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Is the System Really the Solution? Operating Costs in Hospital Systems

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Abstract
Hospital system formation has recently accelerated. Executives emphasize scale economies that lower operating costs, a claim unsupported in academic research. Do systems achieve lower costs than freestanding facilities, and, if so, which system types? We test hypotheses about the relationship of cost with membership in systems, larger systems, and centralized and local hub-and-spoke systems. We also test whether these relationships have changed over time. Examining 4,000 U.S. hospitals during 1998 to 2010, we find no evidence that system members exhibit lower costs. However, members of smaller systems are lower cost than larger systems, and hospitals in centralized systems are lower cost than everyone else. There is no evidence that the system's spatial configuration is associated with cost, although national system hospitals exhibit higher costs. Finally, these results hold over time. We conclude that while systems in general may not be the solution to lower costs, some types of systems are.

Keywords
hospital system, operating cost, centralization, hub-and-spoke

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Introduction

Hospital system formation has accelerated in the new millennium. Following a decline in hospital consolidation after 1996, the number of deals steadily climbed from a low of 38 deals in 2003 to 72 deals in 2010 and 107 deals in 2012 (Irving Levin Associates, 2014). Between 2000 and 2010, the number of systems rose from 325 to 427, whereas the percentage of hospitals in systems crept forward from 51.8% to 57.9% (Burns, Wholey, McCullough, Kralovec, & Muller, 2012). At present, 60% of hospitals are system members (Cutler & Morton, 2013).

Not only are more hospitals joining systems, but the systems themselves are merging to form even larger systems. Several enormous deals have been consummated in the past few years, including

- Community Health Systems and Health Management Associates (206 hospitals in 29 states)
- Tenet Healthcare and Vanguard Health Systems (77 hospitals in 30 markets)
- Trinity Health and Catholic Health East (82 hospitals in 21 states)
- Ascension Health and Alexian Brothers Health System (80 hospitals in 21 states)
- Trinity Health System and Loyola University Health System (47 hospitals in 10 states)

The merits of this trend have been debated. On the one hand, system executives, financial analysts, and consultants believe that systems have improved in their operating performance over time. They commonly stress the positive benefits of scale economies that yield lower operating costs in administrative and back-office functions (e.g., billing, purchasing, transcription) as well as in some clinical areas (e.g., flexible nurse-staffing pools, shared services such as biomedical engineering, and reduced overlap in high-end technologies; Butcher, 2012; Goldstein, Martin, & Nelson, 2010; Keckley, 2014; Keckley, Sorensen, Coughlin, Korenda, & Gusz, 2013; Sweeney & Arrick, 2013).[1] On the other hand, hospital consolidation has been linked to rising hospital prices and health care costs, leading academic researchers (Dafny, 2014; Lewis & Pflum, 2014), as well as the Advisory Board (2014) to question the presence of scale economies. Prior research has found little corroborating evidence that systems achieve lower costs than freestanding facilities. The debate has nevertheless continued, culminating in a recent exchange (Davis, 2014; Frakt, 2015) and the decision by the Commonwealth of Massachusetts to reverse its prior approval of the acquisition of three hospitals by Partners Healthcare (Wittman, 2015).

Recent research has considered whether certain types of systems have lower costs, suggesting that not all systems are alike. Three system types that are frequently mentioned as lower cost are centralized models, regional models in adjacent states, and local hub-and-spoke models. We test hypotheses about the association of cost with different measures of "system-ness": system membership, membership in centralized systems, membership in larger systems, and membership in local hub-and-spoke systems (vs. regional and national systems). We also test whether systems have achieved lower operating costs over time. We thus seek a more precise and comprehensive resolution to the debate over costs in hospital systems.

New Contribution

We examine "system-ness" and its effects on cost in multiple ways. To do so, we utilize three previously developed measures of system structure (dummy variable of membership, system size, system centralization), and develop a new measure based on the system's geographic configuration that distinguishes national, regional, and local hub-and-spoke models. The analysis uses panel data to examine the effects of joining systems and changing system structures. The empirical models test whether changes in system status, system size, and system structure are associated with changes in hospital operating costs. The models also test whether these effects vary during a 12-year panel period. This allows us to assess whether the effects of more recent system formations differ from the effects of earlier system formations, and thus whether the benefits of system-ness are constant or changing over time.

Conceptual Framework

Scale economies can result from expanding production volume over fixed inputs such as property, plant, and equipment, thereby driving down average costs. Such economies can have both production-related and nonproduction-related (e.g., administrative) sources (Besanko, Dranove, & Shanley, 2009). To the degree that fixed inputs cannot be physically combined in horizontal consolidations, the nonproduction-related sources may assume greater importance. These can derive from economies in large-scale management, purchasing, and distribution (Bain, 1968); for consolidations that lead to multiplant operations ("multiplant firms"), they can also include economies in capital raising and promotional activities (Scherer, Beckenstein, Kaufer, & Murphy, 1975). These administrative functions can be centralized at a corporate level and standardized across operating units to reduce transactions costs and staffing levels.

As with firm-level economies, however, multiplant firm economies may be exhausted as the firm grows in size to encompass a larger number of units. Prior research has discovered only weak evidence for scale economies in multiplant firms (Beckenstein, 1975; Canback, Samouel, & Price, 2006; Scherer et al., 1975; Scherer & Ross, 1990). One major reason is the complexity in balancing scale economies in production with transport costs. Another reason is the increased bureaucracy and complexity of these firms that harm firm performance. Additional research shows that multiunit firms perform less well in more dynamic environments due to difficulties in making adaptations across units (Audia, Sorenson, & Hage, 2001).

How might these arguments apply to multihospital systems? Systems with multiple hospital units and other care sites potentially offer the opportunity to coordinate care across the continuum, route patients to the most appropriate and lowest cost sites, and reduce rates of hospitalization and readmission. Systems also permit the rationalization (in terms of both numbers and deployment) of equipment and services, thereby reducing expensive duplication, and hopefully lowering costs. Such benefits may be more easily achieved in systems with strong central governance that can adjudicate service line disputes among operating units. Systems can also provide greater financial viability to smaller hospitals and increase their access to lower cost capital via higher bond ratings. Finally, systems offer lower transportation costs by locating their facilities to increase patient access.

