Adoption of Lean management and hospital performance: Results from a national survey

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Background: Despite being adopted by a large number of hospitals, the relationship between Lean management and hospital performance is mixed and not well understood.

Purpose: We examined the relationships between Lean and hospital financial performance, patient outcomes, and patient satisfaction in a large national sample of hospitals, controlling for relevant organizational and market factors.

Methodology/Approach: A mixed effects linear regression analysis was performed to assess the relationships between adoption of Lean and 10 measures of hospital performance using data from 1,152 hospitals that responded to the 2017 National Survey of Lean/Transformational Performance Improvement in Hospitals. Hospital performance, organizational, and market data over the period 2011–2015 come from the 2015 American Hospital Association Annual Hospital Survey and the respective annual Centers for Medicare & Medicaid Services (CMS) Medicare Cost Report, CMS Hospital Compare, CMS MEDPAR, and the CMS Hospital Service Area File.

Results: Lean adoption was significantly associated at alpha < .05, with lower Medicare spending per beneficiary ($b = -.005$, $p = .027$). None of the other nine associations were statistically significant, although eight of them were in the predicted direction.

Conclusion: Lean adoption is not associated with most measures of hospital performance. It is likely Lean implementation varies greatly across hospitals. Future research should examine the relationships among the various dimensions of Lean implementation and performance.

Practice Implications: If Lean management is to contribute to hospital performance improvement, leaders must be highly cognizant of what "adoption of Lean" actually means in their hospital. Although limited, single-unit Lean initiatives in an emergency room or other patient care unit may improve performance on some unit-specific measures, improvement on hospital-wide measures of performance requires a broad, sustained commitment to the implementation of Lean practices and tools.

Key words: financial performance, hospital performance improvement, Lean management, patient satisfaction, performance assessment, quality of care

Historically, spending for hospital care in the United States has increased faster than the rate of inflation. Over the next 8 years (2020–2027), the rate of hospital spending is projected to average 5.7% per year, whereas the growth in gross domestic product is projected to average 4.7% (Sisko et al., 2019). Thus, there is need to eliminate waste while improving patient safety, quality of care, and the patient experience (Jha et al., 2009). Given increased attention to improving population health and addressing the underlying social determinants of health, the need to control hospital cost and improve quality takes on even greater urgency.

The pressure to improve hospital performance is reflected in a number of public and private sector initiatives. These include the Centers for Medicare & Medicaid Services' (CMS) Hospital Value-Based Purchasing Program, the Hospital-Acquired Condition Reduction Program, the Hospital Readmissions Reduction Program, and various alternative payment models in the Medicare Access and CHIP Reauthorization Act. Private insurers have followed with similar initiatives.

In response to these financial incentives, many U.S. hospitals are adopting transformational performance improvement approaches designed to create a culture of continuous improvement and empower staff with the skills, tools, and resources needed to identify care and resource management problems and implement sustainable changes that improve patient care and efficiency. One such approach is the Lean management system originally developed at Toyota (Ohno, 1988; Shingo & Dillon, 1989), adopted

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by many U.S. manufacturers (Womack & Jones, 2003) and, more recently, by many service-based organizations (Leite & Vieira, 2015; Liker, 2004).

Theory

Influenced by the work of Womack and Jones (2003) and Toussaint (Toussaint & Adams, 2015), we define Lean as an overall management/operating system that uses a continuous improvement culture that empowers frontline workers to solve problems and eliminate waste by standardizing work to improve the value of care delivered to patients. Related approaches are Lean plus Six Sigma, which adds a focus on variance reduction, and Robust Process Improvement, which adds a structured change management component (Chassin & Loeb, 2013).

