Consistency is Key: Does Costing Information Consistency Help Hospitals Manage Costs?

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March 7, 2025

Abstract

Health care costs in the United States make up a larger proportion of gross domestic product than in any other developed country and continue to rise. We examine whether the use of consistent costing information across hospitals ("costing information consistency", or CIC) provides one avenue to reduce these costs. We empirically measure CIC at the hospital level by identifying how many other hospitals in the hospital group to which the hospital belongs also use the same costing system vendor. Using M&A activity among costing system *vendors* as an instrument for exogenous changes in hospital CIC, we find that increased cost comparability from CIC leads to economically significant decreases in hospital costs. These cost reductions appear to be achieved without compromising quality of care. We find no significant association between CIC and declines in patient satisfaction, mortality, or readmission rates. Reductions in expenses as the result of CIC are concentrated in non-clinical services such as administration, medical records, and housekeeping.

Keywords: cost management; costing system; information system integration; value-based care

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1. Introduction

The United States is facing a health care cost crisis. In 2019, even before the global pandemic, health expenditures made up 17.5% of GDP, higher than any other developed country, and hospitals accounted for 31% of that total (Martin et al., 2021; CMS, 2022). There is ample evidence of opportunities for efficiency improvements (Kaplan and Witkowski, 2014; Shrank et al., 2019), but the fragmented way in which hospital information is measured and communicated has impeded the ability of hospitals to identify and address these inefficiencies (Doty et al., 2019). We propose that the use of consistent costing information systems, which track and manage costs, can address these issues by standardizing costing information (Castillo et al., 2018). Such consistency, which we refer to as costing information consistency or CIC, can make it easier for hospitals to compare costs for similar products, services, and procedures and identify cost-reduction opportunities. We expect this comparability to manifest in multiple ways. One way is through consistent terminology and a common interface that allows users to easily identify similar items tracked in different hospitals. Another way is through uniformly aggregating cost categories using similar levels of granularity or similarly defining categories used to group items for summary metrics. Blunt cost management approaches that reduce staffing levels or other resources across the board can have adverse effects on patient health outcomes (Aiken et al., 2014). However, effective use of consistent costing system information has the potential to more efficiently allocate resources and reduce expenses while maintaining quality of care.

The purpose of this study is to examine whether the use of a consistent costing system vendor across hospitals within a hospital group (CIC) is associated with reductions in operating expenses in a sample of U.S. hospitals.[1] Consolidation (i.e., mergers and acquisitions) of costing

[1] A hospital group is a health system that consists of two or more hospitals that are operationally connected and owned or managed by a central entity.

system *vendors* is used as an instrumental variable to create as-if random variation in CIC by prompting changes in costing system usage that are unrelated to attributes of individual hospitals. The use of an instrumental variable approach is critical because hospitals may use CIC to combat already high expenses, giving the false impression that consistency *contributes* to these higher costs. Estimates generated using instrumental variables show that the elasticity of CIC to operating expenses (evaluated for the median hospital) is -0.078. This means the median hospital would save roughly $9 million dollars if the number of in-hospital-group hospitals sharing the same costing system vendor doubled from 3 to 6. Moreover, hospitals do not appear to achieve these cost savings by reducing the quality of care. We find no association between CIC and serious patient outcomes such as mortality or hospital readmissions, and also no association with less drastic aspects of the patient experience as reflected in patient satisfaction. We find that CIC enables hospitals to reduce expenses primarily relating to non-clinical services (for example, administrative expenses or those relating to housekeeping and the cafeteria), which may explain why hospitals are able to increase efficiency without sacrificing the quality of care.

Our study contributes to three literatures. First, we contribute to the literature on healthcare regulation. Administrative and care process standardization is notoriously difficult to achieve via top-down regulation (Kocher, 2021). Sahni et al. (2021) argue that achieving a broad regulatory agreement to reduce health sector spending would be very difficult but that organizations can individually make changes to reduce expenses. Sahni et al. (2021) emphasize the need to address poor data management, and lack of standardization and interoperability. In response, our study identifies a way in which hospital leaders can work within the boundaries of their own organizations to reduce operating expenses. Although increasing CIC is only one of many steps that must be taken to address rising health care costs, this strategy offers a significant reduction in spending with a straightforward intervention that does not require regulatory changes. Indeed, Labro and Stice-Lawrence (2020) find that coercive regulatory pressures to update accounting systems are not effective in lowering hospital operating expenses.

Second, we believe our study has implications about the benefit of consistent cost information for cost management in multi-unit organizations in other industries. Such multi-unit firms are prevalent. Across industries, Census statistics count over 2 million establishments that are part of multi-establishment firms, accounting for 57% of employment (Xi, 2023). Furthermore, there has been substantial growth in the number of establishments per firm over time (Hsieh & Rossi-Hansberg, 2023). Researchers typically do not have access to data on performance at the business unit level or information on the costing system vendors in place, making our study instrumental in understanding this multi-unit firm cost management dynamic more generally. Of course, our data is healthcare sector specific, and cost control is a particularly problematic issue in this sector. This may imply that our magnitude estimate of the potential for operating expense reductions is an upper bound for what may be obtained in other industries.

Third, we contribute to the literature on post-merger and -acquisition integration. The results of this study suggest that mergers and acquisitions are more likely to be profitable when they unite units with consistent costing systems. While Chen et al. (2018) find that acquisition decisions are more profitable when the target firm has higher external financial statement comparability with industry peer firms, we are not aware of any studies highlighting intra-firm internal information comparability. Furthermore, this study may explain the mixed evidence (Schmitt, 2017; Craig et al, 2021) of the impact of *hospital* mergers on operating expenses by highlighting cost information consistency as an omitted, confounding factor.

2. Hypothesis

A shared costing vendor enhances cost information consistency through standardized aggregation, a uniform data-generating process, and a single platform. Comparability of reported costs increases when they are reported at a standardized level of aggregation (e.g., department, provider, patient) or at a standardized time interval (e.g., monthly, quarterly, yearly). Furthermore, a consistent data-generating process where all units in a multi-unit firm use the same costing method (e.g., all hospitals use Relative Value Units or Activity-Based Costing) and the same type of input data (e.g., all use actual payments to vendors rather than vendor list prices) enhances comparability. Additionally, a single reporting platform increases the ease with which one unit's cost data can be compared with that of other units in the firm, as well as reduces communication costs between units in the firm, where staff now can see on a dashboard where the cost discrepancies arise between units. As one CFO of a health system put it, bringing all hospitals on the same cost information system "support[s] a common language" and increases data standardization that brings "high reliability to the information flowing through the health system" (Syntellis, 2020a). Different vendors may make equally valid but different aggregation and reporting choices, which may create frictions when hospitals using different vendors try to communicate. The enhanced comparability because of cost information consistency allows units within the firm to identify which other units are operating certain aspects of their business more cost effectively and learn what their best practices are to subsequently implement similar practices in their own unit.

As an illustration of how cost information consistency allows hospitals in a hospital group to benchmark their expenses against those of others in the hospital group at a granular level, refer to Figure 1 which shows part of the dashboard provided by CostFlex, one of the costing system vendors in our sample. Note how each entity's consistently calculated costs can be compared to those of other entities on a fairly granular level. Furthermore, the comparison can be done specifically for hospitals that are similar in terms of underlying economic operations, such as whether they are a critical access hospital or not, whether they have a similar patient mix, etc. As another example, Heard and Gravas (1997) report about the Trendstar costing software implemented (also in our sample) at Flinders Medical Center that, "Costing systems enable us to review our client base by identifying high-cost individual admissions or groups of admissions, based on intra- and inter-hospital comparisons. Examination of Trendstar data also helps us to understand our case mix in relation to cost. Data may be reported by ANDRGs, principal diagnosis, complications and co-morbidities, procedures performed, age, length of stay, ward, peer review, equiseps, day of stay, etc. Clinician feedback and support are imperative as we jointly formulate ways to investigate any cost anomalies and review procedures." We formulate the following hypothesis:

H1: Increased cost information consistency leads to reductions in hospital operating expenses.

This hypothesis is not without tension. First, there are costs in terms of time, effort and money associated with integrating costing systems to a shared vendor that may increase operating expenses. Second, the frequently used costing system vendor in the hospital group may not necessarily be the best at reflecting the unique circumstances of the focal hospital, making cost management of the focal hospital less effective. Third, hospital executives may be familiar with a particular costing system from prior experience and becoming acquainted with the more frequently used vendor's costing system may make their cost management practices harder to execute. These reasons can also help explain why not every hospital is adopting a costing system that is consistent with that of other hospitals in the hospital group. Furthermore, hospital management may lack the sophistication to understand that substantial operating expense reductions may be obtained by implementing increased cost information consistency, and therefore not pursue a shared costing system vendor.

3. Data Sources and Empirical Design

3.1 Data Sources and Sample

The primary data source for this study is the HIMSS Analytics Database, which provides hospital-level survey data on information technology and operating characteristics, supplemented with data from the CMS (Centers for Medicare and Medicaid Services) Cost Reports. Clinical outcomes and patient satisfaction were obtained from the CMS Hospital Compare database. Hospital group affiliation was identified from a comprehensive roster created by Cooper et al. (2019), which tracks ownership changes from 2001 to 2014. Correctly identifying hospital group membership is critical to correctly measure CIC; otherwise, our measure would incorrectly group together hospitals that do not share information as part of a hospital group. We exclude hospitals that have never installed a costing system.[2] The final sample includes 1,380 nongovernmental, acute care hospitals from 325 unique hospital groups spanning from 2006, when HIMSS began tracking vendor identity consistently, to 2014, when Cooper et al. stopped tracking hospital group membership.

3.2 Primary Variables of Interest

Our primary outcome variable is the inverse hyperbolic sign transformation of dollar operating expenses per bed (*Operating Expenses*). Additional outcomes are average 30-day mortality and readmission rates (*Mortality, Readmissions*), patient satisfaction with various aspects of care, and core clinical versus non-clinical expenses (*Core Clinical (Non-Clinical) Expenses*). All variables are described in detail in the Variable Appendix.

[2] Inferences are unchanged when these hospitals are included.

Empirically*, ihs(CIC)* takes the inverse hyperbolic sine (arcsinh) of the number of hospitals within a hospital group-year that have the same costing vendor as the focal hospital (CIC). The inverse hyperbolic sine transformation, like taking the natural log, normalizes right-skewed data but can accommodate zero values (Burbidge et al., 1988). Therefore, *ihs(CIC)* measures the number of hospitals within the hospital group that have consistent costing information from which the focal hospital can glean insights. In robustness tests, reported in Section 5.2, we use two alternate binary measures of CIC that start with defining a primary costing system vendor for the hospital group by summing up the number of hospitals (for the unweighted measure) or the number of beds (for the weighted measure) that use each vendor. In these binary measures, CIC takes on a value of one if the focal hospital uses the primary costing system vendor.

3.3. Instrumental Variable: Costing Vendor Consolidation

We use an instrumental variables analysis to address selection bias because hospitals do not randomly select their costing vendors, and CIC could be tied to other hospital characteristics that affect operating expenses. For example, hospitals with high operating expenses may use CIC to control their costs.

The presence of costing system *vendor* consolidations (*Vendor Consolidation)* is used as an instrumental variable for CIC. We choose this instrument because we expect that vendor mergers will lead to increases in CIC but have no direct effect on hospital expenses. In particular, we expect vendor mergers to prompt hospital groups to switch the costing vendors at some of their constituent hospitals, and hospitals changing their vendors would likely gravitate towards those already used by other hospitals in the same group. This can happen in several ways. First, vendor consolidation can increase the consolidated vendor's market share and economies of scale, which might allow them to offer more or better support services. This could entice additional hospitals within the same hospital group to adopt the consolidating vendor. On the other hand, although most vendor consolidations are intended to increase market share, efficiency, and profitability, they can potentially prompt hospitals to switch *away* from the consolidating vendor. For example, because merged vendors often combine or retire similar software (Rosenberg, 2018), hospitals forced to migrate to new costing systems when support of older systems is discontinued might choose to switch vendors, and might preemptively switch vendors at the time of the merger in anticipation of future product retirements (Venminder, 2021). Alternatively, a vendor merger could indicate a change in the strategic direction of the vendor, and hospitals might choose to change to a vendor more aligned with their operational needs (Bruce, 2022). Last, vendor mergers intended to reduce the vendor's operating costs might come at the expense of customer service and lead to staff turnover that eliminates longstanding vendor-client relationships. Actual or expected decreases in service quality might, therefore, prompt clients to switch vendors at the time of the merger (MicroMD, 2018; Venminder, 2021). Vendors evidently find these negative post-consolidation effects to be plausible because they cite customer loss as a major risk of consolidations.[3] In short, costing vendor consolidations are disruptions in the software market that can serve as the impetus for hospitals to change vendors for a variety of reasons. Because a major barrier to CIC is adjustment costs, we expect that when hospitals are already changing vendors, they will naturally coordinate costing system vendors within their hospital group. Figure 2 depicts the number of costing vendors involved in consolidations by year. Internet Appendix Table A1

[3] In their 2010 10-K, MedAssets says, "Existing customers, suppliers and distributors may seek to terminate and/or renegotiate their relationships with the combined company as a result of the Broadlane Acquisition. Existing customers may not accept new products or continue as customers of the combined company," and McKesson's 2008 10-K says, "Challenges in integrating software products could impair our ability to attract and retain customers."

provides evidence that CIC increases when hospitals switch either *to* or *from* consolidating vendors after a consolidation, supporting both of these mechanisms as plausible paths for our instrument.[4]

We expect that vendor consolidations will serve as a significant but temporary shock to hospitals' CIC. Anecdotal evidence from a healthcare software vendor representative indicates that there is a yearly period when hospitals negotiate fee increases and have the option to terminate their costing system contracts. Further, costing systems are updated or changed frequently under normal circumstances (every three to four years on average, according to Labro and Stice-Lawrence, 2020) making it plausible for hospitals to accelerate an update by a year or two if they expect benefits from switching. As a result, we expect vendor consolidations to lead to changes in CIC as early as the year of the consolidation. However, over time, CIC can change for many other reasons, including the addition of new hospitals (with different costing systems) to a hospital group, gradual migration to new vendors to meet changing needs, or gradual changes in costing system features and services. Consequently, we do not expect the effect of vendor consolidations on CIC to be permanent. Therefore, in our empirical analyses, we focus on vendor consolidations in the current and prior year and define *Vendor Consolidation* as an indicator variable set to 1 if the hospital's costing system vendor was involved in a consolidation in one of these periods.[5] Figure 3 depicts the frequency of vendor consolidations per hospital within our sample period.[6]

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[4] We empirically demonstrate the power of the instrument in Table 3.

