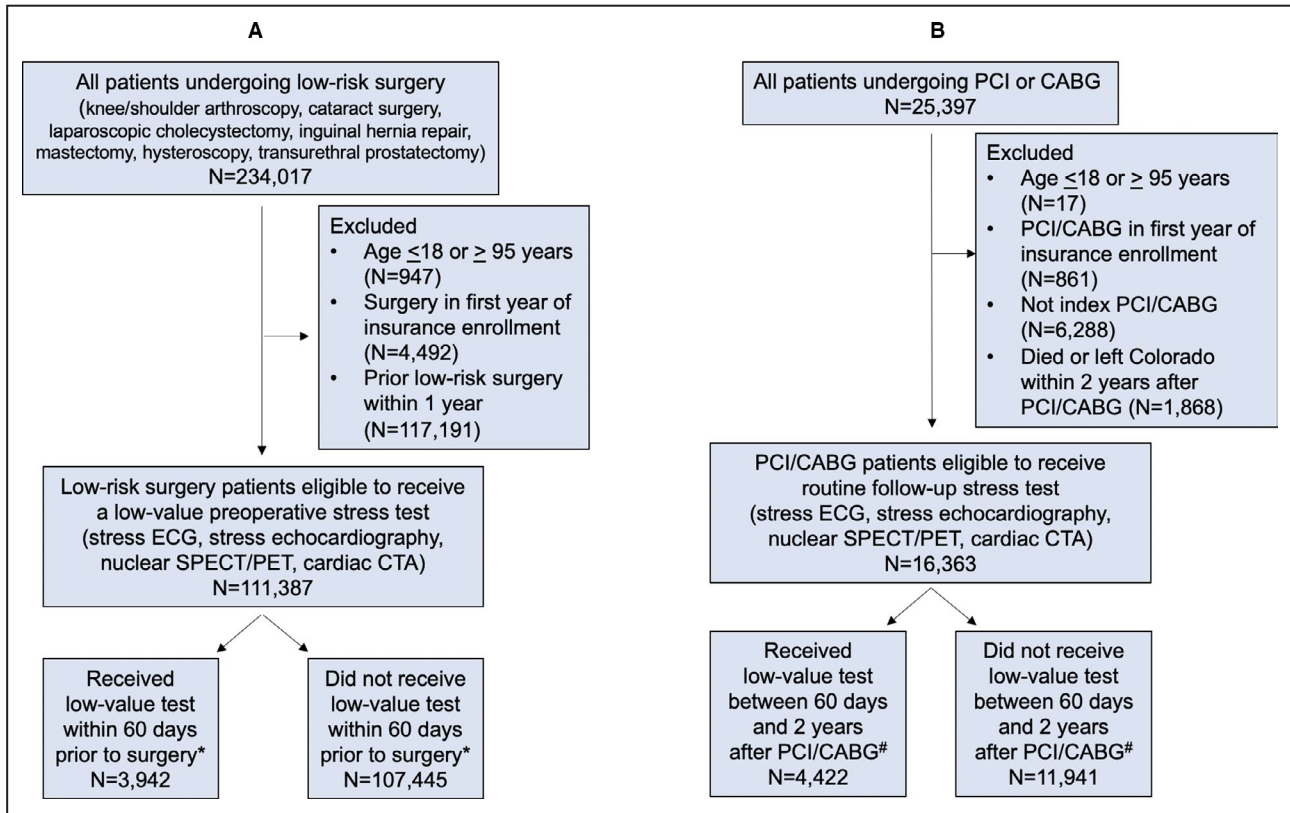


Figure 2. Flow diagrams for creation of low-value testing cohorts.

