Specialty hospitals, which provide care limited to specific medical conditions or procedures, are opening at a rapid pace across the United States.1 Proponents argue that specialty hospitals provide higher-quality health care and greater cost-efficiency by concentrating physician skills and hospital resources needed for managing complex diseases.2,3 Critics claim that specialty hospitals focus primarily on low-risk patients and provide less uncompensated care, which places competing general hospitals at significant financial risk.4,5

However, specialty hospitals raise an additional concern beyond their potential to simply redistribute cases within a health care market. Specialty hospitals are typically smaller than general hospitals and have high rates of physician ownership.6 Physician owners may have stronger financial incentives for providing services that fuel greater utilization. Evidence for the potential of “physician-induced” demand of services exists in other health care settings like clinical laboratory and diagnostic imaging centers where self-referral by physician owners is restricted by federal law.7,8 Thus, the opening of a specialty hospital may be expected to raise utilization more than by simply adding increased capacity for procedures to a market.

We sought to assess whether the opening of specialty cardiac hospitals was associated with increasing population-based rates of coronary revascularization.

For editorial comment see p 998.
associated with greater utilization of coronary revascularization services. We focused on cardiac hospitals since two thirds of Medicare payments to specialty hospitals are related to cardiac conditions.9 To better distinguish the particular effects of specialty hospitals from the simple addition of capacity to a market, we separately compared areas where a cardiac hospital opened with those where new cardiac programs were introduced at general hospitals.

METHODS
Data Sources and Study Population
We obtained from the Centers for Medicare & Medicaid Services (CMS) Medicare Provider and Analysis Review (MEDPAR) Part A, Denominator, and Provider of Service files from 1995 through 2003. Part A files include data on acute care hospitalizations. Denominator files contain data on eligible Medicare beneficiaries for that year including demographic and enrollment information. Provider of Service files contain data on hospital providers including facility characteristics and ZIP code locations. Data on all Medicare beneficiaries aged 65 years or older enrolled in fee-for-service programs within the United States were included.

We used the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedural codes to identify patients undergoing coronary revascularization with coronary artery bypass grafting (CABG) (ICD-9-CM procedural codes 36.10-36.19) without concomitant aortic or valvular surgery and/or percutaneous coronary intervention (PCI) (ICD-9-CM procedural codes 36.01, 36.02, 36.05-36.07, 36.09). Hospitals that performed these procedures during the study period were identified using the same ICD-9-CM procedural codes. We included all hospitals with at least 3 CABG and/or PCI cases during one of the years in which the hospital reported data. The Institutional Review Board of the University of Michigan and the CMS approved this protocol prior to its initiation. The requirement for informed consent was waived and approved.

Specialty Hospital Identification
We categorized all hospitals that performed coronary revascularization into cardiac or general hospitals using an approach similar to the General Accounting Office and Cram et al.10 Specifically, we constructed a cardiac specialty index based on the percentage of cardiac-to-total admissions in Medicare beneficiaries in 2002 and 2003. From this cardiac specialty index, we reviewed the top 100 facilities and selected those that (1) had proprietary or corporate ownership, and (2) did not provide broad medical or pediatric services. Data on additional services available at these hospitals were obtained from the American Hospital Association Annual Survey, the American Hospital Directory, and online hospital Web sites.11,12 One cardiac hospital was excluded due to concerns regarding inconsistent participation within the Medicare program during the study period. To supplement this strategy, we also included any cardiac hospitals identified by the CMS during their recent national survey.13

As we were specifically interested in examining changes in use of coronary revascularization after the opening of a cardiac hospital, we excluded those that opened prior to January 1, 1996, and after December 31, 2002, to ensure at least 1 year of follow-up data. The year of opening was considered the first year that data were reported to the CMS for either procedure.

Statistical Analysis
We used hospital referral regions (HRRs) from the Dartmouth Atlas of Cardiovascular Health Care to identify health care markets.14 Hospital referral regions are large geographic units representing distinct markets for tertiary care that were developed by studying patterns of hospital utilization for major cardiac surgery among Medicare beneficiaries in the early 1990s. Based on their ZIP code, patients and hospitals were assigned to 1 of 306 HRRs. Hospital referral regions were categorized into 3 types: (1) HRRs where a new cardiac hospital opened; (2) HRRs where a new cardiac program in CABG and/or PCI opened at a general hospital; and (3) HRRs where no new programs opened during the study period.