[5] We explore this design choice in Internet Appendix Tables A3 and A4 where we define *Vendor Consolidation* using multiple time windows. We find the strongest first-stage effects of vendor consolidations on CIC in the year of and the year following the consolidation, and our second-stage tests examining the effect of CIC on expenses are strongest when using our instrument defined over that two-year window, consistent with it maximizing the power of our tests by focusing on the window when vendor consolidations serve as the strongest instrument. As a result, we use a two-year window to define *Vendor Consolidation*.

[6] Our vendor consolidation instrument is an indicator variable that turns on in the first stage for some hospitals in some years. This is similar to the staggered difference-in-differences design discussed in Baker et al. (2022). Baker et al. conclude that staggered difference-in-differences designs are problematic when they include already-treated firms in the control group because subsequently-treated firms are then compared to firms who have already received the treatment. Our study is different from the conditions studied in Baker et al. because hospitals can experience multiple vendor consolidations, and we expect the effect of each consolidation to be only temporary (as shown in Internet Appendix Table A3). Internet Appendix Tables D1-D4 demonstrate that our results are similar when we focus on a

3.4 Descriptive Statistics

Table 1 presents descriptive information about the data used in this study. All continuous variables are winsorized at the 1% level. Our sample includes 9,331 yearly observations of 1,380 hospitals over 9 years, 427 core-based statistical areas (CBSAs), and 325 unique hospital groups. The median (mean) hospital has 3 (12) other hospitals in its hospital group that use the same costing system vendor (i.e., would be counted in our CIC measure). For the median value of 3, this translates to an *ihs(CIC)* value of 1.82. 52% of hospitals are academic hospitals (*Academic*), 4% are rural hospitals (*Rural*), and 51% are hospitals belonging to purchasing groups (*Purchasing Group*). 52% of hospital-year observations have been exposed to a vendor consolidation in the current or prior year (*Vendor Consolidation*). The average hospital-year observation has 272 beds (*Bedsize*) and belongs to a hospital group of 27 hospitals (*Hospital Group Size*), with 12.51% (41.04%) of revenues coming from Medicaid (Medicare). The average local hospital market is highly concentrated with an HHI of 3,836.

Table 2 examines raw correlations among several key variables. We find a strong positive correlation between *ihs(CIC)* and our instrumental variable, vendor consolidation, which supports our choice of instrument. Results tabulated in Internet Appendix B2 show that *ihs(CIC)* is very stable over time (85% year-on-year correlation).

4. Empirical Results

We use a two-stage least squares approach to estimate the effect of CIC on hospital operating expenses. Table 3 presents the first-stage regression linking our instrument, *Vendor Consolidation,* with *CIC.* We include several variables that control for the operating environment

sample of hospitals experiencing vendor consolidations for the first time or when we focus on a sample of hospitals experiencing vendor consolidations for a second time or more, confirming that multiple treatments and the presence of already-treated firms in the sample do not pose a problem for our inferences.

of the hospital, including hospital revenues *(ihs(Revenue per bed))*, the level and growth in hospital bed size (*Bedsize, Growth_Bedsize)*, hospital group size (*Hospital Group Size)*, the complexity of patients (Case Mix Index*, CMI*), an indicator for whether the hospital was recently acquired by a hospital group (*Acquired by Hospital Group)*, an indicator for whether the hospital recently adopted a costing system for the first time (*Costing Adopter*), the age (and squared age) of its information technology investments (*Apps_Age, Apps_Age_Squared)*, the proportion of Medicare and Medicaid patients (*% Medicare, % Medicaid)*, the concentration of the local hospital market (*HHI*), an indicator for whether the hospital is a member of a purchasing group (*Purchasing Group Member)*, and indicators for whether the hospital is academic, for profit, religious, specialty or rural (*Academic, For Profit, Religious, Specialty Hospital, Rural*). In addition to control variables, we include CBSA (metropolitan area), year, and hospital group fixed effects. These fixed effects allow us to account for attributes that are constant within region (such as local healthcare policies, regional economic conditions, local access to healthcare resources, patient population demands, and the geography in which the vendor consolidations happen), time (such as federal healthcare policies, advances in medical technology, and inflation), and hospital group (such as centralized administrative policies, shared resources or services, common patient care protocols, governance structure of the hospital group, and the attractiveness of the hospital group as clients for costing vendors). Table 3 shows a strong and significantly positive link between vendor consolidations and CIC. The control variable *Acquired by Hospital Group* loads negatively on CIC, whereas religious hospitals, academic hospitals and hospitals with a larger proportion of Medicare patients (*Religious, Academic, % Medicare)* have higher CIC. We believe the link between CIC and whether the hospital was acquired is somewhat mechanical, because a hospital acquired by a hospital group with a different set of costing system vendors would immediately experience a drop in CIC.

Most importantly, Table 4 reports the results from the second-stage regression linking instrumented *CIC* with *Operating Expenses* and using the same control variables and fixed effects as in Table 3. We examine the time series of this relation by demonstrating the results at several different lags. While *Operating Expenses* and the control variables are all measured in year *t,* instrumented *CIC* is measured at time *t, t-1, t-2,* and *t-3.* The *Acquired by Hospital Group* control ensures that our expense results are not driven by changes in operating expenses during *hospital* mergers and acquisitions, and the *Costing Adopter* control ensures that our results are not driven by the new availability of cost information that was not present before a first-time adoption. The results of these analyses show that *Operating Expenses* are significantly negatively associated with *CIC* in years *t* and *t-1,* indicating immediate benefits of consistent information.[7] Crucially, the heteroskedastic-robust F-statistic from the test of excluded instruments falls well above the critical value of 8.96 in all specifications indicating that *Vendor Consolidation* is a strong instrument (Stock et al., 2002). [8]

[7] The speed with which we document benefits of CIC is consistent with anecdotal evidence that hospital costing systems are implemented and leveraged very quickly. A manager at LifePoint Health, a 61-hospital group, said about their cost accounting platform: "We can get new hospitals up and running in two weeks" (Syntellis, 2020b). The CFO of a 600-bed system said, "Our region was up and running with accurate cost data in a few short months" (Costflex, 2024). Our results are also in line with the evidence reported in Labro and Stice-Lawrence (2020) who show that updating of accounting systems generates immediate operating expense savings in the year of the update and the year after.

[8] Few control variables load in this analysis incremental to patient volume (captured by *ihs(Revenue))* and the variation captured by the fixed effects. However, we also find that expenses are higher in hospitals with greater patient complexity (*CMI)* and lower in those with higher growth (*Growth_Bedside)*, the latter likely because of economies of scale. Religious and Academic hospitals are associated with higher expenses in some columns. Whether or not the hospital was *Acquired by a Hospital Group* becomes significant in Columns 3 and 4 only. Because the only difference between the first two and last 2 columns is the time lag with which CIC is measured (operating expenses and the control variables are measured in year *t* for all columns), we believe the reason for this change is because later columns do not control for *current CIC*. Table 3 shows that CIC is strongly negatively associated with hospital acquisitions. Therefore, in later columns of Table 4, current CIC is an omitted variable that is correlated with the *Acquired by a Hospital Group* variable. This could be remedied by estimating the 4 columns in Table 4 in one specification that includes all four lags of CIC. However, our data lack sufficient power to estimate all four lags of CIC using

These results provide evidence that CIC allows hospitals to better use costing information in order to minimize expenses, even after removing selection bias in CIC, and the effects of CIC induced by vendor consolidations last for about two years. Because the effects of CIC appear to last for only two years, subsequent tables report only these lags. Using the coefficient from Table 4 Column 1 of -0.0820 and following equation [16] in Bellemare and Wichman (2020), we estimate that the elasticity of CIC to operating expenses, evaluated at the median number of hospitals with shared costing system vendors, is -0.0778.[9] With median operating expenses per bed of $521,042, this means that a 100% increase in the number of hospitals in the group that share a vendor (i.e., going from 3 to 6 hospitals, or roughly an eighth of a standard deviation) decreases operating expenses per bed by $40,562. For the median hospital, which has 231 beds, this constitutes an operating expense reduction of $9,369,822. For the mean hospital, a roughly half of a standard deviation increase in the number of hospitals in the hospital group that share a vendor implies a reduction of $12,506,560.[10] Because the budget of the entire IT department is only about 2% of expenses on average (Definitive Healthcare, 2025), these results appear to be driven by hospitals leveraging costing information to reduce expenses, rather than a reduction in the amount spent on costing systems themselves.

Note that our specification includes region, time and hospital-group fixed effects (in addition to time-varying hospital-level control variables), allowing the results to be interpreted as

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instrumental variables in the same equation; an untabulated test attempting this no longer had an F-statistic from the test of excluded instruments that exceeded Stock et al. (2002) critical values.

[9] Bellemare and Wichman (2020, equation [16]) derive that the elasticity equals $\hat{\beta}.\frac{\sqrt{y^2+1}}{y}.\frac{x}{\sqrt{x^2+1}}$. Because $\lim_{y\to\infty}\frac{\sqrt{y^2+1}}{y} = 1$ and $\frac{3}{\sqrt{3^2+1}} = 0.9487$, we calculate the elasticity as -0.0820*0.9487 = -0.0778.

[10] The mean number of hospitals with shared costing system vendors is 12 leading to an elasticity of -0.0802*0.9966 = -0.0799. With mean operating expenses per bed of $575,269, a 100% increase in the number of hospitals with a shared vendor (half of a standard deviation increase) decreases operating expenses per bed by $45,980. For the mean hospital with 272 beds, this constitutes an operating expense reduction of $12,506,560.

the difference in operating expenses between two hospitals in the same region during the same year that belong to the same hospital group with similar patient and payer mixes, ownership, profit status, etc., but with different CIC. In an even more stringent specification, we replace hospital-group fixed effects with hospital fixed effects. Because individual hospitals are effectively operating units within a hospital-group, this specification is analogous to including sub-firm fixed effects (e.g., business unit or factory-level) in other settings. Using this specification for the tests in Table 4 (including tests with both alternative measures of CIC reported in Internet Appendix B), we concluded that our instrumental variable is not strong enough to be used with sub-firm (i.e., hospital-level) fixed effects. In ten out of twelve tests, including in all tests that use *ihs(CIC)* – our main CIC measure, the F-statistic drops (often substantially) below the cutoff value of 8.96 recommended by Stock et al (2002). Accordingly, we continue to use region, time and hospital-group fixed effects in addition to time-varying hospital-level controls in all subsequent tables.

One concern is that the cost savings gained through CIC could come at the expense of quality of care. To examine this possibility, Table 5 studies whether *CIC* is associated with 30-day hospital readmissions or mortality rates (*Mortality, Readmissions*). However, we find no significant association between *CIC* and these clinical outcomes. It does not appear that the cost savings that we document drastically decrease the quality of patient care. In addition, Table 6 investigates more subtle aspects of care quality by examining patient satisfaction with the quality of communication by nurses and doctors, the availability of help, the cleanliness of facilities, pain control, and patients' overall recommendations of the hospital. We focus on the probability of patients giving *negative* ratings to identify negative consequences of cost cutting. Across the board, we find no significant association between *CIC* and any of these patient satisfaction measures, other than for doctors' communication, where *CIC* loads negatively ($p<0.1$), meaning that doctors' communication is less likely to be perceived negatively by the patient.[11] Although a null result can be driven by many factors, including measurement error, the lack of results suggests that any decreases in the quality of care tied to cost savings measures are likely to be small.

Table 7 supports and extends these results by identifying the types of costs that decrease when hospitals have greater CIC. Loosely based on the more granular categories from Woolhandler and Himmelstein (1997), we divide operating expenses into two groups: expenses for core clinical services directly related to patient care (costs of inpatient and outpatient visits and procedures, as well as ancillary care such as radiology) versus non-clinical expenses, defined as total operating expenses minus core clinical expenses.[12] Because these non-clinical expenses do not relate as directly to patient care, reductions in these expenses might be more likely to reduce overall costs without sacrificing care quality. Consistent with this reasoning and the results of Tables 5 and 6, Table 7 shows that only the non-clinical expense category decreases following increases in CIC, while the dollar amount spent on core clinical services experiences no significant change.[13] The fact that the expense reductions associated with CIC are in hospital areas not directly tied to core clinical care is consistent with much of the recent evidence that healthcare costs in the U.S. are particularly high because of an unusually high administrative burden (AHA, 2024; Cantlupe, 2017; Turner et al., 2023). The concentration of expense reductions in the non-clinical expense category might also explain why hospitals are able to achieve these reductions so quickly

[11] We also find no significant association between *ihs(CIC)* and the most positive ratings in each survey category with the exception of patients' overall recommendation of the hospital, where we find that lagged *CIC* is associated with a statistically significant increase in patients reporting they would recommend the hospital.

[12] The 4 operating expense categories given in the CMS cost reports that are *not* considered core clinical expenses are: general services (e.g., administrative and medical records), other reimbursable services (e.g., ambulance and medical equipment for rental), special purpose services (e.g., organ acquisition and interest expense), and non-reimbursable services (e.g., gift shop). The Variable Appendix and Internet Appendix C list more detail about the expenses included in each category.

[13] We caution that the results in columns (2) and (4) have F-text of excluded instrument values of 8.88, which is slightly below the Stock et al (2002) cutoff value of 8.96 and hence should not be interpreted.

as these changes would not require clinical staff to be trained in more cost-effective clinical procedures. In sum, cost savings achieved through greater CIC appear to reduce overall healthcare costs without affecting actual clinical practices much and, therefore, pose a sustainable solution to our current healthcare cost crisis.

5. Investigation of the Exclusion Restriction and Additional Analyses

5.1 Investigation of the Exclusion Restriction

While we believe that vendor consolidations affect expenses indirectly through CIC, we believe it is less likely that costing vendor consolidations would directly affect hospital operating expenses through other channels (a violation of the exclusion restriction). First and foremost, this is because vendor consolidations are driven by vendor-level rather than hospital-level economic forces, and individual hospitals or hospital groups are unlikely to drive consolidation of costing system vendors. However, we explore three potential violations of the exclusion restriction.

First, greater market share and economies of scale could enable consolidated vendors to offer more competitive pricing, thus directly decreasing hospitals' operating expenses through lower software costs rather than through CIC. We think this is unlikely to be the case because greater market share also increases the ability of the vendor to increase prices (Seth, 1990) and engage in price discrimination (Wang and Hui, 2017), and recent research in the retail setting finds that M&A activity leads to *increased* prices (Bhattacharya et al., 2022). Furthermore, anecdotal evidence suggests that vendors do not initiate consolidations with the intent to decrease prices. For example, MedAssets, a leading vendor of healthcare information technology, listed "pricing pressures that could limit our ability to maintain or increase prices" as a risk factor in their 2010 10-K, the same year that the company consolidated with another vendor, suggesting that *decreasing* prices was not part of their post-consolidation plan. Additionally, our anecdotal conversations with sales representatives of hospital software indicate that prices never decrease year over year and, in most cases, increase. In addition to these conceptual arguments, our empirical evidence confirms that this mechanism cannot account for the full magnitude of the effect that we document. Descriptive evidence provided by multiple software providers indicates that *total* IT costs in hospitals amount to approximately 2% of operating expenses (Definitive Healthcare, 2025; Peake Technology, 2021). We find that CIC is associated with an elasticity to operating expenses, when evaluated at the median of CIC, of -0.0778. As described above, a 100% increase in the number of hospitals in the hospital group that share a costing system vendor translates to a roughly $9 ($12) million dollar decrease in total expenses for the median (mean) hospital. The magnitude of these reductions makes it impossible to attribute all of these operating expense decreases to a reduction in costing software costs alone. We conclude that CIC provides opportunities for cost reductions in multiple aspects of hospital operations, not just through the direct costs of information technology.

