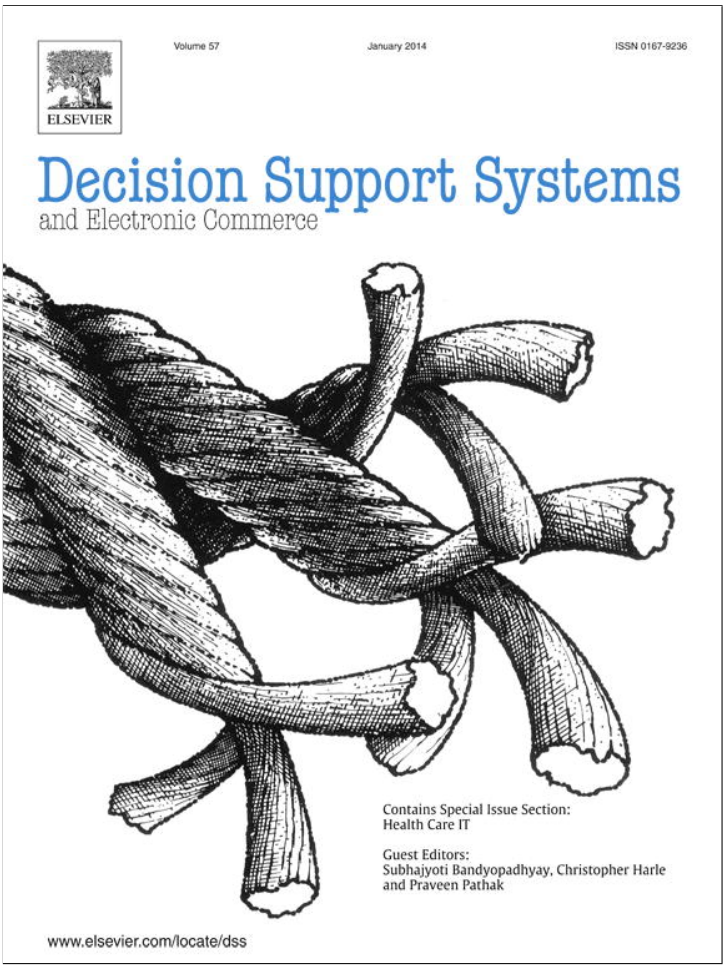

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Information technology and voluntary quality disclosure by hospitals

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ABSTRACT

Information asymmetry between consumers and health care providers is a well-known phenomenon in health care systems. Disclosure of health care quality information is one important mechanism through which hospitals can signal performance to potential patients and competitors, yet little is known about the organizational factors that contribute to voluntary disclosure. In this study we develop an empirical model to investigate the factors associated with choosing to participate in a voluntary quality disclosure initiative, specifically isolating the importance of information technology (IT) in facilitating disclosure. We extend the scope of prior work on the quality disclosure choice by augmenting it with an important decision variable: the operational costs of collecting and reporting quality data. We suggest that IT can facilitate disclosure by reducing these costs, thereby extending the literature on the value of IT. Empirical findings using data from a major voluntary quality disclosure program in California hospitals support our assertion related to the role of IT. Our results further highlight other hospital characteristics contributing to disclosure. We discuss implications of these findings for research and practice.

1. Introduction

Information asymmetries between health care consumers and health care providers such as physicians and hospitals are a widely observed and well-documented phenomenon. For more than two decades, policy makers and advocates have issued calls for hospitals to be more transparent about the quality of care delivered to patients [16,23,43], under the assumption that by reporting quality, hospitals would be more motivated to seek quality improvements. Yet, even the federal government's mandated HospitalCompare program launched under the aegis of the Centers for Medicare and Medicaid Services (CMS) has been criticized for the limited information it reports and the fact that the data often do not reach end users [26,80]. In response to these criticisms, in recent years there has been a sharp increase in coalitions being formed in a number of states for creating voluntary hospital reporting systems that capture richer and more accessible information that can be easily utilized by patients. These programs include *Quality Insights* of Pennsylvania, *West Virginia Medical Institute*, *Quality Insights* of Delaware, and *California Hospital Assessment and Reporting Taskforce (CHART)*, among others.

While voluntary disclosure programs doubtless offer the capability of providing timely and relevant information with broader reach to patients, researchers have found that the willingness to disclose quality information varies considerably among hospitals [62,74]. As noted in related work [57], if hospitals that refuse to report quality provide inferior care, then any reporting system that uses data from only *better* performing hospitals would be artificially inflating average quality assessments. This has sparked a spirited debate on whether there should be mandatory or voluntary quality disclosure from hospitals and other healthcare providers [25,57]. However, despite the significant interest in greater transparency with respect to quality of care, little is known about the nature of the hospitals that voluntarily participate in quality disclosure programs, or the characteristics of hospitals that decide not to report. In particular, there is limited understanding of the role of information technology (IT) in facilitating the decision to disclose. IT can potentially make two important contributions to disclosure: first, IT has been implicated in diminishing information asymmetry [72] and second, to the extent that IT enables efficient capture and processing of quality data, it can be instrumental in reducing the costs of disclosure [39].

