Original Investigation
December 26, 2023

Changes in Hospital Adverse Events and Patient Outcomes Associated With Private Equity Acquisition

Sneha Kannan, MD[1,2,3]; Joseph Dov Bruch, PhD[4]; Zirui Song, MD, PhD[3,5,6]

Author Affiliations Article Information

JAMA. 2023;330(24):2365-2375. doi:10.1001/jama.2023.23147

Related Articles

Interviews

Key Points

Question How do quality of care and patient outcomes change after private equity acquisition of hospitals?

Findings In a difference-in-differences examination of 662 095 hospitalizations at 51 private equity–acquired hospitals and 4 160 720 hospitalizations at 259 matched control hospitals using 100% Medicare Part A claims data, private equity acquisition was associated with a 25.4% increase in hospital-acquired conditions, which was driven by falls and central line–associated bloodstream infections. Medicare beneficiaries at private equity hospitals were modestly younger, less likely to have dual eligibility for Medicare and Medicaid, and transferred more to other acute care hospitals relative to control, likely reflecting a lower-risk population of admitted beneficiaries. This potentially explained a small relative reduction for in-hospital mortality that dissipated by 30 days after hospital discharge.

Meaning Private equity acquisition of hospitals, on average, was associated with increased hospital-acquired adverse events despite a likely lower-risk pool of admitted Medicare beneficiaries, suggesting poorer quality of inpatient care.

Abstract

Importance The effects of private equity acquisitions of US hospitals on the clinical quality of inpatient care and patient outcomes remain largely unknown.

Objective To examine changes in hospital-acquired adverse events and hospitalization outcomes associated with private equity acquisitions of US hospitals.

Design, Setting, and Participants Data from 100% Medicare Part A claims for 662 095 hospitalizations at 51 private equity–acquired hospitals were compared with data for 4 160 720 hospitalizations at 259 matched control hospitals (not acquired by private equity) for hospital stays between 2009 and 2019. An event study, difference-in-differences design was used to assess hospitalizations from 3 years before to 3 years after private equity acquisition using a linear model that was adjusted for patient and hospital attributes.

Main Outcomes and Measures Hospital-acquired adverse events (synonymous with hospital-acquired conditions; the individual conditions were defined by the US Centers for Medicare & Medicaid Services as falls, infections, and other adverse events), patient mix, and hospitalization outcomes (including mortality, discharge disposition, length of stay, and readmissions).

Results Hospital-acquired adverse events (or conditions) were observed within 10 091 hospitalizations. After private equity acquisition, Medicare beneficiaries admitted to private equity hospitals experienced a 25.4% increase in hospital-acquired conditions compared with those treated at control hospitals (4.6 [95% CI, 2.0-7.2] additional hospital-acquired conditions per 10 000 hospitalizations, $P = .004$). This increase in hospital-acquired conditions was driven by a 27.3% increase in falls ($P = .02$) and a 37.7% increase in central line–associated bloodstream infections ($P = .04$) at private equity hospitals, despite placing 16.2% fewer central lines. Surgical site infections doubled from 10.8 to 21.6 per 10 000 hospitalizations at private equity hospitals despite an 8.1% reduction in surgical volume; meanwhile, such infections decreased at control hospitals, though statistical precision of the between-group comparison was limited by the smaller sample size of surgical hospitalizations. Compared with Medicare beneficiaries treated at control hospitals, those treated at private equity hospitals were modestly younger, less likely to be dually eligible for Medicare and Medicaid, and more often transferred to other acute care hospitals after shorter lengths of stay. In-hospital mortality (n = 162 652 in the population or 3.4% on average) decreased slightly at private equity hospitals compared with the control hospitals; there was no differential change in mortality by 30 days after hospital discharge.

Conclusions and Relevance Private equity acquisition was associated with increased hospital-acquired adverse events, including falls and central line–associated bloodstream infections, along with a larger but less statistically precise increase in surgical site infections. Shifts in patient mix toward younger and fewer dually eligible beneficiaries admitted and increased transfers to other hospitals may explain the small decrease in in-hospital mortality at private equity hospitals relative to the control

hospitals, which was no longer evident 30 days after discharge. These findings heighten concerns about the implications of private equity on health care delivery.

Introduction

Private equity firms have increasingly acquired hospitals and physician practices.[1-10] This has garnered scrutiny from policymakers and the public, including the Biden administration and several US Senate and House committees.[11-14] Central to the concern over such acquisitions are the implications for patients—notably the quality of care—given the incentives of private equity to generate financial returns on investment quickly.[6,14] Despite this concern, rigorous evidence on the clinical consequences of private equity acquisition remains scant.[15]

Private equity firms have acquired more than 200 acute care hospitals from nonprivate equity owners. Within private, nongovernment hospitals, private equity has an often distinct business model, in which the acquired entity typically assumes debt in the initial acquisition and is sold within a short time frame (often within 3-7 years).[6] Early evidence[7-10] showed that private equity acquisition was associated with increased charges, reduced staffing, use of profitable service lines, a decreased proportion of patients with Medicare, and increased net income.

However, analogous evidence on quality of care exists only for a few hospital-level process measures, with equivocal results.[8,15] One study of Medicare beneficiaries with cardiovascular and pulmonary disease also found mixed results,[9] including lower mortality among those with acute myocardial infarction treated at private equity hospitals, which could be due to selection of healthier or lower-risk patients.