Second, vendor consolidations might violate the exclusion restriction if vendor M&A activity leads to *hospital* M&A activity, with potential implications for operating expenses. We find this unlikely for two reasons. First, the raw correlation between *Vendor Consolidation* and *Acquired by Hospital Group* is negative in our sample, indicating hospitals are *less* likely to be involved in hospital mergers after a vendor consolidation. Second, anecdotal evidence indicates that IT system compatibility is not a major factor in the decision to merge hospital groups, but that hospital groups often try to standardize their systems *after* they have undergone mergers. Overall, we do not believe that hospital M&A activity (which we control for in our analyses) is likely to be a confounding factor.

Last, another potential violation of the exclusion restriction could arise if changes in CIC are accompanied by increases in the quality of the costing system used by the hospital. This could lead to better cost management arising from higher quality costing information provided by the hospital's *own* costing system rather than the ability to better *compare* with the costing information of other hospitals in the same hospital group (CIC). Vendor consolidations might increase own-hospital costing system quality and CIC simultaneously if the consolidation events serve as a shock that induces hospitals to switch to higher quality costing systems. We address this concern empirically by running a subsample test focusing on hospitals that made no change to their costing system in the year of the vendor consolidation. These hospitals can experience increases in CIC if other hospitals in their system adopt the consolidating vendor but would experience no change in the quality of their own costing system because they are using the same system and model as in prior years. As Table 8 shows, this subsample continues to provide significant evidence that CIC is associated with operating expense reductions in both year 1 and 2. In sum, we believe that the vendor consolidation instrument creates as-if random variation in CIC and satisfies the exclusion restriction.

5.2 Additional Analyses

First, we re-run our operating expense analyses of Table 4, while replacing the CBSA fixed effects and year fixed effects of that table with CBSA times year fixed effects, keeping all other control variables and the hospital group fixed effects as before. This analysis additionally controls for time-varying changes in the region, such as time-varying changes in local healthcare policies, regional economic conditions, local access to healthcare resources, and patient population demands. Importantly, this analysis controls for changes in the geography in which the costing system vendor consolidations happen. Even though we lose just under 2,000 hospital-year observations in this analysis, Table 9 shows robustly that operating expense reductions are obtained in year 1 and year 2 ($p<0.1$). Interestingly, this analysis also documents significant operating expense reductions in year 3 ($p<0.05$).

Second, we investigate the robustness of our analyses to two alternate binary measures of CIC where we define a given hospital as having consistent cost information (*CIC* = 1) when it uses the primary costing vendor of its hospital group. For the *CIC (Unweighted)* measure, the primary costing vendor is identified by summing up the number of hospitals that use each vendor and selecting the vendor used by the greatest number of hospitals. If there is a tie, both vendors are considered primary. If all hospitals within a hospital-group-year used different vendors, then *CIC (Unweighted)* equals 0 for all hospitals in that group-year. For the CIC (Weighted) measure, the primary costing vendor is identified by summing up the number of beds at hospitals that use each vendor and selecting the vendor that has the greatest bed count and is used by at least two hospitals. If all hospitals within a hospital-group-year use different vendors, then *CIC (Weighted)* equals 0 for all hospitals in that group-year. Internet Appendix B replicates all analyses with these two additional measures of CIC, showing results to have the same sign and similar levels of significance. Note that these binary CIC measures take a stricter perspective on CIC in that hospitals that share a vendor with other hospitals in their hospital group that is not the primary vendor for the hospital group would be coded as CIC=0. However, our primary *ihs(CIC)* measure would count that these hospitals have at least some other hospitals in their hospital group that use the same costing vendor.

Last, Internet Appendix A also presents descriptive information on CIC and our vendor consolidation instrument, including how CIC changes over time, the transition matrixes of the binary CIC (Unweighted) measure for different subsamples, and a list of the most common costing system vendors and software models in our sample.

6. Conclusion

The U.S. is currently facing a health care cost crisis. The problem is large enough that no single approach can solve it. We propose that more consistent use of costing information provides one avenue to materially decrease hospital expenses and, thus, health care costs overall. The health care system in the United States is witnessing a shift away from fee-for-service reimbursement models toward value-based payment, which aims to maximize clinical outcomes while minimizing costs (Kaplan and Porter, 2011). The results of this study are very much aligned with this goal and suggest that CIC increases cost comparability and reduces operating expenses by identifying best practices within the hospital group without sacrificing quality of care.[14] Our results suggest that hospitals adopting costing system vendors shared with other hospitals in their hospital group leads to substantial operating expense reductions, indicating that costing information consistency can have a material effect on healthcare costs in the US. CIC likely also presents an effective cost management approach in other developed economies that contain hospital groups, as well as in multi-unit firms in other industries. Furthermore, our results suggests that CIC should be considered when integrating a merged or acquired entity in order to obtain the desired operating expense reductions.

We acknowledge that our results have limitations. First, they may not generalize to more recent periods because we use hospital group membership data from Cooper et al. (2019) that is only available through 2014. If average CIC is now higher, the incremental benefits of additional consistency may be smaller. Additionally, while an instrumental variables approach avoids biased

[14] The presence of value-based payments is not a driver of our CIC effect because value-based payments did not begin until 2013 and only affected two years in our sample; our inferences are unchanged when we exclude these years.

estimates caused by nonrandom selection, it only estimates the local average treatment effect for hospitals affected by the instrument. Thus, the cost reduction estimates apply only to hospitals that would change their costing systems after vendor consolidations. Last, while this study has the advantage of high external generalizability to the hospital sector given its sample size, subsequent studies on a single hospital group using more granular data can dig deeper into channels through which CIC reduces expenses.

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Variable Appendix

Panel A: Costing Vendor Variables

Variable	Definition
ihs(CIC)) Main CIC measure	The inverse hyperbolic sine (arcsinh) of the number of hospitals within a hospital group-year that have the same costing vendor as the focal hospital. The inverse hyperbolic sine transformation, like taking the natural log, is to normalize right-skewed data, but can accommodate zero values (Burbidge et al., 1988).
Vendor Consolidation	This variable identifies whether the hospital's costing system vendor experienced a vendor consolidation in *t* or *t-1*. Specifically, it is an indicator variable equal to 1 in year *t* and *t+1* if a hospital's costing vendor was part of a vendor consolidation event in year *t*.
CIC (Unweighted) Measure used in Section 5.2	Indicator variable for whether the vendor of the costing system of a given hospital-year is the same as the primary costing vendor of the hospital group. The primary costing vendor is identified by summing up the number of hospitals that use each vendor and selecting the vendor used by the greatest number of hospitals. If there is a tie, both vendors are considered primary. If all hospitals within a hospital-group-year used different vendors, then *CIC (Unweighted)* equals 0 for all hospitals in that group-year.
CIC (Weighted) Measure used in Section 5.2	Indicator variable for whether the vendor of the costing system of a given hospital-year is the same as the primary costing vendor of the hospital group. The primary costing vendor is identified by summing up the number of beds at hospitals that use each vendor and selecting the vendor that had the greatest bed count and is used by at least two hospitals. If all hospitals within a system-year used different vendors, then *CIC (Weighted)* equals 0 for all hospitals in that system-year.

Panel B: Dependent Variables

Variable	Definition
Operating Expenses	Total operating expenses divided by *Bedsize,* with the entire ratio then transformed by inverse hyperbolic sine. The primary source of expense information is HIMSS. However, in cases where operating expenses are missing from the HIMSS data, operating expense data from the CMS Cost report for the associated year is used instead. The HIMSS and CMS data both are fairly complete databases; however, the HIMSS database includes data for hospitals which do not accept Medicare/Medicaid payments and which are therefore not included in the CMS data, which is why we primarily use the HIMSS data (the source of our CIC

	variable). In cases where expense data is available in both databases, the correlation between the two is greater than 0.9 (Labro and Stice-Lawrence, 2020).
Core Clinical Expenses	Expenses most directly related to clinical care, divided by *Bedsize,* with the entire ratio then logged. Clinical expenses are identified as 3 of the 7 operating expense categories given in CMS cost reports: expenses for outpatient services (e.g., outpatient clinics), inpatient services (e.g., routine inpatient care, the intensive care unit, etc.), and ancillary services (e.g., radiology and laboratory). More details in Internet Appendix C.
Non-Clinical Expenses	Expenses less directly related to clinical care, divided by *Bedsize,* with the entire ratio then logged. Non-clinical expenses are defined as total operating expenses minus core clinical expenses. The 4 operating expense categories given in the CMS cost reports that are *not* considered core clinical expenses are: general services (e.g., administrative and medical records), other reimbursable services (e.g., ambulance and medical equipment), special purpose services (e.g., organ acquisition and interest expense), and non-reimbursable services (e.g., gift shop). More details in Internet Appendix C.
Mortality	The average 30-day mortality rate for heart attack, heart failure, and pneumonia patients. Mortality rates are from the CMS Hospital Compare database.
Readmissions	The average 30-day readmission rate for heart attack, heart failure, and pneumonia patients. Readmission rates are from the CMS Hospital Compare database.
Nurse Communication	Percentage of survey respondents that indicated nurses sometimes or never communicated well. Survey data are from the CMS Hospital Compare database.
Doctor Communication	Percentage of survey respondents that indicated doctors sometimes or never communicated well. Survey data are from the CMS Hospital Compare database.
Help Availability	Percentage of survey respondents that indicated they sometimes or never received help as soon as they wanted. Survey data are from the CMS Hospital Compare database.
Cleanliness	Percentage of survey respondents that indicated their room and bathroom were sometimes or never clean. Survey data are from the CMS Hospital Compare database.
Pain Control	Percentage of survey respondents that indicated their pain was sometimes or never well controlled. Survey data are from the CMS Hospital Compare database.
Wouldn't Recommend	Percentage of survey respondents that indicated they probably or definitely would not recommend the hospital. Survey data are from the CMS Hospital Compare database.

Panel C: Control Variables

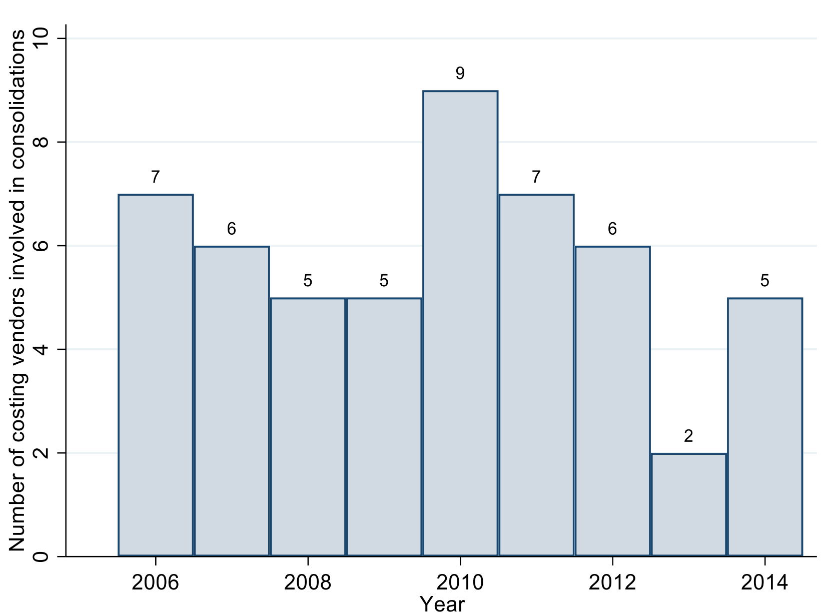
Variable	Definition
Academic	Indicator variable equal to 1 if the hospital is classified as an academic hospital in the HIMSS data, or if the HCRIS data has positive intern salary or is classified as a teaching hospital.
Acquired by Hospital Group	Indicator variable equal to 1 if the hospital has been acquired by a hospital group in the current year (*t*) or in the previous year (*t-1*).
Apps_Age	The average age (years since last update) of all IT applications in the current hospital-year.
Apps_age_squared	The average age (years since last update) of all IT applications in the current hospital-year squared.
Bedsize	Number of beds in the hospital
Case Mix Index (CMI)	Case Mix Index obtained from CMS (Centers for Medicare and Medicaid Services). The CMI represents the average diagnosis-related group (DRG) relative weight for that hospital, where the value assigned to each DRG indicates the amount of resources required to treat patients in that group.
Costing Adopter	Indicator variable equal to 1 in the year that a hospital adopts a costing system for the first time (year *t*) and the year after (year *t+1*). 0 otherwise.
For Profit	Indicator variable equal to 1 if the hospital is ever classified as a for-profit entity in either the HIMSS or HCRIS data.
Growth_Bedsize	$(Bedsize_{t} - Bedsize_{t-1})/Bedsize_{t-1}$
HHI	Yearly Herfindahl-Hirschman Index of hospital concentration measured at the county-year level using all hospital-year observations available, where 10,000 is no competition and near 0 is perfect competition. Calculated as $\sum_{i=1}^{n} s_i^2$ where *n* is the number of hospitals in the county-year and *s* is the percentage of a hospital's bed relative to all bed for hospitals in the county-year.
% Medicaid	The percentage of revenues coming from Medicaid.
% Medicare	The percentage of revenues coming from Medicare.
Purchasing Group Member	Indicator equal to 1 if a hospital is part of a group purchasing organization according to HIMSS data.
Religious	Indicator equal to 1 if the hospital is affiliated with or run by a religious organization, identified by flagging hospital names that use religious terms.
Revenue	Total revenue divided by *Bedsize,* with the entire ratio then transformed by inverse hyperbolic sine. The primary source of revenue information is HIMSS.
Rural	Indicator variable equal to 1 if the hospital is located within a zipcode for which at least 50% of the population lives in a rural area, according to the 2000 U.S. Census, or if the hospital reported it was in a rural area in at least one HCRIS cost report.

Specialty	Indicator variable equal to 1 if the hospital is a specialty hospital, according to data provided in the HCRIS dataset. Non-specialty hospitals: general short- and long-term hospitals. Specialty hospitals: cancer, psychiatric, rehabilitation, religious non-medical, pediatric, alcohol & drug, other.
Hospital Group Size	The number of hospitals within a hospital group.

