Acute Myocardial Infarction Cohorts Defined by International Classification of Diseases, Tenth Revision Versus Diagnosis-Related Groups

Analysis of Diagnostic Agreement and Quality Measures in an Integrated Health System

BACKGROUND: Among Medicare value-based payment programs for acute myocardial infarction (AMI), the Hospital Readmissions Reduction Program uses International Classification of Diseases, Tenth Revision (ICD-10) codes to identify the program denominator, while the Bundled Payments for Care Improvement Advanced program uses diagnosis-related groups (DRGs). The extent to which these programs target similar patients, whether they target the intended population (type 1 myocardial infarction), and whether outcomes are comparable between cohorts is not known.

METHODS: In a retrospective study of 2176 patients hospitalized in an integrated health system, a cohort of patients assigned a principal ICD-10 diagnosis of AMI and a cohort of patients assigned an AMI DRG were compared according to patient-level agreement and outcomes such as mortality and readmission.

RESULTS: One thousand nine hundred thirty-five patients were included in the ICD-10 cohort compared with 662 patients in the DRG cohort. Only 421 patients were included in both AMI cohorts (19.3% agreement). DRG cohort patients were older (70 versus 65 years, \( P < 0.001 \)), more often female (48% versus 30%, \( P < 0.001 \)), and had higher rates of heart failure (52% versus 33%, \( P < 0.001 \)) and kidney disease (42% versus 25%, \( P < 0.001 \)). Comparing outcomes, the DRG cohort had significantly higher unadjusted rates of 30-day mortality (6.6% versus 2.5%, \( P < 0.001 \)), 1-year mortality (21% versus 8%, \( P < 0.001 \)), and 90-day readmission (26% versus 19%, \( P = 0.006 \)) than the ICD-10 cohort. Two observations help explain these differences: 61% of ICD-10 cohort patients were assigned procedural DRGs for revascularization instead of an AMI DRG, and type 1 myocardial infarction patients made up a smaller proportion of the DRG cohort (34%) than the ICD-10 cohort (78%).

CONCLUSIONS: The method used to identify denominators for value-based payment programs has important implications for the patient characteristics and outcomes of the populations. As national and local quality initiatives mature, an emphasis on ICD-10 codes to define AMI
WHAT IS KNOWN

• Medicare administers multiple value-based payment programs for acute myocardial infarction (AMI), some of which use International Classification of Diseases, Tenth Revision (ICD-10) codes to define AMI cohorts while others use AMI diagnosis-related groups. The extent to which the AMI populations identified by these different mechanisms overlap is not known.

WHAT THE STUDY ADDS

• In a large health system in Colorado, there was only 19% agreement between ICD-10 and diagnosis-related groups-based inclusion criteria for value-based programs targeting AMI.
• Compared with patients in the ICD-10 cohort, AMI patients in the diagnosis-related group cohort had significantly higher rates of death both at 30 days and 1 year and readmission at 90 days.
• These differences may be attributable to the fact that only 34% of patients with an AMI diagnosis-related group had a type 1 myocardial infarction, compared with 78% of patients identified by ICD-10 codes.
• Together, these findings suggest that divergent AMI cohorts in value-based programs have the potential to confuse efforts to improve AMI care.

cohorts would better represent type 1 myocardial infarction patients.

National efforts to improve inpatient cardiovascular care now include several value-based payment reforms initiated by the Center for Medicare and Medicaid Services: these include the Hospital Readmissions Reduction Program (HRRP), the Value-Based Purchasing program (VBP), and the voluntary Bundled Payments for Care Improvement Advanced (BPCIA). Because of its relatively high incidence and cost in the Medicare population and the availability of numerous evidence-based therapies that improve outcomes for type 1 myocardial infarction (T1MI), acute MI (AMI) is a condition targeted by all 3 programs.1,2 These programs do not define AMI uniformly, however. Although the BPCIA uses Medicare-severity diagnosis-related groups (DRG) to define eligible AMI hospitalizations,3 the HRRP and VBP programs use AMI codes from the International Classification of Diseases, Tenth Revision (ICD-10).4,5

