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 <0.001) 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;7:00-00.)

Key Words: acute inferior myocardial infarction ▪ cost and cost analysis ▪ insurance, health reimbursement ▪ percutaneous coronary intervention

Hospitalizations for acute myocardial infarctions (AMI) are common and costly. Percutaneous coronary intervention (PCI) is a major contributor to the cost of treating patients with AMI. In recent years, hospitals have increasingly established new PCI programs, with an expansion of PCI hospitals, in the United States, of ≈16.5% from 2004 to 2008.1 This increase in the number of PCI hospitals could have implications for both the quality and cost of care for patients with AMI. Although several recent studies have examined whether increased PCI capability improves access or outcomes,1,4 little is known about the cost of treatment for patients admitted with AMI at PCI hospitals versus non-PCI hospitals. This group has previously found that hospital costs for patients admitted to facilities with and without catheterization capabilities did not differ substantially.4 However, this work was done for patients admitted between 1992 and 1993 in a single state; to our knowledge, there have been no recent comparisons of hospital costs for patients with AMI admitted to PCI versus non-PCI facilities and no such studies done on a national level.

Admission to PCI hospitals may be associated with higher costs for patients with AMI because of higher rates of inpatient procedures compared with non-PCI hospitals.2,6,8
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 that 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 from health insurers, 1 for each admission. In addition, patients discharged from 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,
Standardizing Payments

For each care setting, we standardized payments by calculating a payment that removes the influence of Medicare geographic and policy adjustments to isolate the portion of payment that reflects care decisions. Medicare reimburses providers using several different mechanisms depending on the care setting. We have provided details on the calculation of acute inpatient payments and analogous calculations for all other settings in the Data Supplement.

When the data did not allow for the removal of geographic adjustments, we used the CMS fee schedule data to calculate an average payment and uniformly applied it across all geographic areas. For example, for laboratory services, where Medicare reimburses each state at different amounts, we averaged the payment for an item across all states and replaced the state-specific payment amount for that item in a patient’s claim with the average payment.

We then arrived at a total payment for each episode-of-care by summing our standardized payments for all applicable care settings during a patient’s 30-day episode-of-care. We included payments that began during a patient’s 30-day episode-of-care but ended after by applying a prorated amount. For example, if a patient was admitted to a skilled nursing facility on day 25 of the episode-of-care window and remained in the facility until day 40, we calculated the payment for the entire 16-day period and then divided it by 16 to obtain a daily payment amount. We then multiplied that amount by the number of days the patient was in the care setting during the 30-day episode-of-care payment window (6 in the example above).

Calculating RSPs

We calculated RSP for each hospital using 2-level hierarchical generalized linear models that adjust for patient demographics, such as age and clinical characteristics, including comorbid conditions identified in claims for acute inpatient hospital stays; hospital outpatient care, and physician, radiology, and laboratory services for 12 months before the index admission as well as select conditions indicated by secondary diagnoses codes on index admission. Hospital-level random intercepts were included to account for the clustering, or nonindependence, of patients within hospitals, and to capture hospital-level signal.

We used CMS Condition Category groups to define the comorbid risk-adjustment variables. Candidate risk-adjustment variables were selected for the model on the basis of clinical coherence and strength of association in the same manner as for the CMS AMI mortality measure. We then selected final risk-adjustment variables by bootstrapping multiple stepwise regressions and included those variables that came into the model >90% of the time. We did not risk adjust for diagnoses that may have been complications of care during the index admission because, although complications may contribute to higher costs and payments, they represent potential differences in payment that are influenced by hospital actions, and such differences should be captured by the payment measurement. In addition, we risk adjusted for the patients’ age and their history of PCI and CABG. We have provided the final risk-adjustment variables included in the RSP model and their coefficient estimates in Table IA in the Data Supplement.

We used the following strategy to calculate the hospital-specific RSPs. We calculated these payments as the ratio of predicted AMI payment to expected AMI payment, and multiplied by the national unadjusted average AMI payment. The predicted AMI payment for each hospital was estimated using its patient mix and an estimated hospital-specific intercept. The expected AMI payment for each hospital was estimated given the same patient mix but the average intercept among all hospitals in the sample.

