

Supplementary Appendix

This appendix has been provided by the authors to give readers additional information about their work.

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SUPPLEMENTARY APPENDIX

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A. Transactions

We used data from the Irving Levin Associates Annual Hospital Acquisition Reports to identify hospital mergers or acquisitions that were publicly announced in 2006-2016. Through web-based searches we determined whether each deal was consummated, recorded the date of consummation for each transaction, and excluded those that were not consummated or consummated after December 31, 2016. For each transaction, Irving Levin Associates categorized the hospitals involved as being acquirers or acquired. In many cases, the acquirer was a hospital system or health system. For transactions classified as mergers (rather than acquisitions), Irving Levin Associates considered the acquirer to be the hospital or hospital system whose name was attached to the new merged organization, that had more representation on the combined board, or whose CEO took charge of the merged organization. Of transactions, a minority were classified as mergers as opposed to acquisitions.

To identify hospitals in acquiring systems, we used a database of health systems created as part of research conducted under a multi-year AHRQ-funded center of excellence at NBER and Harvard. Specifically, a large number of administrative and claims datasets (e.g. CMS Provider Enrollment and Chain Ownership System, traditional Medicare and commercial claims data, IRS 990 filings for tax exempt organizations, and SEC 10-k filings) were combined to create a longitudinal database that links hospitals and other health care providers under common ownership or managerial control. We use this health systems database to identify hospitals in acquired systems and hospitals in acquiring systems.

We identified 547 deals consummated during our study period 2007-2016 involving 716 acquired hospitals and 2,252 acquiring hospitals (inclusive of all members of acquiring systems);

many acquiring hospitals participated as acquirers in multiple transactions. Transactions consummated during 2009-2013 comprise our study transactions. These transactions involved 246 hospitals acquired for the first time since 2007.

B. Hospitals

We used the Centers for Medicare and Medicaid Services (CMS) provider of services (POS) file to assess hospital characteristics. The POS file includes all hospitals certified to deliver services to Medicare beneficiaries. All non-federal short term acute care hospitals were eligible for inclusion in our study.

Hospital size was assessed as the total number of hospital beds in the facility including non-participating and non-licensed areas (POS SAS name: CRTFD_BED_CT). Hospitals were coded as having a teaching mission if they had a major affiliation with a medical school (POS SAS name: MDCL_SCHL_AFLTN_CD). We coded hospitals as having for-profit ownership or public ownership according to the ownership type variable in POS data (SAS name: GNRL_CNTL_TYPE_CD). Hospitals with federal and tribal ownership types were excluded. We coded hospitals as located in an urban location according to the urban CBSA indicator in POS data (SAS name: CBSA_URBAN_RRL_IND; note this variable is not available in the POS data until 2011).

We implemented the following inclusion criteria:

1. We included only hospitals that were short-term acute in all study years (2007-2016) in which they were observed in the POS.
2. We excluded hospitals that were classified as critical access hospitals in 2007 and hospitals that converted to critical access status during our study period.

3. We excluded hospitals located in U.S. territories (e.g. Puerto Rico, Guam).
4. We excluded hospitals with fewer than 100 traditional Medicare admissions or fewer than 25 beds in any year the hospital was in operation during the study period, as data on quality were unavailable on many small hospitals below these thresholds.
5. We excluded hospitals if they were missing from claims data in any year from 2008-2012, the period from the year before the first transactions in 2009 to the year before the last transactions we examined in 2013. Because time relative to the transaction year cannot be defined for the control group (there is no transaction for those hospitals, and because acquired hospitals by definition have no missing data in the pre-transaction period (they are still present in the transaction year), this restriction ensured that all hospitals (acquired and other hospitals) consistently had non-missing data in the pre-transaction period. In Table S1 we show the missing rates in post-transaction years overall and specifically for later transactions from 2012-2013 for which this inclusion criterion did not affect missingness in the post-transaction period. As detailed below, overall and for these later transaction years, we find that missing rates in the post-transaction period differed minimally between comparison groups
6. We excluded hospitals involved in mergers in which the acquired hospitals started using the acquiring hospital's ID after the transaction (consolidated reporting). We excluded both the hospitals that stopped using their ID and the hospitals with which they consolidated their reporting. Otherwise, these case would introduce imbalance

in the hospitals included in our sample before and after transaction-related consolidation of reporting/IDs.