Broadly, how AMI populations are defined is important to the work of hospitals, payers, researchers, and rating agencies. Hospitals are continuously analyzing performance data to focus improvement efforts but may not consider whether these data come from DRG or ICD-10 cohorts. Payers may dispense payments for inpatient care according to DRG diagnoses while at the same time measuring quality based on ICD-10 diagnoses. Researchers and rating agencies, meanwhile, usually analyze AMI care based on a single population, either ICD-10 or DRG. In each of these cases, whether observations in one AMI population (eg, DRG) are generalizable to another AMI population (eg, ICD-10) is unknown. An assumption of equivalence between these populations, if untrue, has the potential to undermine efforts to improve AMI care.

With this in mind, we sought to characterize the extent to which DRG and ICD-10 diagnoses of AMI identify similar populations. We used data from a large integrated health system to determine patient-level agreement between AMI cohorts defined by ICD-10 codes versus AMI DRGs. We also compared cohorts according to outcome measures, such as 30-day mortality and readmission that are linked to value-based programs, as well as process measures of excellence in AMI care, such as cardiac rehabilitation referral rates.

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request. In a retrospective cohort analysis, we collected data for all patients who were admitted to a UCHealth hospital between January 1, 2017 and June 30, 2018, and were discharged alive with a diagnosis of AMI according to either the discharge DRG or principal ICD-10 code. UCHealth is a not-for-profit integrated health care system that included 8 Colorado hospitals, including the University of Colorado Hospital, during the timeframe of the study. Eligible AMI diagnoses were chosen to align with value-based payment programs (see Exposure section below). Patients with AMI who did not receive an eligible administrative AMI diagnosis were not included.

Exposure

Patients were divided into 2 cohorts—an ICD-10 cohort and a DRG cohort—although cohorts were not mutually exclusive. The DRG cohort was comprised of patients with a hospitalization during the study period that was assigned 1 of 3 DRGs for AMI described in the inclusion criteria for the BPCIA program.1 Patients in the ICD-10 cohort were hospitalized during the study period with a primary discharge ICD-10 code included on a list of 9 codes used by the HRRP and VBP programs.4,5 A full list of DRGs and ICD-10 codes defining cohort inclusion can be found in Table I in the Data Supplement. For patients with multiple AMI admissions, only their first AMI encounter during the study period was included in the analysis.

Outcomes

Outcome measures were selected for relevance to performance in value-based policy programs: these included rates of 30-day mortality, 1-year mortality, 30-day readmission, and 90-day readmission. To understand rates of resource utilization in the 2 cohorts, we also compared cohorts according to process...
measures, such as length of stay, inpatient medication use, and utilization of cardiac testing and services. Among the medications analyzed were aspirin, beta-blockers, oral P2Y12 inhibitors, and high-dose 3-hydroxy-3-methyl-glutaryl-coenzyme A reductase inhibitors (atorvastatin dose ≥40 mg, rosvuastatin dose ≥20 mg). Among the cardiac tests and services examined were cardiac rehabilitation referrals, cardiac catheterizations, and cardiac imaging tests, including echocardiography, cardiac computed tomography, and cardiac magnetic resonance imaging. Finally, the 10 most common principal ICD-10 diagnoses in the DRG cohort were enumerated, as were the 10 most common DRG assignments in the ICD-10 cohort.

**Statistical Analysis**

Patient-level agreement between the ICD-10 and DRG cohorts was assessed by percent agreement. Univariate logistic regression was used to determine the difference between groups for each categorized characteristic and outcome (eg, medication rates and mortality rates), where the P value associated with the χ² test statistics was reported. Univariate linear regression was used to compare noncategorized characteristics and outcomes (eg, age, mean length of stay), where the P value corresponded to a 2-sample t test assuming equal variances. Some patients were captured by both the ICD-10 and DRG cohorts. Although summary statistics for each cohort include all patients in the cohort, including these overlap patients, statistical comparisons between groups reflect differences between patients included in only one of the cohorts. All statistical analysis and data manipulation were carried out in R, version 3.6.0 (R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria, 2014).

