Background—It is unknown whether hospitals with percutaneous coronary intervention (PCI) capability provide costlier care than hospitals without PCI capability for patients with acute myocardial infarction. The growing number of PCI hospitals and higher rate of PCI use may result in higher costs for episodes-of-care initiated at PCI hospitals. However, higher rates of transfers and postacute care procedures may result in higher costs for episodes-of-care initiated at non-PCI hospitals.

Methods and Results—We identified all 2008 acute myocardial infarction admissions among Medicare fee-for-service beneficiaries by principal discharge diagnosis and classified hospitals as PCI- or non-PCI-capable on the basis of hospitals’ 2007 PCI performance. We added all payments from admission through 30 days postadmission, including payments to hospitals other than the admitting hospital. We calculated and compared risk-standardized payment for PCI and non-PCI hospitals using 2-level hierarchical generalized linear models, adjusting for patient demographics and clinical characteristics. PCI hospitals had a higher mean 30-day risk-standardized payment than non-PCI hospitals (PCI, $20,340; non-PCI, $19,713; P<0.001). Patients presenting to PCI hospitals had higher PCI rates (39.2% versus 13.2%; P<0.001) and higher coronary artery bypass graft rates (9.5% versus 4.4%; P<0.001) during index admissions, lower transfer rates (2.2% versus 25.4%; P<0.001), and lower revascularization rates within 30 days (0.15% versus 0.27%; P<0.0001) than those presenting to non-PCI hospitals.

Conclusions—Despite higher PCI and coronary artery bypass graft rates for Medicare patients initially presenting to PCI hospitals, PCI hospitals were only $627 costlier than non-PCI hospitals for the treatment of patients with acute myocardial infarction in 2008. (Circ Cardiovasc Qual Outcomes. 2014;7:882-888.)

Key Words: acute inferior myocardial infarction ■ cost and cost analysis ■ insurance, health reimbursement ■ percutaneous coronary intervention
WHAT IS KNOWN

• Previous studies have shown that patients presenting to percutaneous coronary intervention (PCI) hospitals undergo more procedures than those presenting to non-PCI hospitals, with uncertain improvement in clinical outcomes. Studies have also shown that the growing number of PCI hospitals has not improved access to PCI for patients.
• Work done in a limited cohort has previously demonstrated no significant difference in hospital costs for patients admitted to facilities with and without catheterization capabilities.

WHAT THE STUDY ADDS

• In a national sample, despite higher procedure rates for patients presenting to PCI hospitals, overall episode-of-care payments for patients presenting to PCI hospitals are only slightly more costly than for patients presenting to non-PCI hospitals with acute myocardial infarction.

Alternatively, non-PCI hospitals may be associated with higher costs for patients with AMI for several reasons. For example, admissions to non-PCI hospitals that require transfer to PCI hospitals for urgent procedures result in 2 payments made at the hospital-level for Medicare patients presenting to non-PCI hospitals without transfer for PCI may later undergo PCI during subsequent admissions or in the outpatient setting. In fact, the costs associated with transfers and deferred procedures for patients admitted to non-PCI hospitals may balance the cost associated with higher procedure rates at PCI hospitals. Understanding the differences in cost of care at PCI hospitals versus non-PCI hospitals may inform practices and policies influencing the conversion of non-PCI hospitals to PCI hospitals.

Accordingly, we sought to characterize the cost of acute episodes-of-care provided by PCI versus non-PCI hospitals for Medicare patients presenting with an AMI. We compared payments made at the hospital-level for Medicare patients for a 30-day episode-of-care to account for the costs of both hospitalizations in the case of a transfer and the costs of follow-up care, including nonacute procedures. In an effort to better understand the reasons underlying hospital-level costs of care, we also conducted secondary patient-level analyses examining rates of patient transfer and coronary revascularization, including both PCI and coronary artery bypass graft (CABG) surgery, for patients presenting to PCI and non-PCI hospitals.

Methods

Data Sources

To identify our cohort, we used the 2008 Chronic Condition Warehouse data set of Medicare administrative claims to identify 100% of fee-for-service beneficiaries who were ≥65 years and had an inpatient admission with a principal discharge diagnosis of AMI as identified using International Classification of Diseases, Ninth revision (ICD-9) codes 410.xx, excluding those with 410.x2.

The Chronic Condition Warehouse data included claims data from the 7 Standard Analytic Files (inpatient, outpatient, skilled nursing facility, home health, hospice, carrier [physician/supplier part B items], and durable medical equipment). We used these data in conjunction with publicly available fee schedules from the Centers for Medicare and Medicaid Services (CMS) and Final Rules published in the Federal Register to calculate the total payment for the episode-of-care, including payments for the index admission and postdischarge payments for readmissions, other postdischarge inpatient care, outpatient services, skilled nursing facilities, home health, physician, or clinical laboratory services, and prosthetics, orthotics, and other medical supplies. We used January 2009 Chronic Condition Warehouse data to calculate postacute care payments for patients discharged from their index (ie, initial) admission in December 2008.

Cohort

The study cohort included Medicare fee-for-service beneficiaries, aged ≥65 years, hospitalized between January 1 and December 31, 2008, with a principal discharge diagnosis of AMI as defined above. We required that all patients had both part A and part B coverage in the year prior to index admission and during the 30-day episode-of-care payment window. We excluded patients who were discharged on the same or next day and did not die or get transferred, patients with inconsistent or unknown vital status, patients with unreliable data, patients who discharged against medical advice, hospice patients, patients transferred to federal hospitals, and patients with missing Medicare-Severity Diagnosis Related Group code or Medicare-Severity Diagnosis Related Group weight. For patients with multiple hospitalizations during this time frame, we randomly selected 1 hospitalization per patient.