In this paper we examine the volitional quality disclosure decision of hospitals. Specifically, we investigate the characteristics of hospitals that choose to participate in voluntary performance reporting. The setting for our study is CHART, California's voluntary public disclosure initiative. CHART policy is set by a board of consumers, employers, health plans, and providers. Because there are no obvious coercive pressures for hospitals to participate[1] — such as those present in other major quality initiatives like CMS and the Joint Commission on Accreditation

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[1] Although there was no specific mandate to report, we note that the initiative was launched in part as a response to the payers' intention to profile all California hospitals with administrative data alone. CHART supports the reporting of administrative and clinical quality data.

of Healthcare Organizations (JCAHO) in which hospitals have strong economic pressure and/or accreditation objectives — this initiative provides a suitable context for examining hospitals' voluntary disclosure decision and the factors that affect it.

This paper makes important contributions to the literature on quality disclosure. Previous studies, predominantly in the economics literature and to a limited extent in healthcare, have primarily focused on the benefits of disclosure. In contrast, our study expands the scope to the cost side factor by examining how hospitals' financial constraints influence disclosure decisions. We identify the pivotal role of IT in quality disclosure decisions, which has the potential to facilitate the data gathering and reporting process. In the remainder of the paper we introduce background material and summarize related literature, constituting Section 2. We describe the data set in Section 3, and report the results of our empirical analysis in Section 4. We conclude the paper in Section 5, discussing limitations of our study, conclusions, and recommendations for future research.

2. Background

2.1. Quality disclosure in healthcare

Consumers have traditionally relied on the recommendations of physicians, friends, and family when choosing healthcare providers [8,28,67]. Given the highly consequential nature of healthcare delivery services and increasing public attention being focused on patient safety issues, not surprisingly, consumers have recently exhibited an interest in systematic quality information and quality disclosure as a key component of consumer directed healthcare [35,71,77]. Although IT has provided platforms such as the Internet through which quality information can be disseminated, the measurement and disclosure of hospital quality has long been a challenge for health care providers. The difficulty faced by hospitals is attributable to two primary causes: first, from the perspective of capturing and reporting the information; and second, the delivery of easily interpretable data to consumers [26,35,80]. The availability of this quality information has the potential to influence consumers when choosing healthcare providers, but the system is flawed from the perspective that consumers may, in effect, undervalue provider quality when faced with imperfect quality information. Thus, imperfect information may result in providers under-investing in quality improvement programs. Health care providers were among the first to recognize this problem and as a result, they formed JCAHO in 1951[2] as a way to standardize and improve the quality of hospital care. The demand for quality information did not end with JCAHO or other federally mandated programs but instead is being addressed by a wide range of initiatives [13]. HospitalCompare is the most notable hospital quality disclosure program. Formed by CMS, HospitalCompare includes strong pay-for-reporting incentives and therefore has near-universal participation.

Prior studies that have explored the impact of quality reporting initiatives, have provided evidence that public reporting of quality helps hospitals improve their services [29,55] and that patients desire information about error disclosure [30] even though they face barriers to finding or interpreting the information [26,35,80]. More troubling is the suggestion that mandatory quality disclosure may discourage reporting quality incidents [82] or cause providers to avoid high-risk patients [21]. Indeed, the limitations of existing mandatory reporting systems and the CMS program have led to the subsequent formation of coalitions in a number of states for creating voluntary hospital reporting systems. These voluntary disclosure programs are intended to provide more relevant quality information, and facilitate access and interpretation by healthcare consumers. However, significant challenges exist. As noted earlier, the willingness to disclose quality information exhibits considerable variation [62,74]. Recent research suggests that providers may be reluctant or simply unable to opt-in to these programs for various reasons including prohibition by state law, fear of data misinterpretation, and legal implications. Incomplete and/or biased (i.e., only relatively high quality hospitals participate) reporting could potentially limit the usefulness of these systems and undermine efforts to achieve transparency [31]. Up to now, however, we have limited understanding of the factors that affect participation decisions in voluntary quality disclosure programs.

2.2. Factors that influence quality disclosure

Even though we have limited understanding of the drivers of quality disclosure, extant literature provides one useful insight: the simple act of opting in or out of a quality reporting program provides important information in and of itself. Indeed, signaling theory [79] suggests that hospitals that opt-in to a voluntary quality disclosure program are conveying to other stakeholders that they are willing to reveal key information about their performance on metrics that are important to consumers. Studies on accreditations such as ISO 9000 have provided evidence of a signaling mechanism [15,81]. However, only a few studies have focused on the disclosure of *quality* information [46,48].

More nuanced studies of financial disclosure have revealed contingencies about disclosure [7], some of which are functions of competitive moves called informed actions and reactions, and others that are related to the information itself. For example, Skinner [76] notes that 'good news' disclosures about financial performance are typically accompanied by quantitative estimates of performance while 'bad news' disclosures are qualitative with only indirect reference to numbers. Other studies have observed that the size of the firm relative to its competitors is related to disclosure [9,12], that greater disclosure is associated with a reduction in stock price mis-valuation [38,76], and that public versus private disclosures have differential market responses [42].

The preponderance of evidence from financial disclosure suggests that better performing firms will disclose more readily than will poorer performing firms [38,40,51]. Because voluntary quality disclosure has received far less attention than financial disclosure, we begin by verifying that hospitals follow a similar disclosure pattern except that hospitals disclose quality information rather than the financial data disclosed by other corporate entities. Since quality is a key indicator of performance in hospitals and often a more important strategic focus than financial metrics (such as those examined in financial disclosure), we expect that better quality increases the likelihood of disclosure [33,73].