**Subgroup Chart Review of University of Colorado Hospital Patients**

All patients in the study who were admitted to the University of Colorado Hospital (UCH) were part of a subgroup analysis in which chart reviews were performed to establish a gold-standard diagnosis based on the Fourth Universal Definition of Myocardial Infarction. Five reviewers completed reviews (Dr Levy, K.S. Ream, Drs Rudofker, Raines, Beck) and uncertain or questionable cases were adjudicated by agreement between 2 reviewers (Dr Levy, K.S. Ream). UCH was chosen for review because all 5 reviewers had access to medical records from this site. More details regarding the methods used for chart reviews are described in the Methods in the Data Supplement.

**Subgroup Analysis**

Baseline characteristics of UCH patients are compared with those of UCH patients in Table II in the Data Supplement. Agreement between patients with chart-confirmed T1MI versus patients in the ICD-10 and DRG cohorts was assessed by percent agreement and dual-comparison Cohen kappa coefficients. Patients with T1MI were then used as the reference group for process and outcome measure comparisons to UCH patients in the ICD-10 and DRG cohorts. Statistical methods were identical to those described above in the Statistical Analysis section.

**Sensitivity Analysis**

Unadjusted analyses, as described above, were used for our main outcome measures because, although covariates are used by Center for Medicare and Medicaid Services and others for risk-adjusted comparisons between hospitals, our analysis was designed to compare cohorts within a single hospital system to highlight differences between cohorts that are directly relevant to local quality measurement and improvement. As a sensitivity analysis of the extent to which differences between cohorts are attributable to measured differences between cohorts, multivariate regression was performed using age, sex, and baseline rates of heart failure, chronic kidney disease, and diabetes as covariates (Table III in the Data Supplement).

**Data Acquisition and Handling**

With the exception of chart review data, all clinical data for the study were obtained from the Health Data Compass, an electronic data warehouse that integrates input from the UCHealth electronic health record with outside sources such as the Colorado State Death Registry and Colorado All Payer Claims Database. This study was reviewed and approved by the Colorado Multiple Institutions Review Board (COMIRB 19-1877).

**RESULTS**

Between January 1, 2017 and June 30, 2018, a total of 2176 patients at UCHealth hospitals had an eligible DRG or primary ICD-10 diagnosis of AMI. Patient demographics and characteristics are described in Table 1. Baseline characteristics between DRG and ICD-10 cohort patients were different, most notably in terms of mean age (70 versus 65 years, P<0.001) and gender (48% female versus 30%, P<0.001). Patients in the DRG cohort also had higher rates of comorbidities, such as heart failure (52% versus 33%, P<0.001), chronic kidney disease (42% versus 25%, P>0.001), and diabetes (41% versus 37%, P=0.041), than the ICD-10 cohort. Furthermore, patients in the DRG cohort were less often cared for by a cardiologist (58% versus 74%, P<0.001).

Out of the total cohort, 662 patients (30%) had an eligible DRG diagnosis of AMI, and 1935 patients (89%) had a primary ICD-10 diagnosis of AMI. Four hundred twenty-one encounters had both an ICD-10 and a DRG diagnosis of AMI, corresponding to 19.3% concordance between the 2 cohorts (Figure 1). Among patients in the ICD-10 cohort who were not assigned a DRG for AMI, 61% were instead assigned a DRG for percutaneous coronary intervention (PCI) or coronary artery bypass graft surgery (CABG; Figure 2). A complete listing of the 10 most frequent ICD-10 assignments for the DRG cohort are provided in Table IV in the Data Supplement, and the 10 most frequent DRG assignments for the ICD-10 cohort are provided in Table V in the Data Supplement.
Significant differences in outcome and process measures were observed between the DRG and ICD-10 cohorts (Table 2). In terms of inpatient medication use, significantly fewer patients in the DRG group were prescribed P2Y12 inhibitors (44.6% versus 81.6%, \( P<0.001 \)) and high dose statins (80.2% versus 92.5%, \( P<0.001 \)) during their inpatient stay. Smaller, but still significant, differences were observed for inpatient aspirin and beta-blocker use. Rates of cardiac catheterization (32.8% versus 65.2%, \( P<0.001 \)) and cardiac rehabilitation referral (22.4% versus 57.8%, \( P<0.001 \)) were also significantly lower in the DRG cohort. The only process measures that were not significantly different between the DRG and ICD-10 cohorts were hospital length of stay and rates of inpatient echocardiography.