Patients undergoing low-risk surgery (A) and coronary revascularization (B). CABG indicates coronary artery bypass graft surgery; CTA, computed tomography angiography; ECG, electrocardiography; PCI, percutaneous coronary intervention; PET, positron emission tomography; and SPECT, single photon emission computed tomography. *Tests related to acute care (emergency department visits or hospital admissions) were not considered low value. #Tests related to acute care (emergency department visits or hospital admissions) or that were followed by repeat coronary revascularization were not considered low value.

guide staged revascularization (i.e., PCI of intermediate severity stenosis identified during the index PCI procedure). We excluded tests that were billed during an acute care visit to an emergency department or during another hospitalization, as these may have been performed for appropriate clinical indications. We did not exclude stress tests that were followed by repeat PCI or CABG, because the designation of low-value stress testing in this scenario is not dependent on the outcome of testing.⁵

Outcome Measures, Covariates, and Statistical Analysis

We calculated the rate of each high- and low-value test overall and stratified by insurance type. The denominator was the number of patients eligible for each clinical scenario; the numerator was the number of patients who received the test. In the AMI and low-risk surgery cohorts, patients could be eligible to receive testing more than once (i.e., 90 days after prior AMI hospitalization or 1 year after prior low-risk surgery). We performed sensitivity analyses counting only the index AMI hospitalization or low-risk surgery. We allowed for overlap between time periods of patients eligible to receive high- and low-value testing in different scenarios (e.g., a patient undergoing low-risk surgery and then hospitalized for AMI could have been counted in both low- and high-value testing cohorts).

We used multivariable logistic regression models with 2-sided *P* values to assess associations between high- and low-value testing and insurance payer, the key independent variable. Models were multilevel to account for clustering of patients by hospital, and adjusted for a variety of patient-level covariates. Covariates were selected for inclusion in the model based on prior studies of high- and low-value care, prior studies examining differences in healthcare utilization between insurance plan types, and clinical reasoning. Patient-level covariates included in the final models were age, sex, and the presence or absence of diabetes mellitus, hypertension, hyperlipidemia, stroke, chronic kidney disease, chronic pulmonary disease, atrial fibrillation, cancer, ischemic heart disease, and HF, except in the HF cohort where patients with a prior history of HF were excluded. We assessed for interaction between insurance type and age, sex, and selected comorbid conditions for each high- and low-value test.

We separately assessed (1) Medicaid versus commercial insurance patients <65 years, and (2) Medicare fee-for-service versus Medicare Advantage patients ≥65 years. This approach is consistent with prior studies and was used to minimize sampling bias, because Medicaid and commercially insured patients are typically ages <65 years, whereas Medicare fee-for-service and Medicare Advantage patients are typically aged ≥65 years.^{16,17} SAS (version 9.4) and Stata (version 13.1) software were used for data cleaning and statistical analysis.

RESULTS

High-Value Testing Cohort Characteristics

We identified 15 893 patients eligible for high-value testing for AMI and 7319 patients eligible for high-value testing for HF (Table 1). For the AMI cohort, the mean age of patients was 67 years [SD, 13.2 years], and 30% were women. The proportion of patients enrolled in fee-for-service Medicare was 44%, in Medicare Advantage was 12%, in Medicaid was 20%, and in commercial insurance was 20%. For the HF cohort, the mean age of patients was 70 years [SD, 15.4 years], and 41% were women. The proportion of patients enrolled in fee-for-service Medicare was 44%, in Medicare Advantage was 16%, in Medicaid was 21%, and in commercial insurance was 14%. Comorbid conditions including chronic pulmonary disease, hypertension, and diabetes mellitus were common among both the AMI and HF cohorts.

ASSOCIATION OF TESTING WITH INSURANCE PROVIDER

Overall, 79% of patients received high-value testing for AMI, and 84% of patients received high-value testing for HF. Rates of testing stratified by insurance provider ranged from 78% to 83% for AMI, and 81% to 90% for HF (Figure 3). Rates of testing increased slightly but similarly across insurance providers in a sensitivity analysis varying the time period for testing from 60 to 90 days following discharge (Table S4). After multivariable adjustment, patients with Medicaid were less likely than patients with commercial insurance to receive high-value testing for both AMI (odds ratio [OR], 0.84 [0.73–0.98]; *P*=0.03) and HF (OR, 0.59 [0.51–0.70]; *P*<0.001; Table 3). Patients with Medicare Advantage were more likely to receive high-value testing than patients with Medicare fee-for-service for AMI (OR, 1.35 [1.15–1.59]; *P*<0.001), but equally likely to receive testing for HF (OR, 1.03 [0.78–1.36]; *P*=0.84; Table 3). The odds of receiving testing were similar in sensitivity analyses (1) excluding safety-net hospitals, and (2) excluding the 3.7% of patients with AMI who were eligible for testing more than once. There were no significant differences in use of testing by sex; for women compared with men the OR for AMI was 0.95 (0.87–1.05), and the OR for HF was 1.01 (0.86–1.20).