Hospital Classification

We classified hospitals as PCI- or non-PCI-capable on the basis of evidence that they performed PCIs in the year before the index admission. Using billing, we defined PCI hospitals as those hospitals that had billed Medicare for ≥10 PCI procedures in 2007, using ICD-9 procedure codes 36.01, 36.02, 36.05, 36.06, 36.07, 00.66, and 17.55 for PCI. Hospitals for which PCI status could not be determined (eg, those with new hospital identities in 2008) were excluded from the analysis (n=13 hospitals).

Primary Outcome

Our primary outcome was 30-day episode-of-care risk-standardized payments (RSPs) at the hospital level. We calculated total payment for the 30-day episode-of-care by summing all payments from the time of index admission through 30 days post admission. We chose 30 days because it is a preset window, which is consistent with publicly reported outcome measures from CMS and is likely to capture associated follow-up care for AMI. For patients who were transferred, we considered the consecutive hospitalizations as a single admission with the 30-day episode beginning with the index admission. All payments for Medicare patients incurred during the second admission as well as during the full 30-day episode were attributed to the initial admitting hospital, constituting 1 episode-of-care.

We used publicly available fee schedules from CMS to calculate payments for claims that occurred in care settings reimbursed under a fee schedule. Reimbursement rates and weights for each care setting were from fiscal year, rate year, or calendar year 2008 or 2009 depending on the care setting, and were identified in either Final Rules published in the Federal Register or fee schedules listed on the CMS Web site. For those care settings not reimbursed using a CMS fee schedule, we obtained the data necessary to calculate payments from applicable CMS Final Rules or via the CMS website (eg, base payments and conversion factors, Medicare-Severity Diagnosis Related Group weights, wage indexes, and average length of stay). We also used the Medicare Enrollment Database to obtain information on enrollment, date of birth, and postdischarge mortality status.
We calculated transfer rates, rates of PCI and CABG, and revascularizations that followed the inpatient admission (subsequent revascularizations), including PCI and CABG performed during readmissions and PCI performed in the outpatient setting within 30 days of admission for patients who began their episode-of-care at PCI and non-PCI hospitals. We defined transferred patients as those patients who were either transferred between hospitals or discharged from 1 acute-care hospital and admitted to a different acute-care hospital on the same or next day, regardless of the discharge disposition listed on the claim. In addition, we calculated unadjusted patient-level payments, including mean total payments, index hospital payments, and postacute care payments for patients presenting to PCI and non-PCI hospitals. We further categorized postacute care payments as payments for readmissions, skilled nursing facilities, other inpatient payments (including inpatient psychiatry, rehabilitation, and long-term care hospitals), outpatient hospital payments, and home health payments. These payments were adjusted to remove payments related to CMS geographic and policy factors but were not risk standardized. We also calculated unadjusted payments for transfer and nontransfer patients at non-PCI hospitals. We identified patients who underwent PCI either during index admission or readmission within the 30-day episode-of-care using ICD-9 codes: 36.01, 36.02, 36.05, 36.06, 36.07, 00.66, and 17.55; CABG using ICD-9 codes: 36.1x; and outpatient PCI using Current Procedural Terminology codes: 92973, 92980, 92981, 92982, 92984, 92985, and 92996.

Statistical Analysis
We performed a hospital-level analysis comparing the mean RSP for PCI hospitals with the mean RSP for non-PCI hospitals. We then performed the following patient-level analyses. We first calculated and compared procedure (PCI and CABG) and transfer rates for patients at PCI and non-PCI hospitals. In addition, we calculated and compared the rate of subsequent revascularizations that occurred after the index discharge but during the 30-day episode-of-care for patients admitted to PCI versus non-PCI hospitals. Procedures for patients who were readmitted within the 30-day episode-of-care but whose admissions extended beyond the end of the 30-day window were included in the subsequent revascularization outcome. We also calculated and compared mean unadjusted patient-level payments, including mean total payments, mean index hospital payments, and mean postacute care payments for patients presenting to PCI and non-PCI hospitals. Procedures for patients who were readmitted within the 30-day episode-of-care but whose admissions extended beyond the end of the 30-day window were included in the subsequent revascularization outcome. We also calculated and compared mean unadjusted payments for transfer and nontransfer patients who presented to non-PCI hospitals. A t test was used to compare RSPs, and χ² tests were used for dichotomous variables. We considered differences as statistically significant when P values were <0.05. All analyses were conducted using Stata/IC statistical software, version 11.1. We obtained institutional review board approval, including waiver of the requirement for participant informed consent, through the Yale University Human Investigation Committee.

Results
Patient Characteristics
Of the 183,755 AMI hospitalizations in 2008 included in this study, 137,427 (76.2%) were admissions to 1415 PCI hospitals and 42,948 (23.8%) to 2716 non-PCI hospitals. Baseline characteristics for patients initially admitted to PCI hospitals versus non-PCI hospitals are shown in Table 1. Of note, patients presenting to PCI hospitals were younger than those presenting to non-PCI hospitals, with patients aged ≥85 years comprising only 26.3% of patients admitted to PCI hospitals as compared with 40.6% of those admitted to non-PCI hospitals. A greater percentage of patients presenting to PCI hospitals had previously undergone PCI when compared with those presenting to non-PCI hospitals (8.4% versus 5.3%, respectively), but a smaller percentage of patients admitted to PCI hospitals had previously undergone CABG (5.7% versus 7.1%, respectively). In addition, 28.6% of patients presenting to PCI hospitals had a history of congestive heart failure compared with 39.9% at non-PCI hospitals, and only 15.2% of