In terms of outcomes, rates of 30-day mortality (6.6 versus 2.5%, \( P<0.001 \)), 1-year mortality (20.8% versus 8.0%, \( P<0.001 \)), and 90-day readmission (26.4% versus 18.9%, \( P=0.006 \)) were all higher in the DRG cohort than the ICD-10 cohort. Differences in rates of 30-day readmission were not statistically significant (18.5% versus 13.9%, \( P=0.065 \)). These results were robust to sensitivity analysis using multivariate comparisons (Table III in the Data Supplement) with the exception of differences in 90-day readmissions, which were no longer statistically significant, and length of stay, for which differences were shown to be significantly different after adjustment (3.9 days in DRG versus 4.0 days in ICD-10, \( P=0.006 \)).

A chart review subgroup analysis of all 645 AMI patients treated at UCH included 525 patients from the ICD-10 cohort and 258 from the DRG cohort. Baseline patient characteristics for the UCH subgroup compared with the UCHHealth cohort are described in Table II in the Data Supplement. Characteristics such as mean age and rates of diabetes, chronic kidney disease, heart failure, and home medication use were different between the UCH cohort and the larger UCHHealth cohort. Yet, agreement between ICD-10 and DRG subgroups from UCH was similar to the overall UCHHealth cohort, with 138 patients being included in both subgroups (21.4% agreement).

| Table 1. Baseline Patient Characteristics of AMI Cohorts |
|---------------------------------------------------------|
| **ICD-10** | **DRG** | **P* value** | **tT1MI-UCH** | **tICD-10-UCH** | **P* value** | **tDRG-UCH** | **P* value** |
|------------|---------|-------------|---------------|----------------|-------------|---------------|-------------|
| n=1935     | n=662   |             | n=425         | n=525          |             | n=258         |             |
| Demographics |         |             |               |                |             |               |             |
| Age, y, median | 65.2 (SD=13.4) | 70.3 (SD=14.9) | \(<0.001\) | 63.7 (SD=13.8) | 63.3 (SD=14.0) | \(0.192\) | 68.3 (SD=15.1) | \(<0.001\) |
| Female | 577 (29.8%) | 321 (48.5%) | \(<0.001\) | 128 (20.1%) | 172 (32.8%) | \(0.758\) | 126 (48.8%) | \(<0.001\) |
| White | 1477 (79.4%) | 492 (74.3%) | 0.095 | 226 (53.2%) | 278 (53.0%) | 0.571 | 136 (52.7%) | 0.649 |
| Cardiology team | 1430 (73.9%) | 385 (58.2%) | \(<0.001\) | 218 (51.3%) | 269 (51.2%) | 0.607 | 107 (41.5%) | 0.006 |
| Medical history |         |             |               |                |             |               |             |
| Diabetes | 713 (36.8%) | 273 (41.2%) | 0.041 | 185 (43.5%) | 220 (41.9%) | \(0.405\) | 103 (39.9%) | 0.104 |
| Hypertension | 1510 (78.0%) | 560 (84.6%) | 0.002 | 324 (76.2%) | 400 (76.2%) | 0.963 | 213 (82.6%) | 0.084 |
| Hyperlipidemia | 1333 (68.9%) | 373 (56.3%) | \(<0.001\) | 216 (50.8%) | 259 (49.3%) | 0.459 | 102 (39.5%) | 0.004 |
| Heart failure | 646 (33.4%) | 347 (52.4%) | \(<0.001\) | 169 (39.8%) | 211 (40.2%) | 0.242 | 136 (52.7%) | \(<0.001\) |
| Peripheral artery disease | 78 (4.0%) | 24 (3.6%) | 0.305 | 15 (3.5%) | 15 (2.9%) | 0.311 | 1 (0.4%) | 0.012 |
| Prior stroke | 330 (17.0%) | 167 (25.2%) | \(<0.001\) | 81 (19.1%) | 103 (19.6%) | 0.325 | 58 (22.5%) | 0.332 |
| COPD | 288 (14.9%) | 138 (20.9%) | \(<0.001\) | 68 (16.0%) | 87 (16.6%) | 0.818 | 61 (23.6%) | 0.010 |
| Chronic kidney disease | 487 (25.2%) | 279 (42.2%) | \(<0.001\) | 118 (27.8%) | 166 (31.6%) | 0.189 | 122 (47.3%) | \(<0.001\) |
| Dementia | 67 (3.5%) | 65 (9.8%) | \(<0.001\) | 11 (2.6%) | 16 (3.1%) | 0.603 | 26 (10.1%) | \(<0.001\) |
| Cancer | 356 (18.4%) | 137 (20.7%) | 0.235 | 61 (14.4%) | 81 (15.4%) | 0.470 | 52 (20.2%) | 0.009 |
| Home medications |         |             |               |                |             |               |             |
| Aspirin | 149 (7.7%) | 100 (15.1%) | \(<0.001\) | 42 (9.9%) | 55 (10.5%) | 0.999 | 48 (18.6%) | \(<0.001\) |
| P2Y12 inhibitor | 91 (4.7%) | 52 (7.9%) | \(<0.001\) | 30 (7.1%) | 36 (6.9%) | 0.279 | 23 (8.91%) | 0.548 |
| Beta-blocker | 172 (8.9%) | 112 (16.9%) | \(<0.001\) | 58 (13.7%) | 68 (13.0%) | 0.116 | 54 (20.9%) | 0.049 |
| Any statin | 172 (8.9%) | 99 (15.0%) | \(<0.001\) | 53 (12.5%) | 64 (12.2%) | 0.715 | 47 (18.2%) | 0.085 |
| ACE inhibitor, ARB, ARNI | 152 (7.9%) | 81 (12.2%) | \(<0.001\) | 51 (12.0%) | 58 (11.1%) | 0.159 | 43 (16.7%) | 0.265 |
| Oral anticoagulation | 34 (1.8%) | 32 (4.8%) | \(<0.001\) | 10 (2.4%) | 14 (2.7%) | 0.999 | 16 (6.2%) | 0.003 |

