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PCI Outcomes in U.S. Hospitals with Varying Structural Characteristics: Analysis of the NCDR® CathPCI Registry®

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Abstract

Background—In the U.S. there continues to be debate about whether certain types of hospitals deliver improved patient outcomes. We sought to assess the association between hospital organizational characteristics and in-hospital outcomes for percutaneous coronary intervention (PCI).

Methods—Retrospective analysis of 2004–2007 data for 694 U.S. hospitals participating in the American College of Cardiology NCDR® CathPCI Registry®. Our analysis focused on 1,113,554 patients who underwent PCI in 471 not-for-profit (NFP) hospitals, 131 major teaching hospitals, 79 for-profit (FP) hospitals, and 13 physician-owned specialty hospitals. Outcomes included in-hospital mortality, stroke, bleeding, vascular injury and a composite representing one or more of the individual complications. We used the current NCDR mortality risk model to calculate risk standardized mortality ratios (RSMR) for each category of hospital and compared hospital groupings for all patients in aggregate and in subgroups stratified by patients' indications for PCI.

Results—Patients treated in major teaching hospitals were younger, while FP hospitals performed greater proportion of PCI for patients with ST-elevation myocardial infarction (STEMI) ($P<.0001$). Specialty hospitals treated patients with less acuity including a lower proportion of patients with STEMI. In unadjusted analyses, specialty hospitals had significantly lower rates of all adverse outcomes compared to NFP, teaching, and FP hospitals including in-hospital mortality (0.7%, 1.2%, 1.4%, and 1.4% respectively; $P<.001$) and the composite endpoint (2.4%, 4.1%, 4.6%, 4.3%; $P<.001$). In adjusted analyses, RSMR was significantly lower for specialty hospitals

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when compared to the other three groups for all patients in-aggregate (RSMR 1.05%, 1.30%, 1.38%, 1.39%; $P<.001$); these differences remained clinically significant but were no longer statistically significant for all subgroup analyses.

Conclusions—Specialty hospitals appear to have lower rates of most adverse outcomes for PCI. Specialty hospitals may have developed expertise in narrow procedural areas that could be adapted to the larger population of general hospitals.

Introduction

There has been long standing interest in the relationship between hospitals' structural/organizational characteristics and patient outcomes.^{1,2} Various studies have compared outcomes in teaching and non-teaching hospitals, for-profit and not for-profit hospitals, and, physician-owned specialty and general hospitals.³⁻⁵ Despite more than two decades of analyses, it remains uncertain whether certain models of hospital care deliver improved outcomes.^{6,7}

The debate over the relationship between hospitals' organizational characteristics and patient outcomes has been re-energized with the emergence of physician-owned specialty hospitals. Supporters have argued that specialty hospitals deliver improved patient outcomes by focusing resources on a single patient population.⁸ Critics counter that improved patient outcomes are an artifact of inadequate risk adjustment and that specialty hospitals are merely the latest attempt to take advantage of inconsistencies in the U.S. reimbursement system.⁹ Available data support both schools of thought. Specialty cardiac hospitals admit patients with less acuity and comorbidity, but they also appear to have risk-adjusted mortality rates that are 5%-15% lower than competing general hospitals for certain conditions.¹⁰⁻¹³ A critical limitation of prior studies has been their reliance upon administrative data sources which have well-recognized shortcomings, including a lack of clinical data on patient complexity and outcomes.

The objective of our study was to use a large clinical registry to compare peri-procedural outcomes for patients who underwent percutaneous coronary intervention (PCI) in four groups of hospitals: 1) not-for-profit (NFP) hospitals; 2) major teaching hospitals; 3) for-profit (FP) hospitals; and 4) physician-owned specialty hospitals.

Methods

Data

We used Medicare Provider and Analysis Review (MedPAR) Part A public use files to identify all hospitals performing one or more percutaneous coronary interventions (PCI) between 2001-2005 using International Classification of Diseases, 9th Clinical Modification (ICD-9-CM) procedure codes (36.01, 36.02, 36.05, and 36.06)(N= 1,609 hospitals). The MedPAR files contain administrative data for all fee-for-service Medicare patients discharged from acute care hospitals excluding Medicare managed care enrollees.¹⁴ Data elements relevant to the current study included the name and location of each hospital and each hospital's Medicare provider number.

