Do All Hospital Systems Have Market Power? Association Between Hospital System Types and Cardiac Surgery Prices

Sung W. Choi, PhD1 and Avi Dor, PhD2

Abstract

Objective: This study explores the price implications of hospital systems by analyzing the association of system characteristics with selected cardiac surgery pricing.

Data Source: Using a large private insurance claim database, the authors identified 11,282 coronary artery bypass graft (CABG) cases and 49,866 percutaneous coronary intervention (PCI) cases from 2002 to 2007.

Study Design: We conducted a retrospective observational study using generalized linear models.

Principal Findings: We found that the CABG and PCI prices in centralized health and physician insurance systems were significantly lower than the prices in stand-alone hospitals by 4.4% and 6.4%, respectively. In addition, the CABG and PCI prices in independent health systems were significantly lower than in stand-alone hospitals, by 15.4% and 14.5%, respectively.

Conclusion: The current antitrust guidelines tend to focus on the market share of merging parties and pay less attention to the characteristics of merging parties. The results of this study suggest that antitrust analysis could be more effective by considering characteristics of hospital systems.

Keywords

health economics, medical cost, efficiency, managed care, disease management

Introduction

The health-care sector in the United States has been in a process of transformation for more than 3 decades.1-3 Health-care providers, including hospitals, physician groups, and insurance plans, have created complex interorganizational relationships within hospital systems.4-7 Hospital systems, which are interorganizational consolidations arising from common ownership among hospitals, have become increasingly prevalent in the United States. In 2017, 3198 US-based community hospitals, accounting for 66% of all US-based community hospitals, were members of a hospital system.8

Among the many possible reasons, there are 2 main rationales behind the proliferation of hospital systems in the United States.9 One reason is a procompetitive efficiency gain from hospital system membership. System membership can enhance efficiency in health-care delivery by enabling participants to pool expensive medical devices to attain economies of scale or scope in health-care delivery and other administrative activities. The American Hospital Association (AHA) has urged hospitals to collaborate with one another to improve efficiency and constrain costs.10 The other reason is the enhanced market power by hospital system membership. Hospital systems can harm competition by leveraging their market power to raise the price of care. Karen Ignagni, the president of America’s Health Insurance Plans, said “the rhetoric is all about efficiency, but the reality is all about higher prices.”11 Hence, the overall competitive effect of hospital system membership is an empirical question.

1 Health Administration, School of Public Affairs, The Pennsylvania State University, Harrisburg, PA, USA
2 Health Policy and Management, Milken Institute School of Public Health, The George Washington University, Washington, DC, USA

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Corresponding Author:
Sung W. Choi, Health Administration, School of Public Affairs, The Pennsylvania State University, 777 West Harrisburg Pike, Middletown, PA 17057, USA.
Email: sxc835@psu.edu

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**Literature Review**

Health-care expenditures in the United States have steadily increased for decades, and in most cases, the growth rate was faster than that of the consumer price index.\(^{12-15}\) Hospital consolidation in the 1990s was suggested as a driver of hospital prices, and those consolidation activities were responsible for a growth of at least 5\% in hospital prices.\(^{16}\)

Many empirical studies of hospital systems have investigated the price implications of hospital system membership. They found that hospital systems have been able to use their enhanced market power over insurers and increase prices more rapidly than stand-alone hospitals.\(^{8,17-21}\)

Most studies that investigated the price effects of hospital system membership used average or list prices as price measures due to data limitations. Neither average nor list prices are accurate measures of actual prices. List prices do not capture payment discounts from insurers to hospitals. When total payments are divided by the total quantity of care to obtain an average value, the varying mixes of services within hospitals cannot be captured by the average payment.\(^{22}\) The measurement errors and information loss due to the use of list or average prices can bias estimates of hospital system payments.

Transaction prices are the actual payments from insurers to providers in the form of reimbursements for health-care services provided.\(^{23}\) Transaction price is different from list or average price because the transaction price refers to a specific admission at the patient level rather than all admissions at the hospital level. Several empirical studies have been able to use a unique data set that includes not only individual and clinical information but also actual payment information from insurers.\(^{17,22-26}\)

Transaction pricing studies for medical procedures found mixed results regarding the association between hospital system membership and surgery price. Some transaction pricing studies have demonstrated that hospital system membership is significantly associated with hospital prices.\(^{17,23}\) In other studies, hospital system membership was found to be insignificantly associated with hospital prices.\(^{26}\)

The mixed results for the price effects of hospital system membership can be explained by the operationalization of the system variable. The majority of articles used an indicator variable for hospital system membership.\(^{16,23,26}\) Other articles have focused more on local market characteristics, such as HMO penetration and market concentration, than on system membership.\(^{22,24,25}\)

Categorizing the massive restructuring of organizational arrangements among health-care providers since 1980s is not an easy task.\(^{27}\) Policy makers in antitrust and regulatory agencies have struggled to describe the responsibilities within those organizational arrangements.\(^{28}\) Although several case studies have focused on evolving health-care organizations, Bazzoli et al’s taxonomy can be regarded as the only empirical classification of hospital systems.\(^{29}\) This taxonomy contributed to the existing literature by generating empirically testable hypotheses for rapidly evolving health-care provider consolidations.