ACE indicates angiotensin-converting enzyme; AMI, acute myocardial infarction; ARB, angiotensin-receptor blocker; ARNI, angiotensin-receptor neprilysin inhibitor; COPD, chronic obstructive pulmonary disease; DRG, diagnosis-related group; ICD-10, International Classification of Diseases, Tenth Revision; T1MI, Type 1 myocardial infarction; and UCH, University of Colorado Hospital.

*Reference group for the main study cohort was ICD-10; reference group for the UCH subgroup was T1MI (T1MI-UCH).

†Subgroup analysis of all patients cared for at the UCH.
Out of the 645 subgroup patients, gold-standard diagnosis based on chart review revealed that 425 (66%) were diagnosed with T1MI, 101 (16%) had type 2 MI (T2MI), and 119 (18%) were diagnosed with nonischemic myocardial injury (NIMI). Focusing on patients with T1MI, 78% (409/525) of patients in the ICD-10–UCH subgroup were diagnosed with T1MI, compared with 34% (89/258) in the DRG-UCH subgroup (Figure 3). Patients that were only captured by the ICD-10–UCH subgroup had the highest proportion of T1MI diagnoses 87% (336/387), compared with 53% (73/138) among patients in both subgroups and 13% (16/120) among patients only included in DRG-UCH subgroup (Figure I in the Data Supplement). Most patients with T1MI not assigned an AMI DRG were assigned a DRG for PCI (189/425, 44%) or CABG (47/425, 11%; Table VI in the Data Supplement). Overall patient-level agreement between T1MI and ICD-10 was fair (80% agreement, kappa 0.49 with 95% CI 0.42 to 0.56), whereas T1MI agreement with the DRG cohort was poor (22% agreement, kappa, −0.47 with 95% CI, −0.54 to −0.40; Table VII in the Data Supplement).