We calculated population-based rates for CABG and PCI in each of the 306 HRRs during each year of the study period. The numerator for these rates was the total number of eligible beneficiaries within the HRR who underwent the procedure during that calendar year. The denominator was the total number of eligible beneficiaries within the HRR in June of that year. Rates were adjusted for differences in age (65-69, 70-74, and 75 years or older), sex, and race (black, nonblack) across HRRs and years using direct standardization.15

Population-based rates of total revascularization (CABG plus PCI), CABG, and PCI were plotted by calendar year with general trends visualized using fractional polynomial regression.16 We constructed multivariable linear regression models to assess the statistical significance of rates of change across the 3 types of HRRs after the opening of new programs. Repeated measures within HRRs were accounted for using generalized estimating equations with robust variance estimators with a first-order autoregressive, exchangeable) correlation structure assumed.17,18 Additional correlation matrix structures (second-order autoregressive, exchangeable) were explored and results were robust to this assumption.

Models accounted for trends in time by including year as a categorical variable. We included interaction terms consisting of time since a new program opened by the type of HRR, ie, HRRs where cardiac hospitals opened and HRRs where new cardiac programs opened at general hospitals. Interaction terms took the value of “0” for HRRs with no new programs. Models were adjusted for the following HRR-level variables: (1) annual population-based rates of acute myocardial infarc-
tion; (2) per capita number of cardiologists and cardiovascular surgeons at the midpoint of the study period; (3) geographic region (Northeast, South, Midwest, West); (4) the opening of multiple new programs (2 or more) over the study period; (5) tertiles of the annual percentage of managed care penetration; and (6) tertiles of a summary score of socioeconomic status calculated from US Census data at the ZIP code level. Nonlinear relationships in rates of change were also evaluated using quadratic terms; results were similar and are not reported.

We performed 3 additional analyses. For PCI, we separately analyzed rates among patients with and without an acute myocardial infarction as identified by ICD-9-CM diagnostic code 410.x1 during their hospitalization. This analysis assessed how our results were influenced by procedural indication. Next, we evaluated rates of change in HRRs prior to the opening of cardiac hospitals or new cardiac programs at general hospitals. This analysis assessed whether cardiac hospitals were selectively opening in already growing markets. Finally, we examined procedural volumes at cardiac hospitals and new cardiac programs at general hospitals as well as their relative contributions to the number of coronary revascularizations performed within an HRR at the end of the study period. All analyses were performed using Stata version 9.0 (StataCorp, College Station, Tex) and P values of <.05 were considered significant. All tests were 2-sided.

RESULTS
We identified 13 HRRs with 14 new cardiac hospitals, 142 HRRs with 245 new cardiac programs at general hospitals, and 151 HRRs with no new programs during the study period. In 2003, the mean (SD) number of beds at the 14 cardiac hospitals was 55 (16), the mean volume of CABG was 233 (151), and the mean volume of PCI was 575 (247). Eleven (79%) of the 14 cardiac hospitals reported providing emergency services, while 1 (7%) reported any affiliation with a medical school. (Specific information regarding the 14 cardiac hospitals available from the authors on request.) Table 1 lists key summary characteristics of the 3 types of HRRs. Hospital referral regions with no new cardiac programs had fewer Medicare enrollees, but rates of total revascularization, CABG, and PCI were not significantly different at the start of the study period. Eleven (85%) of the 13 HRRs where cardiac hospitals opened had at least 1 additional new program open during the study period compared with 50 (35%) of the 142 HRRs where new cardiac programs opened at general hospitals.

Figure 1 and Figure 2 display population-based rates for total revascularization, CABG, and PCI between 1995 and 2003 across the 3 types of HRRs. There was noticeable separation of rates in HRRs where cardiac hospitals opened starting in approximately 1999, coinciding with the median year of opening for these facilities. The rate of change for total revascularization was significantly greater in HRRs after cardiac hospitals opened when compared with HRRs where new cardiac programs opened at general hospitals (difference, +4.2/10,000 per year [95%
confidence interval [CI], 2.0-6.5; \( P < .001 \) and HRRs with no new programs (difference, +4.0/10,000 per year [95% CI, 1.8-6.3]; \( P < .001 \)). Four years after their opening, the relative increase in rates of total revascularization was more than 2-fold higher in HRRs where cardiac hospitals opened when compared with other HRRs (TABLE 2).