To date, there are no analyses of adverse events within the hospitalization, which may provide a better assessment of quality attributable to private equity. Important within-hospitalization outcomes include falls, infections, blood clots, and other hospital-acquired conditions. These are more common than mortality and can emerge without changes in mortality or readmissions. They may also provide a more complete picture of quality of care or patient experience.

We examined the association between private equity acquisitions of US hospitals and hospital-acquired conditions using 100% Medicare Part A claims data. By definition, hospital-acquired conditions are not present at admission, but are acquired during the hospitalization. Hospital-acquired conditions are established measures of inpatient quality, are considered preventable based on guidelines from the US Centers for Medicare & Medicaid Services[16] (CMS), are clinically important for patients, and have been financially relevant for both hospitals and the CMS since 2009.

Notably, the diagnoses underlying hospital-acquired conditions are not used in the assignment of a diagnosis related group and cannot be used to increase diagnosis related group severity (payment); worse performance on these conditions results in Medicare payment reductions.[17] To interpret hospital-acquired conditions in the context of broader hospitalization outcomes, we also assessed the association between private equity acquisition and mortality, length of stay, and discharge disposition.

Methods

Definition of Exposure

The exposure for this analysis was the acquisition of a US nonprivate equity hospital by a private equity firm, which was determined using documents from the US Securities and Exchange Commission, press releases, and mergers and acquisitions data.[8] To be included in this analysis, a minimum of 1 year of Medicare claims data prior to the acquisition and 2 years of data after the acquisition were required, with hospitals contributing up to 3 years of data before and 3 years of data after acquisition. Thus, eligible acquisitions occurred between 2010 (1 year after Medicare implemented financial incentives for the hospital-acquired conditions) and 2017, which allowed for 2 years of data after the acquisition before the COVID-19 pandemic. These eligibility criteria resulted in 51 private equity–acquired acute care hospitals within the study period.

The Hospital Corporation of America acquisition in 2006, which is not considered to be representative of most acquisitions (as demonstrated in prior work[8]), was excluded because it occurred before Medicare data availability. This research was approved by the institutional review board at Harvard Medical School.

We matched each private equity hospital to up to 8 control hospitals (the control hospitals had not been acquired by a private equity firm) using exact matching for year, ownership type, teaching status, and US Census region. Nearest neighbor matching was used for the hospital size (total number of beds). This generated 259 matched control hospitals for the 51 private equity hospitals. One control hospital from Maryland was excluded from the analysis because Maryland was exempt from the CMS' Hospital-Acquired Conditions Reduction Program.[18]

Medicare Data

Using 100% Medicare Part A fee-for-service claims from 2009 through 2019, we obtained all hospitalizations at the 51 private equity–acquired hospitals and the 259 control hospitals. We collected age, sex, race and ethnicity, months of dual eligibility for Medicare and Medicaid, and comorbidities. The race and ethnicity field in Medicare claims is populated from Social Security Administration data;

the categories are mutually exclusive. Race and ethnicity are associated with health care outcomes and were thus included in our analysis. Dual eligibility was defined as being eligible for both Medicare and Medicaid for at least 1 month within a given year. We calculated the van Walraven-Elixhauser comorbidity score, which is a validated predictor of in-hospital mortality (eTable 1 in Supplement 1).[19-21]

The comorbidities were determined using diagnosis codes from the *International Classification of Diseases, Ninth Revision (ICD-9)* and the *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10)* for conditions and diseases that were present at hospital admission.[9,22] We also gathered the admission diagnosis related group, discharge status, length of stay, and any 7-day or 30-day readmissions. Each diagnosis related group was categorized into its Medicare major diagnostic category.[23] Discharge status included discharge home, discharge to a skilled nursing facility or an acute rehabilitation facility, transfer to an acute care hospital, or death (eTable 2 in Supplement 1).

Hospital-Acquired Conditions

The hospital-acquired conditions (delineated by Medicare in 2009) were (1) foreign object retained after a surgery, (2) air embolism, (3) blood incompatibility, (4) stage 3 or 4 pressure ulcers, (5) falls and trauma, (6) catheter-associated urinary tract infections, (7) central line–associated infection, (8) surgical site infections from coronary artery bypass graft surgeries, (9) surgical site infections from bariatric surgeries, (10) surgical site infections from certain orthopedic procedures, (11) manifestations of poor glycemic control (diabetic ketoacidosis and hypoglycemic coma), and (12) deep vein thrombosis (DVT) or pulmonary embolism (PE) after total knee and hip replacement procedures[24] (additional details appear eTable 3 in Supplement 1). In addition, a composite hospital-acquired condition measure was calculated that included an unweighted sum of all hospital-acquired conditions within each hospitalization. A patient was eligible for multiple hospital-acquired conditions within a single hospitalization.

The number of hospital-acquired conditions was calculated per 10 000 eligible hospitalizations. For nonsurgical conditions, all hospitalizations were considered eligible, which is similar to prior reporting.[23] Because Medicare claims data may not accurately identify all indwelling urinary catheters (for the catheter-associated urinary tract infections measure) and central venous catheters (for the central line–associated infection measure), prior work[24] also considered all hospitalizations to be eligible for the evaluation of catheter-associated urinary tract infections and central line–associated infections.

For surgical measures (surgical site infections, DVT, and PE), eligible hospitalizations include those in which the qualifying surgery or procedure was performed; the use of this criterion is in line with CMS reporting.[24-26] Surgical site infections for coronary artery bypass graft surgeries, bariatric surgeries, and certain orthopedic procedures were combined into a composite measure.[24-26] Because air embolism and blood incompatibility are generally very rare events, these measures were not separately examined, but they were included in the composite hospital-acquired conditions measure (eTable 3 in Supplement 1). Two hospital-acquired conditions introduced in 2014 were excluded because many of the private equity acquisitions preceded this date.