We then stratified hospitals into four categories: 1) not-for-profit (NFP); 2) major teaching; 3) for-profit (FP); and 4) physician-owned specialty. We determined whether hospitals were physician-owned specialty cardiac hospitals by comparing the names and locations of hospitals in the MedPAR data with lists of physician owned hospitals published by government regulators.^{10,15} We determined for-profit/not-for-profit status and hospital teaching status by linking each hospital identified in the MedPAR data to the 2005

American Hospital Association (AHA) annual survey data using the hospital provider numbers; hospitals were classified as teaching hospitals if they reported membership in the council of teaching hospitals (COTH).²

Because individual hospitals could meet the criteria for multiple hospital categories simultaneously (e.g., a hospital could be both for-profit and major teaching), we made an *a priori* decision to assign hospitals into categories in the following hierarchical order: 1) specialty hospitals; 2) major teaching hospitals; 3) for-profit hospitals; and 4) not-for-profit hospitals. For example, if a hospital was both a specialty hospital and, not-for-profit, it was categorized as a specialty hospital. Likewise, if a hospital was both a major teaching hospital and not-for-profit, it was categorized as a major teaching hospital. This classification scheme resulted in the identification of 1,037 not-for-profit, 262 teaching, 287 for-profit and 23 physician-owned specialty hospitals.

We then used the American College of Cardiology (ACC) National Cardiovascular Data Registry[®] (NCDR) CathPCI Registry[®] to identify all patients who underwent PCI between January 1, 2004 and December 31, 2007. The CathPCI Registry has been described in detail previously and used extensively in prior research.^{16,17} Briefly, the CathPCI Registry prospectively collects detailed clinical data for quality improvement purposes on all PCI patients treated by participating institutions. Data are entered locally into approved software purchased from vendors certified by the NCDR. Data elements include patient demographics (e.g., age, race, sex), cardiovascular risk factors (e.g., diabetes, hypertension) and comorbidities (e.g., COPD), signs symptoms and diagnostic tests (e.g., stress test results, EKG findings) that might merit performance of PCI, cardiac medications, in-hospital complications and PCI outcomes assessed using standardized definitions established by the NCDR, and the hospital where each procedure was performed. Only data meeting criteria for completeness and accuracy, as determined by data quality and auditing systems are entered into the NCDR[®] (details available at <https://www.ncdr.com/webncdr/DefaultCathPCI.aspx>). A total of 889 hospitals located in the U.S. reported PCI data to the NCDR between January 1, 2004 and December 31, 2007. We excluded 52 hospitals that submitted less than 90 days of data and/or performed less than 10 PCI's per year resulting in identification of 837 eligible hospitals in the CathPCI Registry.

We then attempted to match each eligible hospital in the CathPCI Registry with the corresponding data on hospital ownership, teaching status, and for-profit/not-for-profit status derived from the MedPAR and AHA data. Because the CathPCI Registry does not include hospital Medicare provider numbers or AHA identification numbers, we matched hospitals in the CathPCI Registry with the MedPAR data using hospital name and location (city and state); when uncertainty arose in the matching (e.g., hospital city and state matched but names differed) we used hospital web sites for additional information. We successfully matched 694 of the 837 eligible hospitals (83%) in the CathPCI Registry to hospitals in the MedPAR data. Our subsequent analyses involved all patients who received PCI at any of our 694 study hospitals with the exception of PCI recipients who received their interventions as part of an organ transplant evaluation (n=1495 patients) as PCI indications in such a population are not covered by existing guidelines. Of these 694 hospitals, 471 were not-for-profit, 79 were for-profit, 13 were specialty and 13 were major teaching hospitals.

PCI indications for patients treated in each of the four hospital groups were determined by applying the 2001 ACC guidelines to the CathPCI Registry as these were the guidelines in-place at the time that our patient cohort received their procedures.¹⁸ The indications for PCI for each patient were classified as: 1) potentially life extending (PCI for an ST-elevation myocardial infarction [STEMI]); 2) offering quality-of-life (QOL) benefits (patients with

atypical chest pain, stable angina, unstable angina, a positive stress test or non ST-elevation myocardial infarction [NSTEMI]); and 3) unclear indications (patients who underwent PCI but had no documented angina, chest pain, or positive stress test). A manuscript detailing our methodology for classifying individual procedures into these categories is currently under review as a separate manuscript.