Lean management (also known as Lean production, Lean enterprise, and Lean thinking) involves a set of practices and tools to assess, improve, and monitor work processes (Radnor et al., 2012). A commonly used practice is A3 thinking, in which a strategy to improve a particular performance problem is initiated with the use of a single sheet of A3 paper, measured 11 by 17 inches. A3 reports typically include a problem definition, description of the current condition, a goal or target condition, root cause analysis, interventions or recommendations, and an implementation and sustainability plan. Various tools and other practices are used to develop the A3 report and implement the redesigned work, such as value stream mapping to identify unnecessary, wasteful steps; standardized work processes; visual tracking charts that show actual versus expected performance of a targeted work process; regular (often daily) huddles of collaborating staff to discuss the status of operations, plan for the day, and status of problem-solving efforts; and plan–do–study–act cycles to assess and improve performance. For complex processes, staff from relevant departments may hold a *kaizen* event (*kaizen* is a Japanese term meaning "change for the better"), a short duration improvement project typically lasting a few days with the intent of achieving improvement in the target process. Leaders and managers also make frequent visits to the work place where value is created (*gemba*) to gain an understanding of the work being done and the problems that staff are encountering and to coach staff on how to identify and remedy work-related problems. In these ways, Lean management attempts to establish a culture and operating system that empowers staff to generate continuous improvement through what are often incremental but regular improvements in their work processes (KaiNexus, 2019). The more extensive the implementation of Lean practices, the greater the expected improvement in the hospital's performance across a diverse array of metrics (Chassin & Loeb, 2013; Harrison et al., 2016; Toussaint & Adams, 2015).

Literature Review

Graban (2016) has compiled numerous published and unpublished reports of the use of Lean methods in hospitals to positively affect hospital safety and quality, waiting times, length of stay, flow (e.g., reduced turnaround time for laboratory results, inpatient beds, and operating room availability), patient satisfaction, and financial performance. However, systematic reviews of the published literature, recent research on Lean in hospital settings, and case studies of Lean implementation in health care organizations present a more complicated picture.

Systematic reviews reveal that assessments of Lean's relationship with hospital performance show a likely publication bias favoring studies documenting positive relationships between Lean management and hospital performance. Overall, the reviewed studies show a mixed pattern of reported associations of statistically significant and insignificant associations (D'Andreamatteo et al., 2015; Isfahani et al., 2019; Moraros et al., 2016). Most used small samples of a few units, subjectively assessed outcomes, and used pre–post study designs that were unable to account for confounding factors or alternative explanations for study results. Two recent survey-based studies did examine the relationship between Lean and performance in a large sample of hospitals (Lee et al., 2018; Shortell et al., 2018). However, the measures of Lean adoption and performance were self-reported by a single informant, suggesting a possible bias in favor of finding a positive relationship.

Case study research has documented some of the challenges of implementing Lean in health care organizations (Harrison et al., 2016; Mazzocato et al., 2014; Radnor et al., 2012; Udod et al., 2019). These include the lack of resources and infrastructure support, the challenge of identifying the specific customer for a given Lean initiative, highly complex work processes, and inadequate communication and relationship building among those involved. Research is needed examining the relationship between the degree of Lean implementation and financial performance, patient outcomes, and patient experience. This study is a first step in filling this gap in the literature.

While acknowledging that Lean implementation varies among hospitals that have adopted Lean, it is reasonable to expect hospitals that have adopted Lean and even partially implemented the approach to have better performance outcomes than those that have not adopted Lean. Using independent, objective performance measures, given Lean's emphasis on eliminating waste and improving work processes that add value, we hypothesize that:

1. Lean adoption is negatively associated with Medicare spending per beneficiary, adjusted inpatient expense per discharge, 30-day risk-adjusted mortality index, death rate in low mortality diagnosis-related groups (DRGs), pressure ulcer rate, death rate for surgical patients with serious treatable conditions, and 30-day unplanned readmission rate.
2. Lean adoption is positively associated with earnings before interest, taxes, depreciation, and amortization (EBITDA) margin, adjusted operating profit margin, and patient satisfaction (Hospital Consumer Assessment of Healthcare Providers and Systems [HCAHPS] score).