Figure 1: CostFlex Cost Accounting Analytics Dashboard

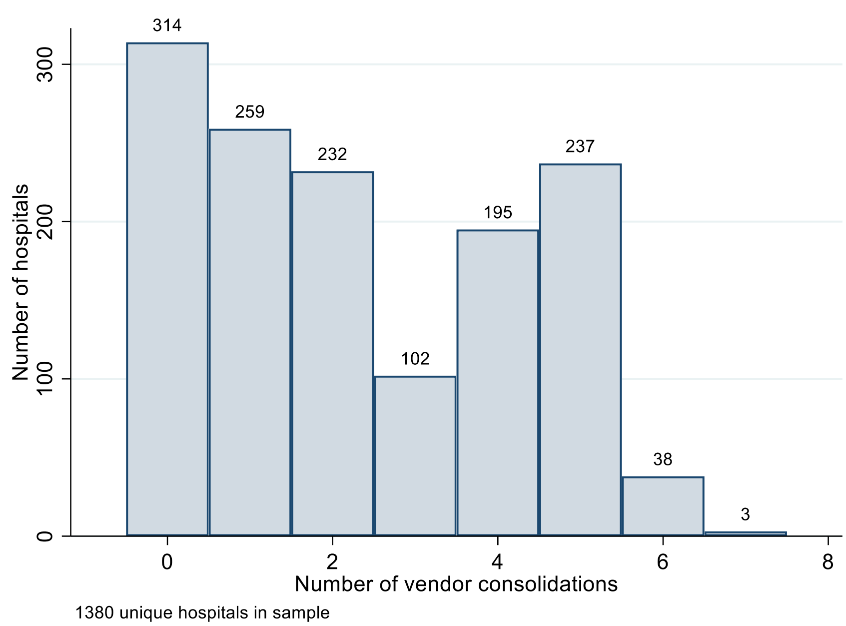
Source: https://www.costflex.com/software-products/cost-based-hospital-benchmarking/ (accessed February 2025)

Figure 2: Number of costing vendors involved in consolidations by year



This figure shows the number of costing vendors for hospitals in our sample who experience a vendor consolidation (either by acquiring or being acquired by another vendor) for each year in our sample.

Figure 3: Frequency of vendor consolidations per hospital within the sample period



This figure shows how frequently hospitals in our sample have a costing vendor who experiences a consolidation. For example, 314 hospitals never have a vendor who consolidates during the sample period; 232 hospitals experience 2 separate vendor consolidations during the sample period.

Table 1. Descriptive Statistics

	Obs.	Mean	SD	P25	Median	P75
ihs(CIC)	9,331	1.99	1.52	0.88	1.82	3.00
CIC	9.331	11.88	22.97	1.00	3.00	10.00
Vendor Consolidation	9,331	0.52	0.50	0.00	1.00	1.00
Operating Expenses per bed	9,331	575,269	283,354	379,679	521,042	707,910
Revenue per bed	9,331	625,774	330,039	406,654	565,918	773,527
Case Mix Index (CMI)	9,331	1.49	0.24	1.31	1.48	1.65
Bedsize	9,331	272	190	128	231	368
Growth_Bedsize	9,331	0.01	0.13	0.00	0.00	0.00
Acquired by Hospital Group	9,331	0.08	0.27	0.00	0.00	0.00
Costing Adopter	9,331	0.05	0.22	0.00	0.00	0.00
Group Size	9,331	27.47	35.64	4.00	11.00	38.00
Apps_Age	9,331	7.09	2.56	5.25	6.90	8.75
Apps_Age_squared	9,331	56.77	39.64	27.56	47.61	76.56
% Medicaid	9,331	12.51	8.98	5.58	10.22	17.47
% Medicare	9,331	41.04	12.01	32.27	41.04	49.68
Purchasing Group Member	9,331	0.51	0.50	0.00	1.00	1.00
Academic	9,331	0.52	0.50	0.00	1.00	1.00
For Profit	9,331	0.38	0.49	0.00	0.00	1.00
Religious	9,331	0.47	0.50	0.00	0.00	1.00
Specialty Hospital	9,331	0.02	0.13	0.00	0.00	0.00
Rural	9,331	0.04	0.19	0.00	0.00	0.00
HHI	9,331	3836	3151	1220	2847	5264
Mortality	8,804	13.02	1.39	12.07	12.97	13.93
Readmissions	8,804	19.62	1.65	18.43	19.47	20.67
Nurse Communication	8,003	5.85	2.87	4.00	5.00	7.00
Doctor Communication	8,003	5.09	2.17	4.00	5.00	6.00
Pain Control	8,003	7.75	2.81	6.00	7.00	9.00
Cleanliness	8,003	10.64	3.99	8.00	10.00	13.00
Help Availability	8,003	12.12	4.99	9.00	11.00	15.00
Wouldn't recommend	8,003	6.01	3.31	4.00	5.00	7.00
Core Clinical Expenses per bed	9,040	246,500	121,399	160,153	225,242	309,157
Non-Clinical Expenses per bed	9,040	330,684	191,563	203,403	290,671	407,092

Hospital-level variables for the full sample period (2006-2014). These data include 9 years, 427 core-based statistical areas (CBSAs), and 325 unique hospital groups. In our regressions, we remove singleton observations; but because these can vary across specifications, we report descriptive statistics before their removal.

Table 2. Correlations

		1	2	3	4	5	6	7	8	9	10	11	12
1	ihs(CIC)												
2	Vendor Consolidation	0.24***											
3	ihs(Operating Expenses)	-0.08***	0.04***										
4	Mortality	0.07***	-0.11***	-0.06***									
5	Readmissions	0.01	0.06***	-0.17***	-0.20***								
6	Nurse Communication	0.10***	-0.06***	-0.21***	-0.10***	0.41***							
7	Doctor Communication	0.10***	-0.03**	-0.06***	-0.09***	0.29***	0.71***						
8	Cleanliness	0.06***	-0.03**	-0.13***	-0.05***	0.31***	0.70***	0.44***					
9	Help Availability	0.07***	-0.03**	-0.12***	-0.13***	0.42***	0.88***	0.67***	0.68***				
10	Pain Control	0.06***	-0.06***	-0.19***	-0.10***	0.39***	0.86***	0.69***	0.63***	0.82***			
11	Wouldn't Recommend	0.07***	-0.11***	-0.28***	-0.03*	0.35***	0.86***	0.71***	0.62***	0.78***	0.80***		
12	ihs(Core Clinical Expenses)	-0.05***	0.05***	0.84***	-0.06***	-0.19***	-0.21***	-0.06***	-0.12***	-0.14***	-0.21***	-0.29***	
13	ihs(Non-Clinical Expenses)	-0.09***	0.02*	0.91***	-0.05***	-0.13***	-0.17***	-0.04***	-0.11***	-0.09***	-0.15***	-0.23***	0.56***

Pearson correlations between *CIC,* the *Vendor Consolidation* instrument, and dependent variables. *** p<0.01, ** p<0.05, * p<0.1

Table 3. First-Stage Regression

Dep. variable:	ihs(CIC)
Vendor Consolidation	0.165***
	(4.857)
ihs(Revenue)	-0.0121
	(-0.292)
CMI	0.0135
	(0.159)
Growth_Bedsize	-0.0377
	(-0.807)
Bedsize	-6.64e-05
	(-0.439)
Hospital Group Size	0.0151
	(1.329)
Acquired by Hospital Group	-0.703***
	(-6.412)
Costing Adopter	0.0698
	(0.909)
Apps_Age	-0.0217
	(-0.619)
Apps_Age_squared	-7.63e-05
	(-0.0389)
% Medicaid	9.59e-05
	(0.0320)
% Medicare	0.00375*
	(1.834)
Purchasing Group Member	-0.00168
	(-0.0452)
HHI	-1.00e-06
	(-0.0872)
Academic	0.0791*
	(1.936)
For Profit	0.0142
	(0.0891)
Religious	0.127**
	(2.256)
Specialty Hospital	-0.0280
	(-0.191)
Rural	-0.0959
	(-0.798)
Observations	9,331
Adjusted R-squared	0.786
Hospital Group, CBSA and Year FE	YES

First-stage regression of the effect of costing *Vendor Consolidation* on *CIC* from a 2SLS instrumental variables analysis. Robust t-statistics clustered by hospital group (*Number of Clusters* = 325) in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4. The Effect of CIC on Operating Expenses

	(1)	(2)	(3)	(4)
Dep. variable:	ihs(Operating Expenses)			
ihs(CIC)$_t$	-0.0820**			
	(-2.345)			
ihs(CIC)$_{t-1}$		-0.0562**		
		(-2.122)		
ihs(CIC)$_{t-2}$			-0.0301	
			(-1.111)	
ihs(CIC)$_{t-3}$				0.0268
				(1.156)
ihs(Revenue)	0.702***	0.694***	0.699***	0.702***
	(32.22)	(28.96)	(30.28)	(33.97)
CMI	0.132***	0.132***	0.134***	0.119***
	(4.679)	(4.557)	(4.548)	(3.826)
Growth_Bedsize	-0.0959***	-0.103***	-0.106***	-0.106***
	(-5.388)	(-5.839)	(-6.316)	(-5.674)
Bedsize	-3.52e-05	-3.77e-05	-3.32e-05	-1.59e-05
	(-1.038)	(-1.082)	(-0.933)	(-0.399)
Hospital Group Size	0.00202	0.00123	0.000645	0.00204
	(1.105)	(0.851)	(0.508)	(1.092)
Acquired by Hospital Group	0.00399	0.0303	0.0710**	0.0941***
	(0.144)	(1.125)	(2.483)	(3.486)
Costing Adopter	0.00580	-0.0278	-0.0382	0.0303
	(0.465)	(-1.258)	(-0.879)	(1.220)
Apps_Age	-0.00830	-0.00134	-0.00393	-0.00289
	(-1.082)	(-0.168)	(-0.519)	(-0.308)
Apps_Age_squared	0.000181	-0.000181	-1.67e-05	-7.02e-05
	(0.382)	(-0.366)	(-0.0339)	(-0.103)
% Medicaid	0.000585	0.000415	0.000437	0.000557
	(0.917)	(0.650)	(0.750)	(1.060)
% Medicare	2.46e-05	-0.000283	-0.000315	-0.000421
	(0.0500)	(-0.597)	(-0.668)	(-0.896)
Purchasing Group Member	0.000555	0.00115	0.000277	0.000573
	(0.0792)	(0.173)	(0.0425)	(0.0715)
HHI	1.26e-06	1.31e-06	1.25e-06	1.07e-06
	(0.631)	(0.656)	(0.637)	(0.553)
Academic	0.0202*	0.0160	0.0142	0.00942
	(1.840)	(1.453)	(1.338)	(0.869)
For Profit	-0.0205	-0.0265	-0.0221	-0.0134
	(-1.100)	(-1.413)	(-1.111)	(-0.572)
Religious	0.0212*	0.0215*	0.0172	0.00916
	(1.835)	(1.786)	(1.430)	(0.705)
Specialty Hospital	0.0152	0.000779	0.00353	0.00343
	(0.607)	(0.0314)	(0.144)	(0.138)
Rural	0.0204	0.0248	0.0281	0.0386
	(0.564)	(0.669)	(0.748)	(0.988)
Observations	9,331	8,941	8,739	8,543
Hospital Group, CBSA and Year FE	YES	YES	YES	YES

F-test of excluded instruments	23.59	9.409	13.24	21.01

A 2SLS instrumental variables analysis of the effect of CIC on hospital operating expenses where *Vendor Consolidation* is an instrument for CIC. Robust t-statistics clustered by hospital group in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5. The Effect of CIC on Clinical Outcomes

	(1)	(2)	(3)	(4)
Dep. variable:	Mortality		Readmissions	
$ihs(CIC)_t$	0.0683		0.258	
	(0.363)		(0.908)	
$ihs(CIC)_{t-1}$		0.0457		0.189
		(0.347)		(1.296)
Observations	8,797	8,436	8,797	8,436
Controls	YES	YES	YES	YES
Hospital Group FE	YES	YES	YES	YES
CBSA FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
F-test of excluded instruments	22.09	9.293	22.09	9.293

A 2SLS instrumental variables analysis of the effect of *CIC* on clinical outcomes where *Vendor Consolidation* is an instrument for CIC. In columns 1-2, the dependent variable is the average of the 30-day mortality rate for heart failure, heart attack and pneumonia. In columns 3-4, the dependent variable is the average of the 30-day readmissions rate for heart failure, heart attack and pneumonia. Robust t-statistics clustered by hospital group in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 6. The Effect of CIC on Patient Dissatisfaction

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dep. variable:	Nurse Communication		Doctor Communication		Help Availability		Cleanliness		Pain Control		Wouldn't Recommend	
$ihs(CIC)_t$	-0.758		-0.847*		-0.871		0.722		-0.667		-0.769	
	(-1.112)		(-1.679)		(-0.792)		(1.065)		(-1.115)		(-0.897)	
$ihs(CIC)_{t-1}$		-1.058		-1.149		-2.005		0.255		-0.967		-1.041
		(-1.123)		(-1.453)		(-1.229)		(0.276)		(-1.148)		(-0.882)
Observations	7,988	7,648	7,988	7,648	7,988	7,648	7,988	7,648	7,988	7,648	7,988	7,648
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Hospital Group FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
CBSA FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
F-test of excluded instruments	14.99	16.59	14.99	16.59	14.99	16.59	14.99	16.59	14.99	16.59	14.99	16.59

A 2SLS instrumental variables analysis of the effect of *CIC* on patient satisfaction measured using survey results, where *Vendor Consolidation* is an instrument for CIC. The dependent variable is the percentage of survey respondents who answered that: nurses sometimes or never communicated well (Columns 1-2), doctors sometimes or never communicated well (Columns 3-4), the patient sometimes or never received help as soon as they wanted (Columns 5-6), the room and bathroom were sometimes or never clean (Columns 7-8), pain was sometimes or never well controlled (columns 9-10), and the patient probably or definitely would not recommend the hospital (Columns 11-12). Sample size is less than prior tables based on the availability of survey data. Robust t-statistics clustered by hospital group in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7. The Effect of CIC on Expenses for Core Clinical versus Non-Clinical Services

	(1)	(2)	(3)	(4)
Dep. variable:	ihs(Core Clinical Expenses)		ihs(Non-Clinical Expenses)	
$ihs(CIC)_t$	0.107		-0.239**	
	(1.607)		(-2.558)	
$ihs(CIC)_{t-1}$		0.0144		-0.122**
		(0.334)		(-2.364)
Observations	9,037	8,659	9,037	8,659
Hospital Group FE	YES	YES	YES	YES
CBSA FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
F-test of excluded instruments	22.27	8.884⁺	22.27	8.884⁺

A 2SLS instrumental variables analysis of the effect of *CIC* on the amount of Core Clinical and Non-Clinical operating expenses. Core clinical patient expenses are those related to outpatient services (e.g., outpatient clinics), inpatient services (e.g., routine inpatient care, the intensive care unit, etc.), and ancillary services (e.g., radiology and laboratory). Non-clinical expenses are all others. Sample size is less than prior tables based on the availability of data. Robust t-statistics clustered by hospital group in parentheses. *** p<0.01, ** p<0.05, * p<0.1. ⁺Note that the F-test values in columns (2) and (4) are slightly below the Stock et al (2002) cutoff value of 8.96 to indicate a valid instrument, so these columns should not be interpreted.