Analyses

First we compared the structural and organizational characteristics of the four categories of hospitals including geographic location, bed size and PCI volume using a one-way ANOVA for continuous and χ^2 tests for categorical data. We examined patient demographics, comorbidity, and clinical characteristics across the four hospital groups using similar methods.

Second, we compared unadjusted in-hospital PCI outcomes across the four hospital groups using χ^2 tests; outcomes included stroke, bleeding, vascular complications and mortality as well as a composite endpoint representing the occurrence of one-or-more of the individual outcomes. We then stratified patients according to the indication for their PCI (i.e., STEMI, QOL benefit, unclear indications) and compared outcomes across hospital groups among patients with similar PCI indications.

Third, we conducted an array of adjusted analyses. We calculated Risk Standardized Mortality Rates CRSMPO for each hospital using methods that have been described previously.^{19,20} Specifically, we created observed-to-expected (O/E) mortality ratios for each hospital using a method that has been used previously while adjusting for an array of patient characteristics that have been used in prior risk-adjustment analyses using the CathPCI data (c-statistic >0.85).²¹ This O/E ratio is calculated for each hospital by dividing the risk adjusted hospital specific estimate by the estimate of expected mortality using the average intercept for all hospitals. This ratio for each hospital is multiplied by the average unadjusted mortality for all hospitals to obtain the final RSMR for each hospital and accounts for clustering of patients within hospitals. We calculated four RSMR ratios for each of our four groups of hospitals: 1) all patients in aggregate; 2) STEMI patients only; 3) patients likely to receive a QoL benefit only; and 4) patients with unclear PCI indications only.

Finally, we investigated the impact of progressive risk-adjustment on the results of our analyses. We used logistic regression models to examine the impact of progressive risk-adjustment on our study results. In particular we compared mortality across the four hospitals groups in: 1) unadjusted models; 2) models that adjusted for patient characteristics only; and 3) models that adjusted for patient characteristics plus hospital PCI volume; and 4) models that adjusted for the factors above plus included hospital random effects. For these models we presented the data as odds ratios (OR) with 95% confidence intervals (CI) with not-for-profit hospitals serving as the reference group. These analyses are important because there has been substantial uncertainty about whether the improved outcomes seen in physician-owned specialty hospitals truly represented improved quality or merely was a reflection of higher procedural volume.

Statistical significance was defined as $P \leq 0.05$. All statistical analyses were performed by the Saint Luke's Hospital Mid America Heart Institute using SAS version 9.2 (SAS Institute, Cary, North Carolina). These analyses were approved by the IRBs at the University of Iowa and Saint Luke's Hospital of Kansas City. This work was funded by grants from the Robert Wood Johnson Foundation (Dr. Cram) and the National Heart, Lung, and Blood Institute at the NIH (R01 HL085347; Drs. Cram and Spertus). Dr. Spertus and the MidAmerica Heart Institute receive funding through a contract from the ACC related to the analysis of the

Cath-PCI Registry. The funding agencies played no role in the data analysis, data interpretation or drafting of this manuscript. This manuscript did undergo review and editing by the NCDR Research and Publication Committee in accordance with ACC protocols and policies.

Results

Our study sample consisted of 1,113,554 patients admitted to 694 hospitals during the study period. As expected, there were significant differences in the characteristics of the four different hospital groups (Table 1). For example, for-profit hospitals were more common in the South and West while specialty hospitals were more common in the South and Midwest; major teaching hospitals tended to be larger than the other types of hospitals.

The characteristics of the patients treated in the four different groups of hospitals differed in a number of clinically significant ways (Table 2). Patients receiving PCI in major teaching hospitals were younger and more likely to be black, while patients receiving PCI in for-profit hospitals were more likely to be admitted through the emergency department. Patients receiving PCI in specialty hospitals were more likely to have had prior revascularization (PCI or CABG), but were less likely to be inpatients at the time of their procedure and had lower acuity (e.g., less cardiogenic shock). Specialty hospitals conducted a lower proportion of their total procedures for STEMI and a higher proportion for unclear indications.

Overall, 4.2% of patients (46,921) experienced one or more adverse in-hospital outcomes following PCI (Table 3). Unadjusted rates of all of the individual adverse outcomes were lower in specialty hospitals compared to the other three groups. Similarly, the percentage of patients experiencing one or more adverse outcome was significantly lower in specialty hospitals (2.4%) than in NFP hospitals (4.1%), major teaching hospitals (4.6%), and FP hospitals (4.3%) ($P < .0001$).