Conversely, some hospital system features may also contribute to higher costs. Large size invariably entails greater bureaucracy (more units, more layers, more divisions) that build up boundaries inside organizations that inhibit communication and coordination. Such boundaries increase complexity and information-processing needs, as well as decrease agility in responding to market changes. Such organizations are less likely to be centralized. Large organizations are also less likely to have cohesive cultures. Multiunit chain operations may face greater coordination and standardization challenges as their operations span multiple geographic markets. Indeed, researchers have found that the distance between hospital merger partners is inversely related to cost savings (Dranove & Lindrooth, 2003). The hospital units themselves may suffer from higher costs due to location, patient mix, and managerial issues that are not easily addressed by joining a system. There is growing recognition that multiplant scale economies may not hold for hospital systems (Beckham, 2014; Saxena, Sharma, & Wong, 2013). This follows from the acknowledged logistical limits to concentrating capacity and volume in geographically dispersed systems, and the limited savings to be reaped from consolidating administrative functions (which comprise less than 15% of operating costs).

Finally, systems may pursue strategies that disregard costs. Research suggests that systems with bargaining leverage over commercial insurers may relax their cost-cutting efforts. This surplus allows cost-expanding strategies such as adopting new technologies and attracting (e.g., employing) physicians, both of which lead to higher costs (Stensland, 2012; Stensland, Gaumer, & Miller, 2010). Some hospital CEOs are themselves skeptical of the cost argument. They suggest that mergers and system efforts are geared more toward differentiation rather than cost control (Dranove & Lindrooth, 2003).

Prior Research and Hypotheses

Beginning in the late 1980s and extending into the 2000s, researchers examined the benefits of horizontal consolidation of hospitals by joining multiunit systems and engaging in mergers and acquisitions (Connor, Feldman, & Dowd, 1998; Cuellar & Gertler, 2005; Dranove, Durkac, & Shanley, 1996; Dranove & Lindrooth, 2003; Gaynor, Laudicella, & Propper, 2012; Harrison, 2011; Madison, 2004; Tennyson & Fottler, 2000; Town, Wholey, Feldman, & Burns, 2006). Several comprehensive literature reviews have summarized the evidence on the effects of system membership (Balto & Kovacs, 2013; Bazzoli, Dynan, Burns, & Yap, 2004; Burns & Pauly, 2002; Friedman & Goes, 2001; Gaynor & Town, 2012; Saxena et al., 2013; Vogt & Town, 2006).

In general, formation of multiunit systems does not reduce operating costs or patient care costs. Going all the way back to Shortell's (1988) early review, the evidence base consistently shows few or no cost-saving effects of hospital systems over freestanding facilities (cf. Clement et al., 1997; Cuellar & Gertler, 2005). This finding is consistent with the weak evidence for scale economies in hospital operation (Besanko et al., 2009) and the observed positive impact of hospital concentration in local markets on surgical costs per case (Robinson, 2011).

The formation of multiunit systems may also increase administrative costs, which may be expected to rise as the number of hospitals in the system increases. Such a finding is suggested by research on large physician group size (Burns, Goldsmith, & Sen, 2013) and physician groups with multiple branch clinics (Gans & Wolper, 2013). Higher administrative costs may reflect several fault lines underlying hospital systems that challenge efficient management (Burns et al., 2012).

First, within a given state or even a more narrowly defined metropolitan area, systems must confront the barriers posed by natural geographic boundaries (e.g., rivers).

Second, systems operating within a given metropolitan area are likely to have hospitals that developed in different neighborhoods with different ethnic and/or racial groups, which becomes reflected in the composition of their medical staffs. This differentiation reduces the chances that medical staff across the system's hospitals know one another and work together.

Third, in such local systems, the hospitals that are brought together have typically competed with one another for decades and thus have a level of distrust and rivalry that is difficult to overcome through common membership in a system. These rivalries are intensified by differences in teaching status and the heterogeneity in medical staff memberships noted above.

Fourth, hospital systems confront a host of structural and functional problems in their governance that stymie coordination. These include an inward (rather than patient-centric) focus, the lack of a common information technology platform, the inability to develop system-wide processes in supply chain management, the inability to coordinate quality management efforts, the unwillingness of system members to cede authority to the system, the inability to align culture and incentives, inadequate attention paid to change management, and the failure to develop a "systems perspective" (Friedman & Goes, 2001). Indeed, years ago Shortell (1988) argued that a core capability of "system-ness" rests on the homogeneity of strategic intent across units in a system.

Thus, we do not expect that the measure of hospital system membership will be associated with lower operating costs. We do expect that the number of hospitals in the system will be positively associated with higher operating costs.

Hypothesis 1: Hospital system members are no lower in operating cost than freestanding facilities.

Hypothesis 2: Hospitals in larger systems (more members) will exhibit higher operating costs than hospitals in smaller systems.

Nevertheless, not all hospital systems are alike. Two dimensions of hospital systems might foster lower operating costs: centralization of functions and standardization of activities.[2] Two different research teams have investigated these effects. First, researchers at the American Hospital Association (AHA) and elsewhere developed an empirical taxonomy of systems based on system differentiation, centralization, and integration.[3] The taxonomy yielded five clusters of hospitals described below (cf. Bazzoli, Shortell, Ciliberto, Kralovec, & Dubbs, 2001; Bazzoli, Shortell, Dubbs, Chan, & Kralovec, 1999; Shortell, Bazzoli, Dubbs, & Kralovec, 2000):[4]

- *Centralized health systems*. Systems with a small number of medium-sized hospitals with a high degree of centralization across all product/service dimensions, moderate differentiation in their physician arrangements, and a broad array of insurance activities. Hospitals are mostly urban, nonprofit, and in close proximity to one another.
- *Centralized physician/insurance health systems*. Systems with highly centralized physician arrangements and insurance products but low centralization of other hospital services. These hospitals also tend to be urban and geographically proximate, but tend to be larger in size and more numerous than those found in the centralized health systems. They also tend to be more church-owned.
- *Moderately centralized health systems*. Systems have moderate levels of centralization across all product/service dimensions and medium levels of differentiation in hospital services, physician arrangements, and insurance activities. The hospitals are largely nonprofit facilities, medium-sized, and more numerous and dispersed geographically than those in the centralized models.
- *Decentralized health systems*. Systems exhibit low levels of centralization across all product/service dimensions, and moderate degrees of differentiation in hospital services, physician arrangements, and insurance activities. The systems tend to have a small number of small-sized hospitals that are geographically dispersed.
- *Independent hospital systems*. Systems are primarily horizontal aggregations of hospitals acting autonomously. There is little centralization and differentiation of hospital services. Systems also have limited centralization and differentiation of physician arrangements and insurance products (i.e., little vertical integration). Hospitals tend to be smaller in size and for-profit facilities.