Methods

Data Sources

The data for these analyses were compiled from multiple sources, including the 2017 National Survey of Lean/Transformational Performance Improvement in Hospitals (the national Lean survey), 2015 American Hospital Association (AHA) Annual Survey, the annual CMS Medicare Cost Report, annual CMS Hospital Compare, annual CMS MEDPAR, and the annual CMS Hospital Service Area File. The AHA Annual Survey of Hospitals is an annual survey of 6,500 hospitals in the United States. Data are collected on a variety of topics, including hospital organizational structure, facilities and services, utilization, physician arrangements, staffing, and community orientation (https://ahasurvey.org/taker/asindex.do). The Medicare Cost Reports consist of information Medicare providers are required to submit in an annual cost report to CMS. The cost report contains provider information such as facility characteristics, utilization data, cost and charges by cost center (in total and for Medicare), Medicare settlement data, and financial statement data (https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Medicare-Provider-Cost-Report). CMS Hospital Compare is the official data set used on the Medicare.gov Hospital Compare Website. These data allow public users to compare the quality of care for numerous diagnoses and procedures at over 4,000 Medicare-certified hospitals across the country (https://catalog.data.gov/dataset/hospital-compare-data-17295). MEDPAR files contain information on Medicare beneficiaries using hospital inpatient services. Data are provided by DRG for all short stay and inpatient hospitals (https://www.cms.gov/Research-Statistics-Data-and-Systems/Files-for-Order/LimitedDataSets/MEDPARLDSHospitalNational). The Hospital Area Service File contains summarized inpatient stay volume, length of stay, and charges by provider number and ZIP code of the Medicare beneficiary (https://data.cms.gov/Medicare-Inpatient/2016-Hospital-Service-Area-File-HSAF-/7w4z-gcgx).

On the basis of literature review, discussion with Lean experts, and pilot testing with 12 Lean performance improvement specialists, we developed a 20-minute online survey to measure Lean adoption and implementation in hospitals. Major topics covered by the survey include whether the hospital had adopted Lean or related performance improvement systems, date of adoption, extent of current use of Lean, approach to implementing Lean, self-reported maturity in using Lean, use of a central improvement team, use of a daily management system, use of Lean tools, and Lean-related training. The AHA fielded the national Lean survey between May and September 2017. It was sent to 4,500 acute care general medical and surgical hospitals in the United States, including pediatric medical and general hospitals to determine how many hospitals had adopted Lean and how extensively Lean had been implemented among adopting hospitals. The survey took approximately 20 minutes to complete and was completed by the Chief Transformation Officer, Chief Improvement Officer, Chief Quality Officer, or equivalent position title in each hospital. The survey was approved by the institutional review board of the University of California, Berkeley.

The sample used for this analysis includes 1,152 hospitals that responded to questions on the national survey asking if the hospital had implemented Lean without Six Sigma, Lean and Six Sigma combined, or Robust Process Improvement.

Study Variables

All of the independent, dependent, and control variables are listed in Table 1, including a variable description, year measured, and data source. As indicated above, the national Lean survey was carried out in 2017, and it is not possible to confidently back-date the measures of the extent of Lean implementation. We have measures of the dependent variables for each hospital from 2011 to 2015 (see further description below). For our independent variable, we used a simple binary measure based on two pieces of information, when Lean was first adopted and the year for which dependent measures are available: yes = hospital reported adopting Lean, Lean plus Six Sigma, or Robust Process Improvement by the end of the year prior to the dependent variable measurement; no = hospital reported that they had not adopted any of the three versions of Lean identified above by the end of the year prior to the dependent variable measurement.

There is some concern that respondents' recollections of their hospital's start date may be subject to a telescoping bias, with a recent adoption being perceived as more remote than it actually is and a distant adoption as being more recent than it is. However, the adoption of Lean management in a hospital is a landmark event that is salient and memorable for our survey respondents, which reduces the risk of telescoping. Moreover, the leadership roles played by our respondents assure their familiarity with the implementation of Lean and reduce the possibility of an accessibility bias. Given the salience of the event and the familiarity of the respondents with Lean in their hospital, we believe any forward or backward telescoping bias in our independent variable is essentially random, which would increase error variance, but the sample estimates would still be unbiased estimates of the population values (Gaskell et al., 2000).

Our dependent variables were measured each year during the period 2011–2015 (with some exceptions noted below), and our control variables were measured in 2015 for each of the 1,152 hospitals in our sample. The data were extracted from the databases described above and compiled for this study by IBM Watson Health.