LOW-VALUE TESTING

Cohort Characteristics

We identified 111 387 patients eligible for low-value testing prior to low-risk surgery and 16 363 patients eligible for low-value testing after PCI/CABG (Table 2). For

Table 1. Characteristics of Patients Eligible for High-Value Testing

	Acute Myocardial Infarction, N=15 893		Heart Failure, N=7319	
	Tested, N=12 619	Not Tested, N=3274	Tested, N=6164	Not Tested, N=1155
Age, y, mean (SD)	66.7 (13.2)	67.1 (13.1)	70.4 (15.4)	71.2 (16.0)
Women, n (%)	3883 (31)	933 (27)	2576 (42)	421 (36)
Insurance, n (%)				
Medicare fee-for-service	5458 (43)	1579 (48)	2818 (46)	560 (48)
Medicare Advantage	1542 (12)	326 (10)	1009 (16)	138 (12)
Medicaid	2412 (19)	692 (21)	1223 (20)	300 (26)
Commercial	2577 (20)	541 (17)	910 (15)	125 (11)
Unknown	630 (5)	136 (4)	204 (3)	32 (3)
Comorbid conditions, n (%)				
Atrial fibrillation	754 (6)	181 (5)	989 (16)	171 (15)
Chronic pulmonary disease	1855 (15)	387 (11)	1329 (22)	193 (17)
Hyperlipidemia	1210 (10)	289 (8)	529 (9)	135 (12)
Hypertension	6326 (51)	1230 (35)	3547 (58)	522 (45)
Stroke	556 (4)	122 (4)	263 (4)	61 (5)
Cancer (breast, colorectal, prostate, or lung)	506 (4)	113 (3)	363 (6)	43 (4)
Chronic kidney disease	3576 (29)	698 (20)	2330 (38)	399 (35)
Diabetes mellitus	3885 (31)	759 (22)	2109 (34)	316 (27)
Heart failure	1781 (14)	419 (12)	n/a	n/a
Ischemic heart disease	4490 (36)	1033 (30)	1860 (30)	330 (29)

n/a, not applicable.

the low-risk surgery cohort, the mean age of patients was 64 years [SD, 16.1 years], and 56% were women. The proportion of patients enrolled in fee-for-service Medicare was 30%, in Medicare Advantage was 17%, in Medicaid was 24%, and in commercial insurance was 25%. For the PCI/CABG cohort, the mean age of patients was 70 years [SD, 15.7 years], and 26% were

women. The proportion of patients enrolled in fee-for-service Medicare was 57%, in Medicare Advantage was 10%, in Medicaid was 16%, and in commercial insurance was 15%. Comorbid conditions including hypertension, chronic kidney disease, and diabetes mellitus were common among both the low-risk surgery and PCI/CABG cohorts.

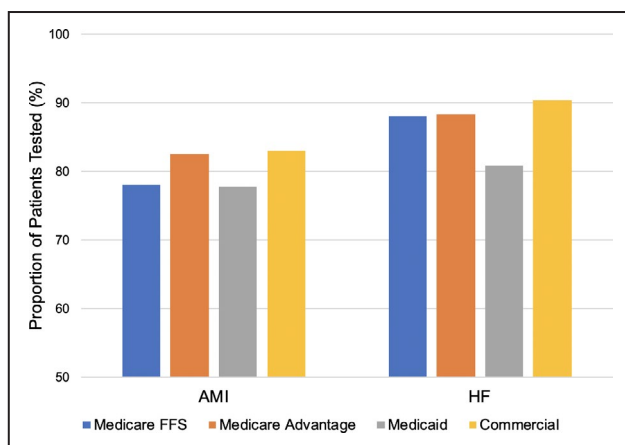


Figure 3. Rates of high-value testing by health insurance provider.