The hospital-acquired conditions were defined using *ICD-9* and *ICD-10* codes for any conditions that were not present at hospital admission, which is consistent with guidelines from the CMS.[23,27-29] Every hospital in the sample had less than 0.01% of inpatient claims with missing diagnoses for conditions present at hospital admission.

For those measures with underlying procedures (catheter-associated urinary tract infections, central line–associated infections, DVT or PE, and surgical site infections), the procedural volume for the hospital was calculated using *ICD-9* and *ICD-10* procedure codes. The procedure codes for the relevant surgeries for DVT or PE and surgical site infections were provided by the CMS. The *ICD-9* and *ICD-10* diagnosis codes for indwelling urinary catheters and percutaneous central lines are publicly available.[30]

Patient Outcomes

Key hospitalization–level outcomes were evaluated to explore the potential link between hospital-acquired conditions and patient outcomes, including discharge status (mortality, transfers, and discharge to home or postacute care), length of stay, and readmission rates. Given these outcomes vary at baseline by indication for admission,[31-33] they were stratified by indication using diagnosis related groups (eg, sepsis is associated with particularly high mortality).

The 4 most common indications for admission were identified (sepsis, heart failure with shock, total hip arthroplasty, and chronic obstructive pulmonary disease or pneumonia) and accounted for more than 20% of all Medicare hospitalizations (eTable 4 in Supplement 1). The remaining hospitalizations comprised an “other” category. In addition to in-hospital mortality, 7-day and 30-day mortality were measured because they are often considered more informative.[34] These were calculated using validated dates of death from the Medicare beneficiary summary file.

Statistical Analysis

We used a difference-in-differences design within an event study framework to assess changes in outcomes attributable to private equity acquisition. The time of acquisition was event year 0 and the outcomes spanned up to 3 years before and 3 years after acquisition. The earliest year prior to acquisition was 2009, which is the year the CMS implemented the use of hospital-acquired conditions. The latest year after acquisition was 2019 (2020 was excluded given COVID-19 pandemic–related disruptions). Of the 51 private equity hospitals included in this analysis, 34 (67%) contributed data for at least 2 years before and 2 years after the acquisition and 17 (33%) contributed data for 3 years before and 3 years after the acquisition.

An ordinary least-squares model was used to compare changes in hospital-acquired conditions and patient outcomes in private equity hospitals relative to those in control hospitals using the following equation:

$$\text{Outcome}_{nijk} = \alpha + \tau(\text{exposure})_{nijk} + \Sigma^{3}_{y=1}\,\delta_y(\text{year after acquisition})_{nijk} + \Sigma^{3}_{y=1}\,\beta_y(\text{year after acquisition} \times \text{exposure})_{nijk} + \Sigma^{2019}_{y=2010}\,\gamma_y(\text{year}) + \eta(\text{age})_{nijk} + \Theta(\text{sex})_{nijk} + \kappa(\text{race and ethnicity})_{nijk} + \upsilon(\text{van Walraven-Elixhauser comorbidity score})_{nijk} + \Sigma^{25}_{y=0}\,\mu_y(\text{major diagnostic category})_{nijk} + \nu(\text{hospital})_i + \varepsilon_{nijk}$$

The outcomes of interest were regressed for hospitalization *n* in hospital *i*, matched group *j*, and year *k* over indicators for the event year, the exposure, and the event year × exposure interaction. Event year was discrete in the model; therefore, baseline was an average for the 3 years before the private equity acquisition and the treatment effect was an average for the 3 years after the acquisition. We adjusted for beneficiary age, sex, race and ethnicity, dual-eligibility status, and van Walraven-Elixhauser comorbidity score.

Fixed effects were included for year of hospitalization and major diagnostic category of hospital admission to assess the within-year and within-category differential changes associated with private equity acquisition for hospitals. The major diagnostic category was used to account for case mix rather than diagnosis related group because complications arising from hospital-acquired conditions can change the diagnosis related group even if the hospital-acquired conditions themselves cannot, making diagnosis related group endogenous.[26,35] In addition, hospital fixed effects were included to help adjust for the time-invariant attributes of the hospital (including its catchment area). The year of the private equity acquisition was excluded from the analysis as a washout period. We tested the assumption of parallel preacquisition trends for all outcomes.[8]

In the sensitivity analyses, we tested the robustness of the findings to the exclusion of patient covariates and admission factors. Consistent with prior research at the hospital level, we also included a model with random intercepts by hospital-matched group and hospital.[8] In addition, a difference-in-differences model with multiple time periods was implemented.[36,37] Because this approach is sensitive to outliers and multilevel covariates, we adjusted for patient factors only and compared its estimates with the baseline model.

Both 95% CIs and Bonferroni-adjusted *P* values are reported. All analyses were performed using Stata version 16 (StataCorp). *P* values were significant at $P < .05$.

Results

The final sample included 662 095 hospitalizations at 51 private equity–acquired hospitals and 4 160 720 hospitalizations at 259 matched control hospitals for hospital stays occurring between 2009 and 2019. The majority were medium-sized hospitals (88%) with between 150 and 350 beds. The hospitals were located across the Midwest, Northeast, South, and West regions of the US. The Medicare beneficiaries had a mean age of 73 years (SD of 14.2 years for private equity hospitals and SD of 13.5 years for control hospitals) and 55% were female (Table 1). Hospital-acquired adverse events were observed within 10 091 hospitalizations.