Ten dependent variables were selected to capture hospital performance on frequently used measures of financial performance (Medicare spending per beneficiary, adjusted inpatient expense per discharge, adjusted operating margin, EBITDA margin), patient outcomes (30-day risk-adjusted mortality index, death rate in low-mortality DRGs, pressure ulcer rate, death rate among surgical patients with serious treatable conditions, and 30-day unplanned readmission rate), and patient satisfaction with their hospital experience (HCAHPS) score. As indicated above, the dependent variables were measured each year from 2011 to 2015, except for three variables from the Medicare Cost Report that were not reported in 2012 and/or 2011: Medicare spending per beneficiary (observed years: 2012–2015), 30-day risk-adjusted mortality index (2013–2015), and 30-day unplanned readmission rate (2012–2015).

Our control variables, taken from the 2017 National Lean Survey and the 2015 AHA Annual Survey, include several organizational and market characteristics found in prior research to be associated with hospital financial performance, patient outcome, and patient satisfaction. These characteristics may influence hospital performance in various ways by affecting, for example, the motivation of management and clinical staff to improve performance or the availability of resources for performance improvement activities, such as benchmarking, training in high-reliability practices, participating in quality improvement programs and collaboratives, increasing staffing

TABLE 1: Description of independent, dependent, and control variables

Variable	Description
Independent variable	
Lean status[a]	Binary indicator measured for each hospital and each year that dependent variables were measured. Yes = hospital reported adopting Lean, Lean plus Six Sigma, and/or Robust Process Improvement by the end of the prior year; No = hospital reported that they had not adopted Lean, Lean plus Six Sigma, or Robust Process Improvement by the end of the year prior to the dependent variable measurement.
Dependent variables	
Medicare spending per beneficiary[b]	Ratio: spending per beneficiary/national median.
Adjusted inpatient expense per discharge[b]	Cost: Cost per inpatient discharge adjusted for case mix and area wage indices.
Adjusted operating profit margin[b]	Percent: A measure of profit as a proportion of revenue after accounting for expenses.
EBITDA margin[b]	Percent: Earnings before interest, tax, depreciation, and amortization/ total operating revenue.
30-day risk-adjusted mortality index[c]	Percent: 30-day risk-adjusted mortality, averaged across patients with heart failure, pneumonia, AMI, COPD, stroke.
Death rate in low-mortality DRGs[d]	Risk-adjusted in-hospital deaths per 1,000 adult discharges for low mortality DRGs (observed – expected/standard deviation). Extreme observations (above the 99.5 percentile) were trimmed.
Pressure ulcer rate[e]	Risk-adjusted pressure ulcer rate per 1,000 adult discharges (observed – expected/ standard deviation). Extreme observations (above the 99.5 percentile) were trimmed.
Death rate among surgical inpatients with serious treatable conditions[e]	Risk-adjusted in-hospital deaths per 1,000 adult elective surgical discharges (observed – expected/standard deviation). Extreme observations (above the 99.5 percentile) were trimmed.
30-day unplanned readmission rate[c]	Percent: patients readmitted to the hospital within 30 days of discharge/all discharges (adjusted for severity of diagnosis).
HCAHPS score[c]	Index: Patient responses to the question "How do patients rate the hospital, overall?" (from a standard survey required by CMS) were coded into low, medium, and high categories, and a weighted scoring system was used to create a summary measure ranging from 100 (100% of patients rate the hospital low) to 300 (100% of hospitals rate the hospital high). HCAHPS stands for Hospital Consumer Assessment of Healthcare Providers and Systems.
Control variables	
Ownership[f]	Categorical: Public, not-for-profit, or investor-owned.
Member of a system or network[f]	Binary.
Core-based statistical area type[f]	Categorical: Metropolitan (urban area of at least 50,000 people), micropolitan (urban areas between 10,000 and 50,000 people), or rural (nonurban area).
Member of Council of Teaching Hospitals[f]	Binary.
Bed size[f]	Categorical: 1–99 beds, 100–399 beds, or 400 or more beds.

(continues)

TABLE 1: Description of independent, dependent, and control variables, Continued

Variable	Description
Market concentration[g]	Categorical: Unconcentrated (HHI from 100 to <1,500), moderately concentrated (HHI from 1,500 to <2,500), highly concentrated (HHI ≥ 2,500).
Percent Medicaid discharges[b]	Percent: Number of discharges under Medicaid/total discharges.
Medical provider ratio[h]	Ratio: primary care providers / (specialists + surgeons).