Besides quality, a second important factor that influences disclosure is competition [46]. In the particular case of healthcare, most services cannot be rendered remotely or virtually, so a consumer must physically travel to the hospital to receive care. Thus, people are likely to utilize some sort of decision calculus to weigh the advantage of localized service relative to the potential for improved quality received from a more distal location. In more rural regions where competition is low, consumers' decision criteria are less a function of quality as they are a function of convenience, since there are few to no alternatives. However, in highly populous urban regions, where consumers have access to more alternatives and can exercise options, competition appears to play an important role in strategic positioning for hospitals.

What is the nature of the effects of competition on hospitals' decisions? D'Aveni [17] suggests that building a sustainable competitive advantage in hypercompetitive markets simply results in a misappropriation of resources, yet notes that unlike perfect competition (i.e. no firms wins), temporary advantages can materialize from dynamic repositioning. In price-quality competition, a firm seeks to offer the best 'value' to a consumer. In traditional markets, some firms choose

[2] The organization was originally named the Joint Commission on Accreditation of Hospital Organizations until 1987.

a low-cost, low-quality strategy while others choose the opposite. This scenario is unlikely to exist in healthcare as insurance dampens consumers' price sensitivity. Furthermore, government programs such as Medicare and Medicaid set prices for a substantial segment of the hospital market, so price competition is unlikely to occur but competition in urban regions is plausible if quality information is made available to consumers.

2.3. IT and the operational costs of quality disclosure

Firms weigh the costs associated with the systematic collection of quality information against the benefits of disclosure [20]. Healy and Palepu [39] provide a detailed review of the disclosure cost literature. Most disclosure costs are associated with the demand-side (i.e., how the market reacts to the disclosed information). Another important, albeit less examined aspect, is that there are costs associated with the generation of information for disclosure. Prior studies in economics reinforce the notion that information disclosure costs can be substantial and disclosure is predicated on a firm's ability to efficiently collect the relevant data. The high cost associated with information collection and synthesis implies that only firms above certain financial leverage or above a threshold level of quality can afford quality disclosure [34,47]. In the context of the Sarbanes–Oxley Act (SOX) of 2002 [14,53,78],[3] the finance literature has intensely debated the costs incurred by firms to meet the complex regulatory disclosure mandated by SOX.[4] Zhang [84] estimates that SOX compliance costs are as high as 1.2 % of the market value of an average firm. The annual Finance Executives International survey of 2007 indicates that for 168 companies with average revenues of $4.7 billion, the average costs to comply were $1.7 million (0.036% of revenue) [24]. Costs for decentralized companies (i.e., those with multiple segments or divisions) were considerably higher than for centralized companies. Further, Foley & Lardner [36] found that the average cost of compliance for companies with under $1 billion in annual revenue was approximately $1.7 to $2.8 million post-SOX, with an increase in more than 100 % due to SOX implementation.

SOX is a prominent example of the substantive operational costs that firms incur for disclosure. There is evidence that when confronted with the high cost to collect more quality information, firms frequently reduce the range of information that they voluntarily collect [56,75]. For example, drug development or food production companies reduce the number of studies or trials that explore the effect of the drug or food product on healthy lifestyles, or on specific populations; unless such disclosure is mandated.

For hospitals, the information required for quality disclosure is often scattered across hospital departments, which can be costly to collect and analyze. This high operational cost is in sharp contrast to financial information disclosure, which is typically based on readily available accounting data. Additionally, given that the market competition effect is not particularly strong among hospitals, the proprietary costs and capital costs identified in the accounting literature should play a less prominent role. Rather, hospitals would tend to be more concerned about and sensitive to the costs of generating quality measures, which might prevent those who are financially constrained to participate in the voluntary disclosure program.

IT can play an important role in facilitating the collection, integration and control of hospital quality information. Several information tools and applications work in an integrated manner to create a hospital data infrastructure and provide the foundation for a quality information collection and archival process. The information collected from divergent sources across departments can be synthesized and used for the purpose of quality disclosure [41,69]. For example, hospitals use health information technologies such as electronic medical records (EMR) and computerized physician order entry systems (CPOE) to archive, exchange, and unify fragmented data into central repositories of patient information. This provides clinicians and hospital administrators with the ability to use evidence-based decision making if they so desire [22]. Specifically, if a patient is initially treated in the Emergency Department (ED) for chest pain, s/he should be given an aspirin upon arrival (see Quality Measures in Table 3) per the quality guidelines specified. Even though an ED doctor or nurse may have entered the order for the aspirin using a CPOE, the information is collected in a central repository containing the patient's entire medical record. Through the use of these tools, administrators and clinicians have immediate access to data and information to make informed decisions in real-time for diagnosis and treatment of patients [37], and the capability to access and collect information from diagnosis and treatment processes, all of which are necessary to disclose quality.