Patient Case Mix

After private equity acquisition, the Medicare beneficiaries admitted at the hospitals were younger by 0.1 years (95% CI, −0.2 to −0.1 years) compared with those admitted to the control hospitals. This reduction in mean age was found only among Medicare beneficiaries aged 65 years or older. However, patients coded with sepsis diagnosis related groups exhibited a larger differential decrease in age by 0.5 years (95% CI, −0.7 to −0.2 years). In addition, the share of patients who were dually eligible for Medicare and Medicaid admitted to private equity hospitals declined by 1.2% compared with those admitted to control hospitals. Private equity hospitals demonstrated essentially no differential changes in beneficiary race, ethnicity, or van Walraven-Elixhauser score in aggregate. However, patients coded with sepsis diagnosis related groups exhibited a 2.8% increase in the van Walraven-Elixhauser comorbidity score even though they were differentially younger (Figure 1 and eTable 5 in Supplement 1).

Hospital-Acquired Conditions

The unadjusted number of hospital-acquired conditions per 10 000 hospitalizations increased among patients treated at private equity hospitals compared with those treated at the control hospitals; the

baseline levels for these conditions were consistent with published rates[24,25] (Figure 2). The distribution of the composite measure of hospital-acquired conditions varied across hospitals (Figure 2 and eFigure 1 in Supplement 1).

In an adjusted analysis, private equity hospitals demonstrated an increase of 4.6 (95% CI, 2.0-7.2) in hospital-acquired conditions per 10 000 hospitalizations compared with the control hospitals ($P = .004$), which is a 25.4% increase from the mean preacquisition level among private equity hospitals. This increase was driven by an additional 1.9 (95% CI, 0.3-3.4) falls per 10 000 hospitalizations at private equity hospitals compared with the control hospitals ($P = .02$), which is a 27.3% increase from the mean preacquisition level, and an additional 1.5 (95% CI, 0.4-2.6) central line–associated infections per 10 000 hospitalizations ($P = .04$), which is a 37.7% increase from the mean preacquisition level (Table 2 and eFigure 2 in Supplement 1).

Of note, the increase in central line–associated infections occurred alongside a smaller number of Medicare beneficiaries receiving percutaneous central lines. Specifically, private equity hospitals placed 37.1 fewer central lines per 10 000 hospitalizations after acquisition compared with the control hospitals, which is a 16.2% reduction (eTable 6 in Supplement 1). In addition, private equity hospitals performed 13.1 fewer operations per 10 000 hospitalizations that qualified for the surgical site infection measure compared with the control hospitals (an 8.1% reduction led by orthopedic and bariatric operations).

However, unadjusted surgical site infections doubled from 10.8 to 21.6 per 10 000 hospitalizations at private equity hospitals and decreased from 17.5 to 12.6 per 10 000 hospitalizations at control hospitals. Adjusted for covariates, surgical site infections increased by 16.0 (95% CI, −2.3 to 34.2) per 10 000 hospitalizations at private equity hospitals compared with control hospitals (equivalent to a 147.8% increase), but this change did not achieve statistical significance (Table 2). The lower statistical precision was partly explained by the smaller sample size of hospitalizations within the surgical site infection measure. There were no observed significant differences between private equity hospitals and control hospitals for the preacquisition trends across the hospital-acquired conditions (eTable 7 in Supplement 1).

Hospitalization Outcomes

In-hospital mortality (n = 162 652 in the population or 3.4% on average) decreased slightly at private equity hospitals (3.5% preacquisition and 3.2% postacquisition) compared with the control hospitals (from 3.5% to 3.3%); there was no differential change in mortality by 30 days after hospital discharge. Adjusted for the observable covariates, the differential decrease in the in-hospital mortality rate was

0.2 percentage points (95% CI, −0.3 to −0.1 percentage points) or a 4.8% reduction relative to the rate of 3.5% at baseline. This differential change in mortality was attenuated and was less statistically significant at 7 days (−0.2 percentage points [95% CI, −0.3 to 0 percentage points]), and was further attenuated and not significant at 30 days (−0.1 percentage points [95% CI, −0.3 to 0 percentage points]) (eTable 8 and eFigure 3 in Supplement 1).

Of note, before acquisition, private equity hospitals trended lower for both 7- and 30-day mortality (0.3 and 0.4 percentage points lower, respectively) than control hospitals; thus, the narrowing of this gap toward 0 after acquisition suggests a relative increase in 7- and 30-day mortality among private equity hospitals compared with the baseline differences in trends (eTable 7 in Supplement 1). A decomposition of mortality results by admission diagnosis appears in eTable 9 in Supplement 1.

In conjunction, Medicare beneficiaries treated at private equity hospitals experienced a reduction in discharges home of 0.6 percentage points (95% CI, −0.8 to −0.4 percentage points) or 1.0% compared with those treated at control hospitals. The patients coded with sepsis diagnosis related groups at hospital admission notably experienced a reduction in discharges home of 1.6 percentage points (95% CI, −2.6 to −0.6 percentage points) or 4.1% (Figure 3 and eTable 10 in Supplement 1).