Bazzoli et al’s taxonomy categorized different groups of hospital systems that share a comparable degree of differentiation (note 1), integration (note 2), and centralization (note 3).\(^{29}\) Differentiation is defined as “selecting the type and scope of services to offer” among member hospitals.\(^{29}\) Organizations with a high level of differentiation provide distinguished health-care services among member organizations, whereas less differentiated organizations provide more uniform services among member organizations. Integration is defined as “the ability to pull the pieces together in order to maximize the value of the services provided.”\(^{29}\) Integration among participating organizations can be achieved through either direct ownership or contractual relationships.\(^{30,31}\) Although common ownerships can lower transaction costs and achieve economies of scale, contractual relationships can flexibly respond to changes in local markets. Centralization is defined as the “degree of health-care services provided at the system level.”\(^{29}\)

Centralized organizations provide most of their services at the system level, whereas decentralized organizations provide most services at the individual hospital level. Bazzoli et al chose hospital services, physician arrangements, and insurance products as key dimensions to be evaluated based on the criteria of differentiation, integration, and centralization.\(^{29}\)

Bazzoli et al identified 4 types of health systems using cluster analysis, categorizing different groups for systems that share a comparable degree of differentiation, integration, and centralization.\(^{29}\) The first cluster is the centralized health and physician insurance system (CHPIHS). These health systems distinguish themselves from other hospitals through their high-level centralization in hospital services, physician arrangements, and insurance products. These health systems are moderately differentiated in hospital services and physician arrangements. Most centralized hospital systems are closely located with member hospitals in urban areas. The CHPIHS is more likely to have strong efficiency gain through centralization and differentiation and have strong market power through small geographic dispersion, compared to stand-alone hospitals.

The second cluster is the moderately centralized health system (MCHS). These hospital systems show a moderate degree of centralization; thus, hospital services, physician arrangements, and insurance products are developed and delivered in both systems and individual hospital settings. Physician arrangements and insurance products in these systems are moderately differentiated among member hospitals, while hospital services are highly differentiated. Compared to the centralized health systems, these systems have a smaller number of member hospitals and more widespread geographic locations. The MCHS is more likely to have moderate efficiency gain through centralization and differentiation and have moderate market power due to large geographic dispersion, compared to stand-alone hospitals.

The third cluster is the decentralized health system (DHS). These health systems are widely decentralized in physician arrangements and insurance products but only moderately centralized in hospital services. Physician arrangements and insurance products are developed and provided at the individual
hospital level. Furthermore, these health systems are extensively differentiated in hospital services, physician arrangements, and insurance products. A few referrals are made among member hospitals. The number of DHS is not large, but the number of a member hospitals is large for each DHS. These DHS member hospitals are located over wide geographic locations. The DHS is more likely to have strong efficiency gain through centralization and differentiation and have strong market power through integration, compared to stand-alone hospitals. The DHS is more likely to have strong efficiency gain through differentiation and have moderate market power due to large dispersion among members, compared to stand-alone hospitals.

The fourth cluster is the independent health system (IHS), whose members have a low level of differentiation and centralization in hospital services, physician arrangements, and insurance products. Almost no referral is made among the member hospitals, and many of these hospital systems are positioned in suburban areas with a small number of member hospitals. The IHS is more likely to have moderate efficiency gain through centralization and differentiation and have low market power due to small number of member hospitals, compared to stand-alone hospitals.

The contributions of this study to the body of health policy literature are as follows: First, this study is an empirical application of a comprehensive taxonomy of hospital systems to procedure-level pricing studies. Bazzoli et al developed an empirically analyzable comprehensive taxonomy of hospital systems based on different patterns of hospital services, physician arrangements, and insurance products.29 This comprehensive taxonomy of hospital systems has been extensively tested in empirical investigations of hospital systems.32–38 Previous medical procedure pricing studies adopted an indicator variable for hospital system membership, resulting in the loss of information across different characteristics of hospital systems.

Second, this study analyzes the transaction prices of cardiac surgeries rather than the list or average prices. Private insurers in the United States pay providers based on negotiated payment rates determined via provider–insurer bargaining.39 Hospitals negotiate payment rates for each procedure with each insurer once a year, leading to substantial variation in reimbursement rates across insurers.40 The transaction prices that the hospital actually receives are determined by negotiations between hospitals and insurers. Hence, transaction price is a better measure of the true price of private health-care service, and this study explores private insurers’ cardiac procedure pricing to analyze its association with hospital system membership.

Finally, this study aims to contribute to ongoing policy discussions related to antitrust guidelines in the health-care market. The Department of Justice (DOJ) and Federal Trade Commission (FTC) have been keeping an eye on hospital systems and potential market power that could distort market competition. From 1989 to 1993, 8 hospital mergers out of more than 200 were challenged by the DOJ and FTC due to the potential anticompetitive effects of those mergers.41 According to the horizontal merger guidelines of the DOJ and FTC, mergers that raise significant antitrust concern are determined by the current level and the change in the market concentration.42

The current antitrust guidelines tend to focus on the market share of the merging parties and pay less attention to the characteristics of the merging parties. Market power is defined as “the ability to profitably maintain prices above competitive levels for a significant period of time.”42 This study aims to analyze whether hospital systems with certain characteristics have significantly higher prices than other hospitals. In this way, we want to improve the current horizontal merger guidelines by determining whether market concentration is the only source of market power.

Method

Data and Study Sample

The main data source for this study was MarketScan commercial claims and encounter data. MarketScan is one of the largest multisource private health insurance databases in the United States. It covers individual demographics, financial measures, and clinical information from health plans and hospitals. At the individual level, MarketScan collects details for 23 million employees and their family members from approximately 100 large private employers and insurance plans.43 This study analyzed MarketScan commercial claims and encounter data from 2002 to 2007.