A set of IT based tools and applications used in hospitals help predominantly in performing administrative tasks related to communicating, coordinating, and planning a wide range of hospital activities (e.g. patient registration, billing, department management software) [65,68]. The early diffusion of administrative IT applications was particularly focused on billing and charge capture capabilities. While most hospitals lack comprehensive EMR systems, administrative applications are frequently linked to clinical data repositories and include report-writing capabilities [27,58]. Quite often, these administrative IT tools provide the much needed capability to capture, store and manage relevant information needed for quality disclosure.

Administrative IT tools and applications generally align to the hospitals' clinical processes. For example, administrative IT tools such as 'patient scheduling' or 'operating room scheduling systems' aid in keeping the track of patient intervention related process measures. Similarly, 'IT based abstracting' or 'nursing management systems' record the post-operative or pre-operative processes of a patient. Other administrative tools such as 'outcomes and quality management tool' coordinate and synchronize with the hospital-level processes and mount an automated quality data collection and disclosure mechanism to collect, analyze and report the quality measures. Several IT vendors are providing such application layers that integrate and synchronize with current process based IT applications in hospitals to provide the capabilities to intelligently aggregate and summarize quality measures [10].

Along with providing capabilities to collect and disseminate quality information, IT tools and applications also help to reduce the effort expended on the procedural requirements of quality disclosure. In the absence of an IT infrastructure, hospital staff must manually record and report quality measures, often at a later time than the actual execution of the process. IT tools and applications help to collect the data and capture at the time and point at which they are generated. Moreover, IT enables a centrally coordinated and automated reporting of the information collected from all the departments and units. As a result, administrators do not have to separately engage staff at unit levels to collect such information, thereby reducing the personnel costs for information collection and reporting for quality disclosure.

To summarize, the role of IT in helping mitigate costs associated with quality information is manifest in three ways: (1) by integrating

[3] The SOX act set new or enhanced standards to strengthen corporate accounting controls and comply with regulatory standards, through 11 titles that describe specific mandates and requirements for financial reporting. The act created a new, quasi-public agency, the Public Company Accounting Oversight Board, or PCAOB, charged with overseeing, regulating, inspecting and disciplining accounting firms in their roles as auditors of public companies. The act also covers issues such as auditor independence, corporate governance, internal control assessment, and enhanced financial disclosure.

[4] Supporters of SOX contend that the legislation was necessary and has played a useful role in restoring public confidence in the nation's capital markets by, among other things, strengthening corporate accounting controls. Further, proponents argue that SOX has been influential in improving the confidence of fund managers and other investors, with regard to the veracity of corporate financial statements. However, opponents claim that the act has introduced an overly complex regulatory environment into U.S. financial markets, thereby forcing the financial service providers to spend time and resources to comply with the requirements of the enacted mandatory disclosure provisions.

disparate and fragmented information across the hospital, (2) by providing a foundational information infrastructure to collect such information, (3) by reducing the administrative efforts spent to collect and report quality. In essence, the cost reduction in quality measurement efforts due to IT investments facilitates hospital participation in voluntary quality disclosure program because it eases the associated financial burden. In this way, IT plays a crucial role in facilitating a hospital's voluntary disclosure decisions.

2.4. Summary

We drew upon prior research in IT impacts, quality disclosure, and quality report cards [62], to identify factors that are likely to be significantly associated with the disclosure decision. We found that most existing work is based in contexts where it is not costly for a provider to disclose quality. However, it may be the case with hospitals that the cost of disclosure is not inconsequential to the decision to opt in for a quality disclosure program. To the degree that some hospitals may face significant operational and financial challenges associated with data capture, there may be variation in willingness to provide data beyond that which is mandated unless it is directly related to improving performance or competitive advantage. That is, a hospital's freedom of action is constrained by the resources that it can utilize. This logic yields two testable hypotheses:

(1) Hospitals with more financial resources would be more likely to participate in voluntary programs.
(2) Disclosure will increase with increasing IT infrastructure endowments.

We have argued for a direct effect of IT on disclosure through the underlying mechanism of cost reduction. IT can also exhibit an indirect effect of IT on disclosure via its effects on quality. It has been suggested that health IT can lead to higher quality [6,61], which in turn would lead to greater propensity to disclose. Our empirical strategy is to explicitly control for the quality differences across hospitals, which allows us to estimate the direct impact of IT on disclosure decisions via reduction of operational costs. We empirically test our two hypotheses in the context of CHART.

3. Data

Our empirical analysis is based on a unique matched dataset compiled from four sources.

3.1. Participation in disclosure

The first data source was the CHART participant list as of August 2007 (URL: http://www.calhospitalcompare.org/About-Us/Participating-Hospitals.aspx). We focus on the 285 acute care, nonfederal hospitals, excluding critical access and specialty hospitals. The primary reason for eliminating these hospitals was that a children's hospital, for example, collects and reports data that are not comparable to the acute care hospitals. Based on this we construct our dependent variable ***Disclosure,*** which indicates whether a hospital participates or does not participate in CHART. Every hospital in California is given the option to disclose its quality but only some choose to do so. Therefore, disclosure can be viewed as a dichotomous decision made by senior management within each hospital regarding whether or not to participate in the voluntary disclosure program. Because this is a voluntary program with no financial incentives associated with participation, the decision to disclose (opt-in) is entirely determined by the hospitals. If the decision is made to opt-in, we code that hospital as a 1, and if it chooses not to disclose its quality, it receives a 0.