Unadjusted outcomes remained significantly better in specialty hospitals among subgroups of patients with similar indications for PCI (Table 3). For example, among patients receiving PCI for STEMI the percentage of patients experiencing one or more adverse outcome was 7.0% in specialty hospitals, 9.6% in NFP hospitals, 11.1% in major teaching hospitals, and 9.8% in FP hospitals ($P < .0001$).

In risk-adjusted analyses (c-statistic 0.92), results were somewhat different (Table 4). Looking at all PCI patients in aggregate, specialty hospitals had a lower RSMR when compared to the other three hospital groups after adjusting for patient characteristics. However, after stratifying patients by indication for PCI, while specialty hospitals did demonstrate lower RSMR among the QoL subgroup, specialty hospitals did not have a statistically significant improvement in RSMR among either the STEMI or unclear indications subgroups. Looking at our results from an alternative perspective (Table 4), specialty hospitals appeared to have improved outcomes for all patients in aggregate and all subgroups, although results were not statistically significant in many of the subgroup analyses. In supplementary analyses that demonstrate the impact of progressive risk-adjustment, results were generally similar (Table 5). Specialty hospitals had substantially improved risk-adjusted mortality in unadjusted analyses and this benefit was consistent among all patients in aggregate and all subgroups. However, with additional adjustment for patient comorbidity this advantage declined. While specialty hospitals continued to have an advantage in results that also accounted for hospital PCI volume (Table 5), the advantage was eliminated with inclusion of hospital random-effects.

Discussion

In an analysis of data from a large clinical registry, we found significantly better in-hospital PCI outcomes for patients treated in physician-owned specialty hospitals as compared with not-for-profit hospitals, major teaching hospitals, and for-profit hospitals. However, the improved outcomes observed in specialty hospitals were significantly attenuated by progressive risk-adjustment and were much smaller among STEMI patients. In aggregate, these results suggest that physician-owned specialty hospitals generate improved patient outcomes but some of this advantage can be accounted for by differences in the complexity of patients treated in the different groups of hospitals.

Our findings extend the current evidence surrounding the potential benefits of specialty hospitals both in the area of cardiovascular disease. Previous studies have demonstrated improved outcomes for specialty hospitals across an array of conditions including PCI, bypass surgery, acute myocardial infarction, and congestive heart failure though these benefits were somewhat attenuated with adjustment for differences in patient case-mix and hospital procedural volume.^{10,11,22} A key limitation of these prior studies have been their exclusive reliance upon administrative data that inadequately captures patient complexity.^{23,24} Given these findings, prior investigators have often expressed concern that the improved outcomes in specialty hospitals may have been the result of unmeasured differences in patient complexity. In many ways, the results of the current study confirm prior study results by demonstrating that specialty hospitals have improved patient outcomes but that at least some of this advantage is related to differences in case-mix; much of the advantage of specialty hospitals disappears in analyses that adjust for differences in patient comorbidity and specialty hospitals have no measurable improvement in mortality among STEMI patients.

In interpreting our results it is important to acknowledge significant and lingering concerns over physician-owned specialty hospitals and the conundrum that they represent. In particular, prior studies have provided evidence that specialty hospitals may avoid more complex patients who are also more costly and less profitable to care for and may drive up utilization of costly interventional procedures.^{15,25} These findings have led to an acrimonious debate at the federal and state level over the wisdom of allowing physicians to invest in hospitals, with many critics calling for an outright ban on physician ownership.²⁶ While banning physician ownership of hospitals is an intuitively appealing solution, such a solution would likely eliminate the chance to obtain knowledge from a group of hospitals that appear to deliver improved outcomes.

Thus, it is important to consider how specialty hospitals may improve patient outcomes. There has been some thought that hospital specialization is merely an alternative measure of hospital procedural volume. However, a growing body of literature now suggests that hospital specialization may be an independent predictor of improved patient outcomes even after accounting for volume.²⁷ In our current analysis we find that adding hospital PCI volume to our models has little impact on the mortality advantage observed in specialty hospitals. It is possible that the improved outcomes seen in specialty hospitals relate to the much maligned physician ownership or the standardization of care that comes with specialization around a single condition or disease. Physician owners of specialty hospitals have strong personal and financial ties to their hospital's success. It is plausible that physician-owners are more engaged in day-to-day hospital operations or more committed to quality improvement efforts than they would without ownership. Such questions warrant further investigation, perhaps using qualitative methods.^{28,29} While it may not be feasible or desirable for most hospitals convert to specialty physician-ownership, lessons learned from specialty hospitals could be implemented widely.