Table 8: The Effects of CIC on Operating Expenses for Hospitals that Make No Change to Their Own Costing System in Consolidation Years

	(1)	(2)
Dep. variable:	ihs(Operating Expenses)	
$ihs(CIC)_t$	-0.0701**	
	(-2.264)	
$ihs(CIC)_{t-1}$		-0.0600**
		(-2.187)
ihs(Revenue)	0.704***	0.696***
	(32.49)	(28.62)
CMI	0.130***	0.132***
	(4.647)	(4.584)
Growth_Bedsize	-0.0953***	-0.0995***
	(-5.133)	(-5.427)
Bedsize	-2.73e-05	-3.14e-05
	(-0.812)	(-0.913)
Hospital Group Size	0.00174	0.00115
	(1.026)	(0.748)
Acquired by Hospital Group	0.00568	0.0204
	(0.223)	(0.779)
Costing Adopter	0.00150	-0.0322
	(0.127)	(-1.402)
Apps_Age	-0.00942	-0.00245
	(-1.244)	(-0.309)
Apps_Age_squared	0.000260	-9.42e-05
	(0.539)	(-0.188)
% Medicaid	0.000444	0.000292
	(0.710)	(0.441)
% Medicare	-6.15e-05	-0.000299
	(-0.129)	(-0.612)
Purchasing Group Member	-0.00322	-0.00157
	(-0.475)	(-0.232)
HHI	9.28e-07	9.61e-07
	(0.453)	(0.460)
Academic	0.0180*	0.0131
	(1.651)	(1.173)
For Profit	-0.0186	-0.0247
	(-1.048)	(-1.361)
Religious	0.0167	0.0188
	(1.438)	(1.500)
Specialty Hospital	0.0169	0.00327
	(0.708)	(0.138)
Rural	0.0226	0.0264
	(0.638)	(0.722)
Observations	9,024	8,639
Hospital Group, CBSA and Year FE	YES	YES
F-test of excluded instruments	21.67	11.04

This table replicates Table 4 but excludes hospitals that make changes to their costing system in years when the hospital experiences a vendor consolidation. Changes include changing the version of the system but keeping the same vendor or switching vendor entirely. As a result, any expense reductions linked to CIC could not be explained by the hospital having switched to a higher quality costing system that would have led to expense reductions even in the absence of greater CIC.

Table 9: Robustness to CBSA-Year Fixed Effects

	(1)	(2)	(3)	(4)
Dep. variable:	ihs(Operating Expenses)			
ihs(CIC)$_t$	-0.0709*			
	(-1.731)			
ihs(CIC)$_{t-1}$		-0.0448*		
		(-1.797)		
ihs(CIC)$_{t-2}$			-0.0635**	
			(-2.206)	
ihs(CIC)$_{t-3}$				-0.0260
				(-0.992)
ihs(Revenue)	0.727***	0.721***	0.720***	0.721***
	(30.60)	(28.35)	(27.65)	(30.20)
CMI	0.130***	0.122***	0.134***	0.131***
	(3.947)	(3.652)	(3.982)	(3.787)
Growth_Bedsize	-0.0797***	-0.0823***	-0.0826***	-0.0826***
	(-4.313)	(-4.044)	(-3.865)	(-3.955)
Bedsize	-2.51e-05	-1.90e-05	-2.50e-05	-1.75e-05
	(-0.662)	(-0.473)	(-0.673)	(-0.425)
Hospital Group Size	0.00256	0.00178	0.00104	0.000164
	(1.509)	(1.432)	(0.634)	(0.0997)
Acquired by Hospital Group	0.0192	0.0552*	0.0803**	0.103***
	(0.576)	(1.968)	(2.525)	(3.556)
Costing Adopter	0.0112	-0.0117	-0.0696	-0.0119
	(0.776)	(-0.585)	(-1.627)	(-0.453)
Apps_Age	-0.00846	-0.000393	0.000998	0.000369
	(-0.904)	(-0.0411)	(0.105)	(0.0378)
Apps_Age_squared	0.000308	-0.000177	-0.000217	-0.000151
	(0.484)	(-0.267)	(-0.324)	(-0.209)
% Medicaid	0.000924	0.000791	0.000739	0.000578
	(1.253)	(1.045)	(1.013)	(0.812)
% Medicare	0.000135	-1.11e-05	-0.000143	-0.000184
	(0.241)	(-0.0214)	(-0.271)	(-0.347)
Purchasing Group Member	-0.00173	0.000766	-0.00172	-0.00394
	(-0.193)	(0.0840)	(-0.178)	(-0.434)
HHI	3.75e-07	2.77e-07	4.88e-07	1.21e-06
	(0.184)	(0.128)	(0.203)	(0.510)
Academic	0.0116	0.00814	0.00668	0.00376
	(1.105)	(0.749)	(0.583)	(0.326)
For Profit	-0.0131	-0.0166	-0.0122	-0.00875
	(-0.669)	(-0.843)	(-0.641)	(-0.421)
Religious	0.0194*	0.0218*	0.0213*	0.0181
	(1.772)	(1.950)	(1.942)	(1.544)
Specialty Hospital	0.0135	0.00164	0.00385	-0.00102
	(0.549)	(0.0695)	(0.158)	(-0.0439)
Rural	0.0240	0.0254	0.0161	0.0241
	(0.633)	(0.661)	(0.413)	(0.592)
Observations	7,385	7,020	6,825	6,646
Hospital Group and CBSA-Year FE	YES	YES	YES	YES
F-test of excluded instruments	13.29	11.23	14.06	20.01

This table replicates the results in Table 4 but replaces separate CBSA and Year fixed effects with CBSA-Year fixed effects.

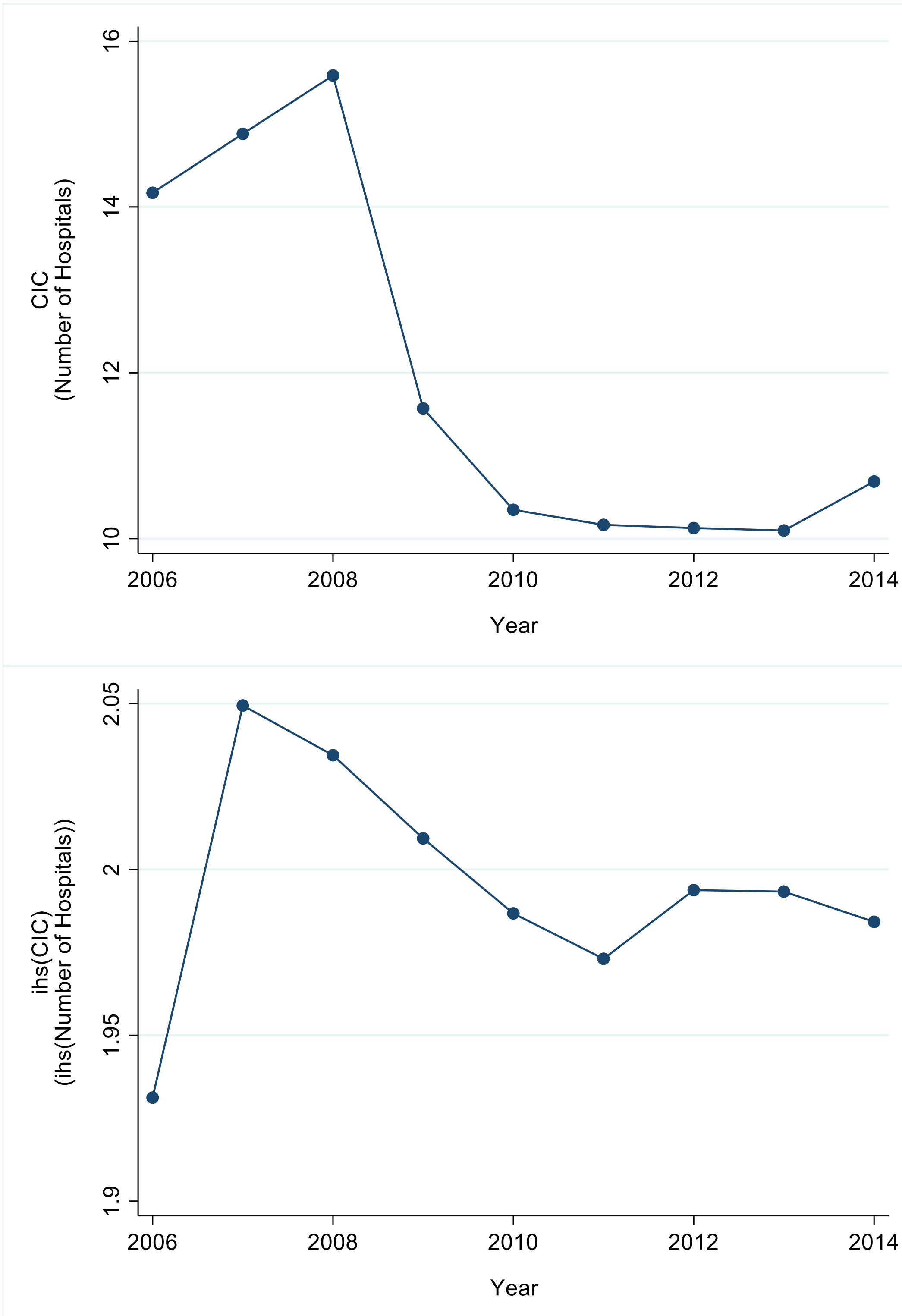
Internet Appendix

Consistency is Key: Does Costing Information Consistency Help Hospitals Manage Costs?

Contents:

Internet Appendix A: Descriptive information on costing systems, costing system vendors, vendor consolidation and costing information consistency

1. Figure A1: Average Number of Hospitals in Hospital Groups That Exhibit Costing Information Consistency over Time



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2. Table A1: Descriptive Information About Costing System Changes and CIC (Unweighted) for Hospitals with Vendor Consolidations, Summarized in Transition Matrices

Panel A. Hospitals With a Vendor Consolidation in Year *t* (N = 2,976)

		CIC(Unweighted)(t)	
		0	**1**
CIC(Unweighted)(t-1)	**0**	53%	47%
	1	1%	99%

Panel B. Hospitals Without a Vendor Consolidation in Year *t* (N = 5,979)

		CIC(Unweighted)(t)	
		0	**1**
CIC(Unweighted)(t-1)	**0**	82%	18%
	1	3%	97%

Panel C. Hospitals That Change Their Own Vendor After a Vendor Consolidation in Year *t* (N = 292)

		CIC(Unweighted)(t)	
		0	**1**
CIC(Unweighted)(t-1)	**0**	15%	85%
	1	2%	98%

Panel D. Hospitals That Don't Change Their Own Vendor After a Vendor Consolidation in Year *t* (N = 2,684)

		CIC(Unweighted)(t)	
		0	**1**
CIC(Unweighted)(t-1)	**0**	69%	31%
	1	1%	99%

This table shows transition matrices examining the value of *CIC(Unweighted)* in year *t* for hospitals based on the level of *CIC(Unweighted)* in year *t-1* for the sample used in column (2) of Table 4 of 8955 hospital year observations with lagged CIC available (8941 + 14 singletons = 8955).We report these transition matrices for one of our binary CIC measures, rather than for the *ihs(CIC)* measure used in the main body of the paper as the matrices for representing the probabilities of moving from one possible integer value to another are much harder to interpret and visualize. Panel A shows the transition between values of *CIC* from *t-1* to *t* for hospitals experiencing a vendor consolidation in year *t*. Panel B shows the same transition for hospitals that did *not* experience a vendor consolidation in year *t.* Descriptives in Panels A and B are consistent with our first-stage analysis reported in Table 3, which shows that vendor consolidations are positively associated with *CIC*. Panel C further focuses on hospitals that experienced a vendor consolidation *and* changed their vendor. Panel D focuses on hospitals that experienced a vendor consolidation and did not change their vendor. Panels C and D explore how CIC increases after a vendor consolidation. Very few hospitals that experience a vendor consolidation experience a *decrease* in CIC, but hospitals experience *increases* in CIC both when they change vendor and when they do not change vendor. This helps better understand that changes in CIC prompted by vendor consolidations are not entirely driven by a hospital changing its own system, but that can also be driven by other hospitals changing vendor. Note that these descriptive transition matrices partition only on whether a hospital has experienced a vendor consolidation in year *t*; in the body of the paper, our final instrument, *Vendor Consolidation,* is defined as 1 if the hospital's vendor has experienced a consolidation in year *t or* year *t-1.*

3. Table A2: Most Common Costing Vendors and Software Models

This table lists the top 10 most common costing vendors in our sample, in order of decreasing frequency.