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, 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. In addition, we calculated and compared mean unadjusted payments for transfer and nontransfer patients who were admitted to non-PCI hospitals. A t test was used to compare RSPs, and y^2 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 183,375 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
### 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=180,375)</th>
<th>PCI (n=137,427)</th>
<th>Non-PCI (n=42,948)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>65–74</td>
<td>56,102</td>
<td>46,640</td>
<td>9,462</td>
</tr>
<tr>
<td>75–84</td>
<td>70,769</td>
<td>54,709</td>
<td>16,060</td>
</tr>
<tr>
<td>≥85</td>
<td>53,504</td>
<td>36,078</td>
<td>17,426</td>
</tr>
<tr>
<td>History of PCI</td>
<td>13,858</td>
<td>11,583</td>
<td>2,275</td>
</tr>
<tr>
<td>History of CABG</td>
<td>10,824</td>
<td>7,772</td>
<td>3,052</td>
</tr>
<tr>
<td>Congestive heart failure (CC 80)</td>
<td>56,486</td>
<td>39,369</td>
<td>17,117</td>
</tr>
<tr>
<td>Angina pectoris/old myocardial infarction (CC 83)</td>
<td>38,210</td>
<td>28,878</td>
<td>9,423</td>
</tr>
<tr>
<td>Heart infection/inflammation, except rheumatic (CC 85)</td>
<td>3,242</td>
<td>2,666</td>
<td>576</td>
</tr>
<tr>
<td>Valvular and rheumatic heart disease (CC 86)</td>
<td>49,155</td>
<td>36,876</td>
<td>12,279</td>
</tr>
<tr>
<td>Congenital cardiac/circulatory defect (CC 87–88)</td>
<td>1,700</td>
<td>1,367</td>
<td>333</td>
</tr>
<tr>
<td>Hypertension and hypertension complications (CC 89–91)</td>
<td>151,080</td>
<td>114,356</td>
<td>38,724</td>
</tr>
<tr>
<td>Metastatic cancer, acute leukemia, and other major cancers (CC 7–8)</td>
<td>71,832</td>
<td>53,063</td>
<td>18,777</td>
</tr>
<tr>
<td>Diabetes mellitus and diabetes mellitus complications (CC 15–19, 119–120)</td>
<td>75,502</td>
<td>56,564</td>
<td>18,938</td>
</tr>
<tr>
<td>Protein-calorie malnutrition (CC 21)</td>
<td>8,974</td>
<td>6,462</td>
<td>2,512</td>
</tr>
<tr>
<td>Other significant endocrine and metabolic disorders (CC 22)</td>
<td>11,246</td>
<td>8,696</td>
<td>2,550</td>
</tr>
<tr>
<td>Obesity/disorders of thyroid, cholesterol, lipids (CC 24)</td>
<td>130,381</td>
<td>100,660</td>
<td>29,721</td>
</tr>
<tr>
<td>Other gastrointestinal disorders (CC 36)</td>
<td>81,382</td>
<td>60,561</td>
<td>20,821</td>
</tr>
<tr>
<td>Osteoporosis and other bone/cartilage disorders (CC 41)</td>
<td>26,437</td>
<td>19,359</td>
<td>7,078</td>
</tr>
<tr>
<td>Iron deficiency and/or unspecified anemia and blood disease (CC 47)</td>
<td>69,629</td>
<td>50,973</td>
<td>18,656</td>
</tr>
</tbody>
</table>