Note. AHA = American Hospital Association; AHRQ = Agency for Healthcare Research and Quality; CMS = Centers for Medicare & Medicaid Services; DRG = diagnosis-related group; EBITDA = earnings before interest, taxes, depreciation, and amortization; HHI = Hirfindahl–Hirschman Index; AMI = acute myocardial infarction; COPD = chronic obstructive pulmonary disease.

[a]Source: 2017 National Survey of Lean/Transformational Performance Improvement in Hospitals.

[b]Source: 2015 Medicare Cost Report.

[c]Source: 2015 CMS Hospital Compare.

[d]Source: 2015 AHRQ Quality Indicators (based on Medicare beneficiary population only—MedPAR).

[e]Source: 2015 AHRQ Quality Indicators.

[f]Source: 2015 AHA Annual Survey.

[g]Source: 2015 CMS Hospital Service Area File.

[h]Source: 2015 Area Health Resources Files.

levels, and purchasing new technological capabilities, such as upgrades to a health information system. These contextual factors may explain some of the variation in our dependent variables (Harrison et al., 2016).

Hospitals with different types of ownership (e.g., public, not-for-profit, or investor-owned) will likely have differing levels of resources available to implement improvement activities and different cultures with respect to strategic and operational planning and decision-making that will influence the extent of performance improvement implementation (Joynt & Jha, 2011; Ly & Cutler, 2018; Sloan et al., 2001). If a hospital is a member of a system or network, hospital clinicians and managers may be connected to colleagues in other health care organizations and the performance improvement ideas that are being tried in those places (Joynt & Jha, 2011; Ly & Cutler, 2018). Hospitals in urban areas are likely to have greater demand on their facilities and staff, thereby increasing the saliency of increasing efficiency (Lutfiyya et al., 2007). The research-oriented culture of teaching hospitals may influence medical and clinical staff to be more open to evidence-based performance improvement (Taylor Jr et al., 1999). Larger hospitals are likely to have more facilities and services than smaller hospitals, providing multiple subunits within which to try out performance improvement activities, and larger hospitals may have greater resources to support performance improvement (Joynt & Jha, 2011). Hospitals serving a higher percentage of Medicaid patients may not have the resources to improve performance (Goldman et al., 2007). The competitive pressures on hospitals in markets with less concentration of hospitals may influence leaders to implement performance improvement as a way to gain competitive advantage over other hospitals (Kessler & Geppert, 2005). Finally, hospitals located in areas where there are more primary care providers relative to specialists may be better able to implement patient-centered medical homes and related innovations designed to reduce readmissions and costs and improve patient outcomes (Herrin et al., 2015).

To explore the relationship between the proposed control variables and Lean adoption, we compared the characteristics of hospitals that reported adopting Lean by the end of 2014 (the year before the most recent outcome data are available) to those that had not. Table 2 reveals that there were significant relationships between Lean adoption and each of the proposed control variables, with the exception of percent Medicaid discharges. As a result, we excluded percent Medicaid discharges from further analyses.

Data Analysis

We used a mixed-effects linear regression model to assess the relationships among Lean adoption and subsequent measures of hospital financial, patient outcome, and patient satisfaction, controlling for hospital-level organizational and market variables. The independent variable was a dichotomous measure of whether the hospital had adopted Lean by the year before the dependent variable was measured. The model included hospital-level random intercepts and indicator variables for the measurement year to control for the relationship between repeated measures in the same hospital and the time trend, respectively. In each model, each hospital could contribute one observation per year. All analyses were conducted using R Version 3.4.1 (R Core Team, 2017). Mixed-effects regressions were carried out using the R package lme4, using the *lmer* command (Bates et al., 2015).