Similar findings were noted when we considered rates for CABG and PCI separately (Table 2). Although rates for CABG declined throughout the study period, the rate of change was less in HRRs after cardiac hospitals opened when compared with HRRs where new cardiac programs opened at general hospitals (difference, +2.1/10,000 per year [95% CI, 0.8-3.4]; \( P = .001 \) and HRRs with no new programs (difference, +1.9/10,000 per year [95% CI, 0.6-3.2]; \( P = .005 \)). The rate of change for PCI also was higher in HRRs after cardiac hospitals opened when compared with HRRs where new cardiac programs opened at general hospitals (difference, +2.4/10,000 per year [95% CI, 0.5 to 4.2]; \( P = .012 \) and HRRs with no new programs (difference, +2.4/10,000 per year [95% CI, 0.5-4.2]; \( P = .011 \)).

For PCI, these results varied when we considered the strength of the procedural indication (FIGURE 3). Among patients with acute myocardial infarction, no significant differences were seen in the rate of change for PCI across HRRs after cardiac hospitals opened (difference, −0.4/10,000 per year [95% CI, −0.9 to 0.1]; \( P = .15 \) when compared with HRRs where new cardiac programs opened at general hospitals; and difference, −0.3/10,000 per year [95% CI, −0.8 to 0.2]; \( P = .26 \) when compared with HRRs with no new programs). In contrast, the rate of change was significantly higher for PCI among patients without acute myocardial infarction in HRRs after cardiac hospitals opened when compared with HRRs where new cardiac programs opened at general hospitals (difference, +2.7/10,000 per year [95% CI, 1.1-4.3]; \( P = .001 \)) and HRRs with no new programs (difference, +2.6/10,000 per year [95% CI, 1.0-4.2]; \( P = .002 \)).

We also examined whether cardiac hospitals were selectively opening in already growing markets. Prior to their introduction, the rate of change for total revascularization was not significantly different in HRRs where cardiac hospitals opened than in HRRs where new cardiac programs opened at general hospitals (difference, +0.7/10,000 per year [95% CI, −0.8 to 2.2]; \( P = .39 \)) or HRRs with no new programs (difference, +0.8/10,000 per year [95% CI, −0.5 to 2.0]; \( P = .24 \)). Finally, we found that at the end of the study...
period cardiac hospitals contributed substantially to the utilization of total revascularization within markets when compared with new cardiac programs at general hospitals. The mean procedural volume of cardiac hospitals in Medicare beneficiaries was 4-fold higher than that of new cardiac programs at general hospitals, while the percentage of coronary revascularizations within the HRRs that was performed at cardiac hospitals was approximately 2-fold higher (Table 3).

**COMMENT**

We found that rates of change for total revascularization, CABG, and PCI were higher for Medicare beneficiaries in HRRs after the opening of cardiac hospitals when compared with HRRs where new cardiac programs opened at general hospitals and HRRs with no new programs. The incremental number of coronary revascularizations in these 13 HRRs that was associated with the opening of cardiac hospitals was approximately 3032 between 1999 and 2003. Although we are unable to comment directly on the appropriateness of these procedures, these findings raise the concern that the opening of cardiac hospitals may lead to greater procedural utilization beyond the simple addi-