The researchers argued their centralized/decentralized cluster variable is a good summary indicator of strategic and structural differences among systems, including the ability to provide cost-effective care (Shortell et al., 2000). In subsequent work, the researchers validated and updated the taxonomy (Dubbs, Bazzoli, Shortell, & Kralovec, 2004), found that a minority of systems was centralized, and reported a shift toward moderately centralized models in the 1990s (Bazzoli et al., 2001). Since that time, research has continued to demonstrate that centralized models remain in the minority, and many categories (e.g., centralized physician/insurance systems, moderately centralized systems, decentralized systems) have remained stable. However, there has been a modest increase in the number of centralized health systems and a large rise in the number of independent hospital systems (Burns et al., 2012). The latter increase reflects a mixture of some incumbent systems migrating away from more centralized clusters with some newly formed systems entering with independent hospital models.

Does this limited survival analysis of system clusters reveal anything about their relative operating costs? Several groups of researchers have analyzed the impact of these five clusters on hospital costs, with somewhat mixed conclusions. Bazzoli, Chan, Shortell, and D'Aunno (2000) reported that independent hospital systems exhibited the highest costs; there were no significant differences in cost among the other categories. They also found no significant differences between the categories in asset efficiency (fixed asset turnover). The authors suggest there are diminishing returns to centralization in hospital systems. By contrast, three other teams of investigators utilizing the AHA cluster measure reported more consistently positive impacts of centralization on operating performance (Burns, Gimm, & Nicholson, 2005; Carey, 2003; Rosko, Proenca, Zinn, & Bazzoli, 2007). Summarizing the evidence we hypothesize the following:

Hypothesis 3: Hospitals in hospital systems with higher levels of centralization are associated with lower operating costs.

Standardization may likewise reduce operating costs by virtue of reducing staffing levels, training costs, unnecessary process variations, and transactions costs with external suppliers. Such efficiencies may be limited in hospital systems. The Health Systems Integration Study found that while administrative functions were more likely than physician and clinical integration functions to be standardized across hospital units, they were not much more so (Gillies, Shortell, Anderson, Mitchell, & Morgan, 1993). Moreover, there was weak bivariate evidence but no multivariate evidence that such standardization of activities affected costs (Gillies et al., 1994; Shortell, Gillies, & Anderson, 1994).

Opportunities for standardization and cost efficiency likely diminish as systems grow larger in size and geographic spread. Multiunit systems are likely to increase in geographic dispersion as they grow in size (number of hospital members) and in space (number of states in which they operate).[5] Such dispersion means dealing with diverse payers, managed care pressures, state regulations, and Medicaid programs. Growth in system size thus mitigates the opportunities for standardization as well as centralization.

A main driver of system centralization and standardization is the limited size (number of hospitals) and geographic dispersion of hospitals within the system (Burns et al., 2012). Hub-and-spoke types of hospital systems appear to be able to centrally coordinate their services and other functions, and thus should have the easier time in demonstrating more systemic behavior. For example, these types may be more active in adopting electronic medical records compared with national types. Along the same lines, Dranove and Shanley (1995) argued that the locus of hospital competition has shifted to local markets, depriving national systems of any significant scale economies and conferring them instead on locally based systems. Reinforcing this observation, Cutler and Morton (2013) report that such types of systems have come to dominate the local market in two thirds of hospital referral regions. Although they provide no survival analysis for hub-and-spoke models, any presumed cost savings should be reflected in their growing dominance among alternative system types. Analysts have found no clear-cut evidence that national systems achieve lower operating costs post-acquisition compared with local and regional systems (Keckley et al., 2013). Executives of regional systems who span adjacent states nevertheless argue that these efficiencies exist (Butcher, 2012). Thus,

> **Hypothesis 4:** Hub-and-spoke types of hospital systems are associated with lower operating costs than other geographic configurations.

Method

Data Sources

We merged data from the AHA Annual Survey (American Hospital Association, 1998-2010), the Area Resource File (ARF), the Centers for Medicare and Medicaid Services (CMS, 1998-2010), Healthcare Cost Report Information System (HCRIS), and a Case Mix Index (CMI) also provided by CMS for the years 1998 through 2010. Data from 2000 to 2010 analyzed by the authors reveal that most systems change their system structure on an infrequent basis.[6] We therefore utilized a long period to capture a sufficient number of these changes. Data were matched based on the reported year from the HCRIS financial reports.

We selected hospitals from the AHA Annual Survey, including those facilities (a) that were located in the 50 U.S. states and the District of Columbia, (b) where we could match up the county Federal Information Processing Standard code in both the AHA and ARF databases, and (c) and where those based in rural areas had 50 or more beds. Prior research has demonstrated that urban and rural hospitals have different cost and production functions; we utilized the urban influence code in the ARF file to distinguish hospitals in urban versus rural areas.[7] The sample hospitals include nongovernment, not-for-profit, investor-owned (for-profit), and government nonfederal hospitals that provided general medical and surgical services (service codes 10 and 50). To attribute hospitals to systems, we used a "corrected" AHA system identification number constructed by Kristin Madison, which has been updated by researchers at Carnegie Mellon University and our research team.[8]

Measures

We study hospitals' operating costs reported in CMS's HCRIS data. Operating costs should, in theory, depend on a hospital's level of outputs and input costs. We focus on the

AHA's adjusted admissions as an output measure and registered nurse wages as a measure of input costs. The adjusted admissions variable is designed to control for the number of outpatient visits, while registered nurses account for the largest source of hospital labor costs. Although not reported here, we also use a more detailed set of measures of output and inputs (e.g., capital stocks reflected in the number of beds) in robustness tests.

Hospital costs also depend on the severity of patient illness, governance (i.e., ownership), and organizational structure. We include the CMI as our primary severity measure, but also control for payer mix using the percentages of Medicare and Medicaid patient days, respectively. Hospital objective functions may also differ. Nonprofit hospitals could, for example, have higher preferences for quality, thus increasing production costs. Similarly, Council of Teaching Hospitals (COTH) members are likely to value education, quality, and research while serving a relatively high-severity population. The CMI measure is provided by CMS, whereas other control variables are drawn from AHA data. Although these variables help control for differences in hospital costs, our econometric models also consider the potential implications of unobserved severity and unobserved input cost variation.

Finally, this article considers the potential consequences of health system organization and how these relationships may change over time. The AHA data include a binary indicator for the hospital's membership in a multihospital system. This indicator is used to test Hypothesis 1. Using the AHA data, we characterized each system on an annual basis by its number of hospitals, which is used to test Hypothesis 2. We also utilized additional AHA data on the proportion of hospitals that were for-profit, the proportion of hospitals that were COTH members, the number of states in which the system operated, the average bed size of hospitals in the system, the variation in bed size across system hospitals, and the average distance between all pairs of hospitals within the system.