Secondary Outcomes
We calculated transfer rates, rates of PCI and CABG, and revascularizations that followed the inpatient admission (subsequent revascularizations), including PCI and CABG performed during readmissions and PCI performed in the outpatient setting within 30 days of admission for patients who began their episode-of-care at PCI and non-PCI hospitals. We defined transferred patients as those patients who were either transferred between hospitals or discharged from 1 acute-care hospital and admitted to a different acute-care hospital on the same or next day, regardless of the discharge disposition listed on the claim. In addition, we calculated unadjusted patient-level payments, including mean total payments, index hospital payments, and postacute care payments for patients presenting to PCI and non-PCI hospitals. We further categorized postacute care payments as payments for readmissions, skilled nursing facilities, other inpatient payments (including inpatient psychiatry, rehabilitation, and long-term care hospitals), outpatient hospital payments, and home health payments. These payments were adjusted to remove payments related to CMS geographic and policy factors but were not risk standardized. We also calculated unadjusted payments for transfer and nontransfer patients at non-PCI hospitals. We identified patients who underwent PCI either during index admission or readmission within the 30-day episode-of-care using ICD-9 codes: 36.01, 36.02, 36.05, 36.06, 36.07, 00.66, and 17.55; CABG using ICD-9 codes: 36.1x; and outpatient PCI using Current Procedural Terminology codes: 92973, 92980, 92981, 92982, 92984, 92985, and 92996.

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Table 1. Baseline Characteristics of the Year 2008 Patients With AMI, Stratified by Initial Admission to PCI or Non-PCI Hospitals

<table>
<thead>
<tr>
<th>Variable</th>
<th>Overall (n=180375)</th>
<th>PCI (n=137427)</th>
<th>Non-PCI (n=42948)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>65–74</td>
<td>56102</td>
<td>46640</td>
<td>9462</td>
</tr>
<tr>
<td>75–84</td>
<td>70769</td>
<td>54709</td>
<td>16060</td>
</tr>
<tr>
<td>≥85</td>
<td>53504</td>
<td>36078</td>
<td>17426</td>
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<tr>
<td>History of PCI</td>
<td>13858</td>
<td>11583</td>
<td>2275</td>
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<tr>
<td>History of CABG</td>
<td>10824</td>
<td>7772</td>
<td>3052</td>
</tr>
<tr>
<td>Congestive heart failure (CC 80)</td>
<td>56486</td>
<td>39369</td>
<td>17117</td>
</tr>
<tr>
<td>Angina pectoris/old myocardial infarction (CC 83)</td>
<td>38210</td>
<td>28787</td>
<td>9423</td>
</tr>
<tr>
<td>Heart infection/infarction, except rheumatic (CC 85)</td>
<td>3242</td>
<td>2666</td>
<td>576</td>
</tr>
<tr>
<td>Valvular and rheumatic heart disease (CC 86)</td>
<td>49155</td>
<td>36876</td>
<td>12279</td>
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<tr>
<td>Congenital cardiac/circulatory defect (CC 87–88)</td>
<td>1700</td>
<td>1367</td>
<td>333</td>
</tr>
<tr>
<td>Hypertension and hypertension complications (CC 89–91)</td>
<td>151080</td>
<td>114356</td>
<td>36724</td>
</tr>
<tr>
<td>Metastatic cancer, acute leukemia, and other major cancers (CC 7–8)</td>
<td>7183</td>
<td>5306</td>
<td>1877</td>
</tr>
<tr>
<td>Diabetes mellitus and diabetes mellitus complications (CC 15–19, 119–120)</td>
<td>75502</td>
<td>56564</td>
<td>18938</td>
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<tr>
<td>Protein-calorie malnutrition (CC 21)</td>
<td>8974</td>
<td>6462</td>
<td>2512</td>
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<tr>
<td>Other significant endocrine and metabolic disorders (CC 22)</td>
<td>11246</td>
<td>8696</td>
<td>2550</td>
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<tr>
<td>Obesity/disorders of thyroid, cholesterol, lipids (CC 24)</td>
<td>130381</td>
<td>100660</td>
<td>29721</td>
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<tr>
<td>Other gastrointestinal disorders (CC 36)</td>
<td>81382</td>
<td>60561</td>
<td>20821</td>
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<tr>
<td>Osteoporosis and other bone/cartilage disorders (CC 41)</td>
<td>26437</td>
<td>19359</td>
<td>7078</td>
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<tr>
<td>Iron deficiency and other/unspecified anemias and blood disease (CC 47)</td>
<td>69629</td>
<td>50973</td>
<td>18656</td>
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</table>

(Continued)

Table 1. Continued

<table>
<thead>
<tr>
<th>Variable</th>
<th>Overall (n=180375)</th>
<th>PCI (n=137427)</th>
<th>Non-PCI (n=42948)</th>
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<tbody>
<tr>
<td>Delirium and encephalopathy (CC 48)</td>
<td>6733</td>
<td>4815</td>
<td>1918</td>
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<td>Dementia (CC 49)</td>
<td>31545</td>
<td>20932</td>
<td>10613</td>
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<td>Drug/alcohol psychosis (CC 51)</td>
<td>2104</td>
<td>1624</td>
<td>480</td>
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<td>Drug/alcohol abuse/dependence (CC 52–53)</td>
<td>17830</td>
<td>14314</td>
<td>3516</td>
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<td>Severe mental illness (CC 54–55)</td>
<td>7958</td>
<td>5625</td>
<td>2333</td>
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<tr>
<td>Reactive and unspecified psychosis (CC 56)</td>
<td>5505</td>
<td>3566</td>
<td>1939</td>
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<tr>
<td>Depression/anxiety (CC 58–59)</td>
<td>19060</td>
<td>13330</td>
<td>5730</td>
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<tr>
<td>Precerebral arterial occlusion and transient cerebral ischemia (CC 97)</td>
<td>27561</td>
<td>20703</td>
<td>6858</td>
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<tr>
<td>Vascular disease and complications (CC 104–105)</td>
<td>45323</td>
<td>33423</td>
<td>11900</td>
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<tr>
<td>Other lung disorders (CC 115)</td>
<td>48611</td>
<td>36612</td>
<td>11999</td>
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<td>Legally blind (CC 116)</td>
<td>1351</td>
<td>929</td>
<td>422</td>
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<tr>
<td>Dialysis status (CC 130)</td>
<td>4035</td>
<td>3199</td>
<td>836</td>
</tr>
<tr>
<td>Internal injuries (CC 160)</td>
<td>1672</td>
<td>1279</td>
<td>393</td>
</tr>
</tbody>
</table>