### Table 1. Continued

<table>
<thead>
<tr>
<th>Variable</th>
<th>Overall (n=180,375)</th>
<th>PCI (n=137,427)</th>
<th>Non-PCI (n=42,948)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delirium and encephalopathy (CC 48)</td>
<td>6,733</td>
<td>4,815</td>
<td>1,918</td>
</tr>
<tr>
<td>Dementia (CC 49)</td>
<td>31,545</td>
<td>20,932</td>
<td>10,613</td>
</tr>
<tr>
<td>Drug/alcohol psychosis (CC 51)</td>
<td>2,104</td>
<td>1,624</td>
<td>480</td>
</tr>
<tr>
<td>Drug/alcohol abuse/dependence (CC 52–53)</td>
<td>17,830</td>
<td>14,314</td>
<td>3,516</td>
</tr>
<tr>
<td>Severe mental illness (CC 54–55)</td>
<td>7,958</td>
<td>5,625</td>
<td>2,333</td>
</tr>
<tr>
<td>Reactive and unspecified psychosis (CC 56)</td>
<td>5,505</td>
<td>3,566</td>
<td>1,939</td>
</tr>
<tr>
<td>Depression/anxiety (CC 58–59)</td>
<td>19,060</td>
<td>13,330</td>
<td>5,730</td>
</tr>
<tr>
<td>Precerebral arterial occlusion and transient cerebral ischemia (CC 97)</td>
<td>27,561</td>
<td>20,703</td>
<td>6,858</td>
</tr>
<tr>
<td>Vascular disease and complications (CC 104–105)</td>
<td>45,323</td>
<td>33,423</td>
<td>11,900</td>
</tr>
<tr>
<td>Other lung disorders (CC 115)</td>
<td>48,611</td>
<td>36,612</td>
<td>11,999</td>
</tr>
<tr>
<td>Legally blind (CC 116)</td>
<td>1,351</td>
<td>929</td>
<td>422</td>
</tr>
<tr>
<td>Dialysis status (CC 130)</td>
<td>4,035</td>
<td>3,199</td>
<td>836</td>
</tr>
<tr>
<td>Internal injuries (CC 160)</td>
<td>1,672</td>
<td>1,279</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, $20,340; non-PCI, $19,713; P<0.001). The range of RSP was similar between PCI and non-PCI hospitals (PCI, $15,251–$27,317; non-PCI, $16,769–$24,597; 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—an $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>Category</th>
<th>Overall</th>
<th>PCI</th>
<th>Non-PCI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hospital (n)</strong></td>
<td>4131</td>
<td>1415</td>
<td>2716</td>
</tr>
<tr>
<td><strong>Volume (n)</strong></td>
<td>180,375</td>
<td>137,427</td>
<td>42,948</td>
</tr>
<tr>
<td><strong>Transfer rate, %</strong></td>
<td>7.7</td>
<td>2.2</td>
<td>25.4</td>
</tr>
<tr>
<td><strong>Index admission PCI rate, %</strong></td>
<td>33.0</td>
<td>39.2</td>
<td>13.2</td>
</tr>
<tr>
<td><strong>Index admission CABG rate, %</strong></td>
<td>8.3</td>
<td>9.5</td>
<td>4.4</td>
</tr>
<tr>
<td><strong>Subsequent revascularizations, %</strong></td>
<td>0.18</td>
<td>0.15</td>
<td>0.27</td>
</tr>
<tr>
<td><strong>30-Day risk-adjusted payment, $</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</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>6,687</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>
</tr>
<tr>
<td>Mean outpatient hospital payment</td>
<td>705</td>
<td>34</td>
<td>925</td>
<td>34</td>
</tr>
<tr>
<td>Mean home health payment</td>
<td>1,086</td>
<td>23</td>
<td>1,020</td>
<td>23</td>
</tr>
</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 postacute 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.
Sources of Funding
This study is supported by grant 1U01HL105270-04 (Center for Cardiovascular Outcomes Research at Yale University) from the National Heart, Lung, and Blood Institute in Bethesda, Maryland. Dr Ross is supported by grant K08 AG032886-05 from the National Institute on Aging and by the American Federation for Aging Research through the Paul B. Beeson Career Development Award Program. Dr Ben-Josef received support for this project from the American Heart Association Student Scholarship in Cardiovascular Disease and the National Research Service Award from the National Institutes of Health. The work for this article was supported in part by Contract Number HHSM-500-2008-0025I/HHSM-500-T0001, Modification No. 000008, entitled Measure & Instrument Development and Support (MIDS)-Development and Re-evaluation of the CMS Hospital Outcomes and Efficiency Measures, funded by the Centers for Medicare and Medicaid Services, an agency of the US Department of Health and Human Services. The content of this work does not necessarily reflect the views or policies of the Department of Health and Human Services nor does mention of trade names, commercial products, or organizations imply endorsement by the US Government. We assume full responsibility for the accuracy and completeness of the ideas presented.

