Lean Management and U.S. Public Hospital Performance: Results From a National Survey

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EXECUTIVE SUMMARY

Many public hospitals have adopted Lean management methodology, but little is known about the extent of Lean adoption or the relationship between Lean adoption and hospital performance. Using data from the 2017 National Survey of Lean/Transformational Performance Improvement in Hospitals, linked with data from the American Hospital Association 2015 Annual Hospital Survey and 2015 Centers for Medicare & Medicaid Services data on hospital performance, we compare public hospitals with nonprofit and for-profit hospitals on the rate of Lean adoption and the extent of Lean implementation. We also assess the associations between Lean adoption by the end of 2014 and measures of public hospital financial performance, patient outcomes, and patient satisfaction measured in 2015.

Among the 288 public hospitals that responded to the survey, 54.2% reported that they had adopted Lean. The average length of time of Lean implementation was 4.58 years. The mean number of units in which Lean was implemented was 11.9 out of 29 possible hospital units, with the emergency department (ED) being the unit in which Lean was most frequently implemented. The most common Lean practices used were daily huddles, plan-do-study-act cycles, visual management, and use of standard work. Lean adoption by 2014 was significantly associated in the direction predicted with earnings before interest, taxes, depreciation, and amortization margin ($b = .042$, $p < .020$) and percentage of patients leaving the ED without being seen ($b = -0.610$, $p < .068$). No significant associations were found between Lean adoption and patient outcomes or patient satisfaction.

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INTRODUCTION

Public hospitals are a crucial part of the healthcare safety net in the United States. Despite their importance, public hospitals generally have fewer resources to deliver care than their private nonprofit and for-profit counterparts do. The high proportions of uninsured and underinsured patients served by public hospitals frequently lead to budget deficits that must be covered by government payers and pressure to tightly control expenditures. Meanwhile, clinicians and managers in those facilities still must demonstrate continuously improving patient outcomes (Felland & Stark, 2012).

The financial and quality improvement challenges faced by public hospitals are exacerbated by the growing burden placed on all hospitals in recent years to become more efficient while meeting ever-higher quality of care and patient outcome targets. Private and public payer initiatives have incentivized hospitals to improve performance by establishing value-based purchasing programs (Rosenthal, Fernandopulle, Song, & Landon, 2004; Ryan & Damberg, 2013). For example, in the private sector, Humana has launched its Hospital Incentive Program to link hospital payment with quality improvements in patient experience, patient safety, and patient outcomes. In the public sector, the Centers for Medicare & Medicaid Services (CMS) has implemented programs to link payment to quality of care targets, including its hospital value-based purchasing program, the hospital-acquired condition reduction program, the hospital readmissions reduction program, and numerous alternative payment models in the Medicare Access and CHIP Reauthorization Act (Centers for Medicare & Medicaid Services, 2017a, 2017b, 2018a, 2018b; Hussey, Liu, & White, 2017). The Affordable Care Act (ACA) increased Medicaid enrollment in many states, leading to a reduction in charity care cases and an increase in revenue from the respective state's Medicaid program. However, it also authorized a number of new care models, such as accountable care organizations and patient-centered medical homes, that emphasize enhanced primary care to reduce hospital admissions and, by extension, hospital revenue. Since the passage of the ACA, the Budget Control Act of 2011 enacted a 2% across-the-board cut to Medicare provider payments. On balance, these reforms have created substantial financial pressure on all hospitals to meet quality targets and become more efficient.

In this article, we use the American Hospital Association's (AHA's) definition of a public hospital as an acute care, general hospital owned by a state, city, county, combined city and county, or district authority (AHA Annual Survey, 2017). Historically, public hospitals have responded to financial pressures by establishing independent governance structures to manage long-term costs, improving revenue collection efforts, and attracting privately insured patients by promoting greater efficiency and quality of care (Felland & Stark, 2012). Recent research has identified another strategy adopted in the past decade by large numbers of public hospitals: the adoption of Lean management to improve financial performance and patient outcomes (Shortell, Blodgett, Rundall, & Kralovec, 2018).