Results

Table 3 includes descriptive information on the independent and dependent variables. For dependent variables measured in 2011, 253 (22%) of the 1,152 hospitals in our sample reported that they had adopted Lean by the previous year (i.e., during 2010 or before). The number of hospitals that reported adopting Lean by the year prior to 2012 increased to 298 (25.9%). A total of 359 (31.2%) hospitals reported adopting Lean prior to 2013, 438 reported adopting Lean

TABLE 2: Comparison of hospitals based on Lean status at end of 2014 on organizational and market characteristics

Characteristic	n	Adopted Lean by end of 2014 (n = 545) n (row %) or mean (SD); range	Not doing Lean by end of 2014 (n = 607) n (row %) or mean (SD); range
Ownership ($p < .001$)*			
Public	281	91 (32.4%)	190 (67.6%)
Not-for-profit	767	434 (56.6%)	333 (43.4%)
Investor-owned	93	16 (17.2%)	77 (82.8%)
Member of a system or network ($p < .001$)*			
Yes	840	444 (52.9%)	396 (47.1%)
No	253	87 (34.4%)	166 (65.6%)
Core-based statistical area type ($p < .001$)*			
Metro (urban area at least 50,000 people)	646	389 (60.2%)	257 (39.8%)
Micro (urban area between 10,000 and 50,000 people)	198	78 (39.4%)	120 (60.6%)
Rural	297	74 (24.9%)	223 (75.1%)
Member of Council of Teaching Hospitals ($p < .001$)*			
Yes	99	67 (67.7%)	32 (32.3%)
No	1,042	474 (45.5%)	568 (54.5%)
Bed size*			
1–99 beds	544	167 (30.7%)	377 (69.3%)
100–399 beds	447	268 (60.0%)	179 (40.0%)
400 or more beds	150	106 (70.7%)	44 (29.3%)
Market concentration ($p = .002$)*			
Unconcentrated (HHI 100 to <1,500)	985	482 (48.9%)	503 (51.1%)
Moderately concentrated (HHI 1,500 to <2,500)	53	27 (50.9%)	26 (49.1%)
Highly concentrated (HHI ≥ 2,500)	89	26 (29.2%)	63 (70.8%)
Percent Medicaid discharges ($p = .330$)	1,125	10.6 (10.1); 0–74.9	10.0 (10.2); 0–68.1
Medical provider ratio ($p < .001$)*[a]	1,113	1.4 (3.6); 0–18.8	2.97 (5.6); 0–18.8

Note. Column total sample sizes vary due to missing data. HHI = Hirfindahl–Hirschman Index.

Sources: 2017 National Survey of Lean/Transformational Performance Improvement in Hospitals, 2015 AHA Annual Survey, 2015 CMS Hospital Service Area File, 2015 Medicare Cost Report, 2015 Area Health Resources Files.

[a]Larger ratio values indicate a larger number of primary care providers than specialists and surgeons.

*$p < .10$ (chi-square test or t test).

prior to 2014 (38%), and 545 (47.3%) hospitals reported adopting Lean prior to 2015.

Table 4 summarizes the 10 mixed-effects regression models by showing the coefficient and 95% confidence interval for our independent variable (Lean status) in each model, listed by the dependent variable. Adopting Lean was significantly associated with lower Medicare spending per beneficiary ($b = -.005$, $p = .027$), and two other relationships approached significance: lower pressure ulcer rate ($b = -.0001$, $p = .071$) and lower 30-day unplanned readmission rate ($b = -.066$, $p = .051$). The other relationships (with the exception of death rate in low-mortality DRGs) trended in the expected

TABLE 3: Independent and dependent variable distribution by year (2011–2015)