The proportion of patients receiving high-value testing to assess left ventricular ejection fraction after hospitalization for acute myocardial infarction (AMI) or incident heart failure (HF) by insurance provider. FFS indicates fee-for-service.

Association of Testing With Insurance Provider

Overall, 4% of patients received low-value testing prior to low-risk surgery, and 27% of patients received low-value testing after PCI/CABG. Rates of testing stratified by insurance provider ranged from 2% to 5% for low-risk surgery and 19% to 37% for PCI/CABG (Figure 4). After multivariable adjustment, there were no significant differences in the use of low-value testing between patients with Medicaid compared with commercial insurance for either low-risk surgery (OR, 1.10 [0.94–1.27]; $P=0.23$) or PCI/CABG (OR, 0.94 [0.81–1.10]; $P=0.44$; Table 3). Patients with Medicare Advantage were less likely to receive low-value testing after PCI/CABG compared with Medicare fee-for-service (OR, 0.63 [0.55–0.72]; $P<0.001$), but equally likely to receive low-value testing prior to low-risk surgery (OR, 1.06 [0.87–1.29]; $P=0.59$; Table 3). The odds of receiving testing were similar in a sensitivity analysis excluding the 3.8% of

Table 2. Characteristics of Patients Eligible for Low-Value Testing

	Low-Risk Surgery, N=111 387		PCI/CABG, N=16 363	
	Tested, N=3942	Not Tested, N=107 445	Tested, N=4422	Not Tested, N=11 941
Age, y, mean (SD)	64.0 (17.0)	63.4 (16.8)	70.3 (15.5)	69.9 (15.7)
Women, n (%)	2025 (51)	60 199 (56)	1206 (27)	3016 (25)
Insurance, n (%)				
Medicare fee-for-service	1427 (38)	32 434 (30)	2553 (58)	6766 (57)
Medicare Advantage	722 (18)	18 130 (17)	293 (7)	1379 (12)
Medicaid	803 (20)	25 558 (24)	807 (18)	1779 (15)
Commercial	668 (17)	27 310 (25)	646 (15)	1746 (15)
Unknown	143 (4)	4192 (4)	123 (3)	271 (2)
Comorbid conditions, n (%)				
Atrial fibrillation	567 (14)	3375 (3)	251 (6)	859 (7)
Chronic pulmonary disease	707 (18)	8464 (8)	618 (14)	1755 (15)
Hyperlipidemia	464 (12)	3846 (4)	516 (12)	1446 (12)
Hypertension	2405 (61)	34 136 (32)	2524 (57)	6467 (54)
Stroke	232 (6)	1592 (1)	170 (4)	553 (5)
Cancer (breast, colorectal, prostate, or lung)	568 (14)	7891 (7)	278 (6)	740 (6)
Chronic kidney disease	1272 (32)	15 997 (15)	938 (21)	2742 (23)
Diabetes mellitus	1171 (30)	17 970 (17)	1357 (31)	3757 (31)
Heart failure	817 (21)	4135 (4)	636 (14)	2122 (18)
Ischemic heart disease	1377 (35)	11 189 (10)	2349 (53)	6139 (51)

CABG indicates coronary artery bypass graft surgery; and PCI, percutaneous coronary intervention.

low-risk surgery patients who were eligible for testing more than once. There were no significant differences in use of testing by sex; for women compared with men, the OR for low-risk surgery was 0.93 (0.84–1.03) and the OR for PCI/CABG was 0.92 (0.84–1.01).