Our primary treatment group included all remaining hospitals acquired from 2009-2013.

Among other hospitals meeting inclusion criteria, we made the following additional exclusions to define our control group:

1. We excluded any hospital from the control group if it was acquired during years outside of the 2009-2013 transactions we focused on in our analyses. That is, we excluded hospitals acquired in 2007-2008 or 2014-2016. This eliminated bias from effects of acquisitions in other years on acquired hospitals.
2. We excluded hospitals located within 5 miles of a hospital acquired in one of our study transactions (2009-2013).
3. We excluded hospitals involved in one of our study transactions as an acquirer when the acquiring hospital was located in the same state as a hospital it acquired. We refer to this set of hospitals as in-state acquirers.

The final data set for our primary analyses contains 2232 hospitals, including 1986 control hospitals and 246 acquired hospitals (198 transactions). For our secondary analyses of local spillovers and effects on acquirers, we used the same control group and estimated differential changes in performance for 142 hospitals located within 5 miles of an acquired hospital and for the 391 in-state acquirers, respectively.

C. Performance Measures

Data on clinical process measures was also obtained from CMS Hospital Compare. The set of clinical process measures reported by hospitals and included in HCAHPS changes

substantially over time. We selected for our analysis seven process measures that were consistently reported over the time period 2007-2014 (see **Table S2** for a description of these measures). We were unable to extend our analyses of clinical process measures to our full study period (2007-2016) because most hospitals ceased reporting these seven measures beginning in 2015.

Data on patient experiences of hospital care are collected by CMS using the Hospital Assessment of Health Care Providers and Systems (HCAHPS) Survey. This survey is administered annually to a sample of adults admitted to hospitals serving Medicare or Medicaid patients (see the CMS Hospital Compare website for details:

<https://www.medicare.gov/hospitalcompare/Data/Overview.html>). We analyzed data on the five measures reported consistently over the 2007-2016 study period (see **Table S3** and <https://www.medicare.gov/hospitalcompare/Data/Data-Updated.html#> for details).

For each hospital in each year, we computed a clinical process composite score equal to the average of z-scores for each component measure with non-missing data. To calculate a z-score for each component measure, we subtracted the sample mean score from the hospital's score and divided the difference by the standard deviation of the score. To mitigate underestimation of effect sizes as the result of sampling error (within-hospital, between-patient variation) contributing to between-hospital variation among hospitals with small sample sizes, we used the standard deviation among the largest fifty percent of hospitals in the sample (size measured by count of beds) to calculate Z scores. We computed patient experience composite scores in the same manner as the clinical process composite score.

Using MedPAR claims for hospital admissions among fee-for-service Medicare beneficiaries, we fit regression models to estimate risk-adjusted, all-cause rates of readmission within 30 days of discharge and risk-adjusted rates of mortality within 30 days of admission for each hospital in each year. Specifically, we fit a model for readmission or death as a function of hospital fixed effects and the following patient characteristics: age, gender, race, indicator for dual enrollment in Medicaid and Medicare, indicator for disability status, indicator for end stage renal disease, and indicators for 27 conditions included in CMS' Chronic Conditions Warehouse (CCW). The coefficients on the hospital fixed effects yielded hospital-level rates.

For each primary outcome measure and each transaction, we computed acquirer quality as the weighted average quality of acquiring hospitals (weights equal the count of hospital beds in the year prior to the transaction) exclusive of system member hospitals acquired during the study period.