We measured system centralization using the AHA's system cluster code (Bazzoli et al., 1999) and, following Burns et al. (2012), we collapsed it to simplify the analysis.[9] We classified systems with a cluster code of 1 or 2 (Centralized Health System, Centralized Physician/Insurance Health System) as "centralized cluster"; we classified systems with a cluster code of 3 (Moderately Centralized Health System) as "moderately centralized cluster"; and we classified systems with cluster codes of 4 or 5 (Decentralized Health System, Independent Hospital System) as "decentralized cluster." AHA researchers have sometimes combined the first two clusters for analysis (Bazzoli et al., 2000). This typology of system clusters is used to test Hypothesis 3. We also conducted additional analyses to test for differences within the simplified categories.

We constructed the systems by aggregating hospitals to the system level by year. We also constructed the average distance between all pairs of hospitals in the system using each hospital's latitude and longitude, the average number of staffed beds across all hospitals in a given system, and the variation in bed-size across all hospitals in a given system.

The AHA researchers found that the system clusters were associated with different spatial configurations. We sought to measure this explicitly and distinctly from centralization during the aggregation of hospitals, as follows. Following Burns et al. (2012), we identified "National" systems as those that operated hospitals in more than three states or had an average distance between hospitals of more than 300 miles. We identified "hub-and-spoke" systems as those with an average distance between hospitals of less than or equal to 100 miles, variation in their staffed beds (across facilities) of greater than 50,000, and at least one COTH member.[10] "Regional" systems included all others. These three system types capture the dimensions of size and geographic dispersion that are used to test Hypothesis 4.

We should note that our measure of system type is distinct from the AHA's cluster measure in two important respects: markets and products. First, the system type measures system differences in the number of hospitals and the geographic markets they serve, irrespective of products and services offered; by contrast, the AHA cluster score measures system differences in a local market (Luke, 2006). Second, the system type focuses on geographic concentration or dispersion; by contrast, the AHA centralization measure is defined by the degree of centralization, differentiation, and the integration of hospital services, physician arrangements, and insurance products.

Model and Estimation

We model the relationship between hospital system organization and hospital operating costs. This is an observational study (i.e., using nonexperimental data) that employs panel data regression techniques. We utilize a difference-in-differences identification strategy that compares changes in hospital costs at institutions that changed organizational structure with cost changes at organizationally stable institutions. Our strategy thus relies on hospital systems altering their structures over time.

More formally, we model the cost of hospital i at time t, C_{it}. Costs are a function of hospital volume $\left(Y_{it}\right)$ as well as labor and capital prices. Wages are denoted by $\left(W_{it}\right)$; variation in capital costs (e.g., interest rates on bonds) are unobserved and excluded from our base specification. We focus on measures of centralization/cluster and system type, but also control for a variety of hospital characteristics $\left(X\right)$ further described below. Our baseline specification is a simple linear regression model,

$$c_{it} = f\left(y_{it}, w_{it}; \alpha\right) + Centralization_{it}\beta + SystemType_{it}\gamma + X_{it}\delta + \mu_i + \tau_t + \epsilon_{it},$$

where the lower case $\{c, y, w\}$ are log values, $\{\alpha, \beta, \gamma, \delta\}$ are parameters to be estimated, and ϵ_{it} is a normally distributed error term. Log values are used to deal with skewness in the variable distributions. Conditional on the hospital and time-fixed effects, μ_i and τ_t respectively, β and γ are the difference-in-difference estimates of the effects of *centralization/cluster* and *system type* on hospital costs.[11] We use f to denote a flexible function and employ a second-order Taylor series expansion in our baseline specification that allows us to estimate linear and nonlinear effects.[12] The model is estimated via maximum likelihood.

Our fixed effect model depends on the assumptions that the parameters $\{\alpha, \beta, \gamma, \delta\}$ and the fixed error component, μ_i, are reasonably stationary over time. These assumptions have both conceptual and econometric implications. Many factors such as the diffusion of information technologies (e.g., electronic health records) and recent trend toward vertical integration (e.g., hospital employment of physicians) are not observed in our data. These and other unobserved factors might change the effect of consolidation and be correlated with the recent growth in hospital mergers. Consequently, we wish to allow γ (and other parameters) to change over time. Econometrically, our identification strategy assumes that unobserved cost shifters are fixed over time within hospitals. This assumption is, intuitively, more reasonable in shorter panels than it is in longer panels. Consequently, we explore potential heterogeneity in both the parameters and the hospital fixed effects by estimating our model on a sequence of two shorter panels. These two panels include the 1998 to 2003 and 2004 to 2010 periods. The year 2003 was chosen as the cut point due to the inflection in the volume of hospital consolidations occurring after that year (Irving Levin Associates, 2014); this year also coincides with a new wave of health plan mergers, a deceleration in national health spending, and the rise of enrollment in high deductible health plans. We explored the use of adjacent cut points (2002, 2004) to demarcate early versus later periods and found nearly identical results. We also explored the use of three time periods as well as interactions between system measures and time and again reached similar conclusions. Additional tests are described in the robustness section.

Results

Univariate Statistics

Table 1 presents univariate statistics for variables in the models. For our analyses, nonprofit and public hospitals were combined into the omitted contrast category of hospital ownership. These numbers are averages taken over the 12-year study period (1998-2010). Table 2 presents the hospital statistics for 1998 and 2010 separately, broken out by system and nonsystem hospitals. System members tend to have higher volumes (12%-16% more) and costs (18%-24% more), and exhibit greater for-profit ownership (two to four times higher).

Figure 1 depicts the trend in hospital system centralization over time. The percentage of highly centralized systems rose from roughly 15% (1998) to nearly 27% (2010), whereas the percentage of moderately centralized systems fell from 47% to 38%. Decentralized systems remained fairly stable, reflecting both entries and exits over time. Figure 2 depicts the trend in the geographic types of systems. Between 1998 and 2010, there has been a small drop in national systems (from 18% to 15%) and a small increase in hub-and-spoke systems (from 13% to 15%).

Multivariate Models of System Effects

Table 3 presents six regression models. The first three models test the effects of the binary measure of system membership; the latter three models allow the effects to depend on system size. The initial model in each group utilizes the entire study period (1998-2010), while the latter two models utilize shorter panels (1998-2003, 2004-2010).

Table 1. Descriptive Statistics.