DISCUSSION

Summary of Findings and Extension of Prior Knowledge

Our study found that health insurance provider is independently associated with use of certain high- and low-value diagnostic cardiovascular tests. Using multivariable models adjusted for a variety of patient characteristics, we found that (1) patients with Medicaid were less likely to receive high-value testing when hospitalized with AMI or incident HF compared with patients with commercial insurance, and (2) patients with Medicare Advantage were more likely to receive high-value testing for AMI and less likely to receive low-value testing after PCI/CABG compared with patients with Medicare fee-for-service. Thus, across 4 high- and low-value diagnostic testing scenarios, Medicaid patients were less likely to receive guideline-concordant testing compared with commercially insured patients, whereas Medicare Advantage patients were more likely to receive guideline-concordant testing compared with fee-for-service Medicare patients.

Our study has several strengths. First, although prior studies have assessed variation in the use of certain high- and low-value diagnostic tests, they have been limited to single insurance providers such as Medicare fee-for-service,^{12,21} or single health systems such as Kaiser Permanente¹⁰ and the Veterans Health Administration.²⁴ Our study finds that a patient's insurance provider is a significant correlate of high- and low-value testing after adjusting for a variety of patient-level factors. Second, we assessed the use of 4 common high- and low-value tests spanning a variety of different cardiovascular conditions. This provided an opportunity to broadly understand the association of insurance providers and insurance plan features on guideline-concordant testing. Our results suggest that differences in insurance plan features, such as reimbursement and quality of care incentives, may lead to differences in use of high- and low-value testing. Insurance plan features may also provide valuable targets to improve use of testing.

Medicaid Versus Commercial Insurance

Prior studies have shown that patients with Medicaid may receive fewer high-value tests and treatments compared with patients with commercial insurance.^{13,14} For example, a recent study found that Medicaid patients hospitalized with AMI received fewer

Table 3. Adjusted Associations of Health Insurance Provider With High- and Low-Value Testing

	High-Value Testing				Low-Value Testing			
	AMI		HF		Low-Risk Surgery		PCI/CABG	
	OR	P Value	OR	P Value	OR	P Value	OR	P Value
Medicare Advantage (compared with Medicare fee-for-service)	1.35 (1.15–1.59)	<0.001	1.03 (0.78–1.36)	0.84	1.06 (0.87–1.29)	0.59	0.63 (0.55–0.72)	<0.001
Medicaid (compared with commercial)	0.84 (0.73–0.98)	0.03	0.59 (0.51–0.70)	<0.001	1.10 (0.94–1.27)	0.23	0.94 (0.81–1.10)	0.44

All models were adjusted for patient characteristics including age, sex, and comorbid conditions. AMI indicates acute myocardial infarction; CABG, coronary artery bypass graft; HF, heart failure; and PCI, percutaneous coronary intervention.

revascularization procedures compared with matched patients with commercial insurance.²⁵ These disparities may occur for several reasons. First, Medicaid patients often receive care at safety-net hospitals and clinics that have fewer resources to provide care overall and to invest in quality-improvement programs in particular.²⁶ Second, there may be differences in the characteristics of clinicians who predominantly serve patients with a particular insurance status or who attend on hospital teams serving these patients.²⁷ Third, Medicaid typically provides lower reimbursement rates for services compared with other insurance providers, which can lead to delays or reduced access to care.²⁸ Our sensitivity analysis showed that the proportion of patients who were receiving delayed testing, within 90 days rather than 60 days, was similar across insurance categories, which suggests that overall access to care, rather than delayed access to care, may have contributed to our observation that Medicaid patients were less likely to receive high-value testing. Finally, although we adjusted for a variety of patient characteristics, unmeasured differences between Medicaid and commercially insured patients, such as socioeconomic factors, could have contributed to the observed differences in use of testing.

Medicare Advantage Versus Traditional Fee-for-Service Medicare

Our study also suggests that insurance plans that measure and incentivize quality metrics may lead to more guideline-concordant care. Patients enrolled in Medicare Advantage were not only more likely to receive high-value testing for AMI, but also less likely to receive low-value testing after PCI/CABG. Other studies have also found that Medicare Advantage patients may receive care that is more concordant with guidelines compared with patients with Medicare fee-for-service.^{15,29} Managed care plans such as Medicare Advantage often directly incentivize the delivery of evidence-based care that has been shown to improve patient outcomes. Many of these quality metrics form the basis on which Medicare Advantage plans receive star ratings and performance bonuses from the Centers for Medicare and Medicaid Services. One quality metric specifically addresses the chronic management of coronary artery disease, which may have contributed to the differences in testing among patients with AMI and patients with PCI/CABG observed in our study. Our results suggest that efforts to measure and report certain quality metrics may be effective in improving guideline-concordant use of diagnostic testing.