	2011		2012		2013		2014		2015	
Variable	***N***	**Mean (*SD*) or *n* (%)**	***N***	**Mean (*SD*) or *n* (%)**	***N***	**Mean (*SD*) or *n* (%)**	***N***	**Mean (*SD*) or *n* (%)**	***N***	**Mean (*SD*) or *n* (%)**
Lean status = yes	1,152	253 (22%)	1,152	298 (25.9%)	1,152	359 (31.2%)	1,152	438 (38.0%)	1,152	545 (47.3%)
Medicare spending per beneficiary	NA	NA	755	0.97 (0.08)	752	0.97 (0.08)	746	0.97 (0.08)	741	0.97 (0.08)
Adjusted inpatient expense per discharge	751	6,886.94 (3,560.65)	735	7,353.97 (11,342.84)	740	8,079.35 (23,584.05)	741	7,372.91 (26,88.71)	746	7,349.94 (2,268.24)
Adjusted operating profit margin	1,026	−17.34 (515.42)	1,077	2.88 (19.52)	1,076	4.26 (32.64)	1,067	2.66 (12.89)	1,073	3.31 (13.07)
EBITDA margin	1,074	−8.32 (477.35)	1,088	9.76 (18.22)	1,096	10.64 (10.24)	1,095	10.24 (14.82)	1,092	10.06 (13.43)
30-day risk-adjusted mortality index	NA	NA	NA	NA	549	12.92 (0.95)	539	12.49 (0.9)	529	13.62 (0.99)
Death rate in low-mortality DRGs	1,088	0 (0.01)	1,093	0 (0.01)	932	0 (0.01)	837	0 (0)	820	0 (0)
Pressure ulcer rate	1,105	0 (0)	1,109	0 (0)	944	0 (0)	836	0 (0)	830	0 (0)
Death rate among surgical inpatients with serious treatable conditions	739	0.09 (0.12)	730	0.08 (0.1)	629	0.08 (0.1)	555	0.07 (0.1)	544	0.07 (0.09)
30-day unplanned readmission rate	NA	NA	1078	15.89 (0.98)	1,084	15.51 (0.94)	1,075	15.19 (0.82)	1,047	15.51 (0.82)
HCAHPS score	926	261.5 (11.32)	953	263.48 (11.19)	997	264.61 (11.26)	1,011	264.49 (11.1)	1,000	265.38 (10.98)

Note. The number of responses varies due to missing data. DRG = Diagnosis-related group; EBITDA = Earnings before interest, taxes, depreciation, and amortization; HCAHPS = Hospital Consumer Assessment of Healthcare Providers and Systems; NA = not available (variable not measured in that year).

Sources: 2017 National Survey of Lean/Transformational Performance Improvement in Hospitals, 2015 Medicare Cost Report, 2015 CMS Hospital Compare, 2015 AHRQ Quality Indicators (MedPAR).

direction, but the effects were weak. The full regression results for each of the 10 regressions are available upon request.

Discussion

With respect to Hypothesis 1, only one of seven predicted negative associations between Lean adoption and various performance measures was supported. Medicare spending per beneficiary was significantly associated with adoption of Lean management. The regression coefficients for four of the other five dependent variables (adjusted inpatient expense per discharge, 30-day risk-adjusted mortality, death rate in low mortality DRGs, pressure ulcer rate, death for patients with serious treatable condition, and 30-day unplanned readmission rate) were in the predicted negative direction, but only blood pressure rate and 30-day unplanned readmission rate approach statistical significance and their effects are small.

TABLE 4: Mixed-effects regression: The association between adoption of Lean and financial, patient outcome, and patient satisfaction measures in 2011–2015, controlling for organizational and market variables

Dependent variable, years observed	No. of observations	No. of hospitals	*b* for independent variable: reported adopting Lean by previous year [95% CI]
Medicare spending per beneficiary, 2012–2015	2,928	737	−0.005** [−0.010, −0.001]
Adjusted inpatient expense per discharge, 2011–2015	3,631	748	−158.747 [−1196.173, 878.678]
Adjusted operating profit margin, 2011–2015	5,003	1,031	4.911 [−10.023, 19.845]
EBITDA margin, 2011–2015	5,094	1,031	3.57 [−10.317, 17.456]
30-day risk-adjusted mortality index, 2013–2015	1,599	559	−0.006 [−0.087, 0.075]
Death rate in low-mortality DRGs, 2011–2015	4,465	1,053	0 [0.000, 0.001]
Pressure ulcer rate, 2011–2015	4,507	1,052	−.0001* [−0.0003, 0.00001]
Death rate among surgical inpatients with serious treatable conditions, 2011–2015	3,112	806	−0.007 [−0.015, 0.001]
30-day unplanned readmission rate, 2012–2015	4,055	1,032	−0.066* [−0.132, 0.000]
HCAHPS score, 2011–2015	4,683	999	0.413 [−0.216, 1.041]

Note. Model includes hospital-level random intercepts, measurement year indicator variables (based on available years of data), and hospital-level organizational and market variables. The number of observations and hospitals varies due to missing data. Each hospital could have contributed one observation per year in each model. Several variables do not have observations for 2011 and/or 2012 because they were not reported in Hospital Compare in those years. CI = confidence interval; DRG = diagnosis-related group; EBITDA = earnings before interest, taxes, depreciation, and amortization; HCAHPS = Hospital Consumer Assessment of Healthcare Providers and Systems.