Disclosures
Drs Ross, Curtis, Kim, Krumholz, and Bernheim report that they receive contract funding from the Centers for Medicare and Medicaid Services to develop and maintain quality measures. Drs Krumholz and Ross receive support from Medtronic, Inc to develop methods of clinical trial data sharing and from the Food and Drug Administration to develop methods for postmarket surveillance of medical devices. Dr Krumholz reports that he chairs a scientific advisory board for UnitedHealthcare. Dr Ross reports that he is a member of a scientific advisory board for FAIR Health, Inc. The other authors report no conflicts.

References
Payments for Acute Myocardial Infarction Episodes-of-Care Initiated at Hospitals With and Without Interventional Capabilities

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Circ Cardiovasc Qual Outcomes. published online November 11, 2014; Circulation: Cardiovascular Quality and Outcomes is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 1941-7705. Online ISSN: 1941-7713

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circoutcomes.ahajournals.org/content/early/2014/11/11/CIRCOUTCOMES.114.000927

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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

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

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

\[
\text{Adjusted Per Diem Base Payment} \times \text{Adoptions for Geographic Factors (e.g. Wage Index)} \times \text{Adoptions for Facility Characteristics (e.g. Rural, Teaching)} \times \text{Adjustments for Patient DRG, Age, & Comorbidities} = \text{Adjusted Per Diem Base Payment}
\]

**Stripped Payment Formula:**

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

*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

\[
\text{Adjusted Base Payment} \times \text{Adoptions for Geographic Factors (e.g. Wage Index)} \times \text{CMG* Weight} \times \text{Adoptions for Facility Characteristics (e.g. Rural, Share of low-income patients, Teaching)} = \text{Adjusted Base Payment}
\]

\[
\begin{align*}
\text{Full LOS} & = \text{Stripped Payment} \\
\text{LOS} \leq \text{ALOS**} & = \text{Stripped Payment} + \text{Outlier Payment w/ Wage Index Removed} (\text{where applicable})
\end{align*}
\]

**Stripped Payment Formula:**

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

* 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:

\[ \text{Stripped Payment} = \left( \frac{\text{APC Amount} \times \text{Units}}{\text{Wage Index} + \text{Outlier Payment}} \right) \]

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:

\[ \text{Stripped Payment} = \left( \frac{\text{Conversion Factor} \times (\text{Work RVU} + \text{Non-Facility Transitioned Practice Expense RVU} + \text{Malpractice Insurance RVU})}{\text{Units}} \right) \]

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:**

\[
\text{Avg. of Urban & Rural Base Rates} \times \text{RUG* Weight} \times \text{Days in SNF} + \text{AIDS Adjustment (where applicable)}
\]

* 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***:

\[
\frac{\text{Actual Payment} + \text{Co} - \text{Insurance}}{\left(\text{SNF Labor Ratio} \times \text{Wage Index}\right) + (1 - \text{SNF Labor Ratio})}
\]

* 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.

**Stripped Payment Formula:**

\[
\text{HHA Base Rate} \times \text{HHRG* Weight} + \frac{\text{Outlier Payment}}{(\text{Labor Ratio} \times \text{Wage Index}) + \text{Nonlabor Ratio}} + \text{DME/POS/O2 Add-ons}
\]

* HHRG (Home Health Resource Group): Comprised of clinical, functional, and service utilization scores based on patient characteristics.

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

Adjusted 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:

RHC/IRC/GIC Base Payment × # Days of Care + Physician Fee

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

\[
\text{Avg. Payment from State DME/POS Fee Schedule} \times \text{Adjustment for New, Used, or Rental Equipment} \times \text{Unit Count} = \text{Standardized Payment} + \text{Part B Drug Fee} \times \text{Unit Count}
\]

DME/POS Standardized Payment:
Avg. Payment from State DME/POS Fee Schedule × Adjustment for New, Used, or Rental Equipment × Unit Count + (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.