Variable	*M* (*SD*)
Hospital and Market Characteristics	
Operating expenses ($000s)	144,543 (189,683)
Adjusted admissions	16,109 (14,028)
Registered nurse wages (hourly)	26.5 (4.83)
Council of Teaching Hospitals member	0.09 (0.28)
For-profit	0.20 (0.40)
% Medicare days	0.50 (0.16)
% Medicaid days	0.18 (0.14)
Case Mix Index	1.37 (0.26)
System Characteristics	
System member	0.6098 (0.4878)
Geographic type	
National system	0.3047 (0.4603)
Hub-and-spoke	0.0597 (0.2370)
Regional	0.2453 (0.4303)
Centralization/cluster	
Decentralized	10.19%
Moderately centralized	39.78%
Centralized	4.12%

Each model controls for the effects of hospital and market characteristics on hospital costs. Hospital costs are a complex product of hospital volume (adjusted admissions), nurse wages, and their interaction. The negative main effect of volume in association with its positive squared term suggests that hospitals become less costly as they increase in scale at the lower end of the size distribution but then become more costly with additional growth. This supports prior research evidence that hospital growth reduces hospital costs at smaller sizes, but hospitals do not enjoy increasing returns to scale thereafter (and may in fact experience decreasing returns to scale). On average, hospital costs increase with nurse wages and the interaction of nurse wages with hospital volume. By contrast, hospital costs are not significantly associated with COTH membership and hospital ownership, conditional on hospital fixed effects. Costs are, however, associated with greater illness severity, as measured by the mix of Medicaid patients and the Medicare CMI.

Consistent with Hypothesis 1, the effect of the binary system indicator on hospital costs is not significant (see columns 1-3). If anything, it tends to exhibit a positive association with costs, suggesting that system membership may increase costs. The latter three models (columns 4-6) add two system size measures: the number of hospitals in the system and its squared term. Consistent with Hypothesis 2, hospital costs are positively and significantly associated with system size (column 4), but only in the latter of the two periods (column 6). We further explore the size effect by analyzing quartiles in the distribution of system size. Hospitals in the upper quartile of system

Table 2. Descriptive Statistics for 1998 and 2010 by System Ownership.

	1998 *M* (*SD*)		2010 *M* (*SD*)	
	Nonsystem	System	Nonsystem	System
Operating expenses	$78,300 (94,100,000)	$92,600 (118,000,000)	$194,000 (242,000,000)	$241,000 (296,000,000)
Adjusted admissions	12,169 (10,812)	13,594 (11,647)	16,531 (15,355)	19,240 (16,740)
Registered nurse wages	21.3 (2.05)	21.3 (2.11)	32.7 (3.93)	32.7 (4.03)
Council of Teaching Hospitals member	0.08 (0.26)	0.09 (0.28)	0.08 (0.28)	0.09 (0.28)
For-profit	0.06 (0.24)	0.26 (0.44)	0.12 (0.33)	0.28 (0.45)

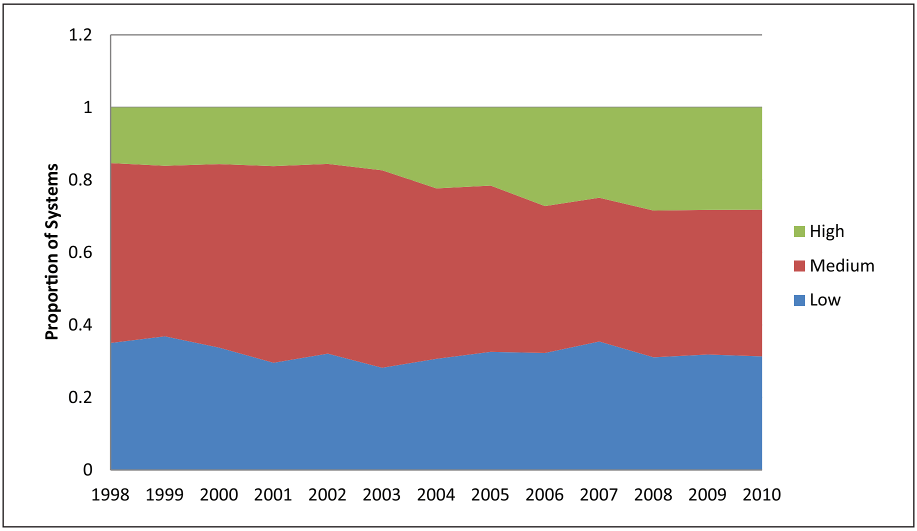

Figure 1. System centralization/cluster by year.

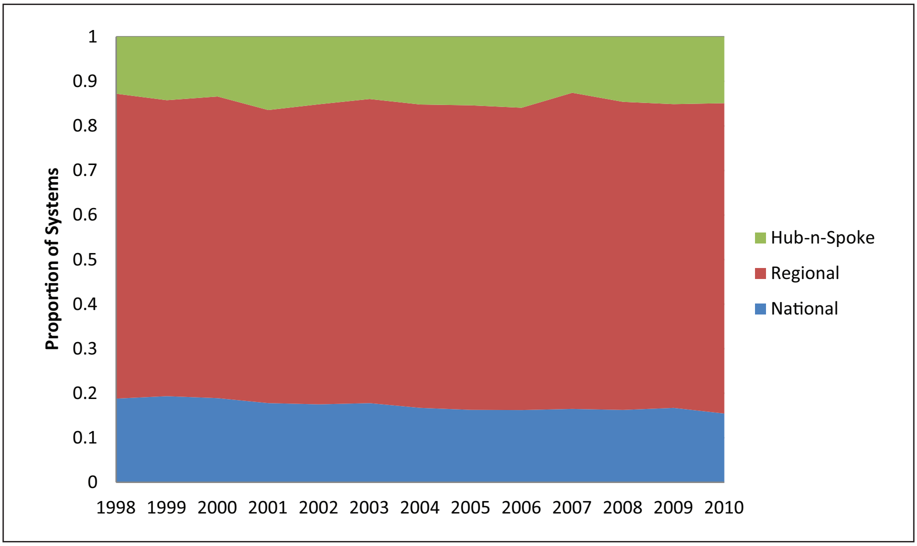

Figure 2. System geographic type by year.

size (30 or more hospitals) had significantly higher costs than all other hospitals; the increase in cost was small, however. These results indicate that systems are no lower in cost than freestanding hospitals, and that very large systems have higher average operating costs.

Table 3. Effects of System and System Size on Log Costs.