The AHA Annual Survey Database was another data source for this study. The AHA Annual Survey Database is a nationally representative hospital database in the United States that collects provider information, including organizational structure, inpatient and outpatient utilization, expenses, physician arrangements, purchasing affiliations, and geographic indicators. This annual survey includes information on “6500 hospitals, 400-plus health-care systems, networks and alliances, 700 health-care organizations and associations, 700 governmental agencies, and 3000 other accredited providers.”44

This study analyzed coronary artery bypass graft surgery (CABG) and percutaneous coronary intervention (PCI) admissions because each procedure satisfies the following conditions: (1) The selected surgery is associated with well-defined surgical procedures in patient-level databases; (2) the selected surgery is among the most common procedures in the United States; (3) the selected surgeries are not discretionary procedures; and (4) the selected surgery is not substitutable for outpatient care.

The study sample included all hospital admissions undergoing a CABG or PCI procedure between January 1, 2002, and December 31, 2007, from the MarketScan commercial claim and encounter data (Figure 1). Among all cases with CABG (n = 53,392), we excluded the following: (1) cases that were 3% outliers in terms of price; (2) cases for which the principal procedure was not CABG; and (3) cases for which the AHA identifier was missing. The final sample size was 11,282 CABG admissions for 2002 to 2007. Following the same exclusion criteria, the
The coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI) samples and exclusion criteria.

**Table 1. Procedural Codes for Cardiac Procedures.**

| ICD-9 Diagnosis Codes | CPT Procedure Codes |
|-----------------------|---------------------|
| Coronary artery bypass graft | Vein only (33510, 33511, 33512, 33513, 33514, 33515, 33516), Venous and arterial graft (33517, 33518, 33519, 33521, 33522, 33523), arterial graft (33533, 33534, 33535, 33536) |
| Percutaneous coronary intervention | Balloon (92982, 92984, 92975), stent procedure (92980, 92981), drug-eluting (G0290, G0291) |

Abbreviations: CPT, Current Procedural Terminology; ICD-9, International Classification of Diseases, Ninth Revision.

The study identified 49,866 PCI admissions. Figure 1 shows the final PCI sample and exclusion criteria in detail.

Table 1 shows the diagnosis and procedure codes for selected cardiac surgeries. All cardiac surgeries were defined in a manner to maximize comparability among procedures as much as possible. In addition, all procedures were segregated by their severity and complexity.

**Variable Definitions**

The dependent variable of this study was the transaction price of cardiac surgeries. This study analyzed the transaction price, that is, the actual payment from insurers to providers during the hospitalization stay. The independent variables of this study were divided into 3 groups: The first group of independent variables was patient characteristics.

The MarketScan commercial claim and encounter data include the age and sex of enrollees; the ethnicity information
of enrollees is not reported in the data. Detailed procedural codes were used to control for patients' disease severity. The Elixhauser index was adopted as the comorbidity index. Comorbidity is defined as "A clinical condition that exists before a patient’s admission to the hospital, is not related to the principal reason for the hospitalization and is likely to be a significant factor influencing mortality and resource use in the hospital."\textsuperscript{45} In this article, comorbidity conditions were operationalized as 4 categorical variables that reflect the number of comorbidities (0, 1, 2, and 3+).

The MarketScan data incorporate varying types of health insurance plans, including basic/major medical plans, comprehensive plans, exclusive provider organization plans, health maintenance organizations (HMOs) plans, noncapitated point of service plans (POS), preferred provider organizations (PPOs) plans, capitated or partially capitated POS plans, and consumer-driven health plans (CDHP). Following Dor et al, this study categorized these plans into 4 groups: fee-based plans, POS plans, HMO plans, and CDHP plans.

The second group of independent variables was hospital attributes. Among the hospital attributes from the AHA Annual Survey, this study controlled for hospital ownership, teaching status, system membership, and system clusters. The AHA Annual Survey identifies 4 types of hospital ownership: (1) government, nonfederal; (2) nongovernment, not for profit; (3) investor owned, for profit; and (4) government, federal. This study defined the hospital ownership types as private not for profit, private for profit, and public. Teaching hospitals were defined as affiliated member hospitals of the Council of Teaching Hospitals and Health Systems. As previously described, clusters of system membership are defined as CHPIHS, MCHS, DHS, and IHS. The status of hospital network membership was also included as an independent variable. The reference group for the hospital system variable was stand-alone hospitals, which do not belong to any hospital system. The reference group for the hospital network variable was non-network hospitals.

The third group of independent variables was the local market condition. The HMO penetration is defined as the number of HMO enrollees divided by the total population in the market. The Herfindahl-Hirschman Index (HHI), which is the sum of squared market share of all the hospitals in the market, was used as a hospital market concentration measure.\textsuperscript{46} Hospital referral region by the Dartmouth Atlas of Health Care was used as the geographic market definition to calculate market competition.

**Analytic Methods**

Individual-level price regressions were performed separately for the CABG and PCI samples. The price equation for each procedure is given by the equation:

\[
p_{ijt} = \alpha + \beta \cdot X_{it} + \gamma \cdot M_{ht} + \delta \cdot Z_{jt} + \mu_j + \epsilon_{ijt},
\]

where \(i\), \(h\), \(j\), and \(t\) index the individual, hospital, local market, and year, respectively. The vector \(X_{it}\) refers to the patient characteristics, including age, sex, disease severity, comorbidity, and health insurance plan type.

Different sets of patient severity measures were adopted across procedures. The number of vessels treated, including single CABG with 1 vessel, 2 vessels, 3 vessels, and 4 or more vessels, was the measure of patient severity for the cases with CABG. Those who underwent multiple CABGs, for example, 2-vessel CABG and 4-vessel CABG performed in a single episode of care, were the reference group for the patients with CABG.