Vendor Name	**Software Model(s)**	**Notes**
McKesson Provider Technologies	Trendstar	
Lawson Software	Insight, Financial Suite	
Meditech	Magic	
Allscripts	Eclipsys, Paragon	Allscripts and Eclipsys merge 2010
MedAssets	Health Management Systems	Vizient, Inc. purchased MedAssets spend and clinical resource management segment in February 2016; MedAssets revenue cycle business continued to operate as a wholly owned subsidiary of Pamplona Capital Management LLP.
Eclipsys Corporation	Transition Systems	Eclipsys merged with Transition Systems in December 1998
Siemens Medical Solutions	Invision, MedSeries 4	
Infor Global Solutions	Lawson/Financial Suite, Insight	Infor acquired Lawson in 2011; prior to that, most common Infor models were M series and SmartStream
Healthcare Management Systems	HMS Monitor	Healthcare Management Systems (held by HealthTech Holdings, Inc.) acquired Medhost in 2010; HealthTech rebranded as Medhost in 2013
PeopleSoft	Financials, J.D. Edwards	Oracle acquired PeopleSoft in January 2005

4. Effect of Vendor Consolidations on CIC Over Time:

Table A3: Time Series Effect of Vendor Consolidations on CIC (First-Stage Results)

	(1)	(2)	(3)	(4)
Dep. variable:		ihs(CIC)		
Vendor Consolidation (One-Year Version)$_t$	0.121***			
	(3.587)			
Vendor Consolidation (One-Year Version)$_{t-1}$		0.0702***		
		(3.028)		
Vendor Consolidation (One-Year Version)$_{t-2}$			0.0569**	
			(2.492)	
Vendor Consolidation (One-Year Version)$_{t-3}$				0.0368
				(1.616)
ihs(Revenue)	-0.0142	-0.0248	-0.0180	-0.0183
	(-0.336)	(-0.551)	(-0.434)	(-0.462)
CMI	0.0140	0.0167	0.0111	0.0452
	(0.164)	(0.196)	(0.130)	(0.510)
Growth_Bedsize	-0.0393	-0.0546	-0.0430	-0.0147
	(-0.804)	(-1.068)	(-0.859)	(-0.307)
Bedsize	-6.06e-05	-6.83e-05	-7.74e-05	-8.57e-05
	(-0.400)	(-0.430)	(-0.509)	(-0.578)
Hospital Group Size	0.0145	0.0158	0.0163	0.0139
	(1.323)	(1.379)	(1.372)	(1.215)
Acquired by Hospital Group	-0.702***	-0.704***	-0.699***	-0.691***
	(-6.361)	(-6.405)	(-6.484)	(-6.289)
Costing Adopter	0.0394	0.0737	0.0421	0.0411
	(0.519)	(0.999)	(0.530)	(0.476)
Apps_Age	-0.0208	-0.0136	-0.0147	-0.0196
	(-0.583)	(-0.379)	(-0.427)	(-0.552)
Apps_Age_squared	-0.000155	-0.000493	-0.000330	-8.79e-05
	(-0.0768)	(-0.241)	(-0.164)	(-0.0429)
% Medicaid	1.19e-05	-0.000123	-0.000331	-4.65e-05
	(0.00394)	(-0.0396)	(-0.107)	(-0.0165)
% Medicare	0.00379*	0.00334	0.00338	0.00390*
	(1.842)	(1.436)	(1.581)	(1.870)
Purchasing Group Member	-0.000522	-0.00642	-0.00505	0.000652
	(-0.0140)	(-0.170)	(-0.136)	(0.0168)
HHI	-7.33e-07	-9.75e-07	-5.13e-07	-1.43e-06
	(-0.0634)	(-0.0818)	(-0.0442)	(-0.127)
Academic	0.0780*	0.0681	0.0521	0.0454
	(1.892)	(1.629)	(1.223)	(1.032)
For Profit	0.00781	-0.0142	-0.0335	-0.0318
	(0.0486)	(-0.0987)	(-0.248)	(-0.244)
Religious	0.133**	0.154***	0.159***	0.153***
	(2.317)	(2.688)	(2.800)	(2.733)
Specialty Hospital	-0.0397	-0.0400	-0.0388	-0.0307
	(-0.262)	(-0.267)	(-0.278)	(-0.206)
Rural	-0.0991	-0.108	-0.112	-0.110
	(-0.823)	(-0.879)	(-0.903)	(-0.869)
Observations	9,331	9,105	9,050	8,984
Adjusted R-squared	0.785	0.792	0.793	0.793
Hospital Group, CBSA and Year FE	YES	YES	YES	YES

This table explores the effect of vendor consolidations on CIC (the first stage in our two-stage least squares analysis) over time. Using an indicator for whether the hospital's costing system vendor has experienced a consolidation in year *t, t-2, t-2,* or *t-3* (*Vendor Consolidation (One-Year Version)* in *t, t-1, t-2,* or *t-3*, respectively*)*, we examine how many years after the vendor consolidation it continues to have a significant effect on CIC. The results show that the association is strongest between CIC and vendor consolidations measured in the same year (column 1) or separated by one year (column 2), but the association is significant even three years after the vendor consolidation (column 3).

Table A4: Second-Stage Effect of Instrumented CIC on Operating Expenses Using Vendor Consolidation Instruments Measured Over Multiple Windows

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. variable:				ihs(Operating Expenses)				
ihs(CIC)$_t$	-0.0807**		-0.0820**		-0.0808*		-0.0590	
	(-2.059)		(-2.345)		(-1.942)		(-1.270)	
ihs(CIC)$_{t-1}$		-0.0187		-0.0562**		-0.0379		-0.0148
		(-0.656)		(-2.122)		(-1.486)		(-0.488)
ihs(Revenue)	0.702***	0.697***	0.702***	0.694***	0.702***	0.696***	0.702***	0.697***
	(32.43)	(30.99)	(32.22)	(28.96)	(32.16)	(29.23)	(32.51)	(30.32)
CMI	0.132***	0.126***	0.132***	0.132***	0.132***	0.129***	0.132***	0.125***
	(4.657)	(4.228)	(4.679)	(4.557)	(4.688)	(4.435)	(4.696)	(4.310)
Growth_Bedsize	-0.0958***	-0.101***	-0.0959***	-0.103***	-0.0958***	-0.102***	-0.0950***	-0.100***
	(-5.344)	(-5.556)	(-5.388)	(-5.839)	(-5.415)	(-5.781)	(-5.395)	(-5.658)
Bedsize	-3.52e-05	-3.07e-05	-3.52e-05	-3.77e-05	-3.52e-05	-3.43e-05	-3.39e-05	-3.00e-05
	(-1.031)	(-0.816)	(-1.038)	(-1.082)	(-1.040)	(-0.957)	(-0.998)	(-0.802)
Hospital Group Size	0.00200	0.00102	0.00202	0.00123	0.00200	0.00113	0.00167	0.000993
	(1.135)	(0.859)	(1.105)	(0.851)	(1.032)	(0.847)	(0.900)	(0.831)
Acquired by Hospital Group	0.00489	0.0555**	0.00399	0.0303	0.00483	0.0426*	0.0202	0.0581**
	(0.169)	(1.995)	(0.144)	(1.125)	(0.153)	(1.811)	(0.613)	(2.385)
Costing Adopter	0.00577	-0.00637	0.00580	-0.0278	0.00577	-0.0174	0.00530	-0.00416
	(0.462)	(-0.315)	(0.465)	(-1.258)	(0.464)	(-0.874)	(0.464)	(-0.201)
Apps_Age	-0.00827	-0.00336	-0.00830	-0.00134	-0.00827	-0.00233	-0.00786	-0.00357
	(-1.098)	(-0.447)	(-1.082)	(-0.168)	(-1.082)	(-0.299)	(-1.078)	(-0.449)
Apps_Age_squared	0.000181	-5.16e-05	0.000181	-0.000181	0.000181	-0.000118	0.000186	-3.82e-05
	(0.382)	(-0.103)	(0.382)	(-0.366)	(0.382)	(-0.233)	(0.392)	(-0.0700)
% Medicaid	0.000585	0.000504	0.000585	0.000415	0.000585	0.000459	0.000586	0.000513
	(0.921)	(0.874)	(0.917)	(0.650)	(0.921)	(0.759)	(0.979)	(0.910)
% Medicare	1.97e-05	-0.000330	2.46e-05	-0.000283	2.00e-05	-0.000306	-6.37e-05	-0.000335
	(0.0387)	(-0.737)	(0.0500)	(-0.597)	(0.0397)	(-0.657)	(-0.124)	(-0.727)
Purchasing Group Member	0.000550	0.00163	0.000555	0.00115	0.000550	0.00138	0.000465	0.00168
	(0.0785)	(0.246)	(0.0792)	(0.173)	(0.0786)	(0.211)	(0.0692)	(0.253)
HHI	1.26e-06	1.22e-06	1.26e-06	1.31e-06	1.26e-06	1.26e-06	1.27e-06	1.21e-06
	(0.633)	(0.676)	(0.631)	(0.656)	(0.634)	(0.665)	(0.682)	(0.670)
Academic	0.0201*	0.0142	0.0202*	0.0160	0.0201*	0.0151	0.0185*	0.0140
	(1.832)	(1.331)	(1.840)	(1.453)	(1.870)	(1.443)	(1.827)	(1.376)
For Profit	-0.0206	-0.0261	-0.0205	-0.0265	-0.0206	-0.0263	-0.0207	-0.0261
	(-1.105)	(-1.280)	(-1.100)	(-1.413)	(-1.104)	(-1.352)	(-1.164)	(-1.257)
Religious	0.0211*	0.0151	0.0212*	0.0215*	0.0211*	0.0184	0.0181	0.0144
	(1.797)	(1.306)	(1.835)	(1.786)	(1.749)	(1.487)	(1.491)	(1.100)
Specialty Hospital	0.0153	0.00302	0.0152	0.000779	0.0153	0.00188	0.0162	0.00325
	(0.613)	(0.126)	(0.607)	(0.0314)	(0.610)	(0.0772)	(0.676)	(0.134)
Rural	0.0206	0.0296	0.0204	0.0248	0.0205	0.0272	0.0229	0.0301
	(0.568)	(0.801)	(0.564)	(0.669)	(0.566)	(0.726)	(0.624)	(0.802)
Observations	9,331	8,941	9,331	8,941	9,331	8,941	9,331	8,941
Vendor Consolidation Window	**1 yr**	**1 yr**	**2 yr**	**2 yr**	**3 yr**	**3 yr**	**4 yr**	**4 yr**
Hospital Group, CBSA and Year FE	YES	YES	YES	YES	YES	YES	YES	YES
F-test of excluded instruments	12.87	5.494+	23.59	9.409	27.27	16.34	15.38	24.16

This table explores how incorporating multiple years' worth of vendor consolidations into the first stage instrumental variable impacts the statistical power to detect a link between instrumented CIC and operating expenses. The instrumental variable in each column is an indicator variable set to if: the hospital's vendor consolidated in the same year that CIC is measured (Vendor Consolidation Window=1); the hospital's vendor consolidated in the same year or the year before CIC is measured (Vendor Consolidation Window=2); the hospital's vendor consolidated in the same year, the year before, or two years before CIC is measured (Vendor Consolidation Window=3). [+]Note that the F-test value in column (2) is below the Stock et al (2002) cutoff value of 8.96 to indicate a valid instrument, so these columns should not be interpreted.

Internet Appendix B: Results Tables with alternate measures of CIC: CIC (Weighted) and CIC (Unweighted)

In our main analyses in the paper, we use a measure of CIC that counts the number of hospitals in the hospital group that share a costing system vendor with the focal hospital. Here, we provide all the tables of the paper using CIC (Weighted) and *CIC (Unweighted)* as discussed in Section 5.2 in the paper. We use the same table numbering as in the paper, preceded by the letter B. All CIC variables are defined in the main Appendix to the paper.

Table B1. Descriptive Statistics

	Obs.	Mean	SD	P25	Median	P75
CIC (Unweighted)	9,331	0.79	0.41	1.00	1.00	1.00
CIC (Weighted)	9,331	0.68	0.47	0.00	1.00	1.00
CIC	9,331	11.88	22.97	1.00	3.00	10.00
ihs(CIC)	9,331	1.99	1.52	0.88	1.82	3.00

This table provides descriptive statistics for all three versions of our CIC measure (ihs(CIC), CIC(Unweighted) and CIC(Weighted)), as well as the raw count of the number of hospitals in the hospital group that share a costing vendor (CIC).

Table B2. Correlations

		1	2	3	4	5	6
1	$ihs(CIC)_t$						
2	$ihs(CIC)_{t-1}$	0.85***					
3	$ihs(CIC)_{t-2}$	0.73***	0.85***				
4	$ihs(CIC)_{t-3}$	0.61***	0.71***	0.84***			
5	CIC (Unweighted)	0.65***	0.56***	0.48***	0.43***		
6	CIC (Weighted)	0.51***	0.41***	0.33***	0.26***	0.73***	
7	Vendor Consolidation	0.24***	0.32***	0.36***	0.31***	0.31***	0.30***

This table provides the correlations between all three versions of our CIC measure, along with lagged versions of the main CIC measure and our instrument, *Vendor Consolidation.* All measures are highly positively correlated, indicative of them capturing the same construct.

Table B3. First Stage Regression using Alternative Measures of CIC

Dep. variable:	(1) CIC (Unweighted)	(2) CIC (Weighted)
Vendor Consolidation	0.0651***	0.0573***
	(5.031)	(3.500)
ln(Revenue)	0.00964	0.0200
	(0.653)	(1.328)
CMI	0.00474	0.0624
	(0.120)	(1.533)
Growth_Bedsize	0.00997	-0.00409
	(0.590)	(-0.199)
Bedsize	2.11e-05	4.25e-05
	(0.360)	(0.768)
Hospital Group Size	-0.00285*	0.00429
	(-1.778)	(1.373)
Acquired by Hospital Group	-0.225***	-0.242***
	(-5.606)	(-6.225)
Costing Adopter	0.0200	0.0312
	(0.760)	(0.901)
Apps_Age	-0.000862	0.00966
	(-0.0828)	(0.580)
Apps_Age_squared	-0.000496	-0.000975
	(-0.778)	(-1.015)
% Medicaid	-0.000460	2.70e-05
	(-0.616)	(0.0224)
% Medicare	0.00161**	0.000569
	(2.390)	(0.603)
Purchasing Group Member	-0.0129	0.0149
	(-0.991)	(0.870)
HHI	-3.43e-06	-4.41e-06
	(-0.772)	(-0.979)
Academic	0.0242	-0.00359
	(1.359)	(-0.231)
For Profit	-0.0354	0.00381
	(-0.793)	(0.0716)
Religious	0.0442**	0.0216
	(2.017)	(1.030)
Specialty Hospital	0.0107	-0.0452
	(0.243)	(-0.636)
Rural	-0.00569	0.0602
	(-0.127)	(1.598)
Observations	9,331	9,331
Adjusted R-squared	0.630	0.604
Hospital Group, CBSA and Year FE	YES	YES

This table presents the first-stage regression from our main instrumental variables analysis for our alternative measures of CIC