AMI indicates acute myocardial infarction; CABG, coronary artery bypass graft; CC, condition category; and PCI, percutaneous coronary intervention.

patients presenting to PCI hospitals had a history of dementia as compared with 24.7% at non-PCI hospitals.

RSPs and Secondary Analyses

PCI hospitals had a higher mean 30-day RSP than non-PCI hospitals (PCI, $20340; non-PCI, $19713; P<0.001). The range of RSP was similar between PCI and non-PCI hospitals (PCI, $15251–$27317; non-PCI, $16769–$24597; Figure). To better understand the factors contributing to this difference in hospital-level payments, we identified the following patient-level patterns of care (Table 2). Patients presenting to PCI hospitals had lower transfer rates (2.2% versus 25.4%; P<0.001) than those presenting to non-PCI hospitals. Patients presenting to PCI hospitals had higher PCI rates (39.2% versus 13.2%; P<0.001) and higher CABG rates (9.5% versus 4.4%; P<0.001) during the index admission than those presenting to non-PCI hospitals. Finally, the rate of subsequent revascularization within 30 days of the initial hospitalization was lower among patients who initially presented to PCI hospitals than to non-PCI hospitals (0.15% versus 0.27%; P<0.0001).
To further investigate the differences in payments between patients who began their episode-of-care at PCI versus non-PCI hospitals, we examined unadjusted patient-level payments for the various care settings included in our calculations of hospital RSPs (Table 3). Patients presenting to PCI hospitals had higher mean unadjusted index hospital payments ($16,111 versus $13,170) but lower mean unadjusted postacute care setting payments ($5,046 versus $5,894) than patients who initially presented to non-PCI hospitals. The difference in mean unadjusted payments for patients who were transferred from non-PCI hospitals compared with those who were not transferred was $12,166 ($27,198 versus $15,032).

Discussion

In this study of Medicare administrative claims, we found that PCI hospitals were associated with slightly higher costs for an episode-of-care for patients with AMI when compared with non-PCI hospitals. The difference is fairly modest—nearly $600 for a 30-day period—and the percentage difference in cost is small, but when spread over the hundreds of thousands of beneficiaries with AMI each year, these cost differences could be meaningful. Nevertheless, it is important to determine whether this extra cost provides extra value, either through improved clinical outcomes, such as mortality or readmission, or improved patient satisfaction, function, or symptom burden.

There are several potential explanations for the differences in cost for AMI episodes initiated at PCI versus non-PCI hospitals. To understand factors that may account for the observed cost difference, we examined several patient-level patterns of care for patients admitted to PCI versus non-PCI hospitals. We found that patients who began their episode-of-care at PCI hospitals had higher PCI and CABG rates during the index admission than those initially admitted to non-PCI hospitals. Procedure rates may contribute substantially to higher costs.

Table 2. Patient Transfer Rates, Procedure Rates, Subsequent Revascularization Rates, and 30-Day Risk-Adjusted Payments by PCI Capability of the Index Hospital

<table>
<thead>
<tr>
<th>Hospital (n)</th>
<th>Overall</th>
<th>PCI (n=137,427)</th>
<th>Non-PCI (n=42,948)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume (n)</td>
<td>4131</td>
<td>1415</td>
<td>2716</td>
</tr>
<tr>
<td>Transfer rate, %</td>
<td>7.7</td>
<td>2.2</td>
<td>23.4</td>
</tr>
<tr>
<td>Index admission PCI rate, %</td>
<td>33.0</td>
<td>39.2</td>
<td>13.2</td>
</tr>
<tr>
<td>Index admission CABG rate, %</td>
<td>8.3</td>
<td>9.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Subsequent revascularizations, %</td>
<td>0.18</td>
<td>0.15</td>
<td>0.27</td>
</tr>
<tr>
<td>30-Day risk-adjusted payment, $</td>
<td>19,928 (1161)</td>
<td>20,340 (1493)</td>
<td>19,713 (869)</td>
</tr>
</tbody>
</table>

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

Table 3. Average Unadjusted Patient-Level Payments by PCI Capability of the Index Hospital

<table>
<thead>
<tr>
<th>Payment Type</th>
<th>PCI (n=137,427)</th>
<th>Percent of Patients Affected</th>
<th>Non-PCI (n=42,948)</th>
<th>Percent of Patients Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean total payment*</td>
<td>20,451</td>
<td>100</td>
<td>18,117</td>
<td>100</td>
</tr>
<tr>
<td>Mean index hospital payment</td>
<td>16,111</td>
<td>100</td>
<td>13,170</td>
<td>100</td>
</tr>
<tr>
<td>Mean postacute care payment</td>
<td>5,046</td>
<td>86†</td>
<td>5,894</td>
<td>84†</td>
</tr>
<tr>
<td>Mean readmission payment</td>
<td>10,168</td>
<td>17</td>
<td>9,415</td>
<td>18</td>
</tr>
<tr>
<td>Mean SNF payment</td>
<td>6,867</td>
<td>20</td>
<td>6,984</td>
<td>32</td>
</tr>
<tr>
<td>Mean other inpatient payment‡</td>
<td>13,782</td>
<td>4</td>
<td>13,705</td>
<td>3</td>
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<tr>
<td>Mean outpatient hospital payment</td>
<td>705</td>
<td>34</td>
<td>925</td>
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<td>Mean home health payment</td>
<td>1,086</td>
<td>23</td>
<td>1,020</td>
<td>23</td>
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</tbody>
</table>

PCI indicates percutaneous coronary intervention; and SNF, skilled nursing facility.