D. Missing performance data

There are a number of reasons that a hospital may be missing data on a performance measure in a particular year. Hospitals may close or cease to serve Medicare beneficiaries. The sample size for some measures may be small and fall below the threshold set for reporting performance in Hospital Compare. At some point following acquisition, an acquired hospital may begin reporting performance data in a consolidated fashion with the acquiring hospital (i.e., under the acquiring hospital's or system's facility identification number), as described above in our exclusion criteria.

We identified hospitals that changed to consolidated reporting by first flagging hospitals whose Medicare CCN identifiers were present in one year but not the following year. These

hospitals were then investigated through web-based searches and look-ups in the online American Hospital Directory (<https://www.ahd.com/search.php>). Of particular concern for this study were instances when a merger or acquisition led to hospital closure. After excluding hospitals that served too few patients to report on study measures at baseline and hospitals that changed to consolidated reporting with another hospital at some point during our study period, we interpret residual missingness (described below) as due to closures or changes in patient populations or service lines that caused hospitals to fall below reporting thresholds for Hospital Compare.

We computed rates of missing performance data by year relative to transaction year (i.e. from -3 to +3) separately for acquired and control hospitals included in our study and calculated missing data rates weighted by hospital beds in the year prior to transaction to reflect the weighting implemented in our main analyses. Because our study period did not include 2006, all hospitals are missing all performance data for that year. This primarily impacts hospital observations for the 2009 transaction cohort (when 2006 corresponds to period -3). We adjusted our reported missing rates by excluding 2006 hospital-year observations from both the numerator and the denominator.

In **Table S1** we report missing rates by year relative to the transaction year for our clinical process composite for the 2009-2011 transaction cohorts and for our patient experience composite for all transaction cohorts (2009-2013). We separately report missing rates for the patient experience composite for the 2012 and 2013 transaction cohorts. Missing rates for these later transaction cohorts could differ from missing rates for earlier transaction cohorts because the inclusion criterion that study hospitals be present in claims data 2008-2012 does

not affect the post-transaction years for the later cohorts. Missing rates for claims measures were similar to patient experience measures and thus are not presented here.

In the first year that HCAHPS patient experience measures were reported (2007), many fewer hospitals submitted data (31% of study hospitals are missing 2007 patient experience measures). This affects missing rates in the pre-transaction period for the 2009 and 2010 cohorts; later transaction cohorts are unaffected. Sensitivity analyses excluding the 2009 and 2010 transaction cohorts generate similar results as our primary analyses based on all 5 transaction-year cohorts.

To compare missing rates between acquired and control hospitals in each year relative to the transaction year (Table S1), we separately assessed missingness for each transaction year (to allow the pre- and post-transaction periods to be defined for the control group), and then calculated average missing rates across transaction years. Missing rates were equal to zero by design in the year prior to the transaction year (because we included hospitals in the sample only if data were present from 2008-2012, covering all years immediately preceding transactions from 2009-2013). Missingness rates after the transaction year were generally low and increased minimally over the post-transaction years. Moreover, missingness over the post-transaction years did not differ meaningfully between acquired and control hospitals. And critically, we did not observe meaningful differences in missingness in post-transaction years between acquired and control hospitals when focusing on the 2012-2013 transactions. Our restriction to hospitals with data present from 2009-2012 eliminated missingness in at least some post-transaction years for transactions from 2009-2011, but not for the 2012-2013 transactions. Thus, the low and similar post-transaction missing rates for acquired and control

hospitals for the 2012-2013 transactions suggests that missingness (e.g., from closures) did not present a source of significant bias.