Table B4. The Effect of Alternative Measures of CIC on Operating Expenses

Results are consistent with those reported in Table 4 in the paper using ihs(CIC) in that both alternative measures of CIC measured at time t and t-1 load negatively on Operating Expenses, whereas no significant relationship exists when CIC is measured further out in the past.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. variable:	ln(Operating Expenses)				ln(Operating Expenses)			
Indep. variable:	CIC(Unweighted)				CIC(Weighted)			
CIC_t	-0.207**				-0.235**			
	(-2.096)				(-2.133)			
CIC_{t-1}		-0.183**				-0.200**		
		(-2.003)				(-2.070)		
CIC_{t-2}			-0.0888				-0.109	
			(-1.076)				(-1.019)	
CIC_{t-3}				0.0673				0.0925
				(1.106)				(1.187)
ln(Revenue per bed)	0.705***	0.697***	0.701***	0.702***	0.708***	0.700***	0.703***	0.700***
	(33.27)	(29.66)	(31.77)	(33.88)	(34.48)	(31.11)	(33.27)	(34.29)
CMI	0.132***	0.128***	0.130***	0.124***	0.146***	0.145***	0.140***	0.115***
	(4.401)	(4.252)	(4.559)	(4.206)	(4.956)	(4.820)	(4.545)	(3.459)
Growth_Bedsize	-0.0907***	-0.102***	-0.106***	-0.107***	-0.0938***	-0.0995***	-0.104***	-0.109***
	(-5.052)	(-5.946)	(-6.349)	(-5.593)	(-5.266)	(-6.224)	(-6.447)	(-5.313)
Bedsize	-2.54e-05	-2.83e-05	-2.69e-05	-2.12e-05	-1.98e-05	-2.75e-05	-2.61e-05	-2.20e-05
	(-0.744)	(-0.814)	(-0.775)	(-0.533)	(-0.547)	(-0.759)	(-0.744)	(-0.551)
Hospital Group Size	0.000192	0.000238	0.000407	0.00156	0.00179	0.00135	0.000745	0.00148
	(0.153)	(0.180)	(0.319)	(1.062)	(1.055)	(0.791)	(0.536)	(1.018)
Acquired by Hospital Group	0.0149	0.0375	0.0803***	0.0892***	0.00454	0.0442*	0.106***	0.0742**
	(0.551)	(1.401)	(2.797)	(3.283)	(0.150)	(1.946)	(2.771)	(2.177)
Costing Adopter	0.00421	-0.0484	-0.0528	0.0346	0.00741	-0.0426	-0.0548	0.0397
	(0.363)	(-1.541)	(-0.907)	(1.203)	(0.573)	(-1.483)	(-0.855)	(1.295)
Apps_Age	-0.00670	0.000236	-0.00338	-0.00360	-0.00425	0.00325	-0.00107	-0.00510
	(-0.874)	(0.0283)	(-0.437)	(-0.410)	(-0.569)	(0.356)	(-0.125)	(-0.542)
Apps_Age_squared	8.43e-05	-0.000312	-5.99e-05	-1.88e-05	-4.24e-05	-0.000475	-0.000222	9.76e-05
	(0.163)	(-0.573)	(-0.114)	(-0.0296)	(-0.0879)	(-0.820)	(-0.372)	(0.143)
% Medicaid	0.000482	0.000369	0.000422	0.000529	0.000583	0.000289	0.000354	0.000644
	(0.837)	(0.615)	(0.743)	(0.991)	(0.891)	(0.425)	(0.581)	(1.205)
% Medicare	5.13e-05	-0.000186	-0.000277	-0.000445	-0.000149	-0.000394	-0.000344	-0.000392
	(0.105)	(-0.403)	(-0.582)	(-0.936)	(-0.299)	(-0.764)	(-0.714)	(-0.845)
Purchasing Group Member	-0.00198	0.00149	0.000353	-0.000258	0.00420	0.00371	-4.61e-05	-0.000137

	(-0.298)	(0.226)	(0.0550)	(-0.0341)	(0.495)	(0.510)	(-0.00698)	(-0.0172)
HHI	6.35e-07	6.75e-07	9.67e-07	1.41e-06	3.07e-07	1.37e-07	7.83e-07	1.44e-06
	(0.347)	(0.350)	(0.522)	(0.717)	(0.164)	(0.0696)	(0.425)	(0.709)
Academic	0.0188*	0.0170	0.0150	0.00823	0.0129	0.0144	0.0144	0.00821
	(1.732)	(1.535)	(1.436)	(0.770)	(1.217)	(1.341)	(1.354)	(0.773)
For Profit	-0.0291	-0.0335	-0.0249	-0.0117	-0.0208	-0.0303	-0.0249	-0.0120
	(-1.477)	(-1.563)	(-1.156)	(-0.503)	(-1.045)	(-1.440)	(-1.116)	(-0.527)
Religious	0.0200	0.0231*	0.0180	0.00876	0.0159	0.0202	0.0176	0.00851
	(1.645)	(1.723)	(1.403)	(0.677)	(1.327)	(1.617)	(1.418)	(0.643)
Specialty Hospital	0.0198	0.00220	0.00413	0.00194	0.00691	-0.00726	-0.00354	0.00849
	(0.766)	(0.0822)	(0.166)	(0.0768)	(0.237)	(-0.259)	(-0.123)	(0.343)
Rural	0.0271	0.0256	0.0285	0.0374	0.0424	0.0423	0.0383	0.0297
	(0.760)	(0.688)	(0.764)	(0.956)	(1.138)	(1.107)	(1.041)	(0.765)
Observations	9,331	8,941	8,739	8,543	9,331	8,941	8,739	8,543
Hospital Group FE	YES	YES	YES	YES	YES	YES	YES	YES
CBSA FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
F-test of excluded instruments	25.31	14.19	18.67	32.93	12.25	11.59	15.00	13.67

Table B5. The Effect of Alternative Measures of CIC on Clinical Outcomes

Results are consistent with those reported in Table 5 of the paper using CIC (Unweighted) in that both alternative measures of CIC measured at time t and t-1 do not exhibit a significant relationship with mortality and readmissions at time t.

Panel A. CIC (Weighted)

	(1)	(2)	(3)	(4)
Dep. variable:	Mortality		Readmissions	
CIC (Weighted)$_t$	0.200		0.757	
	(0.363)		(0.880)	
CIC (Weighted)$_{t-1}$		0.162		0.669
		(0.351)		(1.204)
Revenue per bed	-0.105*	-0.0816	-0.0502	-0.0495
	(-1.686)	(-1.250)	(-0.991)	(-1.035)
CMI	-0.258	-0.313	-0.755***	-0.802***
	(-1.100)	(-1.270)	(-3.777)	(-3.880)
Growth_Bedsize	0.0225	0.0346	-0.0491	-0.0746
	(0.243)	(0.340)	(-0.573)	(-0.787)
Bedsize	-0.000139	-7.75e-05	0.000293	0.000326
	(-0.592)	(-0.327)	(1.272)	(1.350)
Group Size	0.000954	0.00119	-0.0204	-0.0204*
	(0.194)	(0.241)	(-1.643)	(-1.797)
Acquired by Hospital Group	0.139	0.147	0.253	0.184**
	(0.943)	(1.554)	(1.233)	(1.998)
Costing Adopter	0.0361	0.0997	-0.0698	0.123
	(0.442)	(0.872)	(-0.884)	(0.755)
Apps_Age	0.0238	0.00913	-0.0214	-0.0437
	(0.520)	(0.186)	(-0.477)	(-0.882)
Apps_Age_squared	-0.00153	-0.000638	0.00126	0.00243
	(-0.516)	(-0.199)	(0.364)	(0.673)
% Medicaid	-0.00306	-0.00360	0.00578	0.00562
	(-0.929)	(-1.024)	(1.528)	(1.513)
% Medicare	-0.00460	-0.00492	-0.00591*	-0.00616
	(-1.274)	(-1.324)	(-1.761)	(-1.531)
Purchasing Group Member	0.0224	0.0214	0.00565	0.0135
	(0.701)	(0.650)	(0.130)	(0.368)
HHI	3.10e-05*	3.15e-05*	-1.27e-05	-1.21e-05
	(1.846)	(1.797)	(-1.016)	(-0.941)
Academic	0.111	0.111	0.0137	0.0183
	(1.457)	(1.390)	(0.163)	(0.231)
For Profit	-0.0175	-0.0400	0.229*	0.249*
	(-0.148)	(-0.351)	(1.675)	(1.760)
Religious	-0.0351	-0.0167	-0.144**	-0.146**
	(-0.400)	(-0.188)	(-2.068)	(-2.133)
Specialty Hospital	0.683**	0.662**	0.0550	-0.0292
	(2.200)	(2.020)	(0.201)	(-0.116)
Rural	-0.288	-0.338	0.159	0.113
	(-1.131)	(-1.233)	(0.762)	(0.531)

Observations	8,797	8,436	8,797	8,436
Hospital Group FE	YES	YES	YES	YES
CBSA FE and Year FE	YES	YES	YES	YES
F-test of excluded instrument	11	11.40	11	11.40

Panel B. CIC (Unweighted)

	(1)	(2)	(3)	(4)
Dep. variable:	Mortality		Readmissions	
CIC (Unweighted)$_t$	0.181		0.682	
	(0.364)		(0.881)	
CIC (Unweighted)$_{t-1}$		0.154		0.637
		(0.351)		(1.220)
ln(Revenue)	-0.104	-0.0800	-0.0468	-0.0429
	(-1.645)	(-1.209)	(-0.925)	(-0.878)
CMI	-0.242	-0.296	-0.694***	-0.732***
	(-1.015)	(-1.198)	(-3.824)	(-3.787)
Growth_Bedsize	0.0188	0.0378	-0.0631	-0.0614
	(0.203)	(0.359)	(-0.714)	(-0.654)
Bedsize	-0.000137	-7.96e-05	0.000298	0.000318
	(-0.583)	(-0.334)	(1.268)	(1.288)
Hospital Group Size	0.00235	0.00209	-0.0151*	-0.0167*
	(0.483)	(0.395)	(-1.847)	(-1.917)
Acquired by Hospital Group	0.133	0.156	0.230	0.222*
	(1.004)	(1.488)	(1.212)	(1.887)
Costing Adopter	0.0393	0.107	-0.0575	0.152
	(0.492)	(0.820)	(-0.733)	(0.843)
Apps_Age	0.0255	0.0115	-0.0148	-0.0341
	(0.583)	(0.246)	(-0.372)	(-0.781)
Apps_Age_squared	-0.00162	-0.000765	0.000934	0.00191
	(-0.560)	(-0.249)	(0.292)	(0.584)
% Medicaid	-0.00290	-0.00362	0.00638*	0.00554
	(-0.877)	(-1.030)	(1.756)	(1.499)
% Medicare	-0.00475	-0.00508	-0.00647**	-0.00680*
	(-1.315)	(-1.395)	(-2.055)	(-1.824)
Purchasing Group Member	0.0278	0.0234	0.0260	0.0218
	(0.829)	(0.696)	(0.750)	(0.634)
HHI	3.07e-05*	3.11e-05*	-1.39e-05	-1.37e-05
	(1.848)	(1.818)	(-1.080)	(-1.029)
Academic	0.105	0.108	-0.00783	0.00755
	(1.329)	(1.335)	(-0.107)	(0.0987)
For Profit	-0.0150	-0.0410	0.238*	0.245*
	(-0.124)	(-0.356)	(1.741)	(1.661)
Religious	-0.0370	-0.0185	-0.151**	-0.153**
	(-0.415)	(-0.206)	(-2.012)	(-2.167)
Specialty Hospital	0.669**	0.652**	0.00226	-0.0706
	(2.160)	(2.008)	(0.00931)	(-0.300)
Rural	-0.274	-0.323	0.213	0.174
	(-1.073)	(-1.195)	(1.005)	(0.793)
Observations	8,797	8,436	8,797	8,436
Hospital Group FE	YES	YES	YES	YES
CBSA FE and Year FE	YES	YES	YES	YES
F-test of excluded instruments	22.95	13.07	22.95	13.07

Table B6. The Effect of Alternative Measures of CIC on Patient Satisfaction

Results are consistent with those reported in Table 6 of the paper using ihs(CIC) in that both alternative measures of CIC measured at time t and t-1 do not exhibit a significant relationship with five of the six patient satisfaction measures at time t. The only difference is that *CIC (Unweighted)* also does not load significantly on Doctor Communication, whereas *ihs(CIC)* and *CIC (Weighted)* both load significantly negatively at the 10% level on the proportion of patients that indicated that doctors sometimes or never communicated well.

Panel A. CIC (Weighted)

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. variable:	Nurse Communication		Doctor Communication		Help Availability	
CIC (Weighted)$_t$	-2.110		-2.358*		-2.425	
	(-1.133)		(-1.676)		(-0.804)	
CIC (Weighted)$_{t-1}$		-2.919		-3.170		-5.532
		(-1.130)		(-1.437)		(-1.238)
Observations	7,988	7,648	7,988	7,648	7,988	7,648
Controls	YES	YES	YES	YES	YES	YES
Hospital Group FE	YES	YES	YES	YES	YES	YES
CBSA FE and Year FE	YES	YES	YES	YES	YES	YES
F-test of excluded instrument	10.41	12.39	10.41	12.39	10.41	12.39

	(7)	(8)	(9)	(10)	(11)	(12)
Dep. variable:	Cleanliness		Pain Control		Wouldn't Recommend	
CIC (Weighted)$_t$	2.010		-1.857		-2.143	
	(1.017)		(-1.125)		(-0.913)	
CIC (Weighted)$_{t-1}$		0.704		-2.669		-2.873
		(0.274)		(-1.153)		(-0.884)
Observations	7,988	7,648	7,988	7,648	7,988	7,648
Controls	YES	YES	YES	YES	YES	YES
Hospital Group FE	YES	YES	YES	YES	YES	YES
CBSA FE and Year FE	YES	YES	YES	YES	YES	YES
F-test of excluded instrument	10.41	12.39	10.41	12.39	10.41	12.39

Panel B. CIC (Unweighted)

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. variable:	Nurse Communication		Doctor Communication		Help Availability	
CIC (Unweighted)$_t$	-2.419		-2.703		-2.780	
	(-1.076)		(-1.579)		(-0.773)	
CIC (Unweighted)$_{t-1}$		-2.906		-3.156		-5.508
		(-1.105)		(-1.408)		(-1.210)
Observations	7,988	7,648	7,988	7,648	7,988	7,648
Controls	YES	YES	YES	YES	YES	YES
Hospital Group FE	YES	YES	YES	YES	YES	YES
CBSA FE and Year FE	YES	YES	YES	YES	YES	YES
F-test of excluded instrument	16.19	15.00	16.19	15.00	16.19	15.00

	(7)	(8)	(9)	(10)	(11)	(12)
Dep. variable:	Cleanliness		Pain Control		Wouldn't Recommend	
CIC (Unweighted)$_t$	2.304		-2.128		-2.456	
	(1.081)		(-1.070)		(-0.873)	
CIC (Unweighted)$_{t-1}$		0.701		-2.658		-2.860
		(0.275)		(-1.134)		(-0.870)
Observations	7,988	7,648	7,988	7,648	7,988	7,648
Controls	YES	YES	YES	YES	YES	YES
Hospital Group FE	YES	YES	YES	YES	YES	YES
CBSA FE and Year FE	YES	YES	YES	YES	YES	YES
F-test of excluded instrument	16.19	15.00	16.19	15.00	16.19	15.00

Table B7. The Effect of Alternative Measures of CIC on Costs for Patient Care

Results are consistent with those reported in Table 7 of the paper using *ihs(CIC)* in that both alternative measures of CIC measured at time t and t-1 load significantly negatively (at 5%) on non-clinical expenses, but have no significant relationship with core clinical expenses. Note that, in contrast to Table 7 of the paper, all F-tests of excluded instrument are above the Stock et al (2002) value and hence also columns (2) and (4) can be interpreted. In that sense, these robustness results are stronger than those reported in the main body of the paper.