There are a number of limitations to our study. First, while we used a clinical registry with rigorous quality control, the possibility for miscoding (deliberate or accidental) is a concern. The current ACC audit system is not able to validate the veracity of all clinical data elements. Second, while our registry contained a wealth of clinical data, it did not contain all variables of potential interest including detailed information on patients' socioeconomic status or educational attainment. Third, our assessment was limited to in-hospital PCI outcomes and we were unable to assess longer-term outcomes, such as the need for repeat revascularization. Fourth, our study was limited to hospitals participating in the CathPCI Registry that could be linked to Medicare and AHA data and findings should be extrapolated to other hospitals with caution. Likewise, the absolute number of specialty hospitals in our study and in the U.S. is small. Fifth, much of our analysis focused on in-hospital mortality and did not focus as much on other important outcomes including those captured in the CathPCI registry (e.g., bleeding or vascular complications) and those that are not (long term Quality-of-Life). Finally, our stratification of hospitals into four groups is admittedly coarse and does not allow us to examine heterogeneity that might occur among hospitals within a given category.

In summary, we found significantly lower rates of adverse outcomes among patients receiving PCI in specialty hospitals though these results were attenuated somewhat with risk-adjustment. These results add to evidence that physician-owned specialty hospitals may have developed expertise in narrow procedural areas that could be adapted to the larger population of general hospitals.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1
Characteristics of not for-profit, major teaching, for-profit, and physician-owned specialty hospitals

<i>Hospital Characteristics</i>	Not-for-profit n = 471	Major teaching n = 131	For-profit n = 79	Physician-owned specialty n = 13	P-Value
Hospital Region					
1 = West	110 (23.3%)	13 (9.9%)	27 (34.1%)	2 (15.4%)	< 0.001
2 = Northeast	50 (10.6%)	33 (25.1%)	1 (1.2%)	0 (0.0%)	
3 = Midwest	166 (35.2%)	46 (35.1%)	6 (7.6%)	5 (38.5%)	
4 = South	145 (30.7%)	39 (29.7%)	45 (57.0%)	6 (46.2%)	
Hospital Beds, Mean (sd)	351 ± 165	614 ± 225	290 ± 146	97 ± 129	< 0.001
Surgical Backup, number (%)	386 (82.0%)	125 (96.2%)	56 (71.8%)	12 (92.3%)	< 0.001
PCI Volume, Mean (sd)	628 ± 496	967 ± 669	406 ± 334	1053 ± 506	< 0.001
Total Cath Volume, Mean (sd)	1636 ± 1224	2645 ± 1858	1293 ± 969	1975 ± 1111	< 0.001
Number of days contributing data during the study period	865 ± 318	820 ± 353	628 ± 341	970 ± 368	< 0.001
Mean ± SD	90	92	90	183	
Min	1454	1459	1327	1379	
Max					