In contrast, transfers to other acute care hospitals increased 12.2% at private equity hospitals compared with control hospitals (an increase of 0.3 percentage points [95% CI, 0.2-0.4 percentage points]). This differential increase was also largest in patients with sepsis, who experienced a 36.2% increase in transfers from private equity hospitals compared with control hospitals (an increase of 0.9 percentage points [95% CI, 0.5-1.2 percentage points]). Moreover, discharges from private equity hospitals to skilled nursing facilities and acute rehabilitation facilities increased compared with control hospitals, although this trend had emerged preacquisition (Figure 3 and eTables 7 and 10 in Supplement 1).

No differential changes in 7- or 30-day readmission rates were observed. Length of stay among private equity hospitals shortened by 3.4% compared with control hospitals despite trending longer at private equity hospitals preacquisition (eTable 7 and eTable 11 in Supplement 1).

Sensitivity Analyses

In general, the findings were qualitatively similar with alterations to the base model, alternative specifications using random intercepts, and using the multiple time periods difference-in-differences approach[36,37] (eTables 12-15 in Supplement 1). An exception is that patients with sepsis exhibited a differential increase in in-hospital mortality of 0.61 percentage points (95% CI, 0.05-1.27 percentage points) with random intercepts for groups of matched hospitals in place of hospital fixed effects, which

is roughly a 5% increase that would be 15-fold larger and qualitatively distinct from the base estimate of 0.04 percentage points (eTable 14 in Supplement 1).

Discussion

In this quasi-experimental evaluation of hospital quality and outcomes using 100% Medicare Part A claims data, private equity acquisition was associated with a 25% increase in hospital-acquired adverse events through up to 3 years after acquisition, which was driven by a 27% increase in falls and a 38% increase in the volume of central line–associated infections (despite the placement of 16% fewer central lines). Further concerning was the doubling of surgical site infections in private equity hospitals after acquisition, whereas the number of surgical site infections declined in the control hospitals. Although the smaller sample size of surgical hospitalizations rendered this comparison less statistically precise,[24-26] it was particularly alarming because the number of surgical site infections increased even as private equity hospitals performed 8% fewer surgical procedures after acquisition.

Increased adverse events at private equity hospitals coincided with a small shift in patient mix toward younger Medicare beneficiaries, who were also less likely to be dually eligible for Medicare and Medicaid. To the extent these observable characteristics reflect private equity hospitals admitting modestly lower-risk patients (both clinically and socioeconomically), their simultaneous increase in coded disease burden (van Walraven-Elixhauser comorbidity score) compared with the control hospitals may reflect increased coding intensity at private equity hospitals.

Younger and lower-risk patients admitted to private equity hospitals could also help explain the small relative reduction in in-hospital mortality after acquisition. Although adjustment for patient characteristics did not change this mortality estimate, younger Medicare beneficiaries (fewer of whom were dually eligible for Medicare and Medicaid) may have had other unobserved health or social advantages that contributed to lower in-hospital mortality. An alternative explanation (given the increased transfers to other acute care hospitals, decreased discharges home, and shortened length of stay associated with private equity acquisition) is that discharges of relatively sicker patients could have lowered in-hospital mortality through a selection effect. In addition, the lack of improvement in 30-day mortality associated with private equity, especially given preacquisition trends that favored private equity hospitals, suggests that mortality effects are modest and at best mixed.

Our findings add new clinical insights to the literature on private equity and quality, which has focused on aggregate process quality measures.[7-10,15] The 38% increase in central line–associated infections associated with private equity acquisition occurred even as these hospitals placed 16% fewer percutaneous central lines. Such increases in hospital-acquired infections may result from decreased

staffing, changes in operator technique, poorer clinician experience, increased patient illness, or other explanations.[38-42] Even though documented comorbidities (van Walraven-Elixhauser comorbidity score) increased slightly for some patients treated at private equity hospitals relative to patients treated at control hospitals, true comorbidity is difficult to distinguish from coding intensity,[8] which is independently tied to financial incentives. Although private equity hospitals may have incurred increased infections from performing procedures in sicker patients, our findings revealing they treated younger Medicare beneficiaries (especially for sepsis) and fewer dually eligible patients (attributes less susceptible to coding intensity) suggest a healthier patient pool.

Furthermore, hospital-acquired adverse events have been shown to be sensitive to staffing ratios and composition, specifically among nurses.[43-47] Given that private equity firms have reduced staffing and changed the clinician labor mix at acquired hospitals and clinics,[10,48] an analogous cost-cutting strategy in our sample may help explain the increase in hospital-acquired conditions. These adverse events themselves can raise the risk of mortality, which highlights the clinical importance of this evidence.[42]

The increase in hospital-acquired conditions after private equity acquisition is particularly worrisome given the national decline in hospital-acquired conditions,[24,49] as demonstrated by the control group (Figure 2). Taken together, the increased hospital-acquired conditions associated with private equity acquisition spanned the key inpatient settings—from general wards (falls) to intensive care units (central line–associated bloodstream infections), with concern for operating rooms (surgical site infections) as well. Although hospital-acquired conditions are expected to increase the length of stay,[42,50] the mean length of stay modestly declined at private equity hospitals. This increased bed turnover would be directionally consistent with the increased transfers to other hospitals and revenue-enhancing behavior observed under a diagnosis related group payment system.

Limitations

This study has limitations. First, the sample of private equity–acquired hospitals may not generalize to all such hospital acquisitions. Although the implementation of hospital-acquired conditions in 2009 and our Medicare data availability postdated the Hospital Corporation of America acquisition in 2006, thus excluding those hospitals from this study, our sample likely better resembles the typical private equity hospital.[8]

Second, traditional Medicare beneficiaries may not generalize to people with Medicare Advantage, Medicaid, or commercial insurance or to other patients. Medicare Advantage enrollment accelerated during the study period, although evidence of differential growth within private equity hospitals and

nonprivate equity hospitals is lacking. Nevertheless, the growth in Medicare Advantage may shift the inpatient mix for traditional Medicare.