Panel A. CIC (Weighted)

	(1)	(2)	(3)	(4)
Dep. variable:	Core Clinical Expenses		Non-Clinical Expenses	
CIC (Weighted)$_t$	0.300		-0.674**	
	(1.486)		(-2.244)	
CIC (Weighted)$_{t-1}$		0.0511		-0.433**
		(0.323)		(-2.006)
Observations	9,037	8,659	9,037	8,659
Controls	YES	YES	YES	YES
Hospital Group FE	YES	YES	YES	YES
CBSA FE and Year FE	YES	YES	YES	YES
F-test of excluded instrument	11.36	10.57	11.36	10.57

Panel B. CIC (Unweighted)

	(1)	(2)	(3)	(4)
Dep. variable:	Core Clinical Expenses		Non-Clinical Expenses	
CIC (Unweighted)$_t$	0.264		-0.591**	
	(1.621)		(-2.356)	
CIC (Unweighted)$_{t-1}$		0.0469		-0.397**
		(0.326)		(-2.032)
Observations	9,037	8,659	9,037	8,659
Controls	YES	YES	YES	YES
Hospital Group FE	YES	YES	YES	YES
CBSA FE and Year FE	YES	YES	YES	YES
F-test of excluded instrument	23.87	13.24	23.87	13.24

Internet Appendix C: Detailed Components Included in the Clinical and Non-Clinical Expense Categories

Core Clinical Expenses:

- **Inpatient Routine Service Cost Centers**
    - Adults and pediatrics (general routine care)
    - Intensive Care Unit
    - Coronary care unit
    - Burn intensive care unit
    - Surgical intensive care unit
    - Other special care
    - Subprovider-IPF
    - Subprovider-IRF
    - Subprovider
    - Nursery
    - Skilled nursing facility
    - Nursing facility
    - Other long-term care
- **Outpatient Service Cost Centers**
    - Rural health clinic
    - Federally qualified health center
    - Clinic
    - Emergency
    - Observation Beds
    - Other outpatient service
    - Partial hospitalization program
- **Ancillary Service Cost Centers**
    - Operating room
    - Recovery room
    - Labor room and delivery room
    - Anesthesiology
    - Radiology-diagnostic
    - Radiology-therapeutic
    - Radioisotope
    - Computed tomography (CT) scan
    - Magnetic Resonance Imaging (MRI)
    - Cardiac catheterization
    - Laboratory
    - PBP clinical laboratory services-program ony
    - Whole blood and packed red blood cells
    - Blood storing, processing, and trans.
    - Intravenous therapy
    - Respiratory therapy

- Physical therapy
  - Occupational therapy
  - Speech pathology
  - Electrocardiology
  - Electroencephalography
  - Medical supplies charged to patients
  - Implantable devices charged to patients
  - Drugs charged to patients
  - Renal dialysis
  - ASC (non-distinct part)
  - Other ancillary
  - Allogeneic stem cell acquisition

Non-Clinical Expenses
Non-clinical expenses are calculated as Total Operating Expenses minus Core Clinical Expenses. The non-clinical expense categories are:

- **General Service Cost Centers**
  - Capital related costs-buildings and fixtures
  - Capital related costs-movable equipment
  - Other capital related costs
  - Employee benefits department
  - Administrative and general
  - Maintenance and repairs
  - Operation of plant
  - Laundry and linen service
  - Housekeeping
  - Dietary
  - Cafeteria
  - Maintenance of personnel
  - Nursing administration
  - Central services and supply
  - Pharmacy
  - Medical records and medical records library
  - Social service
  - Other general service
  - Nonphysician anesthetists
  - Nursing program
  - Inten and res. Service-salary and fringes
  - Intern and res. Other program costs
  - Paramedical ed. program
- **Nonreimbursable Cost Centers**
  - Gift, flower, coffee shop, and canteen
  - Research

- Physicians' private offices
- Nonpaid workers
- Other nonreimbursable

- **Other Reimbursable Cost Centers**
  - Home program dialysis
  - Ambulance services
  - Durable medical equipment-rented
  - Durable medical equipment-sold
  - Other reimbursable
  - Outpatient rehabilitation provider
  - Intern-resident service (not appvd. tchng. prgm.)
  - Home health agency
- **Special Purpose Cost Centers**
  - Kidney acquisition
  - Heart acquisition
  - Liver acquisition
  - Lung acquisition
  - Pancreas acquisition
  - Intestinal acquisition
  - Islet acquisition
  - Other organ acquisition
  - Interest expense
  - Utilization review-SNF
  - Ambulatory surgical center (distinct part)
  - Hospice
  - Other special purpose

Internet Appendix D: Exploring Whether It Is Appropriate to Use Vendor Consolidations as an Instrumental Variable When the Same Hospital Can Be Exposed to Multiple Consolidations During the Sample Period

Our vendor consolidation instrument is an indicator variable that turns on in the first stage for some hospitals in some years. This is similar to the staggered difference-in-differences design discussed in Baker et al. (2022).[15] Baker et al. conclude that staggered diff-in-diff designs are problematic when they include already-treated firms in the control group and the treatment has a permanent, one-time effect on the outcome. This is because when already-treated firms are included in the control group, it changes the baseline against which subsequently-treated firms are compared. As shown in Figures 2 and 3, vendor consolidations (our "treatment") are frequent and can occur repeatedly for the same hospital. Therefore, it is important to determine whether our first-stage regressions are subject to the problem described in Baker et al. As we will demonstrate with our tests below, our study does not suffer from this problem of the inappropriate, already-treated control group because the effect of vendor consolidations on CIC dissipates over time (Internet Appendix Table A3) and subsequent consolidations continue to have the same effect on CIC (Internet Appendix Tables D1 and D3). In other words, because the effect of vendor consolidations is temporary (a condition not studied in Baker et al.), already-treated observations are appropriate to include in the "control sample." Below we demonstrate that our results are similar either when just focusing on a sample of likely first-time vendor-consolidating hospitals (Tables D1 and D2) or when focusing on a sample of repeated vendor-consolidating hospitals (Tables D3 and D4). This confirms that the effect of vendor consolidations is similar even for subsequent vendor consolidations that affect the same hospital, confirming that multiple treatment does not pose a problem for our inferences.

[15] Baker, A. C., Larcker, D. F., & Wang, C. C. (2022). How much should we trust staggered difference-in-differences estimates?. *Journal of Financial Economics*, *144*(2), 370-395.

Table D1. First Stage Regression of the Effect of Initial Vendor Consolidations on CIC

Dep. variable:	ihs(CIC)
Vendor Consolidation	0.170***
	(3.156)
Revenue per bed	0.0391
	(0.953)
CMI	0.0895
	(0.809)
Growth_Bedsize	-0.0173
	(-0.365)
Bedsize	-0.000199
	(-1.586)
Group Size	0.00222
	(0.267)
Acquired by Hospital Group	-0.719***
	(-5.476)
Costing Adopter	0.101
	(1.113)
Apps_Age	-0.0253
	(-0.464)
Apps_Age_squared	7.36e-05
	(0.0239)
% Medicaid	0.000931
	(0.368)
% Medicare	0.00710**
	(2.498)
Purchasing Group Member	0.00728
	(0.131)
HHI	5.31e-06
	(0.408)
Academic	0.0686
	(1.498)
For Profit	-0.0122
	(-0.0648)
Religious	0.0985
	(1.276)
Specialty Hospital	-0.0864
	(-0.414)
Rural	-0.165
	(-1.160)
Observations	5,305
Adjusted R-squared	0.793
Hospital Group, CBSA and Year FE	YES

This table presents the results of the first stage of a two-stage least squares analysis. It shows the link between our instrument (*Vendor Consolidation*) and *CIC*. This table only includes vendor consolidations for hospital-year observations where it is the first time that the hospital was exposed to a vendor consolidation in our sample period. Hospitals experiencing vendor consolidations are included in years before they experience the vendor consolidation, and for all years after the first consolidation but before another vendor consolidation affects the same hospital. After that they are excluded from the sample.

Table D2. The Effect of CIC on Operating Expenses after Initial Vendor Consolidation

	(1)	(2)
Dep. variable	ihs(Operating Expenses)	
ihs(CIC)$_t$	-0.0877*	
	(-1.857)	
ihs(CIC)$_{t-1}$		-0.0309
		(-0.931)
ihs(Revenue)	0.684***	0.671***
	(27.47)	(24.37)
CMI	0.150***	0.131***
	(3.653)	(3.126)
Growth_Bedsize	-0.110***	-0.111***
	(-5.232)	(-5.200)
Bedsize	-2.81e-05	8.26e-06
	(-0.673)	(0.181)
Hospital Group Size	0.000791	0.00100
	(0.510)	(0.589)
Acquired by Hospital Group	-0.0257	0.0181
	(-0.719)	(0.517)
Costing Adopter	0.00414	-0.0193
	(0.298)	(-0.911)
Apps_Age	-0.00935	0.000541
	(-1.008)	(0.0534)
Apps_Age_squared	0.000399	-0.000148
	(0.710)	(-0.218)
% Medicaid	0.000811	0.000662
	(1.148)	(0.928)
% Medicare	-0.000111	-0.000740
	(-0.163)	(-1.265)
Purchasing Group Member	-0.00527	-0.00476
	(-0.456)	(-0.487)
HHI	2.41e-06	2.31e-06
	(0.791)	(0.851)
Academic	0.00809	-0.00309
	(0.625)	(-0.240)
For Profit	-0.0349	-0.0419
	(-1.455)	(-1.647)
Religious	0.0144	0.0151
	(1.021)	(0.871)
Specialty Hospital	0.0380	0.0269
	(1.315)	(0.943)
Rural	0.00743	0.0188
	(0.165)	(0.438)
Observations	5,305	4,979
Hospital Group, CBSA and Year FE	YES	YES
F-test of excluded instruments	9.962	9.147

This table presents the results of the second stage of a two-stage least squares analysis. It shows the link between instrumented *CIC* (where *Vendor Consolidation* is the instrument) and *Operating Expenses*. This table only includes vendor consolidations for hospital-year observations where it is the first time that the hospital was exposed to a vendor consolidation in our sample period. Hospitals experiencing vendor consolidations are included in the sample in years before they experience the vendor consolidation, and for all years after the first consolidation but before another vendor consolidation affects the same hospital. After that they are excluded from the sample.

Table D3. First Stage Regression of the Effect of Repeated Vendor Consolidations on CIC

Dep. variable:	ihs(CIC)
Vendor Consolidation	0.218***
	(3.275)
ihs(Revenue)	0.0544
	(1.300)
CMI	0.0520
	(0.270)
Growth_Bedsize	0.0199
	(0.333)
Bedsize	-0.000119
	(-0.574)
Hospital Group Size	0.00727
	(1.355)
Acquired by Hospital Group	-0.483***
	(-2.942)
Costing Adopter	0.195*
	(1.658)
Apps_Age	-0.0348
	(-0.798)
Apps_Age_squared	0.00229
	(0.809)
% Medicaid	0.00181
	(0.514)
% Medicare	0.00211
	(0.614)
Purchasing Group Member	0.00367
	(0.108)
HHI	-9.78e-06
	(-1.058)
Academic	0.0170
	(0.271)
For Profit	-0.429***
	(-2.858)
Religious	0.249**
	(2.512)
Specialty Hospital	-0.0373
	(-0.139)
Rural	-0.0458
	(-0.321)
Observations	4,042
Adjusted R-squared	0.872

Hospital Group, CBSA and Year FE	YES

This table presents the results of the first stage of a two-stage least squares analysis. It shows the link between our instrument (*Vendor Consolidation*) and *CIC*. This table only includes vendor consolidations for hospital-year observations that have previously experienced a vendor consolidation in our sample period. Hospitals that have previously experienced vendor consolidations are included in the sample starting two years after the first vendor consolidation. Before that they are excluded from the sample. Hospitals that experienced a second vendor consolidation the year immediately after their first vendor consolidation were also excluded from the sample to prevent overlap with the initial vendor consolidation sample used in Tables D1 and D2.

Table D4. The Effect of CIC on Operating Expenses after Repeated Vendor Consolidations

	(1)	(2)
Dep. variable:	ihs(Operating Expenses)	
$ihs(CIC)_t$	-0.117*	
	(-1.731)	
$ihs(CIC)_{t-1}$		-0.146
		(-1.624)
ihs(Revenue)	0.698***	0.698***
	(21.73)	(20.82)
CMI	0.142***	0.127**
	(2.877)	(2.347)
Growth_Bedsize	-0.0599***	-0.0775***
	(-2.751)	(-3.458)
Bedsize	-0.000104**	-0.000129**
	(-1.989)	(-2.289)
Hospital Group Size	0.00143	0.00110
	(0.911)	(0.673)
Acquired by Hospital Group	-0.0159	-0.0196
	(-0.413)	(-0.430)
Costing Adopter	0.0310	-0.0674
	(1.187)	(-1.216)
Apps_Age	-0.00834	0.00799
	(-0.798)	(0.765)
Apps_Age_squared	0.000339	-0.000551
	(0.503)	(-0.958)
% Medicaid	-0.000898	-0.00147
	(-0.935)	(-1.470)
% Medicare	-0.000738	-0.00100
	(-0.892)	(-1.109)
Purchasing Group Member	0.00806	0.00514
	(0.780)	(0.469)
HHI	-5.24e-06**	-7.37e-06***
	(-2.001)	(-2.636)
Academic	0.000528	-0.00157
	(0.0351)	(-0.0947)
For Profit	-0.0614	-0.0547
	(-1.342)	(-1.236)
Religious	0.0252	0.0359
	(0.883)	(1.006)

Specialty Hospital	0.0368	0.00728
	(0.624)	(0.102)
Rural	-0.0879	-0.110*
	(-1.513)	(-1.889)
Observations	4,042	3,858
Hospital Group, CBSA and Year FE	YES	YES
F-test of excluded instruments	10.73	8.474[+]

This table presents the results of the second stage of a two-stage least squares analysis. It shows the link between instrumented *CIC* (where *Vendor Consolidation* is the instrument) and *Operating Expenses*. This table only includes vendor consolidations for hospital-year observations that have previously experienced a vendor consolidation in our sample period. Hospitals that have previously experienced vendor consolidations are included in the sample starting two years after the first vendor consolidation. Before that they are excluded from the sample. Hospitals that experienced a second vendor consolidation the year immediately after their first vendor consolidation were also excluded from the sample to prevent overlap with the initial vendor consolidation sample used in Tables D1 and D2. [+]Because the F-test of excluded instruments in column (2) is slightly below the cutoff value of 8.96, this test should not be interpreted.