E. Model Specification

To assess the extent to which post-transaction changes in performance for acquired hospitals differed from concurrent changes for control hospitals in the same state, we estimated the following linear regression model for each hospital performance measure:

$$E(y_{ijt}) = \beta_0 + \beta_1 Acquired_Transyr_{it} + \beta_2 Acquired_Posttransyr_{it} + \beta_3 Patient_Characteristics_{it} + \beta_4 Hospital_i + \beta_5 Year_t \times State_j$$

where y_{ijt} is the value of the quality measure for hospital i in state j and year t . The vector of coefficients (β_2) on the term $Acquired_Posttransyr_{it}$ (a vector of indicators denoting the post-transaction year for acquired hospitals and equal to zero for control hospitals) are the quantities of interest—the differential changes in performance for acquired hospitals relative to control hospitals in each year after the transaction year. For a given post-transaction year, the differential change represents the difference between the observed performance for acquired hospitals and their expected performance if the pre-transaction difference had remained unchanged in the post-transaction period (i.e., the estimated effect of acquisition). The $Acquired_Transyr_{it}$ term removes the transaction year from the difference-in-difference estimation (treating it as a transition year) and does not affect our estimates of the differential change in performance in the post-transaction period. $Hospital_i$ is a vector of hospital fixed effects, $Year_t \times State_j$ a vector of fixed effects for each state-year combination, and $Patient_Characteristics_{it}$ a vector of the hospital-level case mix variables described above. We also included interactions between baseline hospital characteristics and year to control for differing trends between different types of hospitals; these interactions did not affect estimates appreciably.

F. Analyses of Pre-Transaction Period Trends

We conducted analyses to examine the plausibility of the key assumption of our difference-in-difference analysis—that the pre-transaction difference between control and acquired hospitals would have remained constant in the absence of the acquisitions. We estimated the following model for each performance measure:

$$E(y_{ijt}) = \beta_0 + \beta_1 Acquired_Transyr_{it} + \beta_2 Acquired_Posttransyr_{it} + \beta_3 Acq_i X Year_t + \beta_4 Patient_Characteristics_{it} + \beta_5 Hospital_i + \beta_6 Year_t \times State_j$$

where y_{ijt} is the value of the quality measure for hospital i in state j and calendar year t . The $Acquired_Transyr_{it}$ term removes the transaction year from the difference-in-difference estimation, treating it as a transition year. The vector of coefficients (β_2) on the term $Acquired_Posttransyr_{it}$ (a vector of indicators denoting the post-transaction year for acquired hospitals and equal to zero for control hospitals) contains estimates of the differential changes in performance for acquired hospitals relative to control hospitals in each year after the transaction year. The term $Acq_i X year_t$ denotes an interaction between an indicator of the hospital being in the acquired group and year (specified continuously). This term estimates the linear change over the pre-transaction period in the difference between acquired and control hospitals. Results are presented in **Table S4**.

G. Placebo Tests in the Pre-transaction Period

We conducted placebo tests to investigate whether there were differential changes in performance between acquired and control hospitals in the pre-transaction period. We

estimated regressions for 3 placebo tests measuring differential change in performance of acquired hospitals relative to control hospitals from pre-transaction period t-3 to t-2, from t-3 to t-1, and from (t-3 + t-2) to t-1. The results are reported **Table S5**. The estimated differential change for the clinical process composite from t-3 to t-1 (a hypothetical 2-year effect) is significantly different from zero and nearly equal in magnitude to the estimated differential change in performance post-acquisition.

H. Difference in Differences Estimates for Different Post-Transaction Periods

Difference-in-differences estimates for each of the individual post-transaction periods (seem model specification in section G of this appendix) are presented in **Table S6**.

I. Difference in Differences Estimates for Individual Composite Component Measures

Using our primary specification (Appendix section G), we estimated differential changes in the post-transaction performance of acquired hospitals on each of the individual measures included in the patient experience and clinical process composites (**Table S7**).

J. Sensitivity Tests

To assess potential bias from changes in the characteristics of patients admitted to acquired hospitals, we substituted unadjusted mortality and readmission measures for adjusted versions of these dependent variables and estimated a regression that excluded patient characteristics as control variables. **Table S8** compares estimates from our main analyses to

estimates from models with unadjusted performance measures (mortality and readmissions) and not controlling for characteristics of patients admitted (all performance measures).

Table S9 presents the results of a sensitivity analysis of our results to weighting observations by hospital bed count.