The baseline characteristics for patients with T1MI were more similar to the ICD-10–UCH subgroup than the DRG-UCH subgroup: although the ICD-10 cohort was not significantly different from the T1MI cohort in any of 20 baseline characteristics examined in this study, the DRG-UCH cohort was significantly different according to thirteen of twenty baseline characteristics including age, sex, and rates heart failure and chronic kidney disease, among others (Table 1). Patients with T1MI were also more similar to ICD-10 patients in terms of process and outcomes measures in that there were no significant differences between patients with T1MI and the ICD-10–UCH subgroup. Patients in the DRG-UCH group, in contrast, were significantly different from patients with T1MI in terms of 30-day mortality (5.0% versus 1.7%, \( P = 0.013 \)), 1-year mortality (23.6% versus 10.4%, \( P < 0.001 \)), rates of stress testing (11.6% versus 2.1%, \( P < 0.001 \)), cardiac catheterization (31.4% versus 66.4%, \( P < 0.001 \)), referral to cardiac rehabilitation (6.6% versus 16.0%, \( P < 0.001 \)) and rates of inpatient use of aspirin (99% versus 91%, \( P < 0.001 \)), P2Y12 inhibitors (38% versus 80%, \( P < 0.001 \)), high-dose statins (85% versus 96%, \( P < 0.001 \)), and beta-blockers (76%...
versus 94%, \( P<0.001 \); Table 2). These findings were also robust to sensitivity analysis using multivariate comparisons (Table II in the Data Supplement) with the exception of differences in 30-day mortality and inpatient aspirin use, which were no longer statistically significant, and length of stay, for which differences were shown to be significantly different after adjustment (4.9 days in DRG-UCH versus 5.8 days in T1MI, \( P<0.001 \)).

**DISCUSSION**

In a retrospective cohort study of patients admitted to a large integrated health system in Colorado, only 19% of AMI patients were included in both the ICD-10 and DRG cohorts. The poor agreement between cohorts is partly explained by the observation that the majority of ICD-10 cohort patients (61%) were assigned a DRG for PCI or CABG. Perhaps more notably, patients in the DRG cohort were significantly less likely to receive medical therapy for AMI or undergo cardiac catheterization and had significantly higher rates of mortality and readmission. A subgroup analysis of patients admitted to the UCH suggests that these differences may, in part, be attributable to lower rates of true T1MI in the DRG cohort (34%) compared with the ICD-10 cohort (78%). Similar to the ICD-10 cohort, the majority of patients with T1MI in the UCH subgroup were assigned a procedural DRG for PCI or CABG.

The simplest and most actionable conclusion to draw from these data is that hospitals must take considerable care when examining institutional outcomes and process measures for AMI patients. In particular, attention must be paid to how these patient populations are defined, as AMI populations defined by a DRG may be fundamentally different and receive different care than populations defined by ICD-10 codes. There are numerous practicing clinicians involved in the care of patients with AMI who likely have little, if any, understanding of the differences in these methodologies. Moreover, Chief Medical and Quality Officers, who contend with quality issues related to all the documented diagnoses in a hospital, typically think of AMI as 1 group of patients, not 2. Extrapolating assumptions regarding performance (outcomes) and methods for improvement from one population (eg, ICD-10) to a second dissimilar population (eg, DRG) carries the risk of sub-optimizing patient care. That risk rises significantly when well-intentioned clinicians and leaders are not aware they are making this mental leap.

As it relates to national health policy, in addition to recent concerns raised about the equity, safety, and efficacy of value-based payment programs, these findings raise concern regarding a lack of standardization in AMI inclusion criteria. Our findings are particularly relevant to hospitals participating in the BPCIA program for AMI, which uses an AMI DRG to define program inclusion and an ICD-10 based cohort for measuring the quality of AMI care. Our findings suggest that quality is measured in a group of patients (ICD-10 cohort) that is substantially different from the
patients actually included in the program (DRG cohort). The program’s use of 2 differing definitions for AMI—as opposed to holding the population definition constant—is akin to asking hospitals to do 2 things at once.