Potential Clinical Consequences

Underuse of high-value testing and overuse of low-value testing can both worsen patient outcomes.

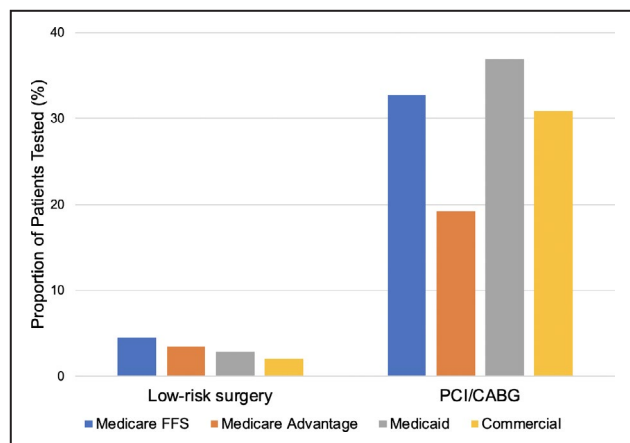


Figure 4. Rates of low-value testing by health insurance provider.

The proportion of patients receiving low-value stress testing prior to low-risk surgery and after percutaneous coronary intervention (PCI)/coronary artery bypass graft surgery (CABG) by health insurance provider. FFS indicates fee-for-service.

Beneficial therapies that reduce mortality are often initiated based on results of high-value tests, such as initiation and dose titration of β -blockers in patients with incident HF and reduced systolic function.¹⁹ Similarly, performance of low-value testing can prompt unnecessary subsequent invasive procedures, such as coronary angiography, that carry risks of bleeding and stroke. Low-value cardiovascular testing also contributes to medical overspending and unnecessary downstream consequences. Therefore, the observed differences in use of testing in our study represent an opportunity to optimize testing to improve patient outcomes and reduce healthcare costs.

Limitations

Although we accounted for a wide variety of patient-level variables in our multilevel regression models, unmeasured confounders, such as tobacco use or family history, could have contributed to observed differences in use of high- and low-value testing. We studied the use of high- and low-value tests in specific scenarios that could be identified using administrative claims data. Use of other high- and low-value tests, as well as tests of uncertain appropriateness, may differ. Our data set did not have information on whether symptoms may have prompted stress testing after PCI/CABG. Some stress tests were likely clinically indicated, and it is difficult to ascertain whether the numbers of clinically indicated tests vary by insurance type. Similar to prior studies, we excluded tests performed in association with acute-care visits that may have been prompted by changes in symptoms. Race/ethnicity was not available in our data set, so we were unable to adjust for these demographics in our

models. Hospital-level characteristics were not available in our data set. Although we tested for interaction between comorbid conditions and insurance type and adjusted for comorbidities in our regression models, residual confounding is still a possibility given the imbalance of comorbid conditions between the groups that did and did not receive testing. We did not have sufficient power to assess for differences in clinical outcomes between patients who received or did not receive high- or low-value testing. Our data set did not include information on prior authorizations or disapprovals of such requests. We used all-payer data from the state of Colorado, which provided important information on insurance plan enrollment but may have limited the generalizability of our findings.

CONCLUSIONS

Health insurance provider is independently associated with use of certain high- and low-value diagnostic cardiovascular tests. Medicaid patients were less likely to receive guideline-concordant testing compared with commercially insured patients, whereas Medicare Advantage patients were more likely to receive guideline-concordant testing compared with fee-for-service Medicare patients. Our results suggest that reimbursement and quality incentives may affect use of guideline-concordant testing, and that features of insurance plans could be useful targets to improve use of testing.