3.2. Quality measures

We obtained hospital quality measures from Hospital Quality Alliance (HQA), which is the largest national public–private collaboration to collect hospital data regarding the quality of care [44]. Although the database has twenty-one quality measures, we focus on the ten included in the original "starter set," [83]. These ten measures have been shown to reflect a hospital's quality performance on metrics such as mortality rates in randomized trials with controlled populations [45]. Further, as hospitals were given strong financial incentive to report these measures, we have data for most hospitals, which allows a more meaningful comparison between the disclosure and non-disclosure groups since the newly added measures have significantly more missing values. The ten measures are related to three clinical conditions: Heart Attack, Heart Failure, and Pneumonia. For Heart Attack, there are five performance measures: ACE Inhibitor or ARB for Left Ventricular Systolic Dysfunction (LVSD), Aspirin at Arrival, Aspirin at Discharge, Beta Blocker at Arrival, Beta Blocker at Discharge. For Heart Failure, there are two performance measures: ACE Inhibitor or ARB for Left Ventricular Systolic Dysfunction (LVSD), and Assessment of Left Ventricular Function (LVF). For Pneumonia, there are three measures: Pneumococcal Vaccination, Initial Antibiotic(s) within 4 Hours of arrival, and Oxygenation Assessment.

Based on these metrics, we conduct a series of analyses to construct quality measures of hospitals. First, we perform factor analysis on the available stable measures to extract a major quality index (***Quality***). Factor loadings are provided in Table 3. Following the convention in the literature, we regard a measure as stable if it is based on discharge data from at least 25 patients [45,49]. Additionally, we construct summary scores for each clinical condition and use the three summary scores as quality measures [45]. Across different quality measure constructions, we have comparable results in the statistical analysis, suggesting that our findings are robust to different methods for constructing the quality index. In subsequent sections, we only report the findings based on the factor analysis. More details on the construction of the *Quality* variable are provided in the appendix.

3.3. IT capital

To assess a hospital's IT endowment, we constructed a measure for Health IT capital stock that is calculated using financial data from the California Office of Statewide Health Planning and Development (OSHPD) database. Although these data do not describe IT capital stock directly, they do provide capital depreciation measures. While economists typically estimate depreciation as asset value reductions, accounting depreciation is a deterministic function of asset age. The Modified Accelerated Cost Recovery System (MACRS) specifies that information systems are depreciated over a five-year period. We thus define ***IT_Capital*** over a one-year timeframe at time t as five times the IT capital depreciation measure, assessed at time $t+1$. This specification assumes that IT capital investment changes are reasonably smooth. This assumption was validated using data from 1997–2007. Furthermore, our capital stock measures were compared to the Pacific area hospital capital stock levels reported in the HIMSS Annual Report — the results were nearly identical. Our measure of IT capital for each hospital is an average of year 2003–2005 (for further validation of this capital stock measure see [52]). Health IT capital data in our analysis include a one-year lag.

As a further robustness check, we also construct the count of administrative IT (***IT_Admin***). This variable is constructed from a third source of data: the 2007 HIMSS Analytics database (derived from the Dorenfest IHDS + Database). Of the 285 acute care hospitals, in California, we matched 262 hospitals to the HIMSS Analytics database with administrative application measures. Quality disclosure costs are a function of the ease with which relevant information is captured, stored, and managed in a hospital setting. Thus, we would expect the cost of quality

disclosure to decrease as the count of each hospital's administrative IT applications increases. Examples of administrative IT are patient registration systems, management reporting systems, patient scheduling systems, operating room scheduling systems, IT based abstracting, and nursing management systems.

3.4. Financial measures

Our financial measures also come from the California Office of Statewide Health Planning and Development (OSHPD) from which we obtained hospital financial performance and other institutional measures. Based on this data we calculated return on assets (***ROA***), which is defined as the ratio of net income to total assets. Return on assets is an accounting-based measure of contemporaneous financial performance and is frequently used to measure profitability of operations [11,60]. We also calculated ***Leverage***, defined as ratio of total debt to total assets, to reflect the capital structure of the hospital. Higher leverage implies more debt for the hospital and thus higher financial risks. These measures were available for 247 out of 285 hospitals. To avoid losing observations in the regression analysis, we create a binary variable for those hospitals whose financial data is not available.

3.5. Other controls

From OSHPD we also obtained other hospital characteristics including number of staffed beds (***Beds***), teaching status (***Teaching***), percentage of Medicaid patients (***Medicaid_pct***). For-profit status is measured by two dummy variables, private ***Non_profit*** and private ***For_profit***, where the public hospitals are the default comparison group. This set of variables constitutes the typical collection of controls included in hospital level analyses. We also construct a competition measure, which is the count of hospitals within 15-mile radius of the focal hospital (***Competition***).[5] Definitions of key variables are provided in Table 1, with summary statistics in Table 2.

4. Empirical analysis

4.1. Comparison of disclosure versus non-disclosure groups

We first describe the differences between the disclosure and non-disclosure groups. As of August 2007, among a total of 285 California hospitals in our sample, 188 hospitals (66.0%) had voluntarily elected to participate in CHART. As evident from Table 4, disclosure hospitals are significantly larger as measured by the number of staffed beds (238/169, $p<0.001$). There are significantly fewer public hospitals in the disclosure group than in the non-disclosure group. By contrast, there are more private nonprofit hospitals in the disclosure than in the non-disclosure group. Both these differences are significant at $p<0.001$ level. The disclosure group admits a lower percentage of Medicaid patients (20%), compared to 33% in non-disclosure hospitals. We also observe a substantial difference in the quality of healthcare between the two groups: disclosure hospitals tend to have higher quality as measured by the quality index constructed from HQA quality measures ($p<0.001$).