Table 2
Characteristics of patients treated in study hospitals

	Not-for-Profit n = 713642	Major Teaching n = 308372	For-Profit n = 54545	Physician-owned Specialty n = 36995	P-Value
Demographics					
Patient Age Years, mean (sd)	64.21 ± 12.15	63.84 ± 12.23	64.20 ± 12.24	65.16 ± 11.95	< 0.001
Gender, number (%) Male	472904 (66.27%)	207244 (67.21%)	36339 (66.62%)	24194 (65.40%)	< 0.001
Race/Ethnicity, number (%)					< 0.001
Caucasian	621344 (87.16%)	259142 (84.16%)	44107 (80.95%)	33299 (90.07%)	
Black	38178 (5.36%)	25471 (8.27%)	3439 (6.31%)	1700 (4.60%)	
Hispanic	17313 (2.43%)	6782 (2.20%)	3563 (6.54%)	1526 (4.13%)	
Asian	9573 (1.34%)	2929 (0.95%)	702 (1.29%)	112 (0.30%)	
Native American	1944 (0.27%)	655 (0.21%)	499 (0.92%)	43 (0.12%)	
Other	24523 (3.44%)	12950 (4.21%)	2176 (3.99%)	291 (0.79%)	
Admission Source, number (%)					< 0.001
Outpatient Referral	318427 (44.63%)	136032 (44.12%)	24528 (45.00%)	22212 (60.05%)	
Emergency Department	237108 (33.23%)	75522 (24.49%)	19926 (36.56%)	6245 (16.88%)	
Transfer-Acute Care Facility	138449 (19.40%)	87545 (28.39%)	8440 (15.48%)	7066 (19.10%)	
Transfer-Non-Acute Care Facility	8888 (1.25%)	3627 (1.18%)	500 (0.92%)	1340 (3.62%)	
Other	10609 (1.49%)	5603 (1.82%)	1113 (2.04%)	127 (0.34%)	
Inpatient Status at time of PCI	606149 (84.95%)	264766 (85.87%)	45849 (84.07%)	30849 (83.39%)	< 0.001
Insurance Payer, number (%)					< 0.001
Government	373753 (52.39%)	158080 (51.28%)	28706 (52.67%)	21838 (59.03%)	
Commercial	224753 (31.50%)	87834 (28.50%)	15866 (29.11%)	11251 (30.41%)	
HMO	77949 (10.93%)	45058 (14.62%)	7212 (13.23%)	2162 (5.84%)	
None	36591 (5.13%)	16734 (5.43%)	2669 (4.90%)	1723 (4.66%)	
Non U.S. Insurance	413 (0.06%)	534 (0.17%)	51 (0.09%)	19 (0.05%)	
Comorbidities, number (%)					

	Not-for-Profit n = 713642	Major Teaching n = 308372	For-Profit n = 54545	Physician-owned Specialty n = 36995	P-Value
Previous MI (>7 Days)	190691 (26.72%)	92681 (30.06%)	14262 (26.15%)	11601 (31.36%)	< 0.001
CHF	70964 (9.94%)	33417 (10.84%)	5450 (9.99%)	4727 (12.78%)	< 0.001
Previous Valvular Surgery	7462 (1.05%)	3756 (1.22%)	579 (1.06%)	512 (1.38%)	< 0.001
Previous Cardiac Transplant	1021 (0.14%)	803 (0.26%)	244 (0.45%)	27 (0.07%)	< 0.001
Previous CABG	131307 (18.40%)	58913 (19.11%)	9511 (17.44%)	8812 (23.82%)	< 0.001
Previous PCI	257899 (36.14%)	108437 (35.17%)	18474 (33.87%)	15832 (42.79%)	< 0.001
Diabetes	230620 (32.32%)	103425 (33.54%)	17961 (32.93%)	11987 (32.40%)	< 0.001
Previous History - Renal Failure	35936 (5.04%)	18331 (5.94%)	2906 (5.33%)	1943 (5.25%)	< 0.001
Hypertension	540865 (75.79%)	240685 (78.05%)	42083 (77.16%)	28947 (78.25%)	< 0.001
Clinical Presentation, number (%)					
PCI Urgency					
Elective	342680 (48.03%)	148546 (48.17%)	29594 (54.26%)	18919 (51.16%)	< 0.001
Urgent	256444 (35.94%)	111531 (36.17%)	15514 (28.44%)	14352 (38.81%)	
Emergency	112506 (15.77%)	47376 (15.36%)	9305 (17.06%)	3531 (9.55%)	
Salvage	1915 (0.27%)	902 (0.29%)	130 (0.24%)	178 (0.48%)	
Cardiogenic Shock	15383 (2.16%)	6599 (2.14%)	1333 (2.44%)	453 (1.22%)	< 0.001
Ejection Fraction, mean (sd)	52.87 ± 12.80	51.41 ± 12.60	53.41 ± 12.48	51.35 ± 12.57	< 0.001
PCI Indications, number (%)					
STEMI/Survival Benefit	113913 (15.96%)	47909 (15.54%)	9132 (16.74%)	4488 (12.13%)	< 0.001
Potential QOL Benefit	569594 (79.82%)	246609 (79.97%)	42864 (78.58%)	30621 (82.77%)	
Unclear Indications	30135 (4.22%)	13854 (4.49%)	2549 (4.67%)	1886 (5.10%)	