A central assumption of value-based payment programs—exemplified by the HRRP, VBP, and BPCIA programs—is that there are modifiable behaviors that can be incentivized by restructuring hospital payments. In the case of AMI, the evidentiary basis for good behaviors that improve readmission rates, such as cardiac rehabilitation, are primarily based on trials in patients with T1MI. Performance measures endorsed by the American Heart Association and American College of Cardiology cater specifically to the care of patients with T1MI. This is, in part, because there are very few evidence-based therapies for patients with T2MI and NIMI. Improving outcomes in the non-T1MI population is an active area of research, but in the meantime, care of these patients should not be lumped together with care of individuals with T1MI.

| Table 2. Univariate Comparison of Quality Measures and Rates of Resource Utilization Among Different AMI Cohorts |
|-------------------------------------------------|----------------|----------------|----------------|----------------|----------------|
| | ICD-10 n=1935 | DRG n=662 | *T1MI-UCH n=425 | *ICD-10–UCH n=525 | *DRG-UCH n=258 |
| Outcome measures |  |  |  |  |  |
| 1 y mortality | 168 (8.7%) | 147 (22.2%) | 44 (10.4%) | 53 (10.1%) | 61 (23.6%) |
| Reference | P<0.001 | Reference | P=0.134 | P<0.001 |
| 30-d mortality | 51 (2.64%) | 47 (7.1%) | 7 (1.7%) | 8 (1.5%) | 13 (5.0%) |
| Reference | P<0.001 | Reference | P=0.078 | P<0.013 |
| 90-d readmission | 365 (18.9%) | 171 (25.8%) | 93 (21.9%) | 114 (21.7%) | 68 (26.4%) |
| Reference | P=0.016 | Reference | P=0.236 | P=0.445 |
| 30-d readmission | 269 (13.9%) | 123 (18.6%) | 62 (14.6%) | 76 (14.5%) | 45 (17.4%) |
| Reference | P=0.065 | Reference | P=0.454 | P=0.719 |
| Medications administered |  |  |  |  |  |
| Aspirin | 1916 (99.0%) | 622 (94.0%) | 424 (99.8%) | 519 (98.9%) | 235 (91.1%) |
| Reference | P<0.001 | Reference | P=0.992 | P<0.001 |
| P2Y12 inhibitors | 1579 (81.6%) | 295 (44.6%) | 340 (80.0%) | 393 (74.9%) | 98 (38.0%) |
| Reference | P<0.001 | Reference | P=0.846 | P<0.001 |
| High-dose statin | 1790 (92.5%) | 531 (80.2%) | 407 (95.8%) | 500 (95.2%) | 219 (84.9%) |
| Reference | P<0.001 | Reference | P=0.923 | P<0.001 |
| Beta-blocker | 1804 (93.2%) | 553 (82.5%) | 401 (94.4%) | 477 (90.9%) | 197 (76.4%) |
| Reference | P<0.001 | Reference | P=0.940 | P<0.001 |
| Process measures |  |  |  |  |  |
| Length of stay | 4.03 d | 3.88 d | 5.81 d | 5.79 d | 4.88 d |
| Reference | P=0.059 | Reference | P=0.448 | P=0.054 |
| Echocardiography | 1294 (66.9%) | 421 (63.6%) | 218 (51.3%) | 271 (51.6%) | 122 (47.3%) |
| Reference | P=0.052 | Reference | P=0.551 | P=0.209 |
| Stress test | 24 (1.2%) | 33 (5.0%) | 9 (2.1%) | 20 (3.8%) | 30 (11.6%) |
| Reference | P<0.001 | Reference | P=0.879 | P<0.001 |
| Cardiac CT | 7 (0.4%) | 11 (1.7%) | 3 (0.7%) | 4 (0.8%) | 8 (3.1%) |
| Reference | P=0.001 | Reference | P=0.288 | P=0.991 |
| Cardiac MRI | 11 (0.6%) | 8 (1.2%) | 8 (1.9%) | 11 (2.1%) | 7 (2.7%) |
| Reference | P=0.016 | Reference | P=0.588 | P=0.332 |
| Cardiac catheterization | 1262 (65.2%) | 217 (32.8%) | 282 (66.4%) | 323 (61.5%) | 81 (31.4%) |
| Reference | P<0.001 | Reference | P=0.818 | P<0.001 |
| Cardiac rehabilitation referral | 1118 (57.8%) | 148 (22.4%) | 68 (16.0%) | 79 (15.0%) | 17 (6.6%) |
| Reference | P<0.001 | Reference | P=0.981 | P<0.001 |