Three different PCI types accounted for 49,866 PCI admissions: (1) balloon procedures; (2) drug-eluting procedures; and (3) stent procedures. Patient severity for the balloon and drug-eluting procedures was measured by the number of vessels treated, while patient severity for the stent procedure was measured by the number of stents used. Another severity measure was included for those who underwent thrombolytic infusion surgery, which is the injection of a blood clot–bursting drug. Likewise, the reference group for the PCI admissions was patients who underwent multiple PCIs in a single episode of care. Three Elixhauser variables for comorbidities (1, 2, 3+) were included, and the no comorbidity (0) group constituted the reference category. Three plan types (HMOs, POS, and CDHP) were included; the reference category was fee-based plans.

The vector \(M_{ht}\) refers to hospital \(h\)'s attributes, including private not for profit, private for profit, teaching status, network membership, and system cluster (CHPIHS, MSHS, DHS, and IHS). The reference categories for ownership, teaching status, and system membership were public hospitals, nonteaching hospitals, and stand-alone hospitals, respectively. The vector \(Z_{jt}\) refers to local market conditions, including HMO penetration rate and the HHI. The variable refers to the year effect, and refers to the random effect.

The transaction price variable had a right-skewed distribution, which is a typical characteristic of health-care outcome variables. This tail problem violates the assumptions of linear regression and can cause biased estimates of the standard errors. One standard method of robust estimation is log transformation to smooth skewed distributions in statistical estimation.\textsuperscript{47} When the dependent variable is log-transformed, the results should be back-transformed into the original scale for meaningful interpretation of the results. Several retransformation methods were available for this process.\textsuperscript{48,49} However, it is complicated to retransform when heteroskedasticity is present.\textsuperscript{49,50}

As an alternative method, generalized linear models (GLMs) were developed and tested among economists.\textsuperscript{51,52} The GLM method solves the retransformation issue by using the link function instead of transforming the dependent variable itself.\textsuperscript{52} In addition, the presence of heteroskedasticity can be controlled by a variance structure in the model.\textsuperscript{53} This study used the GLM method to obtain robust standard errors in the price equations with log-link and Gaussian distribution.
The CABG sample consisted of 11,282 patients whose principal procedure was CABG (Table 2). The average CABG price for all sample hospital admissions was US$36,712. The average CABG vary across system type from US$33,441 of IHS to US$37,203 of DHS. In the CABG sample, CHPIHS were more likely to be private not for profit, teaching, network affiliated, and large in terms of size and market share than stand-alone hospital (SAH). In addition, CHPIHS were located in more concentrated market, higher HMO penetration rate, and larger metropolitan area than SAH. The PCI sample included 49,866 patients whose main reason for hospitalization was PCI. The average unadjusted PCI price for this sample was US$22,485 (Table 3). The average PCI value across system type from US$19,885 of IHS to US$23,696 of DHS. In the PCI sample, CHPIHS were more likely to be not for profit, teaching, network affiliated, and large in terms of size and market share. In addition, CHPIHS were located in more concentrated market, higher HMO penetration rate, and had higher portion of emergency PCI delivery than SAH. Market concentration was measured using system HHI, which was 0.194 for the CABG sample and 0.198 for the PCI

### Descriptive Statistics

| Dependent variable | CHPIHS | MCHS | DHS | IHS | SAH | Total |
|--------------------|--------|------|-----|-----|-----|-------|
| Mean               | 36,802.6 | 36,035.6 | 37,057.3 | 37,035.6 | 36,711.9 | 36,802.6 |
| SD                 | 385.5   | 366.5 | 316.8 | 826.4 | 180.8 |

### Patient demographics

| Age               | 56.118 | 55.976 | 56.033 | 56.543 | 56.067 |
|-------------------|--------|--------|--------|--------|--------|
| Female (reference)| 0.208  | 0.182  | 0.306  | 0.305  | 0.204  |
| Male              | 0.792  | 0.818  | 0.709  | 0.795  | 0.796  |
| Elixhauser 0 (reference) | 0.393 | 0.323 | 0.131 | 0.154 | 0.409 |
| Elixhauser 1      | 0.323  | 0.320  | 0.175  | 0.158  | 0.378  |
| Elixhauser 2      | 0.131  | 0.175  | 0.161  | 0.378  | 0.801  |
| Elixhauser 3++    | 0.154  | 0.158  | 0.156  | 0.156  | 0.717  |
| Multi CABGs (reference) | 0.642 | 0.621 | 0.659 | 0.746 | 0.719 |
| Single CABG—1 vessel | 0.173 | 0.168 | 0.137 | 0.119 | 0.717 |
| Single CABG—2 vessels | 0.116 | 0.103 | 0.079 | 0.045 | 0.717 |
| Single CABG—3 vessels | 0.033 | 0.070 | 0.079 | 0.039 | 0.717 |
| Single CABG—4 vessels | 0.033 | 0.039 | 0.046 | 0.051 | 0.717 |
| Emergency          | 0.297  | 0.250  | 0.224  | 0.350  | 0.717 |
| Nonemergency (reference) | 0.703 | 0.750 | 0.776 | 0.650 | 0.717 |