The above comparison also reveals that the disclosure group has greater IT capacity. The average disclosure hospital has $8.87 mm in IT capital, compared to $5.61 mm for non-disclosure hospitals. With respect to the count of administrative IT applications, disclosure hospitals have 30 applications compared to 26 for non-disclosure hospitals. Finally, disclosure hospitals have better financial performance than non-disclosure hospitals, as reflected in higher ROA and lower leverage ratio. We do not find academic status or location to be significant differentiators for disclosure and non-disclosure hospitals.

[5] We also applied alternative values of distance radii to construct the competition measure, such as 5-mile, 10-mile, and 25-mile. Our major findings are not sensitive to the radius value except beyond the 25-mile threshold.

Table 1
Definitions of key variables used in the analysis.

Variable	Definition
Disclosure	Dependent variable, a binary variable indicating whether the hospital participates in CHART or not
Quality	The principal quality factor extracted from HQA quality measures
IT_Capital	Average IT capital between year 2003 to 2005
IT_Admin	Count of administrative information system applications adopted by a hospital
Medicaid_pct	Percentage of Medicaid patients among all patients of a hospital
Rural	1 if a hospital is located in rural area, 0 otherwise
ROA	Ratio of net income to total assets
Leverage	Ratio of total debt to total assets
Bed	Number of staffed beds
Teaching	1 if a teaching hospital, 0 otherwise
Non_profit	1 if a hospital is private non-profit, 0 otherwise
For_profit	1 if a hospital is private for-profit, 0 otherwise
Competition	Count of hospitals within 15 mile radius

4.2. Logit model

Since the disclosure decision is a binary variable, we apply the following logit model to examine the impact of a hospital's IT capacity:

$$\begin{aligned} Logit(Disclosure) = {} & \beta_0 + \beta_1 ROA + \beta_2 Leverage + \beta_3 IT + \beta_4 Bed \\ & + \beta_5 Quality + \beta_6 Competition + \beta_7 Rural \\ & + \beta_8 Non\_profit + \beta_9 For\_profit + \beta_{10} Teaching \\ & + \beta_{11} Medicaid\_pct + \varepsilon \end{aligned}$$

In the above specification, ***ROA*** and ***Leverage*** are used to measure the financial status of the hospital. ***IT*** is measured in two ways — as accumulative capital, and as a count of administrative IT of a hospital. Among the control variables, it is worth noting the importance of ***Quality***. First, prior research on signaling has emphasized the critical role of quality in disclosure decisions. Second, as noted earlier, IT can influence quality disclosure both directly (by influencing the cost of collecting quality data) and indirectly (by improving quality). By controlling for quality, we are able to isolate and identify the direct impact of IT on disclosure.

Regression results are reported in Table 5. Column 1 reports the baseline model. We find that disclosure is significantly associated with higher quality. The coefficient of ***Quality*** is 0.589 and significant at $p<0.01$ level. We also find that nonprofit hospitals are more likely to disclose their quality than public hospitals. On the other hand, hospitals with a higher percentage of Medicaid patients are less likely to disclose their quality (coefficient −0.0211, $p<0.05$).

In column 2 we add two financial measures, ***ROA*** and ***Leverage***. Consistent with our conjecture, we find that a hospital's financial status has significant impact on the disclosure decision, even after controlling for quality and nonprofit status. Specifically, although

Table 2
Summary statistics.

Variable	Mean	Std. Dev.	Min	Max
Disclosure	0.66	0.47	0	1
Quality	0.00	1.00	−7.26	0.94
IT_Capital	7.76	13.5	0.02	107
IT_Admin	27.3	5.65	8	45
Medicaid_pct	0.25	0.19	0.003	0.84
Rural	0.08	0.27	0	1
ROA	0.03	0.14	−0.62	0.43
Leverage	0.40	0.98	0.05	14.3
Bed	216	149	20	902
Teaching	0.08	0.28	0	1
Non_profit	0.60	0.49	0	1
For_profit	0.24	0.42	0	1
Competition	17.5	17.9	0	62

Table 3
Factor analysis — quality measures.*

Variable	Factor
	Correlation coefficient
Patients Given Aspirin at Arrival	0.85
Patients Given Aspirin at Discharge	0.83
Patients Given Beta Blocker at Arrival	0.88
Patients Given Beta Blocker at Discharge	0.93
Patients Given ACE Inhibitor or ARB for Left Ventricular Systolic Dysfunction (LVSD)	0.67
Patients Given ACE Inhibitor or ARB for Left Ventricular Systolic Dysfunction (LVSD)	0.69
Patients Assessed and Given Pneumococcal Vaccination	0.36
Patients Given Initial Antibiotic(s) within 4 Hours After Arrival	0.25
Patients Given Oxygenation Assessment	0.52
Variance explained	0.92

* Factor loading is the correlation between an observed variable and an underlying factor. Values greater that 0.4 indicate a strong loading.