Table 3

PCI outcomes in four categories of hospitals

	Not-for-Profit n = 713642	Major Teaching n = 308372	For-Profit n = 54545	Physician-owned Specialty n = 36995	P-Value
PCI Outcomes- all patients, number (%)					
CVA/Stroke	2466 (0.35%)	725 (0.24%)	98 (0.18%)	58 (0.16%)	<0.001
Bleeding Complication *	15830 (2.22%)	8125 (2.63%)	1275 (2.34%)	433 (1.17%)	<0.001
Vascular Complication **	6128 (0.86%)	2648 (0.86%)	412 (0.76%)	204 (0.55%)	<0.001
In Hospital Mortality	8849 (1.24%)	4234 (1.37%)	780 (1.43%)	271 (0.73%)	<0.001
In Lab Mortality	1061 (0.15%)	524 (0.17%)	94 (0.17%)	25 (0.07%)	<0.001
≥ 1 adverse outcome	29488 (4.13%)	14202 (4.61%)	2349 (4.31%)	882 (2.38%)	<0.001
PCI Outcomes- STEMI, number (%)	Not-for-Profit n = 113913	Major Teaching n = 47909	For-Profit n = 9132	Physician-owned Specialty n = 4488	
CVA/Stroke	689 (0.60%)	260 (0.54%)	34 (0.37%)	18 (0.40%)	0.009
Bleeding	5313 (4.66%)	2812 (5.87%)	409 (4.48%)	124 (2.76%)	<0.001
Vascular	1132 (0.99%)	463 (0.97%)	83 (0.91%)	34 (0.76%)	0.383
In Hospital Mortality	5074 (4.45%)	2438 (5.09%)	454 (4.97%)	173 (3.85%)	<0.001
In Lab Mortality	649 (0.57%)	337 (0.70%)	62 (0.68%)	15 (0.33%)	<0.001
≥ 1 adverse outcome	10906 (9.57%)	5336 (11.14%)	891 (9.76%)	315 (7.02%)	<0.001
PCI Outcomes- QOL benefit, number (%)	Not-for-Profit n = 569594	Major Teaching n = 246609	For-Profit n = 42864	Physician-owned Specialty n = 30621	
CVA/Stroke	1695 (0.30%)	446 (0.18%)	57 (0.13%)	39 (0.13%)	<0.001
Bleeding	10040 (1.76%)	5028 (2.04%)	813 (1.90%)	299 (0.98%)	<0.001
Vascular	4747 (0.83%)	2050 (0.83%)	313 (0.73%)	156 (0.51%)	<0.001
In Hospital Mortality	3510 (0.62%)	1653 (0.67%)	303 (0.71%)	90 (0.29%)	<0.001
In Lab Mortality	391 (0.07%)	171 (0.07%)	31 (0.07%)	10 (0.03%)	0.119
≥ 1 adverse outcome	17627 (3.09%)	8348 (3.39%)	1370 (3.20%)	537 (1.75%)	<0.001
PCI Outcomes- unclear indications, number (%)	Not-for-Profit n = 30135	Major Teaching n = 13854	For-Profit n = 2549	Physician-owned Specialty n = 1886	
CVA/Stroke	82 (0.27%)	19 (0.14%)	7 (0.27%)	1 (0.05%)	0.015
Bleeding	477 (1.58%)	285 (2.06%)	53 (2.08%)	10 (0.53%)	<0.001
Vascular	249 (0.83%)	135 (0.97%)	16 (0.63%)	14 (0.74%)	0.215
In Hospital Mortality	265 (0.88%)	143 (1.03%)	23 (0.90%)	8 (0.42%)	0.056

	Not-for-Profit n = 713642	Major Teaching n = 308372	For-Profit n = 54545	Physician-owned Specialty n = 36995	P-Value
In Lab Mortality	21 (0.07%)	16 (0.12%)	1 (0.04%)	0 (0.00%)	0.195
≥ 1 adverse outcome	955 (3.17%)	518 (3.74%)	88 (3.45%)	30 (1.59%)	< 0.001

* Bleeding includes bleeding at percutaneous entry site, retroperitoneal bleeding, GI bleeding, G/U bleeding or other site

** Vascular complication includes vascular occlusion at access site, peripheral embolization, dissection or pseudoaneurysm formation

Table 4
Risk Standardized Mortality Rates (RSMR) for hospitals with varying ownership