### Hospital characteristics

| Private not-for-profit | 0.933  | 0.885  | 0.673  | 0.717  | 0.719  |
| Private for-profit     | 0.000  | 0.106  | 0.013  | 0.193  | 0.224  |
| Public (reference)    | 0.067  | 0.242  | 0.214  | 0.183  | 0.764  |
| Teaching              | 0.535  | 0.758  | 0.786  | 0.817  | 0.715  |
| Nonteaching (reference) | 0.465 | 0.426 | 0.637  | 0.331  | 0.452  |
| Network               | 0.627  | 0.574  | 0.669  | 0.548  | 0.487  |
| Non-network (reference) | 0.373 | 0.358 | 0.390  | 0.100  | 2.905  |
| System size           | 4.601  | 5.054  | 3.950  | 3.026  | 2.905  |
| Market Share          | 0.313  | 0.258  | 0.246  | 0.261  | 2.905  |

### Insurance types

| Plan: Fee based (reference) | 0.737  | 0.727  | 0.811  | 0.807  | 0.799  |
| Plan: HMO                 | 0.115  | 0.124  | 0.069  | 0.090  | 0.774  |
| Plan: POS                 | 0.142  | 0.140  | 0.116  | 0.100  | 0.128  |
| Plan: CDHP                | 0.005  | 0.008  | 0.004  | 0.003  | 0.018  |

### Market structure

| System HHI          | 0.216  | 0.192  | 0.196  | 0.220  | 0.194  |
| HMO penetration     | 0.278  | 0.224  | 0.256  | 0.137  | 0.229  |
| Rural area (reference) | 0.077 | 0.036 | 0.009  | 0.109  | 0.054  |
| Small metro area    | 0.254  | 0.436  | 0.376  | 0.556  | 0.429  |
| Large metro area    | 0.669  | 0.532  | 0.615  | 0.334  | 0.516  |

### Table 2. Descriptive Statistics for the CABG by System Type.

| Dependent variable | CHPIHS | MCHS | DHS | IHS | SAH | Total |
|--------------------|--------|------|-----|-----|-----|-------|
| Mean               | 36,802.6 | 36,035.6 | 37,057.3 | 37,035.6 | 36,711.9 | 36,802.6 |
| SD                 | 385.5   | 366.5 | 316.8 | 826.4 | 180.8 |

### Abbreviations:

- CABG: coronary artery bypass grafting
- CDHP: consumer-driven health plans
- CHPIHS: centralized health and physician insurance system
- DHS: decentralized health system
- HH: Herfindahl-Hirschman Index
- HMO: health maintenance organizations
- IHS: independent health system
- MCHS: moderately centralized health system
- PCI: percutaneous coronary intervention
- POS: point of service plans
- SAH: stand-alone hospital
- SD: standard deviation

### Results

#### Descriptive Statistics

The CABG sample consisted of 11,282 patients whose principal procedure was CABG (Table 2). The average CABG price for all sample hospital admissions was US$36,712. The average CABG vary across system type from US$33,441 of IHS to US$37,203 of DHS. In the CABG sample, CHPIHS were more likely to be private not for profit, teaching, network affiliated, and large in terms of size and market share than stand-alone hospital (SAH). In addition, CHPIHS were located in more concentrated market, higher HMO penetration rate, and larger metropolitan area than SAH. The PCI sample included 49,866 patients whose main reason for hospitalization was PCI. The average unadjusted PCI price for this sample was US$22,485 (Table 3). The average PCI value across system type from US$19,885 of IHS to US$23,696 of DHS. In the PCI sample, CHPIHS were more likely to be not for profit, teaching, network affiliated, and large in terms of size and market share. In addition, CHPIHS were located in more concentrated market, higher HMO penetration rate, and had higher portion of emergency PCI delivery than SAH. Market concentration was measured using system HHI, which was 0.194 for the CABG sample and 0.198 for the PCI
The average HMO penetration rate was 22.9% for CABG sample and 21.5% for PCI sample. The rates are lower than the results of existing studies, which means the markets covered in this study were less concentrated than existing studies.54,55

For both groups, the average age of the patients was mid-50s (CABG: 56.06%; PCI: 54.18%). The majority were male (CABG: 80.4%; PCI: 77.2%). As measured by the Elixhauser index, 38.8% of the patients with CABG did not have any comorbid condition. The proportions of patients with CABG who had 1, 2, and 3 or more conditions were 30.8%, 15.3%, and 15.2%, respectively. Among the patients with PCI, 46.1% did not have any comorbid condition. The proportions of patients with PCI who had 1, 2, and 3 or more comorbid conditions were 31.3%, 14.4%, and 8.2%, respectively.

Multiple measures were adopted to control for severity among the patients with CABG and PCI. Approximately 15.4% of all patients with CABG underwent 1-vessel CABG, and 4.3% underwent CABG of 4 or more vessels. More than half (64.8%) had multiple CABG procedures during 1 episode of care. The proportion of CABG procedures performed in emergency settings was 24.5%.

### Table 3. Descriptive Statistics for the PCI by System Type.

| Dependent variable                  | CHPIHS | MCHS | DHS | IHS | SAH | Total |
|-------------------------------------|--------|------|-----|-----|-----|-------|
| Hospital price (US$)                | Mean   | SD   | Mean | SD  | Mean | SD    |
| Total                               | 23 276.3 | 189.0 | 23 695.9 | 115.8 | 22 883.4 | 153.8 | 19 885.4 | 339.1 | 21 950.3 | 76.5 | 22 485.8 | 56.1 |
| Mean                                | 25.490 | 0.111 | 25.493 | 0.072 | 25.413 | 0.081 | 25.020 | 0.232 | 25.155 | 0.042 | 25.685 | 0.031 |
| SD                                  | 0.276 | 0.006 | 0.276 | 0.004 | 0.276 | 0.005 | 0.276 | 0.005 | 0.276 | 0.005 | 0.276 | 0.005 |