Third, use of *ICD-9* and *ICD-10* codes may not capture all hospital-acquired conditions[51]; however, we adhered to the methods of the CMS. Similarly, the procedure codes for indwelling urinary catheters and central venous catheters may not capture all such procedures. In addition, Medicare hospitalizations did not include observation stays and outpatient care.

Fourth, given private equity acquisitions are not random and private equity firms may acquire hospitals for unobserved reasons, our findings remain susceptible to unmeasured confounding and do not imply causation.

Conclusions

Private equity acquisition was associated with increased hospital-acquired adverse events, including falls and central line–associated bloodstream infections, along with a larger but less statistically precise increase in surgical site infections. Shifts in patient mix toward younger and fewer dually eligible beneficiaries admitted and increased transfers to other hospitals may explain the small decrease in in-hospital mortality at private equity hospitals relative to the control hospitals, which was no longer evident 30 days after discharge. These findings heighten concerns about the implications of private equity on health care delivery.

Article Information

Back to top

Accepted for Publication: October 22. 2023.

Corresponding Author: Zirui Song, MD, PhD, Department of Health Care Policy, Harvard Medical School, 180A Longwood Ave, Boston, MA 02115 (song@hcp.med.harvard.edu).

Author Contributions: Dr Kannan had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: Kannan, Song.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: Kannan.

Critical review of the manuscript for important intellectual content: All authors.

Statistical analysis: All authors.

Obtained funding: Kannan, Song.

Administrative, technical, or material support: Song.

Supervision: Song.

Conflict of Interest Disclosures: Dr Bruch reported receiving personal fees from the Robert Wood Johnson Foundation and grants from the Rx Foundation. Dr Song reported receiving personal fees from the Research Triangle Institute, Google Ventures, and VBID Health. No other disclosures were reported.

Funding/Support: This work was supported by grant T32HL15502-03 from the National Heart, Lung, and Blood Institute (awarded to Dr Kannan), grant 3P01AG032952-14S1 from the National Institute on Aging (awarded to Dr Song), and grant 20-04402 from Arnold Ventures (awarded to Dr Song).

Role of the Funder/Sponsor: The funders/sponsors had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Data Sharing Statement: See Supplement 2.

Additional Contributions: We thank Daria Pelech, PhD (Congressional Budget Office), for comments on this work without compensation and the audience members for comments and feedback at the 2023 AcademyHealth Annual Research Meeting and the Society of General Internal Medicine annual meeting.

References

1. Zhu JM, Polsky D. Private equity and physician medical practices—navigating a changing ecosystem. *N Engl J Med*. 2021;384(11):981-983. doi:10.1056/NEJMp2032115PubMed Google ScholarCrossref

2. Offodile AC II, Cerullo M, Bindal M, Rauh-Hain JA, Ho V. Private equity investments in health care: an overview of hospital and health system leveraged buyouts, 2003-17. *Health Aff (Millwood)*. 2021;40(5):719-726. doi:10.1377/hlthaff.2020.01535PubMedGoogle Scholar Crossref

3. Bruch J, Zeltzer D, Song Z. Characteristics of private equity–owned hospitals in 2018. *Ann Intern Med*. 2021;174(2):277-279. doi:10.7326/M20-1361PubMedGoogle ScholarCrossref

4. La Forgia A, Bond AM, Braun RT, et al. Association of physician management companies and private equity investment with commercial health care prices paid to anesthesia practitioners. *JAMA Intern Med*. 2022;182(4):396-404. doi:10.1001/jamainternmed.2022.0004 ArticlePubMedGoogle ScholarCrossref

5. Bain & Company. Global healthcare private equity and M&A report 2023: down but not out. Accessed March 31, 2023. https://www.bain.com/insights/topics/global-healthcare-private-equity-ma-report

6. Gondi S, Song Z. Potential implications of private equity investments in health care delivery. *JAMA*. 2019;321(11):1047-1048. doi:10.1001/jama.2019.1077 ArticlePubMedGoogle ScholarCrossref

7. Zhu JM, Hua LM, Polsky D. Private equity acquisitions of physician medical groups across specialties, 2013-2016. *JAMA*. 2020;323(7):663-665. doi:10.1001/jama.2019.21844 ArticlePubMedGoogle ScholarCrossref

8. Bruch JD, Gondi S, Song Z. Changes in hospital income, use, and quality associated with private equity acquisition. *JAMA Intern Med*. 2020;180(11):1428-1435. doi:10.1001/jamainternmed.2020.3552 ArticlePubMedGoogle ScholarCrossref

9. Cerullo M, Yang K, Joynt Maddox KE, McDevitt RC, Roberts JW, Offodile AC II. Association between hospital private equity acquisition and outcomes of acute medical conditions among Medicare beneficiaries. *JAMA Netw Open*. 2022;5(4):e229581. doi:10.1001/jamanetworkopen.2022.9581 ArticlePubMedGoogle ScholarCrossref

10. Cerullo M, Lin YL, Rauh-Hain JA, Ho V, Offodile AC II. Financial impacts and operational implications of private equity acquisition of US hospitals. *Health Aff (Millwood)*. 2022;41(4):523-530. doi:10.1377/hlthaff.2021.01284PubMedGoogle ScholarCrossref