J. Adjustment for testing of multiple outcomes

In our main analyses we have four primary performance measures: patient experience composite, clinical process composite, 30-day mortality, and 30-day readmission. We adjusted for multiple testing in analyses of our 4 primary outcomes using the Hochberg procedure.ⁱ

Table S10 presents our main results with and without adjustment for multiple comparisons.

K. Acquired hospital subgroup analyses

We performed two subgroup analyses, to evaluate whether acquisition effects were different for hospitals acquired by a hospital (or system) in the same state (61% of acquisitions), or for hospitals acquired by a hospital (or system) of higher or lower quality (i.e., scoring in the top or bottom quartile for a given measure in the year prior to the acquisition). For transactions in which the acquirer was a health system, we computed acquirer quality as the weighted average performance of hospitals in the system (weight=hospital bed count).

Stratified estimates by acquirer quality quartile are reported in **Table S11**. Difference-in-difference estimates for acquired hospitals with in-state acquirers are reported in **Table S12**.

L. Analysis of local spillovers and effects on in-state acquirers

To assess the potential for local competitive spillovers, we estimated differential changes in the quality of hospitals located within 5 miles of an acquired hospital (i.e. local hospitals) and among in-state acquirers. Estimates of differential changes in quality among in-state acquirers and local hospitals are reported in **Table S13** and **Table S14** respectively.

We find no clear and consistent evidence of acquisition effects on in-state acquirers. Results did show a modest differential decline in in-state acquirers' performance on the process measure composite. We cannot conclusively interpret this as an effect of acquisition, however, for two reasons. First, the secondary and subgroup analyses were exploratory and included many comparisons. Any adjustment for multiple comparisons would render this result not statistically significant (the unadjusted P value was 0.04). Second, in-state acquirers had substantially higher pre-transaction performance (+0.27 SDs) on process measures than control hospitals. As shown in Table S3, average performance on process measures was very high, suggesting hospitals with higher scores may have been approaching a ceiling effect. Thus, the differential post-acquisition decline among in-state acquirers (a differential improvement among controls) may have been due to secular increases in performance on these measures (e.g., due to performance-based reimbursement or more complete documentation or reporting) that disproportionately affected control hospitals because their lower scores were less subject to ceiling effects. As we note in our discussion, the converse of this scenario could explain our finding of a differential improvement in process measure performance among acquired hospitals, which had lower baseline performance on these measures than controls (Table 3).

Table S1. Rates of Missing Data for Composite Measures ⁱ

Period	Clinical Process Composite 2009-2011 Transactions ⁱ		
	Acquired	Control	Difference
-3	0.00%	0.18%	-0.18%
-2	0.00%	0.11%	-0.11%
-1	0.00%	0.00%	0.00%
0	0.00%	0.06%	-0.06%
1	0.50%	0.23%	0.27%
2	0.50%	0.51%	-0.01%
3	3.33%	0.92%	2.41%

Period	Patient Experience Composite 2009-2013 Transactions ⁱ		
	Acquired	Control	Difference
-3	3.98%	6.15%	-2.17%
-2	4.82%	4.90%	-0.08%
-1	0.00%	0.00%	0.00%
0	0.29%	0.21%	0.08%
1	0.41%	0.43%	-0.02%
2	0.85%	0.73%	0.12%
3	1.04%	1.10%	-0.05%

Period	Patient Experience Composite 2012-2013 Transaction Cohorts		
	Acquired	Control	Difference
-3	0.00%	0.13%	-0.13%
-2	0.00%	0.06%	-0.06%
-1	0.00%	0.00%	0.00%
0	0.00%	0.40%	-0.40%
1	0.80%	0.80%	0.00%
2	0.39%	1.13%	-0.74%
3	0.09%	1.46%	-1.37%