**Abbreviations:** CABG, coronary artery bypass grafting; CDHP: consumer-driven health plans; CHPIHS, centralized health and physician insurance system; DHS, decentralized health system; HHI, Herfindahl-Hirschman Index; HMO: health maintenance organizations; IHS, independent health system; MCHS, moderately centralized health system; PCI, percutaneous coronary intervention; POS: point of service plans; SAH: stand-alone hospital; SD, standard deviation.
Among the cases with PCI, 83.3% underwent single PCI with 1 stent, and 0.1% underwent single PCI with multiple stents. The proportions of single PCI with 1-vessel and multiple-vessel PCIs were 4.7% and 0.1%, respectively. In addition, 0.1% of patients with PCI underwent thrombolytic infusion PCI and 11.7% underwent multiple PCI procedures during 1 episode of care. More than half (55.5%) of the patients received PCIs in emergency settings.

Regarding hospital characteristics, the 2 samples had comparable features. Privately owned not-for-profit hospitals accounted for 78.5% of CABG admissions and 74.1% of PCI admissions, while teaching hospitals accounted for 28.5% of CABG cases and 20.0% of cases with PCI. Network member hospitals performed 51.3% of CABG cases and 42.9% of PCI cases, while 64.4% of CABG cases and 43.9% of PCI cases were performed at system member hospitals. The proportions of CABGs performed at CHPHIS, MCHS, DHS, and IHS were 18.1%, 22.5%, 20.9%, and 2.8%, respectively. The proportions of PCIs performed at CHPHIS, MCHS, DHS, and IHS were 8.5%, 18.5%, 14.9%, and 1.9%, respectively.

The majority of patients with CABG and PCI were enrolled in fee-based health insurance plans (77.4% and 78.7%, respectively). The proportions of the HMO, POS, and CDHP/HDHP plans accounted for 10.0% of the reference group by 5.4% and 14.5%, respectively. The majority of patients with PCI underwent thrombolytic infusion PCI during 1 episode of care. More than half (55.5%) of PCI cases performed at CHPIHS, MCHS, DHS, and IHS were single PCI with 1 stent. The proportions of single PCI with 1 vessel was lower than that of the reference group by 38.4% (model 1) and 37.9% (model 2), respectively. The proportions of PCI cases performed at CHPIHS, MCHS, DHS, and IHS were 77.4%, 18.5%, 12.8%, and 18.1%, respectively. The proportions of single PCI with 1 stent was lower than that of the reference group by 7.3% (model 1) and 7.5% (model 2), respectively.

**Pricing Regressions**

Table 4 shows the results of pricing regressions for the 11,282 cases with CABG and 49,866 cases with PCI. For both samples, an indicator variable for hospital system status was adopted in model 1, while hospital system cluster variables were adopted in model 2. In general, the 2 models showed comparable coefficients and significance.

Comorbid conditions were significantly associated with the CABG and PCI prices. Having 1 comorbid condition was associated with the CABG price increases of 3.2% (model 1) and 3.4% (model 2). Having 3 or more comorbidities was associated with a 14.8% (model 2) increase in the CABG price. Similarly, having 1 comorbid condition was associated with PCI price increases of 8.2% (model 1) and 7.9% (model 2), respectively. Having 3 or more comorbid conditions was associated with a 17.1% (model 1 and 2) increase in the PCI price.

We also found that CABG and PCI prices were significantly associated with the patient severity measures. The price of single CABG with 1 vessel was lower than the multiple CABG price (reference group) by 9.3% (model 1) and 9.5% (model 2). The price of single CABG with 3 vessels was higher than that of the reference group by 5.4% (model 1) and 5.5% (model 2), respectively. The price of a single PCI with 1 stent was lower than the multiple PCI price (reference group) by 14.7% (model 1) and 14.6% (model 2), respectively. The price of a single PCI with 1 vessel was lower than that of the reference group by 38.4% (model 1) and 37.9% (model 2), respectively. The CABG and PCI prices in an emergency setting were higher than nonemergency CABG and PCI prices by 18.1% (model 2) and 23.6% (model 1 and 2), respectively.

The CABG and PCI prices were significantly associated with the characteristics of the hospital at which the procedures were performed. Private not-for-profit hospitals had lower CABG prices than public hospitals by 11.6% (model 1) and 12% (model 2), respectively. Private for-profit hospitals had higher PCI prices than public hospitals by 8.8% (model 1) and 8.9% (model 2), respectively. Network member hospitals had significantly higher CABG and PCI prices than non-network hospitals by 6.4% (model 1) and 5.0% (model 1), respectively.

Hospital system status variables were insignificantly associated with both CABG and PCI prices. System member hospitals’ CABG and PCI prices were not significantly different from that of stand-alone hospitals.

However, the association between system cluster variables and the cardiac procedure prices showed more meaningful results. The CHPHIS had significantly lower CABG and PCI prices than stand-alone hospitals by 4.4% and 6.4%, respectively. Moreover, IHS also had significantly lower CABG and PCI prices than stand-alone hospitals by 15.4% and 14.5%, respectively. The MCHS had a higher PCI price than stand-alone hospitals, while DHS had a lower PCI price than stand-alone hospitals. The results suggest that not all system member hospitals had higher CABG and PCI prices than stand-alone hospitals and there existed structural differences in CABG and PCI prices across system cluster.