AMI indicates acute myocardial infarction; CT, computed tomography; DRG, diagnosis-related group; ICD-10, International Classification of Diseases, Tenth Revision; MRI, magnetic resonance imaging; T1MI, type 1 myocardial infarction; and UCH, University of Colorado Hospital.

*Part of a subgroup analysis of all patients cared for at the UCH.
If value-based programs are to more effectively target T1MI, the subgroup analysis from our study strongly supports using an ICD-10 based definition for AMI over a DRG-based definition. The ICD-10 group was comprised of a higher percentage of patients with T1MI than the DRG group (78% versus 34%) and, not surprisingly, the ICD-10 cohort was more representative of outcomes and patterns of care among patients with T1MI. Our data suggest that this is likely because the majority of patients with T1MI (55%) end up with a procedural DRG, either for PCI or CABG (Table IV in the Data Supplement), a finding that is consistent with nationwide trends in revascularization. The AMI DRG, therefore, includes only those leftover patients who were likely either too ill to undergo revascularization or for whom revascularization was not indicated. This is perhaps not surprising given that this group was composed primarily (66%) of patients with T2MI and NIMI. With this in mind, patients included in DRGs for AMI may be suboptimal targets for payment reforms designed to improve AMI—specifically T1MI—care.

It is important to note that ICD-10–based AMI cohorts are not perfect—over 20% of ICD-10 patients in our subgroup analysis had either T2MI or NIMI, which is similar to prior studies of ICD, Ninth Revision codes. Although our results suggest that patients with T1MI and ICD-10 patients have similar outcomes, our single-center analysis is likely underpowered to detect small differences observed in other studies. Furthermore, although the ICD-10 system certainly has more diagnostic specificity than the DRG system, ICD-10 only recently implemented a code for T2MI and still does not have a code for NIMI. Although this new T2MI code is omitted from the cohort definitions for HRRP and VBP programs, patients with T2MI and NIMI will continue to be misclassified in clinician documentation and, in some cases, included in these programs. They may simply be included less than a similar program, like the BPCI-A, using DRG-based cohorts.

A critical question is whether there is a better way to define and administer AMI cohorts for value-based programs. Given the existing infrastructure of clinical cardiovascular registries, it is appropriate to determine whether these registries more reliably track performance measures among AMI patients. Transcatheter aortic valve replacement could provide a blueprint for this path as registry participation is mandated under the national coverage decision and as transcatheter aortic valve replacement is increasingly paid for under the BPCI-A. This provides an opportunity to use registry data to assess the quality of transcatheter aortic valve replacement care within this value-based program.

This study has multiple limitations. First, it was conducted in a single integrated system of hospitals and, by design, only included patients with a coded diagnosis of AMI according to the discharge DRG or principal ICD-10 code. With this in mind, these findings must be applied with caution since they may be biased by institution-specific documentation and coding practices. Given the algorithmic nature of coding and secular trends in AMI...
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In conclusion, we found that a cohort defined by AMI DRGs differed significantly from a cohort derived using principal ICD-10 codes for AMI: there was little overlap between cohorts and DRG cohort patients had more comorbidities and higher rates of mortality and readmission. Likely contributing to these findings, we observed that many AMI patients in the ICD-10 cohort were assigned a procedural DRG for revascularization and that the DRG cohort contained a significantly higher proportion of patients with T2MI and NIMI than the ICD-10 cohort. As national policy programs mature in defining patient populations and optimal measures of care, these findings suggest a need to revisit disparate and imperfect administrative definitions of AMI.

ARTICLE INFORMATION

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Disclosures

This program evaluation was determined to not be human subjects research by the Colorado Multiple Institutional Review Board.

Supplemental Materials

Supplemental Methods

Figure I

Table I–VII

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