Table S2. Clinical Process Measures

Study label for clinical process measures	HCAHPS Measure Identifier	Abbreviated Measure Name for Appendix Tables	2008 Average ⁱ
Percentage of heart attack patients with given aspirin at discharge	AMI_2	Heart Attack	95.9
Percentage of heart failure patients given an evaluation of left ventricular systolic (LVS) function	HF_2	Heart Failure 1	96.1
Percentage of heart failure patients given ACE Inhibitor or ARB for left ventricular systolic dysfunction (LVSD)	HF_3	Heart Failure 2	91.9
Percentage of pneumonia patients given the appropriate initial antibiotic(s)	PN_6	Pneumonia	88.7
Percentage of surgery patients who received preventative antibiotic(s) one hour before incision	SCIP_INF_1	Surgery 1	90.4
Percentage of surgery patients whose preventative antibiotic(s) are stopped within 24 hours after surgery	SCIP_INF_3	Surgery 2	95.1
Percentage of surgery patients who received the appropriate preventative antibiotic(s) for their surgery	SCIP_INF_2	Surgery 3	87.0

ⁱ Weighted by hospital bed count

Table S3. Patient Experience Measures

Study Performance Measure	Abbreviated Measure Name for Appendix Tables	HCAHPS Measure Identifier and Technical Measure Title	Measure as Posted on Hospital Compare	2008 Average ⁱ
Would definitely recommend the hospital, %	Recommended	H-HSP-RATING-9-10 Overall rating of hospital (global measure)	Patients who gave their hospital a rating of 9 or 10 on a scale from 0 (lowest) to 10 (highest)	67.1
Rated hospital 9 or 10,	Overall Rating	H-RECMND-DY Willingness to recommend the hospital (global measure)	Patients who reported YES, they would definitely recommend the hospital	62.3
Reported nurse always communicated well, %	Nurse Communication	H-COMP-3-A-P Responsiveness of hospital staff (composite measure)	Patients who reported that they "Always" received help as soon as they wanted	71.4
Reported doctor always communicated well, %	Doctor Communication	H-COMP-2-A-P Communication with doctors (composite measure)	Patients who reported that their doctors "Always" communicated well	77.4
Reported receiving help when needed, %	Getting Help		Patients who reported that their nurses "Always" communicated well	57.6

ⁱ Weighted by hospital bed count

Table S4. Estimates of Pre-transaction trends

Performance Measure	Adjusted difference between acquired and control hospitals in pre- transaction trends
Patient Experience Composite, SD (N=24,435)	0.00 (-0.04, 0.04)
Clinical Process Composite, SD (N=18,734)	0.13 (0.00, 0.26)
Mortality within 30 days of admission, percentage points (N=25,999)	0.00 (-0.07, 0.07)
30-day readmissions, percentage points (N=25,999)	-0.14 (-0.24, -0.04)

Table S5. Placebo Tests in the Pre-transaction Period

Performance Measure	Differential change for acquired vs. control hospitals during pre-transaction period		
	From t-3 to t-2 (hypothetical 1-year effect)	From the t-3 and t-2 period to t-1 (hypothetical 1-year effect)	From t-3 to t-1 (hypothetical 2-year effect)
Patient Experience Composite, SD (N=24,435)	0.09 (0.04, 0.15)	-0.04 (-0.11, 0.04)	0.01 (-0.08, 0.10)
Clinical Process Composite, SD (N=18,734)	0.10 (-0.13, 0.33)	0.18 (0.02, 0.34)	0.24 (-0.03, 0.51)
Mortality within 30 days of admission, percentage points (N=25,999)	-0.02 (-0.13, 0.09)	0.01 (-0.10, 0.11)	-0.002 (-0.13, 0.13)
30-day readmissions, percentage points (N=25,999)	-0.27 (-0.45, -0.10)	-0.13 (-0.27, 0.01)	-0.28 (-0.48, -0.07)