The market share of hospital system also significantly associated with CABG and PCI prices. When market share increased by 10%, the CABG prices increased by 6.7% (model 1) and 6.5% (model 2), respectively. In the same situation, the PCI prices increased by 5.3% (model 1) and 5.2% (model 2), respectively. System size measured by the number of member hospitals was significantly associated with CABG and PCI prices, but the effect size was relatively small. The interaction term between system cluster and market share showed mixed effects on CABG and PCI prices. When the market share increased by 10%, the PCI prices for CHPHIS increased by 1.67%. For DHS, 10% increase in market share was associated with 4.2% decrease in CABG prices.

The type of health insurance plan was also significantly associated with the CABG and PCI prices. The CABG price for HMO enrollees was significantly lower than that of fee-based plan enrollees (reference group) by 8.4% (model 1) and 7.9% (model 2). The CABG price for patients with CDHP plans was 25.2% higher than that of the reference group (models 2). The PCI price for HMO enrollees was also lower than that of the reference group by 15.6% (model 1) and 15.8% (model 2). The PCI price for patients with a POS plan was higher than that of the reference group by 7.3% (model 1) and 7.5% (model 2).

Market concentration and HMO penetration rate were significantly associated with the PCI price. When the system HHI increased by 0.1, the CABG price decreased by 6.8% (models 1 and 2) and PCI price decreased by 5.0% (model 2). When the
Table 4. The Generalized Linear Model Results for the CABG and PCI Admissions.

|                  | CABG Model 1 | CABG Model 2 | PCI Model 1 | PCI Model 2 |
|------------------|--------------|--------------|-------------|-------------|
|                  | Parameter Estimate | Standard Error | Parameter Estimate | Standard Error | Parameter Estimate | Standard Error | Parameter Estimate | Standard Error |
| **Patient demographics** | | | | | | | | |
| Age × 10         | −0.009       | 0.008        | −0.009       | 0.008        | −0.026          | 0.003         | −0.027          | 0.003         |
| Male             | −0.006       | 0.012        | −0.008       | 0.012        | 0.026          | 0.006         | 0.027          | 0.006         |
| Elixhauser 1     | 0.032        | 0.012        | 0.034        | 0.012        | 0.082          | 0.006         | 0.079          | 0.006         |
| Elixhauser 2     | 0.133        | 0.014        | 0.135        | 0.014        | 0.115          | 0.007         | 0.114          | 0.007         |
| Elixhauser 3+    | 0.146        | 0.015        | 0.148        | 0.015        | 0.171          | 0.009         | 0.171          | 0.009         |
| Single vessels 1 | −0.093       | 0.014        | −0.095       | 0.014        | 0.171          | 0.009         | 0.171          | 0.009         |
| Single vessels 2 | 0.023        | 0.016        | 0.024        | 0.016        | 0.237          | 0.005         | 0.237          | 0.005         |
| Single vessels 3 | 0.054        | 0.019        | 0.055        | 0.019        | 0.237          | 0.005         | 0.237          | 0.005         |
| Single vessels 4+ | 0.016       | 0.024        | 0.018        | 0.024        | 0.237          | 0.005         | 0.237          | 0.005         |
| **Hospital characteristics** | | | | | | | | |
| One stent        | −0.147       | 0.008        | −0.146       | 0.008        | 0.008          | 0.009         | 0.008          | 0.009         |
| Multiple stents  | 0.008        | 0.109        | 0.010        | 0.109        | 0.010          | 0.109         | 0.010          | 0.109         |
| One vessel       | −0.384       | 0.015        | −0.379       | 0.015        | 0.007          | 0.012         | 0.007          | 0.012         |
| Multiple vessels | −1.093       | 0.175        | −1.070       | 0.182        | 0.066          | 0.076         | 0.066          | 0.076         |
| Thrombolytic infusion | 0.325        | 0.089        | 0.279        | 0.086        | 0.236          | 0.005         | 0.236          | 0.005         |
| Emergency        | 0.184        | 0.011        | 0.181        | 0.011        |  0.236         | 0.005         |  0.236         | 0.005         |
| **Market share** | | | | | | | | |
| System member    | −0.116       | 0.021        | 0.007        | 0.008        |  0.020         | 0.031         |  0.020         | 0.031         |
| System × market share | −0.220      | 0.054        | −0.012       | 0.024        |  | | |
| CHPIHS × market share | −0.044      | 0.018        | −0.064       | 0.013        |  | | |
| MCHS × market share | −0.021       | 0.016        | 0.052        | 0.008        |  | | |
| DHS × market share | −0.001       | 0.019        | −0.057       | 0.011        |  | | |
| IHS × market share | −0.154       | 0.045        | −0.145       | 0.020        |  | | |
| CHPIHS × market share | −0.061       | 0.049        | 0.167        | 0.034        |  | | |
| MCHS × market share | −0.272       | 0.080        | −0.125       | 0.027        |  | | |
| DHS × market share | −0.418       | 0.075        | 0.112        | 0.046        |  | | |
| IHS × market share | 0.025        | 0.093        | −0.035       | 0.132        |  | | |
| **Insurance type** | | | | | | | | |
| Plan: HMO        | −0.084       | 0.017        | −0.079       | 0.018        | −0.156          | 0.009         | −0.158          | 0.009         |
| Plan: POS        | −0.003       | 0.014        | −0.005       | 0.014        | −0.073          | 0.008         | −0.075          | 0.008         |
| Plan: CDHP/HDHP  | 0.250        | 0.063        | 0.252        | 0.063        | −0.046          | 0.032         | −0.053          | 0.032         |
| **Market structure** | | | | | | | | |
| HMO penetration × 10 | 0.007        | 0.004        | 0.006        | 0.004        | −0.015          | 0.002         | −0.012          | 0.002         |
| HHI system × 10  | −0.688       | 0.082        | −0.682       | 0.083        | −0.488          | 0.040         | −0.503          | 0.040         |
| Small metro area | 0.011        | 0.022        | 0.016        | 0.022        | −0.107          | 0.011         | −0.116          | 0.011         |
| Large metro area | −0.001       | 0.024        | 0.007        | 0.024        | −0.169          | 0.012         | −0.177          | 0.012         |
| **Year dummies** | | | | | | | | |
| 2003             | 0.074        | 0.019        | 0.073        | 0.019        | 0.100          | 0.014         | 0.098          | 0.014         |
| 2004             | 0.088        | 0.016        | 0.086        | 0.016        | 0.201          | 0.012         | 0.203          | 0.012         |
| 2005             | 0.158        | 0.020        | 0.154        | 0.018        | 0.240          | 0.012         | 0.240          | 0.012         |
| 2006             | 0.219        | 0.021        | 0.217        | 0.020        | 0.272          | 0.012         | 0.279          | 0.012         |
| 2007             | 0.222        | 0.025        | 0.214        | 0.024        | 0.298          | 0.013         | 0.296          | 0.012         |
| **Total**        | 11 282       | 49 866       | 11 282       | 49 866       | 11 282          | 49 866         | 11 282          | 49 866         |