	System membership			System size (number of hospitals)		
Variable	All (1998-2010)	Early (1998-2003)	Late (2004-2010)	All (1998-2010)	Early (1998-2003)	Late (2004-2010)
ln(adjusted admissions)	−0.446*** (0.0744)	−0.336*** (0.120)	−0.653*** (0.125)	−0.439*** (0.0741)	−0.324*** (0.120)	−0.641*** (0.125)
ln(registered nurse wage)	−1.720*** (0.403)	−1.837** (0.782)	−1.417** (0.651)	−1.804*** (0.405)	−1.800** (0.788)	−1.458** (0.651)
ln(adjusted admissions)^2	0.0383*** (0.00425)	0.0209*** (0.00371)	0.0395*** (0.00546)	0.0382*** (0.00423)	0.0208*** (0.00370)	0.0397*** (0.00543)
ln(registered nurse wage)^2	0.261*** (0.0586)	0.214* (0.123)	0.149 (0.0940)	0.276*** (0.0590)	0.212* (0.123)	0.160* (0.0942)
ln(registered nurse wage) × ln(adjusted admissions)	0.0315* (0.0163)	0.0665** (0.0329)	0.0549** (0.0273)	0.0293* (0.0163)	0.0633* (0.0330)	0.0501* (0.0272)
Council of Teaching Hospitals member	0.0139 (0.0210)	0.0288 (0.0273)	0.00130 (0.0253)	0.0145 (0.0210)	0.0291 (0.0273)	0.00119 (0.0250)
For-profit	0.000436 (0.0171)	0.00588 (0.0276)	−0.00929 (0.0298)	−0.0136 (0.0172)	0.00149 (0.0279)	−0.0252 (0.0297)
% Medicare days	0.0114 (0.0171)	−0.00733 (0.0190)	−0.0158 (0.0235)	0.0128 (0.0171)	−0.00805 (0.0189)	−0.0146 (0.0235)
% Medicaid days	0.0495*** (0.0190)	−0.00705 (0.0212)	0.0203 (0.0248)	0.0486*** (0.0188)	−0.00832 (0.0212)	0.0207 (0.0247)
Case Mix Index	0.259*** (0.0274)	0.190*** (0.0434)	0.154*** (0.0290)	0.261*** (0.0274)	0.189*** (0.0434)	0.155*** (0.0291)
System member	0.00460 (0.00852)	−0.00206 (0.0114)	0.00951 (0.0118)	−0.0139 (0.00895)	−0.0108 (0.0118)	−0.0136 (0.0125)
System size (hospitals)				.000930*** (0.000255)	0.000317 (0.000358)	0.00156** (0.000622)
System size^2				−2.61e-06** (1.13e-06)	−2.29e-07 (1.40e-06)	−5.86e-06 (3.63e-06)
Constant	20.21*** (0.800)	20.58*** (1.442)	22.01*** (1.358)	20.32*** (0.804)	20.48*** (1.457)	22.03*** (1.353)
Observations	39,816	18,892	20,924	39,816	18,892	20,924
R^2	0.707	0.443	0.463	0.708	0.443	0.465
Number of hospitals	3,884	3,563	3,435	3,884	3,563	3,435

Note. Robust standard errors in parentheses; models include time and hospital fixed effects.
***$p < .01$. **$p < .05$. *$p < .1$.

Table 4. Effects of Centralization/Cluster and Geographic Type on Log Costs.

Variable	All (1998-2010)	Early (1998-2003)	Late (2004-2010)
ln(adjusted admissions)	−0.478*** (0.0745)	−0.333*** (0.120)	−0.774*** (0.110)
ln(registered nurse wage)	−1.866*** (0.399)	−1.809** (0.774)	−1.465** (0.643)
ln(adjusted admissions)^2	0.0397*** (0.00432)	0.0213*** (0.00375)	0.0426*** (0.00534)
ln(registered nurse wage)^2	0.281*** (0.0584)	0.213* (0.122)	0.126 (0.0923)
ln(registered nurse wage) × ln(adjusted admissions)	0.0325** (0.0164)	0.0638* (0.0333)	0.0728*** (0.0261)
Council of Teaching Hospitals member	0.0100 (0.0206)	0.0329 (0.0276)	0.00436 (0.0250)
For-profit	−0.0146 (0.0175)	0.00120 (0.0285)	−0.0329 (0.0300)
% Medicare days	0.0133 (0.0171)	−0.00747 0.0190)	−0.0130 (0.0234)
% Medicaid days	0.0498*** (0.0186)	−0.00611 (0.0206)	0.0159 (0.0248)
Case Mix Index	0.259*** (0.0273)	0.188*** (0.0434)	0.150*** (0.0290)
Decentralized	0.0114 (0.0115)	0.00834 (0.0125)	0.00736 (0.0231)
Moderately centralized	0.00985 (0.0110)	0.0119 (0.0124)	0.00334 (0.0232)
Highly centralized	−0.0345** (0.0154)	−0.0148 (0.0186)	−0.0253 (0.0267)
National	0.0249* (0.0148)	−0.00945 (0.0184)	0.0474** (0.0235)
Hub-and-spoke	−0.0151 (0.0138)	−0.0391** (0.0164)	0.000540 (0.0223)
Regional	−0.0136 (0.0104)	−0.00128 (0.0124)	−0.00679 (0.0176)
Constant	20.61*** (0.793)	20.52*** (1.435)	22.72*** (1.306)
Observations	39,256	18,766	20,490
R^2	0.713	0.448	0.476
Number of hospitals	3,866	3,560	3,410

Note. Robust standard errors in parentheses; models include time and hospital fixed effects.
***$p < .01$. **$p < .05$. *$p < .1$.

Models in Table 4 replace the binary system membership indicator with three measures of centralization/cluster and three measures of geographic type. Consistent with Hypothesis 3, hospital system clusters with the highest levels of centralization are significantly associated with lower costs overall (column 1) and in both periods (columns 2 and 3). The coefficients for moderately centralized and decentralized clusters are nonsignificant but positive in direction, suggesting they may be more costly hospitals. Partly consistent with Hypothesis 4, hospitals belonging to hub-and-spoke models exhibit lower costs (and significantly so during the earlier period—see column 2). Regional types also reveal a negative but nonsignificant association with costs, whereas national types exhibit a significantly positive association with costs. Consistent with the models presented in Table 3, larger systems and national systems have significantly higher average costs, particularly in the later period.

We sought to provide some idea of the magnitude of the cost difference between hospitals in these different settings. We first compared the base costs of a freestanding hospital with the costs of a system member: system hospitals had slightly higher costs (average 0.2% per year). We then compared hospitals with different levels of centralization. The most highly centralized hospitals had roughly 3.3% lower costs, whereas the moderately centralized and decentralized hospitals had roughly 1% higher costs.

Given the above results that large system size and centralization influence costs, we investigated whether there might be any interaction effects. We incorporated multiplicative terms for system size and each of our centralization measures in additional models. There were no significant scale effects or interaction effects across centralization clusters or geographic types.