Table S6. Difference in Differences Estimates for Each Post-Transaction Year

Performance Measure	Differential change for acquired vs. control hospitals from pre-transaction period to:			
	1 st post-transaction period	2 nd post-transaction period	3 rd post-transaction period	4 th post-transaction period
Patient Experience Composite, SD (N=24,435)	-0.15 (-0.24, -0.06)	-0.17 (-0.25, -0.08)	-0.17 (-0.26, -0.07)	-0.24 (-0.32, -0.16)
Clinical Process Composite, SD (N=18,734)	0.22 (0.08, 0.36)	0.23 (0.05, 0.38)	0.22 (0.05, 0.38)	0.21 (0.06, 0.36)
Mortality within 30 days of admission, percentage points (N=25,999)	-0.05 (-0.20, 0.10)	-0.06 (-0.25, 0.13)	-0.03 (-0.20, 0.14)	-0.14 (-0.37, 0.09)
30-day readmissions, percentage points (N=25,999)	0.10 (-0.14, 0.34)	0.04 (-0.31, 0.39)	-0.10 (-0.53, 0.34)	-0.02 (-0.47, 0.44)

Table S7. Difference in differences Estimates for Composite Component Measures

Performance Measure ⁱ	Pre-transaction difference between acquired and control hospitals (95% CI)	Differential change from pre-transaction period to third post-transaction year (95% CI)
Patient Experience Composite		
Doctor communication N=24,436	-0.02 (-0.18, 0.14)	-0.09 (-0.22, 0.04)
Nurse communication N=24,436	-0.07 (-0.19, 0.06)	-0.18 (-0.27, -0.08)
Getting Help N=24,435	-0.12 (-0.29, 0.06)	-0.16 (-0.26, -0.06)
Overall Rating N=24,436	-0.19 (-0.30, -0.07)	-0.21 (-0.30, -0.11)
Recommended N=24,436	-0.23 (-0.35, -0.11)	-0.19 (-0.29, -0.08)
Clinical Process Composite		
Heart Attack N=15,278	-0.27 (-0.47, -0.08)	0.25 (0.03, 0.48)
Heart Failure 1 (hf2) N=18,490	-0.28 (-0.61, 0.06)	0.35 (0.06, 0.63)
Heart Failure 2 N=16,928	-0.23 (-0.46, -0.002)	0.23 (-0.005, 0.47)
Pneumonia N=18,474	-0.13 (-0.33, 0.06)	0.29 (0.09, 0.49)
Surgery 1 N=17,834	-0.19 (-0.50, 0.11)	0.16 (-0.12, 0.45)
Surgery 2 N=17,81	-0.10 (-0.27, 0.08)	0.02 (-0.17, 0.20)
Surgery 3 N=17,789	-0.10 (-0.22, 0.02)	-0.01 (-0.21, 0.19)

ⁱThe units for all performance measures in this table are standard deviations.

Table S8. Sensitivity of Main Results to Inclusion of Controls for Patient Characteristics

Performance Measure	Differential change from pre-transaction period to third post-transaction year	
	Without adjustment for patient Characteristics	With adjustment for Patient Characteristics
Patient Experience Composite, SD (N=24,435)	-0.16 (-0.26, -0.07)	-0.17 (-0.26, -0.07)
Clinical Process Composite, SD (N=18,734)	0.23 (0.07, 0.39)	0.22 (0.05, 0.38)
Mortality within 30 days of admission, percentage points (N=25,999)	-0.05 (-0.23, 0.12)	-0.03 (-0.20, 0.14)
30-day readmissions, percentage points (N=25,999)	-0.08 (-0.56, 0.39)	-0.10 (-0.53, 0.34)

Table S9. Sensitivity of Main Results to Weighting by Hospital Beds

Performance Measure	Differential change from pre-transaction period to third post-transaction year	
	Unweighted	Weighted by hospital bed count [†]
Patient Experience Composite, SD (N=24,435)	-0.21 (-0.30, -0.13)	-0.17 (-0.26, -0.07)
Clinical Process Composite, SD (N=18,734)	0.33 (0.10, 0.57)	0.22 (0.05, 0.38)
Mortality within 30 days of admission, percentage points (N=25,999)	-0.08 (-0.27, 0.10)	-0.03 (-0.20, 0.14)
30-day readmissions, percentage points (N=25,999)	-0.05 (-0.37, 0.27)	-0.10 (-0.53, 0.34)