Abbreviations: CABG, coronary artery bypass grafting; CHPIHS, centralized health and physician insurance system; DHS, decentralized health system; HHI, Herfindahl-Hirschman Index; IHS, independent health system; PCI, percutaneous coronary intervention; MCHS, moderately centralized health system

* P < .01.
* P < .1.
* P < .05.
HMO penetration increased by 10%, the PCI price decreased by 1.5% (model 1) and 1.2% (model 2), respectively.

Discussion

This study examined the association between hospital system membership and cardiac surgery prices. The results of this study show that CHPIHS and IHS had significantly lower CABG and PCI prices than stand-alone hospitals after controlling for patient characteristics, hospital attributes, and market conditions. Our results confirm the existing studies that found efficiency gains among system member hospitals.56,57

The DOJ and FTC guidelines for horizontal mergers and acquisitions explain the antitrust analysis process that the agencies use to evaluate the anticompetitive effects of hospital arrangements. The Antitrust Agencies regard mergers and acquisitions under the following conditions as potentially anticompetitive: First, significant antitrust concern arises for mergers and acquisitions that result in HHI increases of more than 100 points in either a moderately concentrated market (HHI between 1500 and 2500) or a highly concentrated market (HHI above 2500). Second, the Antitrust Agencies regard mergers and acquisitions resulting in HHI increases of more than 200 points as generating or reinforcing market power.58

According to the Horizontal Merger Guidelines, the definition of market power is “the ability to profitably maintain prices above competitive levels for a significant period of time.”42 The Antitrust Agencies determine potentially anticompetitive mergers and acquisitions based on the level of market concentration and the change in market concentration.58 However, there are many other sources of market power, including product quality, proximity to consumers, information, and so on.59 This study shows evidence that certain types of hospital systems (CHPIHS and IHS) have significantly lower prices of care than stand-alone hospitals. The results suggest that the Antitrust Agencies can improve the efficiency of antitrust analyses by focusing on moderately centralized hospital system.

This study also found a significant and positive association between hospital network membership and cardiac surgery prices (Table 3). The CABG price at network member hospitals was higher than that of stand-alone hospitals by 6.4% (models 1 and 2). In addition, the PCI price at network member hospitals was higher than that of stand-alone hospitals by 5.0% (model 1) and 3.6% (model 2).

The results are consistent with existing studies that emphasize that direct ownership in hospital systems can lead to better coordination of purpose, strategy, and action than contractual relationships in health networks.32 In addition, the transaction cost framework predicts that direct ownership in hospital systems can evade transaction costs, including monitoring and coordination, that can occur in contractual relationships among network member hospitals.60,61

Limited generalizability is a limitation of this study. The MarketScan data do not provide a representative sample of the US population. The results of this study can be generalized at most to Americans covered by employer-sponsored insurance. The MarketScan commercial claims and encounters data (2002-2007) were merged with the AHA Annual Survey Database using AHA identification numbers (AHA IDs). A considerable number of hospital admissions in the MarketScan data did not include AHA IDs, so the study sample included only those admissions with AHA IDs.

This study did not analyze the association between hospital network clusters and cardiac surgery prices. The original taxonomy by Bazzoli et al (1999) included different types of health network affiliations, such as centralized health networks, moderately centralized health networks, decentralized health networks, and independent health networks. However, the network type variables were not included in the AHA Annual Survey Database for 2002 to 2007. The results of this essay cannot be generalized to different clusters of hospital networks.

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ORCID iD

Sung W. Choi, PhD https://orcid.org/0000-0001-9990-762X
Avi Dor, PhD https://orcid.org/0000-0003-4475-4333

Notes

1. Organizations with a high level of differentiation provide distinctive health-care services among member organizations, whereas less differentiated organizations provide more uniform services among member organizations.
2. Integration among participating organizations can be achieved through either direct ownership or contractual relationships. Although common ownerships can lower transaction costs and achieve economies of scale, contractual relationships can flexibly respond to changes in local markets.
3. Centralized organizations provide most of their services at the system level, whereas decentralized organizations provide most services at the individual hospital level.

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Author Biographies

Sung W. Choi is an assistant professor of Health Administration at the School of Public Affairs, Penn State Harrisburg.

Avi Dor is a professor in the Department of Health Policy and Management at the Milken Institute School of Public Health, George Washington University (GW), and Director of its Health Economics and Health Policy PhD Programs.