*Mean total payments are price standardized but not risk standardized.
†These are the percentages of total patients who were alive after the index admission and had ≥1 postacute care claims within the 30-day postadmission window.
‡Other inpatient payments include payments for inpatient psychiatry, inpatient rehabilitation, and long-term care hospitals.
However, patients initially admitted to non-PCI hospitals had substantially higher transfer rates and subsequent revascularization rates than patients initially admitted to PCI hospitals. Patients who are transferred accrue the cost of 2 hospitalizations, which may in part balance the cost of higher procedure rates at PCI hospitals. Similarly, the increased usage of post-acute care resources by patients admitted to non-PCI hospitals adds to the cost of the 30-day episode-of-care initiated at non-PCI hospitals.

The results of this study are consistent with an earlier study conducted by this group, in which long-term costs and outcomes were examined for patients admitted to Connecticut hospitals with or without onsite cardiac catheterization facilities. The study by Krumholz et al found no significant difference in hospital costs during the 3 years after the initial admission for patients admitted to hospitals with and without cardiac catheterization capability. Despite similar findings, the study variables differed substantially from those used in this study. This previous work was done for patients admitted between 1992 and 1993 in a single state, and costs were defined by each patient’s hospital charge record and each hospital’s Medicare cost-to-charge ratios. Conversely, our study evaluated the hospital-level payment made for Medicare patients admitted nationwide, and in the setting of growing numbers of PCI facilities in 2008.

Our finding that the cost of care at PCI and non-PCI hospitals is only modestly different affects recent discussions on regionalization of AMI care and establishment of new PCI programs. Many studies have considered whether regionalization of AMI care would benefit patients with AMI, but few, if any, have considered the cost implications of such a change in patient management. If AMI care were to be regionalized, patients with AMI who present to non-PCI hospitals would be immediately transferred to specialty regional centers with the capacity to perform PCI, without admission to non-PCI hospitals. Our findings suggest that sending all patients directly to PCI hospitals may slightly increase payments for Medicare patients admitted with AMI, and likely to be associated with increased PCI usage. Because patients who present with AMI may benefit from more rapid access to PCI, and in light of our findings that payments to PCI versus non-PCI hospitals do not differ dramatically, regionalization of AMI care may provide an efficient option for the treatment of these patients.

Although this work demonstrates that episodes-of-care arising at PCI hospitals are not substantially more expensive, the findings should not be interpreted to suggest that opening new PCI programs in the absence of an organized system for regionalization of care is a cost-effective strategy for AMI care. Several recent studies have shown that overall access to PCI has not changed in recent years, despite increased availability of PCI hospitals. Moreover, the growth in the number of PCI hospitals has not led to improvements in time to treatment. Furthermore, the evidence on mortality and readmission rates at PCI and non-PCI hospitals is not clear. Recent studies have shown that although mortality is lower on average for patients who present to PCI hospitals, there exists significant variation in mortality rates among PCI hospitals across the country, such that non-PCI hospitals may provide superior care to PCI hospitals in some areas. This suggests that increasing the absolute number of PCI hospitals may not lead to improved care for patients with AMI.

This study has several limitations. First, we did not assess whether the modestly higher payment to PCI hospitals contributes to better outcomes for patients, including decreasing mortality and readmissions. The effect of admission to PCI versus non-PCI hospitals on patient mortality and readmission requires further investigation. We did not adjust for differences in the size of the hospitals or other hospital characteristics; it is possible that the difference in payment to PCI versus non-PCI hospitals may in part relate to these differences in hospital characteristics because PCI and non-PCI hospitals often differ in characteristics, such as urban versus rural setting, teaching versus nonteaching designations, and volume status. Our analysis of transfers included only those patients who were admitted to the initial presenting hospital and transferred to a second hospital; we were unable to analyze patients presented to the emergency department of one hospital before being transferred and admitted to a second hospital. In addition, we used Medicare admission data only, and results may not be applicable to the general population or other insurers, given different payment structures. However, Medicare is the country’s largest insurer and Medicare patients make up a large proportion of patients with AMI. We did not include payments for Medicare part D drugs. Because patients who did not undergo PCI may rely more heavily on medical management than those who have undergone the procedure, excluding these payments may lower the average payment for non-PCI hospitals, the overall difference in payments between PCI and non-PCI hospitals was exaggerated. However, given a payment window of only 30 days, the added cost of medications is likely not substantial. Also, our study did not evaluate payments for patients with AMI that extended beyond the 30-day episode-of-care. Therefore, we did not account for those patients who underwent a procedure >30 days after their initial admission. Similarly, we did not account for payments accrued after 30 days attributable to outpatient care, skilled nursing facilities, hospice, or other services. Finally, our study does not address the question of what types of patients were more likely to be transferred from non-PCI hospitals to undergo PCI. Therefore, we were unable to appreciate whether high-risk patients who presented to PCI and non-PCI hospitals were treated similarly. It is possible that high-risk patients are transferred less often because of their unstable condition. Because patients who presented to non-PCI hospitals were generally older than those presenting to PCI hospitals, and therefore at higher risk of complication during transfer, this may contribute in part to the lower procedure rates attributed to non-PCI hospitals.