	Population N=694	Not-for-Profit N=471	Major Teaching N=131	For-Profit N=79	Physician-owned Specialty N=13	P-value
ALL Patients						
RSMR	1.27	1.30 (1.26-1.33)	1.38 (1.33-1.43)	1.39 (1.27-1.51)	1.05 (0.91-1.20)	<0.001
Not for Profit Comparison (p-value)		NA	0.005	0.15	0.002	
STEMI Patients						
RSMR	4.64	4.62 (4.52-4.73)	4.89 (4.73-5.05)	4.93 (4.56-5.29)	4.29 (3.77-4.81)	0.009
Not for Profit Comparison (p-value)		NA	0.006	0.11	0.22	
QoL Patients						
RSMR	0.62	0.65 (0.63-0.67)	0.68 (0.65-0.71)	0.69 (0.61-0.76)	0.47 (0.38-0.56)	<0.001
Not for Profit Comparison (p-value)		NA	0.12	0.37	<0.001	
Unclear Indications						
RSMR	0.91	1.05 (0.98-1.13)	1.10 (0.98-1.21)	1.02 (0.76-1.27)	0.81 (0.51-1.11)	0.359
Not for Profit Comparison (p-value)		NA	0.54	0.78	0.12	

RSMR models used standard NCDR risk adjustment mortality models that adjusted for patient demographics, comorbidity, and acuity. Additional information is available at: <http://www.ncdr.com>

Table 5
Mortality for hospitals with varying ownership after adjusting for patient characteristics and hospital PCI volume

	Not-for-Profit n = 713642	Major Teaching n = 308372	For-Profit n = 54545	Physician-owned Specialty n = 36995
<i>ALL Patients</i>				
Unadjusted	1(REF)	1.11 (1.07-1.15)	1.15 (1.07-1.24)	0.59 (0.52-0.66)
Adjusted (Patient Factors)	1(REF)	1.06 (1.02-1.11)	1.22 (1.12-1.33)	0.73 (0.64-0.83)
Adjusted (Patient + Hospital Volume)	1(REF)	1.08 (1.03-1.13)	1.21 (1.11-1.31)	0.74 (0.64-0.84)
Adjusted (Patient + Hospital Volume + Site as Random Effect)	1(REF)	1.13 (1.03-1.24)	1.18 (1.03-1.35)	0.79 (0.61-1.03)
<i>STEMI</i>	Not-for-Profit n = 113913	Major Teaching n = 47909	For-Profit n = 9132	Physician-owned Specialty n = 4488
Unadjusted	1(REF)	1.15 (1.09-1.21)	1.12 (1.02-1.24)	0.86 (0.74-1.00)
Adjusted (Patient Factors)	1(REF)	1.12 (1.06-1.19)	1.21 (1.08-1.35)	0.89 (0.75-1.06)
Adjusted (Patient + Hospital Volume)	1(REF)	1.12 (1.06-1.19)	1.21 (1.08-1.35)	0.89 (0.75-1.06)
Adjusted (Patient + Hospital Volume + Site as Random Effect)	1(REF)	1.16 (1.05-1.29)	1.18 (1.01-1.38)	1.05 (0.78-1.41)
<i>QoL Benefit</i>	Not-for-Profit n = 569594	Major Teaching n = 246609	For-Profit n = 42864	Physician-owned Specialty n = 30621
Unadjusted	1(REF)	1.09 (1.03-1.15)	1.15 (1.02-1.29)	0.48 (0.39-0.59)
Adjusted (Patient Factors)	1(REF)	1.00 (0.94-1.07)	1.23 (1.08-1.40)	0.57 (0.46-0.71)
Adjusted (Patient + Hospital Volume)	1(REF)	1.03 (0.96-1.10)	1.21 (1.06-1.37)	0.58 (0.46-0.72)
Adjusted (Patient + Hospital Volume + Site as Random Effect)	1(REF)	1.08 (0.97-1.21)	1.18 (0.99-1.40)	0.57 (0.41-0.80)
<i>Unclear Indications</i>	Not-for-Profit n = 30135	Major Teaching n = 13854	For-Profit n = 2549	Physician-owned Specialty n = 1886
Unadjusted	1(REF)	1.18 (0.96-1.44)	1.03 (0.67-1.57)	0.48 (0.24-0.97)
Adjusted (Patient Factors)	1(REF)	1.06 (0.85-1.32)	1.13 (0.72-1.78)	0.60 (0.28-1.28)
Adjusted (Patient + Hospital Volume)	1(REF)	1.13 (0.90-1.43)	1.09 (0.69-1.71)	0.63 (0.30-1.34)
Adjusted (Patient + Hospital Volume + Site as Random Effect)	1(REF)	1.13 (0.85-1.49)	1.10 (0.67-1.81)	0.64 (0.27-1.49)