ROA is not significant, the variable ***Leverage*** has a negative coefficient of −1.229, and significant at $p<0.05$ level. As higher leverage implies that the hospital bears more debt, this finding suggests that hospitals with worse financial conditions are much less likely to participate in voluntary quality disclosure. Our explanation is that disclosure requires significant efforts in collecting data and summarizing information and possibly, the need to hire dedicated staff, which might be too cost prohibitive for these hospitals.

We then estimate the role of IT in quality disclosure in Column 3 and 4 of Table 5. Column 3 reports the findings when IT is measured as accumulative capital. We find that its coefficient is 0.401, and significant at $p<0.001$ level. This result means that hospitals with higher IT capital are much more likely to disclose their quality. Note that our IT capital measure is based on an average of year 2003–2005, two years before the disclosure decision which is in 2007. Thus, the finding conforms to Granger causality, rather than pure correlation. Additionally, since it is unlikely that hospitals increase their IT investment several years before the voluntary disclosure program is envisioned, the endogeneity issue of IT is less a concern here.

To further examine the robustness of the above findings, we also apply another measure of IT by using the count of administrative IT.

Table 4
Baseline characteristics of hospitals relative to quality disclosure.

Characteristic	Non-disclosure hospitals	Disclosure hospitals	*p*-Value of the difference between two groups
No. of hospitals	97	188	na
No. of staffed beds	169	238	<0.001
Academic status — percentage in group			
Teaching hospital	7%	10%	0.49
Location — percentage in group			
Urban	90%	93%	0.60
Ownership — percentage in group			
Public	2%	12%	<0.001
Private nonprofit	29%	76%	<0.001
Private for-profit	46%	12%	<0.001
Percentage of Medicaid patients	33%	20%	<0.001
Quality factor	−0.54	0.17	<0.001
IT capital ($MM)			
IT capital	5.61	8.87	0.06
Count of administrative applications	26	30	0.02
Financial Status			
Return on assets	−0.01	0.04	0.01
Financial leverage	0.64	0.24	0.01

Table 5
Regression results with quality disclosure as dependent variable.

	(1)	(2)	(3)	(4)
VARIABLES	adding Quality	adding Financial Conditions	adding IT Capital	adding IT-Admin
Quality	0.589***	0.508**	0.445**	0.511**
	(0.216)	(0.220)	(0.223)	(0.226)
ROA		−1.340	−1.134	−1.574
		(1.294)	(1.314)	(1.377)
Leverage		−1.229**	−1.112**	−1.092*
		(0.564)	(0.566)	(0.567)
IT_Capital			0.401***	
			(0.153)	
IT_Admin				1.520**
				(0.656)
Bed	0.0106	0.405**	0.262	0.381*
	(0.127)	(0.196)	(0.203)	(0.200)
Teaching	0.205	0.718	0.585	0.633
	(0.594)	(0.670)	(0.686)	(0.698)
Rural	−0.254	−0.0571	0.203	0.0912
	(0.616)	(0.626)	(0.656)	(0.641)
Non_profit	1.555***	2.154***	2.404***	2.213***
	(0.452)	(0.508)	(0.537)	(0.522)
For_profit	−0.311	0.750	1.333**	0.780
	(0.492)	(0.577)	(0.630)	(0.585)
Competition	−0.114	−0.215	−0.209	−0.160
	(0.146)	(0.156)	(0.157)	(0.157)
Medicaid_pct	−0.021**	−0.011	−0.008	−0.012
	(0.009)	(0.009)	(0.010)	(0.010)
Constant	0.478	1.698**	1.855**	0.899
	(0.585)	(0.760)	(0.788)	(0.910)
Other controls	Dummy variables indicating availability of quality, financial and IT measures			
Observations	285	285	285	285

Standard errors in parentheses.
***$p<0.01$, **$p<0.05$, *$p<0.1$.

The coefficient is 1.520 and significant at $p<0.05$ level (Column 4, Table 5). The above evidence suggest that hospitals with more administrative IT applications might enjoy higher efficiency in collecting and reporting quality information, therefore reducing the operational costs of quality disclosure.

Besides the statistical significance, we also find that the magnitude of IT to be substantial. Holding all other variables at their mean value, one standard deviation above the average in IT capital (in logarithm) leads to an 11.1% increase in the probability of disclosure. Similarly, if a hospital's financial leverage is one standard deviation higher than the average, this leads to 19.3% reduction in the probability of disclosure. Therefore, both hypotheses developed in Section 2 are supported. The logit model fits our data reasonably well. It predicts disclosure correctly 81% of the time. The Hosmer–Lemeshow fit test also suggests a good fit of our model to the data.

5. Discussion and conclusion

In this study, we extend the literature on quality disclosure and identify the effect of operational costs in a hospital's disclosure decision. We hypothesized that conditional on the same quality, hospitals with better IT infrastructure and financial conditions are more likely to disclose. Based on 285 acute-care hospitals in California, we find supporting evidence for the hypotheses. Hospitals with worse financial conditions are less likely to disclose, suggesting that the operational costs of disclosure can negatively influence the disclosure decision. Interestingly, firms with higher IT capital are more likely to disclose, even after controlling for the difference in quality and financial conditions. This finding is consistent with our conjecture that IT helps reduce the operational cost of disclosure. Additionally, we find that higher quality hospitals and non-profit hospitals are more likely to disclose, consistent with existing literature.