11. Medicare Payment Advisory Commission. Report to the Congress: Medicare and the health care delivery system. Published June 2021. Accessed March 31, 2023. https://www.medpac.gov/document/june-2021-report-to-the-congress-medicare-and-the-health-care-delivery-system/

12. Tanne JH. US Congress investigates effects of $80bn private equity industry on government healthcare programme. *BMJ*. 2020;370:m3490. doi:10.1136/bmj.m3490PubMed Google ScholarCrossref

13. US Senate Committee on Banking, Housing, and Urban Affairs. Protecting companies and communities from private equity abuse. Published October 20, 2021. Accessed March 31, 2023. https://www.banking.senate.gov/hearings/protecting-companies-and-communities-from-private-equity-abuse

14. US Congress. Examining private equity's expanded role in the US health care system. Published March 25, 2021. Accessed March 31, 2023. https://www.congress.gov/event/117th-congress/house-event/111415

15. Borsa A, Bejarano G, Ellen M, Bruch JD. Evaluating trends in private equity ownership and impacts on health outcomes, costs, and quality: systematic review. *BMJ*. 2023;382:e075244. doi:10.1136/bmj-2023-075244PubMedGoogle ScholarCrossref

16. LaBresh KA, Lux L, Eng T. Evidence-based guidelines for selected and candidate hospital-acquired conditions: final report. Published January 8, 2010. Accessed March 31, 2023. https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/HospitalAcqCond/Downloads/evidenced_based_guidelines_report.pdf

17. US Centers for Medicare & Medicaid Services. Hospital-acquired conditions. Updated August 2022. Accessed March 31, 2022. https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/HospitalAcqCond/Hospital-Acquired_Conditions

18. US Centers for Medicare & Medicaid Services. Eligibility: hospital-acquired condition reduction program. Accessed March 31, 2023. https://qualitynet.cms.gov/inpatient/hac/participation

19. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care*. 1998;36(1):8-27. doi:10.1097/00005650-199801000-00004PubMedGoogle ScholarCrossref

20. van Walraven C, Austin PC, Jennings A, Quan H, Forster AJ. A modification of the Elixhauser comorbidity measures into a point system for hospital death using administrative data. *Med Care*. 2009;47(6):626-633. doi:10.1097/MLR.0b013e31819432e5PubMed Google ScholarCrossref

21. Thompson NR, Fan Y, Dalton JE, et al. A new Elixhauser-based comorbidity summary measure to predict in-hospital mortality. *Med Care*. 2015;53(4):374-379. doi:10.1097/MLR.0000000000000326PubMedGoogle ScholarCrossref

22. Stagg V. ELIXHAUSER: Stata module to calculate Elixhauser index of comorbidity. Accessed March 31, 2023. https://ideas.repec.org/c/boc/bocode/s458077.html

23. US Centers for Medicare & Medicaid Services. *ICD-10-CM*/PCS MS-DRG v37.0 definitions manual. Accessed March 31, 2023. https://www.cms.gov/icd10m/version37-fullcode-cms/fullcode_cms/P0002.html

24. Healy D, Cromwell J. Hospital-acquired conditions—present on admission: examination of spillover effects and unintended consequences: final report. Published September 2012. Accessed March 31, 2023. https://www.cms.gov/medicare/medicare-fee-for-service-payment/hospitalacqcond/downloads/hac-spillovereffects.pdf

25. Snow CL, Holtzman L, Waters H, et al. Accuracy of coding in the hospital-acquired conditions—present on admission program: final report. Published June 30, 2012. Accessed July 19, 2023. https://www.cms.gov/medicare/medicare-fee-for-service-payment/hospitalacqcond/downloads/accuracy-of-coding-final-report.pdf

26. Miller RD Jr, Eng T, Kandilov AMG, Cromwell J, McCall N. Readmissions due to hospital-acquired conditions (HACs): multivariate modeling and under-coding analyses: final report. Published September 2012. Accessed March 31, 2023. https://www.cms.gov/medicare/medicare-fee-for-service-payment/hospitalacqcond/downloads/final-report-readmissions.pdf

27. Triche EW, Xin X, Stackland S, et al. Incorporating present-on-admission indicators in Medicare claims to inform hospital quality measure risk adjustment models. *JAMA Netw Open*. 2021;4(5):e218512. doi:10.1001/jamanetworkopen.2021.8512 ArticlePubMedGoogle ScholarCrossref

28. US Centers for Medicare & Medicaid Services. CMS report to Congress: assessing the feasibility of extending the hospital acquired conditions (HAC) IPPS payment policy to non-

IPPS settings. Published December 2012. Accessed March 31, 2023. https://innovation.cms.gov/files/x/hospacquiredconditionsrtc.pdf

29. US Centers for Medicare & Medicaid Services. Hospital acquired conditions: coding. Updated July 2022. Accessed March 31, 2023. https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/HospitalAcqCond/Coding

30. Illinois Department of Public Health. Commonly used *ICD-10* procedure codes. Accessed March 31, 2023. https://dph.illinois.gov/content/dam/soi/en/web/idph/files/publications/commonicd10procestate1911.pdf

31. Kramarow EA. Sepsis-related mortality among adults aged 65 and over: United States, 2019. Published November 2021. Accessed November 27, 2023. https://www.cdc.gov/nchs/products/databriefs/db422.htm