### Table 2. Adjusted Rates of Coronary Revascularization per 10,000 After the Opening of New Programs*

<table>
<thead>
<tr>
<th>Type of Procedure</th>
<th>Baseline Year</th>
<th>Year 2</th>
<th>Year 4</th>
<th>% Change (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary revascularization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HRRs with cardiac hospital</td>
<td>134.4 (5.5)</td>
<td>151.2 (7.0)</td>
<td>160.2 (9.0)</td>
<td>+19.2 (+6.1 to +32.2)</td>
</tr>
<tr>
<td>HRRs with new cardiac program at a general hospital</td>
<td>136.1 (2.4)</td>
<td>144.5 (2.3)</td>
<td>145.0 (2.3)</td>
<td>+6.5 (+3.2 to +9.9)</td>
</tr>
<tr>
<td>HRRs with no new program</td>
<td>132.8 (2.5)</td>
<td>141.6 (2.6)</td>
<td>142.6 (2.8)</td>
<td>+7.4 (+3.2 to +11.5)</td>
</tr>
<tr>
<td>CABG</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HRRs with cardiac hospital</td>
<td>51.6 (2.7)</td>
<td>52.4 (2.9)</td>
<td>49.6 (3.6)</td>
<td>−3.9 (−17.6 to +9.9)</td>
</tr>
<tr>
<td>HRRs with new cardiac program at a general hospital</td>
<td>54.4 (1.0)</td>
<td>51.0 (0.9)</td>
<td>44.1 (0.8)</td>
<td>−18.9 (−21.7 to −16.0)</td>
</tr>
<tr>
<td>HRRs with no new program</td>
<td>52.4 (0.8)</td>
<td>49.3 (0.8)</td>
<td>42.8 (1.0)</td>
<td>−18.3 (−22.1 to −14.5)</td>
</tr>
<tr>
<td>PCI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HRRs with cardiac hospital</td>
<td>82.4 (4.0)</td>
<td>98.8 (4.9)</td>
<td>110.9 (6.2)</td>
<td>+34.6 (+19.8 to +49.4)</td>
</tr>
<tr>
<td>HRRs with new cardiac program at a general hospital</td>
<td>81.9 (2.0)</td>
<td>93.6 (2.0)</td>
<td>100.9 (2.1)</td>
<td>+23.2 (+18.2 to +28.2)</td>
</tr>
<tr>
<td>HRRs with no new program</td>
<td>80.5 (2.0)</td>
<td>92.1 (2.1)</td>
<td>99.4 (2.4)</td>
<td>+23.5 (+17.5 to +29.4)</td>
</tr>
<tr>
<td>PCI with AMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HRRs with cardiac hospital</td>
<td>27.0 (1.1)</td>
<td>29.4 (1.1)</td>
<td>31.2 (1.2)</td>
<td>+15.6 (+6.7 to +24.8)</td>
</tr>
<tr>
<td>HRRs with new cardiac program at a general hospital</td>
<td>26.8 (0.6)</td>
<td>29.9 (0.5)</td>
<td>32.5 (0.6)</td>
<td>+21.3 (+17.2 to +25.7)</td>
</tr>
<tr>
<td>HRRs with no new program</td>
<td>27.8 (0.6)</td>
<td>30.7 (0.5)</td>
<td>33.2 (0.7)</td>
<td>+19.4 (+14.7 to +23.7)</td>
</tr>
<tr>
<td>PCI without AMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HRRs with cardiac hospital</td>
<td>55.6 (3.6)</td>
<td>69.4 (4.6)</td>
<td>79.0 (5.9)</td>
<td>+42.1 (+21.4 to +62.9)</td>
</tr>
<tr>
<td>HRRs with new cardiac program at a general hospital</td>
<td>55.4 (1.7)</td>
<td>63.8 (1.7)</td>
<td>68.1 (1.8)</td>
<td>+22.9 (+16.4 to +29.2)</td>
</tr>
<tr>
<td>HRRs with no new program</td>
<td>52.9 (1.7)</td>
<td>61.5 (1.8)</td>
<td>66.0 (2.0)</td>
<td>+24.8 (+17.4 to +32.3)</td>
</tr>
</tbody>
</table>

Abbreviations: AMI, acute myocardial infarction; CABG, coronary artery bypass grafting; CI, confidence interval; HRRs, hospital referral regions; PCI, percutaneous coronary intervention.

*Adjusted for age, sex, race, US region, baseline year of 1999, presence of multiple new programs within the HRR, and mean socioeconomic status of the HRR.
†The baseline year of 1999 was used to reflect the midpoint of the study period when calculating the adjusted rates.

### Figure 3. Population-Based Rates of Percutaneous Coronary Intervention (PCI) With and Without Acute Myocardial Infarction (AMI) by Year in Hospital Referral Regions (HRRs) With Cardiac Hospitals, HRRs With New Cardiac Programs at General Hospitals, and HRRs With No New Programs

Rates were adjusted for age, sex, and race using direct standardization. Trend lines were generated using fractional polynomial regression.
tion of capacity to a market. This is particularly worrisome since cardiac hospitals may not substantially improve clinical outcomes when compared with general hospitals with similar procedural volumes.14

An additional finding was that among patients with acute myocardial infarction, the subset of patients who are likely to gain the most clinically from PCI,20,21 there was no association between the opening of cardiac hospitals and the rate of change for PCI. The rate of change for PCI in patients without acute myocardial infarction, in contrast, was significantly higher in HRRs where cardiac hospitals opened. Although we could not assess appropriateness, the benefits of PCI are frequently less clear in this group of patients,22 suggesting that our findings may be partly driven by more discretionary cases. Finally, we found that cardiac hospitals had significantly higher procedural volumes than new cardiac programs at general hospitals and were responsible for more than twice the share of revascularizations within an HRR performed by the end of the study period.