The finding that health IT investments amplify the voluntary disclosure of quality has important policy implications. This effect is conditional on measured quality and appears to be a result of direct reduction in disclosure costs. Consequently, federal subsidies for health IT adoption in the HITECH Act of 2009 [2] may, in effect, increase quality disclosure and transparency. Health IT investments may also facilitate the implementation of pay-for-performance programs designed to reward providers that improve the quality or efficiency of healthcare delivery.

This paper makes an important contribution to the growing literature of business value of IT in healthcare. IS researchers have examined the adoption of health IT in various settings [1,3,50,58,70], as well as the impact of health IT on quality and efficiency [4,5,18,19,59,63,64]. Our research expands the above scope by signifying health IT's role in facilitating quality transparency in hospitals. This indirect effect, while not often examined in existing studies, might hold the potential for substantial social value by empowering consumer choice [54] and facilitating hospital competition.

We also contribute to the disclosure debate. Our finding that participation of voluntary disclosure programs are inhibited by financial distress suggests that voluntary disclosure mechanisms may produce misleading or confusing information. Lower quality hospitals are less likely to participate, suggesting that hospitals selectively report in accordance with their own interests. Consumers might interpret non-participation as a negative quality signal. However, it should be emphasized that a hospital's financial leverage also decreases participation conditional on quality. Thus, quality disclosure provides mixed signals and consumers should be cautious when interpreting these results. One important implication of this finding is that hospitals may choose to selectively participate in quality disclosure programs as a function of the specific information required. For example, if the cost of disclosing poor heart failure results is high, a hospital may choose not to participate but they may participate in another program that reports pneumonia data. In effect the hospital is adjusting its transparency levels to accommodate its known internal quality and the costs of reporting [32].

There are several potential extensions for future research. As discussed previously, health IT may also affect disclosure indirectly through quality. If health IT improves quality then this quality improvement should further enhance increased participation. Although we have controlled for the quality effect in our empirical analysis and focus on the direct impact of IT on disclosure, we believe the indirect health IT effects and the role of IT in pay-for-performance initiatives merit further study.

We acknowledge some limitations of this work. First, we used a coarse measure of IT adoption and did not specifically investigate which IT applications or categories of IT are associated with disclosure. Thus far, the extant literature has not examined more granular classifications of IT nor has it considered the mechanisms through which the individual IT applications act. With our current data we were unable to identify these relationships, primarily because hospitals employ large numbers of IT applications which may affect disclosure independently or interactively. It is likely that these interactions between applications are important triggers of disclosure, and merit further study in future work. Additionally, the utilization of many applications is highly correlated within hospitals. Our current data are insufficient to provide insights beyond what we have noted, but perhaps with a longer time series of data future research will be able to categorize the IT in a more meaningful way and find more nuanced relationships.

Another limitation of our study is that there are other costs associated with disclosure beyond those we have tested. Prior literature provides several reasons why a firm would choose not to disclose information, some of which include not revealing performance to competitors, increased legal costs, and not wanting to have to educate consumers on what the information within the disclosure means [39,46,66,76]. Additionally, our quality control is limited in scope. Future studies might want to expand the quality measures to other dimensions including patient satisfaction. Finally, this study is based on acute-care hospitals in California, therefore readers should be cautioned of the generalizability of the findings.

In conclusion, the need for easily accessible and interpretable quality information about hospitals is critical for enabling healthcare consumers to make more informed choices about one of the most consequential services they consume. While legislators can mandate quality disclosure, the constraints that hospitals face in generating accurate "quality" information are not insubstantial. Understanding these constraints and taking policy action to address them is important for realizing the vision of a consumer directed healthcare system.

Appendix A. Factor analysis on quality measures

Based on the 10 HQA quality measures specified in the Data section, we use iterated principal factor analysis to construct overall quality scores for each hospital. We found that 283 out of 285 hospitals have complete data on the 10 measures and included them in the construction. The factor analysis suggests that there is one major factor with an Eigen value of 3.62, while other factors have Eigen values that are less than 0.5. The first factor explains 87% of the variation in the quality measures. This suggests that it is appropriate to use the first quality factor as a quality index to represent the overall quality of the hospital. The statistical findings reported in the Empirical Analysis section do not change qualitatively if we include more quality factors after either performing orthogonal or oblique rotation to construct the quality index.

To ensure the robustness of the above quality index construction, we further limit the factor analysis to only stable HQA measures (i.e., measures constructed from at least 25 patients). One heart attack quality measure, ACE Inhibitor or ARB for Left Ventricular Systolic Dysfunction (LVSD), is dropped from the factor analysis because only 119 out of 285 hospitals' scores are stable for this measure. Therefore, 202 hospitals have stable measures for the remaining nine measures. Similar to what was described above; we find one prominent factor within the quality index (for details on loadings see Table A1 below). We thus use this quality factor as the quality index for each hospital. We create a binary variable for those hospitals that do not have nine complete and stable measures to avoid losing observations in the regression analysis. The empirical analysis yields very similar and comparable results across the above two methods for constructing quality indices. In the paper, we report results using the quality index based on stable quality measures.

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