32. Ramiah RD, Ashmore AM, Whitley E, Bannister GC. Ten-year life expectancy after primary total hip replacement. *J Bone Joint Surg Br*. 2007;89(10):1299-1302. doi:10.1302/0301-620X.89B10.18735PubMedGoogle ScholarCrossref

33. Anderson JD, Wadhera RK, Joynt Maddox KE, et al. Thirty-day spending and outcomes for an episode of pneumonia care among Medicare beneficiaries. *Chest*. 2020;157(5):1241-1249. doi:10.1016/j.chest.2019.11.003PubMedGoogle ScholarCrossref

34. Borzecki AM, Christiansen CL, Chew P, Loveland S, Rosen AK. Comparison of in-hospital versus 30-day mortality assessments for selected medical conditions. *Med Care*. 2010;48(12):1117-1121. doi:10.1097/MLR.0b013e3181ef9d53PubMedGoogle ScholarCrossref

35. Kandilov AMG, Coomer NM, Dalton K. The impact of hospital-acquired conditions on Medicare program payments. *Medicare Medicaid Res Rev*. 2014;4(4):mmrr2014-004-04-a01.PubMedGoogle Scholar

36. Callaway B, Sant'Anna P. Difference-in-differences with multiple time periods. *J Econ*. 2021;225(2):200-230. doi:10.1016/j.jeconom.2020.12.001Google ScholarCrossref

37. Rios-Avila F, Sant'Anna P, Callaway B. CSDID: Stata module for the estimation of difference-in-difference models with multiple time periods. Accessed March 31, 2023. https://econpapers.repec.org/software/bocbocode/s458976.htm

38. Agency for Healthcare Research and Quality. Appendix 3: guidelines to prevent central line–associated blood stream infections. Accessed March 31, 2023. https://www.ahrq.gov/hai/clabsi-tools/appendix-3.html

39. Patel PK, Olmsted RN, Hung L, et al. A tiered approach for preventing central line–associated bloodstream infection. *Ann Intern Med*. 2019;171(7 suppl):S16-S22. doi:10.7326/M18-3469PubMedGoogle ScholarCrossref

40. Saint S, Greene MT, Fowler KE, et al. What US hospitals are currently doing to prevent common device-associated infections: results from a national survey. *BMJ Qual Saf*. 2019;28(9):741-749. doi:10.1136/bmjqs-2018-009111PubMedGoogle ScholarCrossref

41. Saint S, Meddings J, Fowler KE, et al. The guide to patient safety for health care–associated infections. *Ann Intern Med*. 2019;171(7 suppl):S7-S9. doi:10.7326/M18-3443PubMedGoogle ScholarCrossref

42. Bysshe T, Gao Y, Heaney-Huls K, et al. Final report: estimating the additional hospital inpatient cost and mortality associated with selected hospital-acquired conditions. Published November 2017. Accessed March 31, 2023. https://www.ahrq.gov/sites/default/files/publications2/files/hac-cost-report2017.pdf

43. Lichtig LK, Knauf RA, Milholland DK. Some impacts of nursing on acute care hospital outcomes. *J Nurs Adm*. 1999;29(2):25-33. doi:10.1097/00005110-199902000-00008PubMed Google ScholarCrossref

44. Kovner C, Gergen PJ. Nurse staffing levels and adverse events following surgery in US hospitals. *Image J Nurs Sch*. 1998;30(4):315-321. doi:10.1111/j.1547-5069.1998.tb01326.xPubMedGoogle ScholarCrossref

45. Jackson M, Chiarello LA, Gaynes RP, Gerberding JL. Nurse staffing and healthcare-associated infections: proceedings from a working group meeting. *J Nurs Adm*. 2002;32(6):314-322. doi:10.1097/00005110-200206000-00007PubMedGoogle Scholar Crossref

46. Staggs VS, Dunton N. Associations between rates of unassisted inpatient falls and levels of registered and non-registered nurse staffing. *Int J Qual Health Care*. 2014;26(1):87-92. doi:10.1093/intqhc/mzt080PubMedGoogle ScholarCrossref

47. Cooke M, de la Fuente M, Stringfield C, et al. The impact of nurse staffing on falls performance within a health care system: a descriptive study. *J Nurs Manag*. 2022;30(3):750-757. doi:10.1111/jonm.13555PubMedGoogle ScholarCrossref

48. Bruch JD, Foot C, Singh Y, Song Z, Polsky D, Zhu JM. Workforce composition in private equity–acquired versus non-private equity–acquired physician practices. *Health Aff (Millwood)*. 2023;42(1):121-129. doi:10.1377/hlthaff.2022.00308PubMedGoogle Scholar Crossref

49. Agency for Healthcare Research and Quality. AHRQ national scorecard on hospital-acquired conditions: updated baseline rates and preliminary results 2014-2017. Published January 2019. Accessed March 31, 2023. https://www.ahrq.gov/sites/default/files/wysiwyg/professionals/quality-patient-safety/pfp/hacreport-2019.pdf

50. Dunne TJ, Gaboury I, Ashe MC. Falls in hospital increase length of stay regardless of degree of harm. *J Eval Clin Pract*. 2014;20(4):396-400. doi:10.1111/jep.12144PubMed Google ScholarCrossref

51. Waters TM, Chandler AM, Mion LC, et al. Use of *International Classification of Diseases, Ninth Revision, Clinical Modification*, codes to identify inpatient fall-related injuries. *J Am Geriatr Soc*. 2013;61(12):2186-2191. doi:10.1111/jgs.12539PubMedGoogle ScholarCrossref