[†] For acquired hospitals, hospital bed count was measured in the year prior to the transaction. For control hospitals, hospital bed count was measured in 2011 (i.e. the middle of our study period)

Table S10. Adjustment for Testing of Multiple Outcomes

Measure	Difference-in-Differences Coefficient	Original P-value	Adjusted P-value
Mortality within 30 days of admission, percentage points	-0.03	0.72	0.72
30-day readmissions, percentage points	-0.10	0.66	0.72
Clinical Process Composite, SD	0.22	0.01	0.03
Patient Experience Composite, SD	-0.17	0.0007	0.0028

Table S11. Stratification of Estimates by Acquirer Quality Quartile

Performance Measure	Differential change from pre-transaction period to post-transaction period	
	Hospitals with Higher Quality Acquirers	Hospitals with Lower Quality Acquirers
Patient Experience Composite, SD	-0.03 (-0.19, 0.13)	-0.26 (-0.47, -0.05)
Clinical Process Composite, SD	0.14 (0.03, 0.26)	0.05 (-0.20, 0.29)
Mortality within 30 days of admission, percentage points	-0.05 (-0.39, 0.29)	-0.14 (-0.44, 0.15)
30-day readmissions, percentage points	0.23 (-0.30, 0.76)	0.27 (-0.17, 0.71)

Table S12. Difference in Differences Estimates of Acquisition Effects on Hospitals Acquired by In-State Acquirers

Performance Measure	Adjusted difference between acquired and control hospitals in pre-transaction trends	Differential change from pre-transaction period to third post-transaction year
Patient Experience Composite, SD (N=19,885)	0.00 (-0.05, 0.05)	-0.14 (-0.28, -0.01)
Clinical Process Composite, SD (N=16,471)	0.12 (-0.05, 0.28)	0.18 (0.01, 0.36)
Mortality within 30 days of admission, percentage points (N=21,160)	-0.01 (-0.09, 0.08)	0.12 (-0.13, 0.37)
30-day readmissions, percentage points (N=21,160)	-0.22 (-0.34, - 0.09)	-0.09 (-0.73, 0.55)

Table S13. Difference in Differences Estimates of Acquisition Effects on In-State Acquirers

Performance Measure	Adjusted difference between in-state acquirers and control hospitals in pre-transaction trends	Differential change from pre-transaction period to third post-transaction year
Patient Experience Composite, SD (N=24,435)	-0.01 (-0.05, 0.02)	0.06 (-0.10, 0.22)
Clinical Process Composite, SD (N=18,734)	0.04 (-0.03, 0.11)	-0.15 (-0.24, -0.06)
Mortality within 30 days of admission, percentage points (N=25,999)	0.02 (-0.04, 0.08)	0.04 (-0.09, 0.17)
30-day readmissions, percentage points (N=25,999)	0.00 (-0.09, 0.09)	0.08 (-0.15, 0.31)

Table S14. Difference in Differences Estimates of Effects of Acquisitions on Hospitals within 5 Miles of Acquired Hospital

Performance Measure	Adjusted difference between acquired and control hospitals in pre-transaction trends	Differential change from pre-transaction period to post-transaction period
Patient Experience Composite, SD (N=19,761)	0.06 (0.01, 0.11)	0.05 (-0.06, 0.15)
Clinical Process Composite, SD (N=16,515)	-0.09 (-0.17, -0.01)	-0.05 (-0.22, 0.13)
Mortality within 30 days of admission, percentage points (N=21,085)	0.02 (-0.05, 0.09)	0.14 (-0.06, 0.33)
30-day readmissions, percentage points (N=21,085)	0.04 (-0.10, 0.19)	-0.09 (-0.52, 0.34)

References

ⁱ Sankoh, AJ, Huque MF, Dubey SD. Some comments on frequently used multiple endpoint adjustment methods in clinical trials. *Statistics in medicine* 1997:2529-2542