Our findings differ somewhat from a recent study performed by the Medicare Payment Advisory Commission (MedPAC).23,24 In that study, HRRs where cardiac hospitals opened had a mixed association with utilization of CABG and PCI between 1996 and 2002. The likely explanation for the discrepancy between reports is that the MedPAC study did not account for the specific years that a specialty hospital was open. As a result, HRRs where cardiac hospitals opened in 2002 were considered the same as those that opened in 1997, although the former would be expected to only briefly affect utilization. A shorter study period also may have restricted the ability to detect potential associations. Another key difference between the 2 reports is that ours also examined rates of change in HRRs after the development of new cardiac programs at general hospitals. Distinguishing between the particular effect of cardiac hospitals and the mere addition of new cardiac programs at general hospitals is critical given recent growth in hospital-based services for coronary revascularization over the last decade.

Among potential mechanisms underlying our findings, the most concerning is the influence of physician ownership on decisions regarding the use of coronary revascularization. Self-referral of patients by physician owners to facilities where they have significant financial interest is generally prohibited by federal antikickback laws with the exception of “whole” hospitals.25 Hospitals—including specialty hospitals—are exempted because they typically provide a diverse enough array of services so that physician owners are thought to gain little from self-referral. However, specialty hospitals are smaller and provide fewer services than general hospitals making them more analogous to departments within general hospitals, which are regulated by federal antikickback laws.25

Our findings could also be explained by issues unrelated to physician ownership. Specialty hospitals may lead to higher utilization of these procedures through improved efficiencies in patient care that do not directly reflect financial incentives. Cardiac hospitals might have opened in markets already predisposed to higher rates of coronary revascularization due to patient factors or local market conditions, although we found no direct evidence that this was occurring. Finally, anecdotal reports suggest that higher utilization of these procedures within a market may be due to general hospitals positioning themselves more aggressively after the opening of a specialty hospital.9,26 However, a national survey of 603 US hospitals by the General Accounting Office found little evidence this was occurring.27

Our study should be interpreted with the following limitations in mind. First, this analysis cannot comment on the “correct” population-based rate for coronary revascularization. In fact, it may be that the opening of cardiac hospitals leads to more appropriate use of these procedures. Future studies will need to focus on this issue at both cardiac and general hospitals.

Second, in this type of analysis we are unable to fully attribute higher rates of coronary revascularization in HRRs where cardiac hospitals opened to these specific facilities. Instead, changes in the use of coronary revascularization after the opening of cardiac hospitals reflect the environment in which they and other competing hospitals exist. Our findings of higher procedural volumes at cardiac hospitals and their greater market share at the end of the study period are only suggestive of their role in higher rates of coronary revascularization.

Third, we were unable to evaluate the extent to which physician ownership at cardiac hospitals—which report-

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Table 3. Coronary Revascularizations Performed in Medicare Beneficiaries by Cardiac Hospitals and New Cardiac Programs at General Hospitals at the End of the Study Period (2003)

<table>
<thead>
<tr>
<th>Cardiac Hospitals</th>
<th>New Cardiac Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary Revascularizations per Hospital, Mean (SD), No.</td>
<td>Coronary Revascularizations in the HRR Performed at Cardiac Hospitals, Mean (SD), %</td>
</tr>
<tr>
<td>HRRs with cardiac hospitals</td>
<td>808.6 (370.5)</td>
</tr>
<tr>
<td>HRRs with new cardiac programs at general hospitals</td>
<td>NA</td>
</tr>
</tbody>
</table>

Abbreviations: HRRs, hospital referral regions; NA, not applicable.
edly ranges from 21% to 49%—influences utilization given a lack of publicly available information.21-23 Fourth, data in this analysis were limited to Medicare beneficiaries (although this group does represent a majority of the patients undergoing coronary revascularization in the United States). Finally, we identified only 14 cardiac hospitals that opened during the study period. Although specialty hospitals have generated great controversy among policy makers, they are a relatively new phenomenon and important differences may exist across individual facilities. Expiration of the moratorium on new specialty hospital construction is expected to increase their numbers in the coming years.

Despite these limitations, our findings may have important policy implications. The CMS recently issued their final report to Congress implementing a strategic plan for specialty hospitals.11 Their plan primarily involves revisions to the inpatient prospective payment systems to “level the playing field” between specialty and general hospitals and limit financial incentives for investing in certain services simply due to profitability. It also proposes new “gainsharing” and value-based payment approaches to better align physician and hospital incentives toward improving care at general hospitals. Reforms directly related to physician ownership include enhanced transparency of financial relationships. More stringent measures, such as limiting investments by physician owners, were not included. The extent to which additional measures are needed will require further data on appropriateness of care at specialty hospitals as well as the impact of greater utilization of these procedures on patient outcomes.

Author Contributions: Drs Nallamothu, Rogers, and Birkmeyer had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

REFERENCES