(APC Fee Schedule Amount) x Unit Count x 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:

[Conversion Factor x (Work RVU + Transitioned Practice Expense RVU + Malpractice Insurance RVU)] x Adjustment Factor Related to Procedures x Adjustment Factor for Non-Physicians x 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
** GPC = Geographic Practice Cost Index
*** HPQA = Health Professional Storage Area
† 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

Standardized Payment Formula:
Avg. Payment from State Clinical Diagnostic Laboratory Fee Schedule \times 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

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

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

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</th>
<th>Risk Adjustment Variate</th>
<th>Coefficient Estimate</th>
<th>Standard Error</th>
<th>Payment Ratio (PR)*</th>
<th>95% Confidence Interval for PR</th>
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<td>9.807</td>
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<td>Demographics</td>
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<td>Demographics</td>
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<td>1.000</td>
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<td>Cardiovascular</td>
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<td>(0.804-0.823)</td>
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<td>Congestive Heart Failure</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>
<td>-0.041</td>
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<td>0.960</td>
<td>(0.952-0.967)</td>
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<td>Condition</td>
<td>OR</td>
<td>SE</td>
<td>95% CI</td>
<td></td>
<td></td>
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<td>Cardiovascular Heart</td>
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<td>(1.18-1.25)</td>
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<td>Infection/Inflammation, Except Rheumatic (CC 85)</td>
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<td>1.215 (1.18-1.25)</td>
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<td>1.019 (1.01-1.03)</td>
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<td>Cardiovascular Congenital Cardiac / Circulatory Defect (CC 87-88)</td>
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<td>1.096 (1.06-1.14)</td>
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<td>Cardiovascular Hypertension and Hypertension Complications (CC 89-91)</td>
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<td>0.954 (0.95-0.96)</td>
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<td>Other Metastatic Comorbidity Cancer / Acute Leukemia and Other Major Cancers (CC 7-8)</td>
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<td>0.008</td>
<td>0.909 (0.89-0.92)</td>
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<td>Other</td>
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<td>Diabetes Complications</td>
<td>Other Comorbidity</td>
<td>Protein-Calorie Malnutrition (CC 21)</td>
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<td>0.046 0.003 1.047</td>
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<td>(CC 15-19, 119-120)</td>
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<td>(1.094-1.128)</td>
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<td>Other Comorbidity</td>
<td>Osteoporosis and Other Bone/Cartilage Disorders (CC 41)</td>
<td>Iron Deficiency and Other / Unspecified Anemias and Blood Disease (CC 47)</td>
<td>Delirium and Encephalopathy (CC 48)</td>
<td>Dementia (CC 49)</td>
<td>Drug / Alcohol Psychosis (CC 51)</td>
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<td>------------------------------------------------------------------------</td>
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<td>-0.030 0.004 0.970 (0.962-0.978)</td>
<td>0.051 0.003 1.053 (1.046-1.060)</td>
<td>0.022 0.009 1.022 (1.005-1.039)</td>
<td>-0.107 0.004 0.898 (0.891-0.906)</td>
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<td>Other Comorbidity</td>
<td>Condition</td>
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<td>Upper CI</td>
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<td></td>
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<tr>
<td>Severe Mental Illness (CC 54-55)</td>
<td>0.022</td>
<td>0.008</td>
<td>1.022</td>
<td>(1.006-1.038)</td>
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<tr>
<td>Reactive and Unspecified Psychosis (CC 56)</td>
<td>-0.037</td>
<td>0.009</td>
<td>0.964</td>
<td>(0.947-0.981)</td>
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<tr>
<td>Depression / Anxiety (CC 58-59)</td>
<td>-0.035</td>
<td>0.005</td>
<td>0.966</td>
<td>(0.956-0.976)</td>
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<td>Precerebral Arterial Occlusion and Transient Cerebral Ischemia (CC 97)</td>
<td>0.040</td>
<td>0.005</td>
<td>1.041</td>
<td>(1.032-1.050)</td>
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<td>Vascular Disease and Complications (CC 104-105)</td>
<td>0.015</td>
<td>0.004</td>
<td>1.015</td>
<td>(1.007-1.022)</td>
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<td>Other Lung Disorders (CC 115)</td>
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<td>0.004</td>
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<td>(1.039-1.054)</td>
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<td>Comorbidity</td>
<td>Payment Ratio</td>
<td>Standard Error</td>
<td>OR</td>
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<td>Legally Blind (CC 116)</td>
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<td>Dialysis Status (CC 130)</td>
<td>0.119</td>
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<td>1.126</td>
<td>(1.098-1.156)</td>
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<td>Internal Injuries (CC 160)</td>
<td>0.141</td>
<td>0.017</td>
<td>1.151</td>
<td>(1.113-1.191)</td>
<td></td>
</tr>
</tbody>
</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).