Model Robustness

A variety of problems could violate the assumptions of our empirical approach. In particular, the difference-in-differences strategy assumes that time-varying unobserved cost shifters are uncorrelated with changes in system membership, centralization/cluster, or system type. Changes in the cost trends of hospitals can lead to system membership changes that affect the coefficient estimates. Hospitals or systems could, for example, acquire competitors or reorganize in response to financial performance (financial slack). Conversely, systems may acquire financially distressed (i.e., inefficient and high-cost) hospitals. Both are time-varying factors not observed in the data.

We employed a variety of strategies to examine the dynamic flexibility of our empirical model. We examined preperiod (i.e., before system status changes) time trends to test for time-varying cost differences.[13] We also allowed for separate time trends for different groups based on initial system status; for example, some types of hospitals (those that join systems) become more or less costly over time than those that do not. In each case, the results support our difference-in-differences identification strategy and are consistent with the results presented above.

The identifying assumptions of fixed effects models are more likely to be violated in long time series environments. We employed a variety of strategies to test these assumptions. First, we estimated our model using a sequence of shorter panels. Examples of this approach are presented in Tables 3 and 4. We found similar results using alternative cut points and shorter panels. As noted above, we estimated models with group-specific time trends, allowing the error to change over time for groups. We also estimated models using differenced (e.g., $\left(c_{it}-c_{it-1}\right)=f\left(c_{it}-c_{it-1};\beta\right)+\epsilon_{it}$) data. Similar to fixed effects models, these approaches assume that the error is "fixed" but only impose this assumption over a short fixed period (i.e., two adjacent years for a first-differenced model). We estimated multiple differenced models using a variety of lag structures. Finally, we estimated quasidifferenced models, allowing for a richer set of time series properties (e.g., autocorrelation). The results of each of these tests supported the assumptions used in our models and reinforced the results presented in Tables 3 and 4.

We also explored a variety of alternative cost function specifications. These include multiproduct models that incorporate inpatient and outpatient volumes as well as a richer set of data on wages. We explored parameter heterogeneity by estimating the models using a different sample (including small rural hospitals) and allowing system status effects to vary over time (e.g., system clusters and system types have different effects over time).[14] We controlled for capital inputs (e.g., number of beds) and allowed these to interact with other inputs and outputs. We allowed for time lags of varying lengths in system status effects. In each case, the results are consistent with those presented above.

The skewness of health care data may introduce problems of bias and precision (cf. Manning & Mullahy, 2001). We tested for these problems using first-differenced quantile regression and a repeated cross-section specification estimated via generalized linear models. The results of these alternative specifications support the log specification employed in our base model.

Finally, we utilized two alternative measures of system type. In one measure, we altered the definition of hub-and-spoke to include more local systems with slightly greater distance and/or less size dispersion among their members; in another measure, we defined the hub as an academic medical center rather than a COTH member. The model results in Table 4 remained consistent.

Discussion

Study Limitations

Our findings must be considered as preliminary, given that they suffer from several limitations. First, we do not measure total treatment costs, but only observe the hospital portion of patient care. Thus, we cannot measure the effects of system centralization and system type on broader health care costs. This could be important if centralized or hub-and-spoke systems substitute more ambulatory for inpatient care, or reduce readmissions or other forms of longer term (e.g., postacute) health spending. Despite the use of a CMI, we do not and cannot conduct adequate risk adjustment to control for patient severity of illness, which is associated with hospital cost. Finally, we do not and cannot address time-varying changes in unobserved hospital characteristics correlated with system status changes; we can only make statistical adjustments for certain hospital and system characteristics. Modeling of fixed effects does not minimize the foregoing problems.

Second, our time series ends in 2010 just as health care reform was being implemented. We are not concerned here, however, since the trend in system clustering between 2010 and 2012 shows no discernible path (results available from authors).

Third, we have collapsed the centralized health system and centralized physician/insurance health system clusters to facilitate our analyses. We may need to disentangle these two clusters in future research for several reasons. Given the notoriety and recognition bestowed on fully integrated models like Kaiser and Geisinger, as well as the recent interest of hospital systems to diversify into the health plan business, the centralized physician/insurance models are of growing interest. The literature also suggests that such models may be least costly. Unfortunately, the number of hospital systems in this cluster has not been growing. By contrast, growth has occurred in the centralized health systems.

Fourth, we have relied on a single measure of system centralization/decentralization developed by the AHA researchers; however, this measure has been developed from a good portion of other measures in the AHA Annual Survey, validated over time, and found to be associated with related measures such as the locus of decision making within the system. Moreover, according to the AHA researchers, this measure captures important strategic and structural differences between systems. We might also explore alternative ways to construct our three hospital system types (National, Hub-and-spoke, Regional) and conduct additional analyses to ascertain if model results are sensitive to variable construction. For example, we might vary the definition of "National" systems based on the number of states in which the system operates. We did include hospital variance in bed-size in the construction of this measure that might encompass this, however.

Finally, data limitations may impede our efforts to detect the effect of system geographic types on cost. As is evident from Figure 2, there has been little movement by systems over time from one geographic model to another. Longer time frames may be necessary here. Future research might also consider alternate measures of geographic centrality and dispersion to discern such effects. The work of Cutler and Morton (2013) suggests the importance of this line of inquiry.

Conclusions

One major finding is that membership in hospital systems is not associated with lower operating costs. A second major finding is that the lack of system effects has been fairly stable over time. Despite changes in information technology and vertical integration, most hospital systems have not improved their operating performance. The one exception is the slight deterioration in hospital costs observed among hospitals belonging to larger and national systems.

Why might multihospital systems fail to reduce costs? One explanation is that the logic of integrating is more important than the structure of integration. For example, Booz and Company research suggests that the driver behind merger success is the development of capabilities that support the system's goals and market position (Saxena et al., 2013). These capabilities are integrated sets of skills spanning the system's strategy, people, processes, and technologies in value-adding ways. A second, related explanation is that the people are more important than the facilities. Thus, the composition, talent level, and collaboration among the top management team is critical for system success (Advisory Board, 2008). A third possibility is that systems need to develop shared service organizations that provide cost savings across hospital units while offering flexible solutions that meet each unit's needs (Advisory Board, 2013), or that regional systems need to reorganize by reducing their number of geographic divisions and administrative overhead (Johnson, 2014). Fourth, hospitals may be able to glean savings in collaborative efforts that do not entail system formations.[15]

Although system formation is not associated with costs, some systems exhibit lower costs than others. We find that hospitals in smaller systems have lower costs than hospitals in larger systems. A large number of members may make it more difficult to operate hospital units in an efficient manner, perhaps reflecting excessive administrative overhead and complexity as noted above. We also find some evidence here that centralized governance may serve to extract value from hospital systems. This result confirms some prior research on the financial advantages of centralized physician/insurance systems. It may also explain why there has been a slow but steady increase since the early 2000s in the percentage of centralized health systems (cf. Burns et al., 2012).