*$p < .10$. **$p < .05$.

With respect to Hypothesis 2, none of the three predicted positive relationships were supported. Although the regression coefficients for the three dependent variables (EBITDA margin, adjusted operating profit margin, and the HCAHPS score) were in the predicted direction, none of the coefficients were statistically significant.

Although performance improvement strategies such as Lean management have empirical support for improving performance when assessed at the unit level, such as in an emergency department or medical-surgical patient care unit, hospitals frequently struggle with broad, sustained system-wide implementation. Hospitals must make significant investments of time and other resources to transform the organizational culture, institute effective Lean management policies and practices, and diffuse these throughout the organization. Many Lean initiatives suffer because of lack of sufficient leadership commitment to provide the necessary resources to implement Lean on an organization-wide basis. Performance improvement is also affected by the responses of clinical, managerial, and support staff to the Lean-related behavioral changes asked of them. This is especially true of the nursing and medical staff, who may be reluctant to participate in Lean management training and practices because of work overload, suspicion of the motives of senior management, and/or fears that standardization of work will compromise their ability to vary care as required to address individual patient needs. For all these reasons, hospitals may officially adopt some aspects of Lean management but fail to implement Lean culture, practices, and tools widely enough to have substantial effects on organizational performance. Future research should focus on understanding the relationship between hospital performance and the extent of Lean implementation, including factors such as leadership support, extent of training in Lean practices and tools, and breadth of participation in key Lean activities.

Our findings need to be considered within the context of a number of limitations. The 26% response rate to the national Lean survey on which our measure of Lean implementation is based raises concern that there may be a response bias in our study sample. We controlled for key organizational and market variables where there were differences between responding and nonresponding hospitals, but there may be other variables that should be controlled, such as leadership predisposition to adopt and implement Lean, that are difficult to assess with survey data. Furthermore, it is possible that there are other unobserved organizational or market characteristics that influence both the adoption of Lean and the observed outcomes limiting our ability to claim that the relationship is causal (Harrison et al., 2016). Given there are some differences between the responding and nonresponding hospitals, we cannot strictly generalize our findings to the universe of U.S. hospitals.

The implementation of organizational changes to streamline and improve key work processes may take a number of years. Although we investigated the possible effects on 2015 hospital performance on the number of years that Lean had been implemented (by the end of 2014), the results were not statistically significant, suggesting that Lean implementation does not proceed in a strictly linear way over time. Indeed, the case studies summarized above indicate some of the ways that inconsistent leadership support, cultural resistance, lack of resources, and other contextual factors may cause Lean implementation to ebb and flow over time, with resulting inconsistency in performance improvement efforts. Future research using detailed survey questions on Lean implementation, as well as interviews, observations, and related qualitative methods, preferably with longitudinal designs, are needed to address these issues. The findings, of course, are restricted to the hospital sector of health care and do not address the ambulatory/primary care (Hung et al., 2017) or post-acute care sectors. Future research should address the Lean implementation–performance relationship in these sectors.

Practice Implications

On the basis of our findings and the research reviewed above, it appears that if Lean management is to contribute to hospital performance improvement across an array of financial, patient outcome, and patient satisfaction indicators, leaders must be highly cognizant of what "adoption of Lean" actually means in their hospital. Although limited, single-unit Lean initiatives in an emergency room or other patient care unit may improve performance on some unit-specific measures, such as product waste and patient waiting time, improvement on hospital-wide measures of performance requires a broad, sustained commitment to the implementation of Lean philosophy, practices, and tools.

Conclusion

There is relatively widespread adoption of the Lean management system and related transformational performance improvement approaches in U.S. hospitals. This study documents that Lean adoption, without further information regarding the extent of implementation, is not significantly associated with 9 of 10 commonly used measures of hospital performance. Only reduction in Medicare spending per beneficiary was significantly associated with Lean adoption, an important finding, but one that stands alone in comparison to our other results. Clearly, Lean can be implemented in many different forms and with varying levels of commitment. Given these findings, the challenges of implementing the Lean approach on a hospital-wide basis merit further study along with ongoing examination of the relationship between the extent of Lean implementation and hospital performance.

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