In conclusion, this study demonstrates that despite increased PCI and CABG rates for patients who begin their 30-day episode-of-care at PCI hospitals, hospital-level payments to PCI hospitals are only modestly higher than hospital-level payments to non-PCI hospitals for the treatment of patients with AMI.
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**Disclosures**

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**References**

Payments for Acute Myocardial Infarction Episodes-of-Care Initiated at Hospitals With and Without Interventional Capabilities
Gal Ben-Josef, Lesli S. Ott, Steven B. Spivack, Changqin Wang, Joseph S. Ross, Sachin J. Shah, Jeptha P. Curtis, Nancy Kim, Harlan M. Krumholz and Susannah M. Bernheim

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Data Supplement (unedited) at:
http://circoutcomes.ahajournals.org/content/suppl/2014/11/11/CIRCOUTCOMES.114.000927.DC1
SUPPLEMENTAL MATERIAL
Supplemental Methods

Standardizing Payments

To standardize payments, we calculated a payment that removes the influence of Medicare geographic and policy adjustments in order to isolate the portion of payment that reflects care decisions. Medicare reimburses providers using several different mechanisms depending on the care setting. We provide details on the calculation of acute inpatient payments below. Figures 1-17 demonstrate our calculations for acute inpatient payments as well as payments for all other care settings.

For acute inpatient stays, the Inpatient Prospective Payment System (IPPS) payments for each patient begin with an operating and capital base payment, which are held constant over a given fiscal year. Where applicable, these base payments are then adjusted for geographic differences in wages and cost of living. Geographically adjusted payments are then multiplied by the weight associated with a patient’s Medicare-Severity Diagnosis Related Group (MS-DRG). The MS-DRG accounts for the patient’s principle discharge diagnosis, procedures, complications, age, gender, and comorbidities. For hospitals that qualify, additional adjustments are made for indirect medical education and disproportionate share policy payments. Finally, where applicable, adjustments are made for short-stay patients and patient discharge destination. In the case of extraordinarily costly patients, an outlier payment may also be applied.
Supplemental Figures

Figure 1. Standardizing payments for the inpatient prospective payment system (IPPS) setting

\[
\text{Operating \& Capital Base Payments} \times \text{Adjustments for Geographic Factors (e.g. Wage Index)} \times \text{DRG* Weight} = \text{Adjusted Base Payment}
\]

- \text{Full LOS}
- \text{Short LOS and discharged to other acute IPPS hospital or post-acute care}

\[
\text{Per Case Payment Rate}\]

\[
\text{Per Diem Payment Rate}\]

Stripped Payment Formula:

\[
\frac{(\text{Operating Base Payment} + \text{Capital Base Payment}) \times \text{DRG Weight}}{(\text{Labor Ratio} \times \text{Wage Index}) + \text{Nonlabor Ratio}} + \frac{\text{DRG Outlier Payment}}{(\text{Labor Ratio} \times \text{Wage Index}) + \text{Nonlabor Ratio}} + \frac{\text{Capital Outlier Payment}}{(\text{Wage Index})^2}
\]

* DRG (Diagnosis Related Group): Includes principal diagnosis, procedure, complications, and comorbidities

Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007

Figure 2. Standardizing payments for the long term care hospitals (LTCH) payment setting

\[
\text{LTCH Base Payment} \times \text{Adjustments for Geographic Factors (e.g. Wage Index)} \times \text{DRG* Weight} = \text{Adjusted Base Payment}
\]

\[
\text{Full LOS} = \text{Stripped Payment} + \text{Outlier Payment w/ Wage Index Removed (where applicable)}
\]

\[
\text{LOS} \leq 5/6 \text{ of geometric mean LOS} = \text{Stripped Payment}
\]

Stripped Payment Formula:

\[
\frac{(\text{Base Payment} \times \text{DRG Weight} \times \text{LOS Adjustment}) + \text{Outlier Payment}}{(\text{Labor Ratio} \times \text{Wage Index}) + \text{Nonlabor Ratio}}
\]

* DRG (Diagnosis Related Group): Includes principal & secondary diagnoses, procedures, age, sex, discharge status

Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007
Figure 3. Standardizing payments for the inpatient psychiatric facility payment setting

Stripped Payment Formula:

\[
\text{Stripped Payment} = \left( \frac{\text{Per Diem Base Payment} \times \text{DRG Weight} \times \text{Age Adjustment} \times \text{Comorbidity Adjustment} \times \text{LOS Adjustment}}{\text{Outlier Payment}} \right) + \text{ECT Adjustment} + \text{Outlier Payment w/ Wage Index Removed} \]

(Where applicable)

Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007

Figure 4. Standardizing payments for the inpatient rehabilitation facility (IRF) payment setting

Stripped Payment Formula:

\[
\text{Stripped Payment} = \left( \frac{\text{IRF Base Payment} \times \text{CMG Weight} \times \text{LOS Adjustment}}{\text{Outlier Payment}} \right) + \text{Outlier Payment w/ Wage Index Removed} \]

(Where applicable)

\* CMG (Case-Mix Group): Includes diagnoses requiring rehabilitation, functional status, cognitive status, age, and comorbidities

\*\* ALOS = Average Length of Stay for CMG

Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007
Figure 5. Standardizing payments for the hospital outpatient and community mental health centers (CMHCs) payment setting

Stripped Payment Formula:

\[
\text{Outlier Payment} = \frac{(\text{APC Amount} \times \text{Units})^\dagger + \text{Outlier Payment}}{\left(\frac{\text{Labor Ratio} \times \text{Wage Index}}{\text{Non-Labor Ratio}}\right)}
\]

* APC (Ambulatory Payment Classification): Measures resource requirements of services
** SCCH = Sole Community Hospital
*** Hold Harmless: Additional payments to hospitals (e.g., cancer, children’s, non-SCCH with <100 beds) that experience losses under ORFS system compared to cost-based system
^ This amount is adjusted for any modifiers such as reduced or discontinued procedures.

Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007.

Note: Outpatient hospital claims can include services paid under the clinical lab, ambulance, physician, DME/POS/PEN, and Part B drugs fee schedules as well. Payments for those services are calculated according to the applicable payment formula.

Figure 6. Standardizing payments for the comprehensive outpatient rehabilitation facilities (CORFs) and outpatient rehabilitation facilities (ORFs) payment setting

Stripped Payment Formula:

\[
\text{Stripped Payment} = \frac{\text{Conversion Factor} \times (\text{Work RVU} \times \text{Complexity of Service & Expenses}) \times (\text{Non-Facility Transitioned Practice Expense RVU} + \text{Non-Facility Transitioned Practice Expense GPIC} + \text{Non-Facility Transitioned Practice Expense SPCI})}{\text{Conversion Factor} \times (\text{Work RVU} \times \text{Complexity of Service & Expenses})}
\]

* RVU (Relative Value Units): Account for the relative costliness of the inputs used to provide services; clinician's work, practice expenses, and professional liability insurance (PLI) expenses
** GPIC = Geographic Practice Cost Index

Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007.
Figure 7. Standardizing payments for prospective payment system skilled nursing facility (SNF) claims

Standardized Payment Formula:
Avg. of Urban & Rural Base Rates x RUG Weight x Days in SNF + AIDS Adjustment (where applicable)

* RUG (Resource Utilization Group) includes therapy and service use, presence of certain medical conditions, and activity of daily living score
Note: This payment diagram is adapted from the MedPAC Payment Basics series, October 2007

Figure 8. Standardizing payments for critical access hospital (CAH) swing bed skilled nursing facility (SNF) claims

Standardized Payment Formula:
Actual Payment + Co – Insurance
(SNF Labor Ratio x Wage Index) + (1 – SNF Labor Ratio)

† CAH Swing Bed SNF Claims are not given a RUG weight
Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007

Figure 9. Standardizing payments for the home health agency (HHA) payment setting

Low Utilization Payment Adjustment (LUPA) HHA Claims:
If HHA Claim has 4 or less visits in entire 60-day episode, the standardized LUPA per visit payment rate is applied. Standardized LUPA payment rate is published each year in the HHA PFS Final Rule.

Low Utilization Payment Adjustment (LUPA) HHA Claims:
If HHA Claim has 4 or less visits in entire 60-day episode, the standardized LUPA per visit payment rate is applied. Standardized LUPA payment rate is published each year in the HHA PFS Final Rule.

Stripped Payment Formula:
HHA Base Rate x HHRG Weight + Outlier Payment + DME/POS/O2 Add-ons
(Labor Ratio x Wage Index) + Nonlabor Ratio

Note: HHA claims can include DME/Pharmacy/O2 as well. Payment for those claim lines are calculated according to the DME/POS payment formula.
Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007
Figure 10. Standardizing payments for hospice

**Continuous Home Care (CHC) Base Payment**

**Routine Home Care (RHC) Base Payment**

**Inpatient Respite Care (IRC) Base Payment**

**General Inpatient Care (GIC) Base Payment**

Adjustments for Geographic Factors (e.g., Wage Index)

**Hourly Base Payment**

**CHC Stripped Payment Formula:**
\[
\frac{\text{CHC Base Payment}}{24} \times \# \text{ Hours of Care} + \text{Physician Fee}
\]

**RHC, IRC, GIC Stripped Payment Formula:**
\[
\text{RHC/IRC/GIC Base Payment} \times \# \text{ Days of Care} + \text{Physician Fee}
\]

Note: For Sept. 15th, 2012 CMS deliverable, a standardized (average) Physician fee was used. A stripped Physician fee will be used for NGS model.

Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007

Figure 11. Standardizing payments for durable medical equipment (DME)/prosthetics, orthotics, and surgical supplies (POS)/parenteral and enteral nutrition (PEN) claims

**DME/POS Claims:**

**DME/POS Standardized Payment:**

Avg. Payment from State DME/POS Fee Schedule \* Adjustment for New, Used, or Rental Equipment \* Unit Count = Standardized Payment + Part B Drug Fee \* Unit Count

**PEN Claims:**

The PEN fee schedule is a national fee schedule (i.e. there is no variation from state to state). Thus, all PEN claims were assigned the PEN fee schedule amount.

Note: Where applicable, Part B Drugs associated with DME claims were assigned the DME infusion limit amount from the Part B Drugs fee schedule.

Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007
Figure 12. Standardizing payments for the ambulatory surgical center (ASC) payment setting

Stripped Payment Formula:
The amount equal to (ASC Conversion Factor x APC Relative Weight) is given on the ASC fee schedule.

\[(\text{APC Fee Schedule Amount}) \times \text{Unit Count} \times \text{Adjustment Factor for Multiple, Reduced, or Continued Procedures} \]

\* APC = Ambulatory Payment Classification

Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007

Figure 13. Standardizing payments for physician services

Stripped Payment Formula:

\[\text{Conversion Factor} \times (\text{Work RVU} + \text{Transitioned Practice Expense RVU} + \text{Malpractice Insurance RVU}) \times \text{Adjustment Factor Related to Procedures} \times \text{Adjustment Factor for Non-Physicians} \times \text{Units} \]

\* RVU (Relative Value Units): Account for the relative costliness of the inputs used to provide services: clinician's work, practice expenses, and professional liability insurance (PLI) expenses

\** GPI = Geographic Practice Cost Index

\*** HPQA = Health Professional Quality Area

\dagger The physician fee schedule lists separate PE RVUs for facility and non-facility settings.

Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007
Figure 14. Standardizing payments for clinical labs

| Avg. Payment from State Clinical Diagnostic Laboratory Fee Schedule | x | Unit Count | = | Standardized Payment |

Standardized Payment Formula:
Avg. Payment from State Clinical Diagnostic Laboratory Fee Schedule x Unit Count

Labs Under the Automated Multi-Channel Chemistry Code (AMCC) Payment Algorithm Standardized Payment Formula:
Actual Payment + Co-insurance + Deductible

Figure 15. Standardizing payments for Part B drugs

| Part B Drugs National Fee Schedule Amount | x | Unit Count | = | Standardized Payment |

The Part B Drug fee schedule is a national fee schedule (i.e. there is no variation from state to state). Thus, all Part B Drug claims were assigned the national fee schedule amount.

Standardized Payment Formula:
Part B Drugs National Fee Schedule Amount x Unit Count

Note: Where applicable, Part B Drugs associated with DME claims were assigned the DME infusion limit amount from the Part B Drugs fee schedule.
Figure 16. Standardizing payments for rural health clinics (RHCs) and federally qualified health clinics (FQHCs)

RHCs:
Each year Congress determines a RHC per visit payment limit. We remove the portion of the payment likely attributable to wages using the SNF state rural wage index.

Stripped Payment Formula:
\[
\frac{\text{Actual Payment} + \text{Co} - \text{Insurance} + \text{Deductible}}{\text{(Outpatient Labor Ratio x Wage Index) + (1 - Outpatient Labor Ratio)}}
\]

FQHCs:
FQHC payments are an all-inclusive per visit amount based on reasonable costs. Given the resources necessary to determine whether the FQHC is located in a rural or urban area, we did not adjust for wages in the current data.

Standardized Payment Formula:
\[
\text{Actual Payment} + \text{Co-insurance}
\]
Note: A FQHC PPS is scheduled to be implemented in 2014.

Figure 17. Standardizing payments for renal dialysis facilities (RDFs)

Given that the 2008/2009 Renal Dialysis payment rates are adjusted by patient-specific body measurements which we do not have in our data, as well as capped at an amount equal to 3 dialysis sessions per week, we chose to remove the portion of the payment likely attributable to wages using the RDF wage index.

Stripped Payment Formula:
\[
\frac{\text{Actual Payment} + \text{Co} - \text{Insurance} + \text{Deductible}}{\text{(Outpatient Labor Ratio x Wage Index) + (1 - Outpatient Labor Ratio)}}
\]
Note: A Renal Dialysis PPS was implemented in 2011.
Supplemental Table

Calculating RSPs

Table A1. Variables used to calculate the risk standardized payment model

<table>
<thead>
<tr>
<th>Risk Adjustment Category</th>
<th>Risk Adjustment Variable</th>
<th>Coefficient Estimate</th>
<th>Standard Error</th>
<th>Payment Ratio (PR)*</th>
<th>95% Confidence Interval for PR</th>
</tr>
</thead>
<tbody>
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<td>Intercept</td>
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<td>9.807</td>
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<td>-</td>
<td>-</td>
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<td>Demographics</td>
<td>Age (65 – 74)</td>
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<td>(1.249-1.270)</td>
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<td>-</td>
<td>1.000</td>
<td>-</td>
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<td>History of PCI</td>
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<td>Congestive Heart Failure (CC 80)</td>
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<td>(0.949-0.963)</td>
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<td>Cardiovascular</td>
<td>Angina Pectoris/Old Myocardial Infarction (CC 83)</td>
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<td>(0.952-0.967)</td>
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<td>Conditions</td>
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<td>SE</td>
<td>OR</td>
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</tr>
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<td>Cardiovascular Heart Infection/Inflammation, Except Rheumatic (CC 85)</td>
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<td>1.215</td>
<td>(1.184-1.247)</td>
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<td>0.004</td>
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<td>Cardiovascular Congenital Cardiac / Circulatory Defect (CC 8788)</td>
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<td>(1.060-1.134)</td>
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<td>Cardiovascular Hypertension and Hypertension Complications (CC 89-91)</td>
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<td>0.954</td>
<td>(0.945-0.962)</td>
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<td>Other Metastatic Cancer / Acute Leukemia and Other Major Cancers (CC 7-8)</td>
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<td>Other Comorbidity</td>
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<td>(0.954-0.967)</td>
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<td>(1.005-1.039)</td>
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<td>0.936</td>
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<td>Other Comorbidity</td>
<td>Other Comorbidity</td>
<td>Other Comorbidity</td>
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<td>Reactive and Unspecified Psychosis (CC 56)</td>
<td>Depression / Anxiety (CC 58-59)</td>
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<td>Vascular Disease and Complications (CC 104-105)</td>
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<td>(1.006-1.038)</td>
<td>(0.947-0.981)</td>
<td>(0.956-0.976)</td>
<td>(1.032-1.050)</td>
<td>(1.007-1.022)</td>
<td>(1.039-1.054)</td>
</tr>
<tr>
<td>Other Comorbidity</td>
<td>Category</td>
<td>Payment Ratio</td>
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<tr>
<td>Legally Blind</td>
<td>(CC 116)</td>
<td>-0.073</td>
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<tr>
<td>Dialysis Status</td>
<td>(CC 130)</td>
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<td>Internal Injuries</td>
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<td>1.151</td>
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<td>(1.113-1.191)</td>
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</table>

PCI denotes percutaneous coronary intervention; CABG, coronary artery bypass graft; CC, condition category.

Model $r^2 = 0.05$

* The payment ratio is the exponentiated coefficient estimate (the relative effect of the risk factor on total payment).