ARTICLE INFORMATION

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Affiliations

From the Division of Cardiology, University of Colorado Anschutz Medical Campus, Aurora, CO (V.K., P.K., D.J.M., P.M.H., F.A.M.); University of Colorado School of Medicine, Aurora, CO (B.M.); Veterans Affairs Eastern Colorado Health Care System, Aurora, CO (S.R., P.M.H.); and Minneapolis Heart Institute and Minneapolis Heart Institute Foundation, Minneapolis, MN (S.M.B.).

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Disclosures

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Supplementary Material

Tables S1–S4

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Supplemental Material

Table S1. International Classification of Diseases, Ninth- and Tenth- Revision (ICD-9 and 10) and Current Procedural Technology (CPT) Codes used to identify cardiovascular tests and procedures.

Test / Procedure	Codes
Transesophageal Echo (TEE)	CPT: 93312, 93313, 93314, 93315, 93316, 93317, 93318
Transthoracic Echo (TTE)	CPT: 93303, 93304, 93306, 93307, 93308
Stress Electrocardiogram (ECG)	CPT: 93015, 93016, 93017, 93018
Single-photon emission computed tomography (SPECT)	CPT: 78451, 78452, 78464, 78465, 78468, 78469
Stress echocardiogram (Stress Echo)	CPT: 93350, 93351
Cardiac computed tomography angiography (CCTA)	CPT: 75571, 75572, 75573, 75574, 76497
Nuclear Positron Emission Tomography (PET)	CPT: 78459, 78491, 78492
Stress Cardiac MRI	CPT: 75559, 75563
Left heart catheterization with left ventriculography	CPT: 93451, 93452, 93453, 93458, 93459, 93460, 93461, 93563, 93564, 93565, 93566, 93567, 93568
Percutaneous coronary intervention	ICD-9: 0.66, 36.01, 36.02, 36.03, 36.04, 36.05, 36.06, 36.07, 36.09, 17.55 ICD-10: 0270XXX, 0271XXX, 0272XXX, 0273XXX CPT: 92920, 92924, 92928, 92933, 92937, 92941, 92943
Coronary artery bypass surgery	ICD-9: 36.10, 36.11, 36.12, 36.13, 36.14, 36.15, 36.16, 36.17, 36.19 ICD-10: 0210XXX, 0211XXX, 0212XXX, 0213XXX

Table S2. CPT codes used to identify low-risk surgeries.

Low-risk surgeries:	
Knee arthroscopy	29866-29868, 29870, 29873-29877, 29879-29889
Shoulder arthroscopy	29805-29807, 29819-29828
Cataract surgery	66982, 66984
Laparoscopic cholecystectomy	47562, 47563
Inguinal hernia repair	49650, 49651
Mastectomy	19303, 19304, 19305, 19306, 19307
Hysteroscopy	58558
Transurethral Prostatectomy	52601

Table S3. ICD-9 and ICD-10 codes used to identify hospitalizations for acute myocardial infarction and heart failure.

Diagnosis	ICD-9	ICD-10
Heart Failure (HF)	402.XX, 404.XX, 428.XX	I09.81, I11.0, I13.0, I13.2, I50.XX
Acute Myocardial Infarction (AMI)	410.0-410.9	I21.0-I21.4

Table S4. Sensitivity Analysis Increasing High-Value Testing Time Interval From 60 to 90 Days Following Discharge.

	Acute Myocardial Infarction N=15,893		Heart Failure N=7,319	
	Tested 60 days N=12,619	Tested 90 days N=13,280	Tested 60 days N=6,164	Tested 90 days N=6,502
Medicare fee-for-service	5458 (43)	5788 (44)	2818 (46)	2980 (46)
Medicare Advantage	1542 (12)	1615 (12)	1009 (16)	1055 (16)
Medicaid	2412 (19)	2530 (19)	1223 (20)	1298 (20)
Commercial	2577 (20)	2684 (20)	910 (15)	953 (15)
Unknown	630 (5)	663 (5)	204 (3)	216 (3)