Centralized systems still represent a minority of all systems. In our sample where 61% of hospitals are in systems, 28% are situated in national geographic types with moderate centralization, 12% are situated in regional types with moderate centralization, and 9% are regional models that are decentralized. This may help explain why system effects have not been observed to date (here or elsewhere). The slow movement to centralized models suggests only minor improvement in cost reduction in the near term. Researchers may want to analyze the handful of systems migrating from less centralized to centralized models to discern what changes have been undertaken. We should also point out that "centralized" systems may not be able to act in a centralized fashion that might yield cost reductions (Muller & Kruse, 2015).

Implications for Health Reform

Cost containment comprises one part of the "Triple Aim," and is a major goal of the Patient Protection and Affordable Care Act and other new payment, contracting, and measurement initiatives. The U.S. health care delivery system is currently responding to these initiatives through a series of new structures, including medical homes, large physician groups/networks, physician employment, service lines, centers of excellence, the formation of hospital systems, and accountable care organizations (ACOs). The latter two solutions—hospital systems and ACOs—are interrelated. ACOs require a continuum of providers who can develop a host of capabilities to manage the risks they assume (Accountable Care Organization Learning Network, 2011). Because of the scale and costs involved in their implementation, ACOs are often (but not always) spearheaded by hospitals that have integrated with other hospitals and physicians.

To succeed with the ACO strategy, providers will need to go beyond integrated structures to act in concerted fashion. For two decades, researchers and consultants have argued the dual advantages of organized systems—the ability to standardize functions and centralize governance and other activities—which can enable them to achieve the triple aim (Advisory Board, 2007; Gillies et al., 1994; Shortell, Gillies, Anderson, Erickson, & Mitchell, 1996). Our research suggests that many hospital systems may lack these capabilities and that these systems' ability to contribute to lower cost health care is nonexistent or limited at best.

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Notes

1. They also now mention a system's greater ability to leverage investment in population health management due to increased size of the geographic market served.
2. Evidence for the effects of centralization and standardization on health system performance is mixed, however. On the one hand, the bulk of the evidence suggests that some degree of centralization promotes efficiency, while decentralization degrades it. On the other hand, there are few signs that hospital systems are becoming more systemic along these lines. Early evidence showed that health systems are more disjointed than standardized (Beckham, 2014; Burns et al., 2001); more recent evidence showed that systems are fragmenting over time rather than centralizing (Burns et al., 2012). According to AHA researchers, at least during the 1990s, many hospital systems pursued more decentralized approaches that augmented individual hospital autonomy at the expense of system-level direction, coordination, and centralization.
3. Differentiation reflects the percentage of inpatient and outpatient activities provided by system hospitals across an array of 15 clinical "service dimensions" (e.g., general acute care, pediatrics, women's health, surgical, long-term care, etc.), as well as the number of different physician arrangements and insurance products offered. Centralization reflects the percentage of activities in a given dimension (and the extent to which physician arrangements and insurance products are) provided at the system rather than hospital level. Integration reflects the percentage of activities in a given dimension available through contracts with outside providers, as well as the degree to which physician arrangements are owned (vs. contracted). Using the AHA Annual Survey data, they analyzed the degree to which hospitals in a given system coordinated their provision of hospital services, their physician arrangements, and their insurance products (if any) at the system versus the hospital level.
4. The researchers also derived a sixth cluster of "Miscellaneous" for systems that could not be classified into the other five clusters due to missing information from the AHA Annual Survey.
5. We do not consider the opposite case (systems grow but decrease in geographic dispersion) to be likely. We will investigate this in further research.
6. From 1998 to 2012, over 95% of systems remained in the same spatial configuration and over 80% of systems remained in the same centralization cluster on a year-by-year basis. For more detail, see Figures 1 and 2 in text and Burns et al. (2012).

7. Small rural hospitals have cost and production function parameters that differ from larger urban hospitals; inclusion of both sets of facilities in the same model often yields findings that are difficult to interpret (Rich Lindrooth, personal communication). The exclusion of smaller rural hospitals and their systems from the analysis did not change the model results (see the discussion of robustness tests in the results section). The exclusion of rural systems does help partially explain why our sample contains 369 systems analyzed here (2010 data), whereas the observed number of total hospital systems in 2010 is 427 (see Burns et al., 2012).
8. We thank Kristin Madison, Marty Gaynor, and colleagues for providing us with these data. See Madison (2004) for more information on these data.
9. We also tested for differences within these collapsed categories. We could not reject the hypothesis that the parameters were equal across the aggregated categories. As noted in our limitations section, there was little time series variation in the collapsed categories, so we do not wish to overemphasize the nonresult.
10. The variance level of 50,000 represents the top quartile in the distribution. COTH member hospitals commonly serve as local referral centers for radiological services.
11. The inclusion of hospital fixed effects helps control for the nonobservable selection bias that results from hospitals joining systems, which is a nonrandom process that may be associated with hospital costs. The hospital fixed effect helps us interpret the results from the difference-in-difference estimation as the effect of a hospital joining a system. The inclusion of time-fixed effects helps control for nonobservable and time-varying causes of system membership, which again helps us interpret the difference-in-difference results.
12. For example, the marginal effect of an additional admission on hospital costs may differ for small hospitals compared with larger hospitals. We therefore use both admissions and squared admissions as variables to allow for effects that may not be constant over different hospital size categories.
13. This procedure tests whether the event of a hospital joining a system in later years affects hospital costs today (or, conversely, do hospital costs today predict whether or not it joins a system in the future).
14. For example, this might occur if centralized systems make differential investments in physician integration arrangements and/or information technologies that affect their cost structure.
15. Hospitals can join forces in other ways besides ownership-based, multiunit systems. Paralleling the trend of hospital system formation, there has been a renewed interest in the development of hospital strategic alliances and networks. These networks can reside primarily within one state (e.g., Stratus Healthcare in Georgia, Cleveland Clinic and ProMedica in Ohio), or in neighboring states (BJC Collaborative in Missouri and Illinois; AllSpire Health Partners in Pennsylvania and New Jersey). These network models seek cost cutting in group purchasing, product distribution, population health management, and shared clinical programs. Some consultants go so far as to assert advantages such as the "economies of connection" in sharing soft assets like information, best practices, expertise, and software (Advisory Board, 2013; Beckham, 2014).

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