LEAN MANAGEMENT

Lean, a performance improvement approach originally developed as the Toyota Production System (Spear, 2004),

has gained traction in healthcare for its focus on continuous improvement through frontline worker empowerment, elimination of activities that do not add value, and standardization of work processes (Barnas, 2014; Toussaint & Gerard, 2010). Lean is defined in the context of this article as an overall management and operating system that uses a continuous improvement culture that empowers frontline workers (nurses, physicians, other caregivers, support staff) to solve problems and eliminate waste by standardizing work to improve the value of care delivered to patients (Shortell et al., 2018). Lean provides a set of principles, methods, and tools for identifying organizational process performance issues (e.g., value stream mapping), identifying potential solutions (e.g., A3 thinking), and assessing impacts of performance improvement initiatives (e.g., plan-do-study-act [PDSA] cycles). Many hospitals have also implemented variations of Lean such as Lean Plus Six Sigma, which adds variance reduction, and Robust Process Improvement, which adds a structured change management component intended to quickly deploy solutions at identified, targeted needs (Chassin & Loeb, 2013).

Previous research regarding Lean in healthcare settings has been largely conducted using small-scale studies of Lean's use in one or a few nonprofit hospital units. Systematic reviews indicate that most studies use pre–post evaluation designs with limited ability to assess confounding factors or alternative explanations for study results. Further, the studies have shown mixed results, with some reporting positive results with respect to efficiency gains, quality of care, and patient satisfaction, and other studies reporting no statistically significant associations with health outcomes and patient satisfaction (Glasgow, Scott-Caziewell, & Kaboli, 2010; Moraros, Lemstra, & Nwankwo, 2016; Vest & Gamm, 2009). Each of these reviews concludes that there is a lack of rigorous evidence to support claims that Lean improves the performance of healthcare organizations and calls for more rigorous research.

Recent research regarding larger samples of hospitals has found cross-sectional associations between Lean adoption and self-reported measures of performance (Lee, McFadden, & Gowen III, 2016; Shortell et al., 2018). The present study goes beyond these findings by examining important independent performance measures with a 1-year lag between Lean adoption by 2014 and performance measures in 2015.

Hypotheses

We first assessed the extent to which Lean management had been adopted (as of 2017) in U.S. public hospitals and how the rate of adoption compared to the rates for nonprofit and for-profit hospitals. Lean adoption includes adoption of Lean alone, Lean Plus Six Sigma, or Robust Process Improvement. We expected the lower level of resources typically available for performance improvement in public hospitals to decrease the likelihood of Lean adoption relative to other hospitals.

> Hypothesis 1: The rate of Lean adoption among public hospitals is lower than that for nonprofit and for-profit hospitals.

We next examined the extent of Lean implementation among public hospitals

that adopted Lean as of 2017. We expected that the relatively lower level of resources in public hospitals would result in less extensive implementation of Lean, specifically Lean implementation in fewer hospital units and use of fewer tools than is the case in hospitals with other types of ownership.

> Hypothesis 2: Public hospitals that have adopted Lean will have less extensive implementation than nonprofit or for-profit hospitals.

Finally, we examined the associations between Lean adoption by 2014 and selected indicators of public hospital financial performance, patient outcomes, and patient satisfaction reported by federal agencies in 2015, the most recent year for which CMS hospital performance data were available. We expected that the adoption of Lean's philosophy, practices, and tools would improve managerial and clinical work processes, resulting in better hospital performance across financial, patient outcome, and satisfaction indicators.

> Hypothesis 3: Public hospitals that implemented Lean at the end of 2014 were associated with better hospital financial performance, patient outcomes, and patient satisfaction measured in 2015 than public hospitals that have not implemented Lean, controlling for organizational and market factors.

METHODS

The 2017 National Survey of Lean/Transformational Performance Improvement in Hospitals was administered by the AHA and sent to 4,500 U.S. acute care general medical and surgical hospitals. Major topics covered by the survey included 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 (DMS), use of Lean tools, number of Lean tools used, and Lean-related training. (Details are provided in the Data Sources section.)

Using data from the national survey, we calculated three measures of Lean adoption, including the percentage of hospitals responding that they were currently implementing any Lean and the average number of years Lean had been implemented. Because hospitals can simultaneously use more than one performance improvement approach, we also calculated the percentage of hospitals using Lean as their *primary* performance improvement approach. Chi-square testing was conducted to assess the significance of any differences in the percentages of Lean adoption and use of Lean as the primary method of performance improvement across types of hospital ownership. Finally, we performed an ANOVA (analysis of variance) to test the significance of the differences in the average number of years doing Lean by hospital ownership.

The extent of Lean implementation by hospital ownership category was measured by calculating the average number of hospital units (e.g., emergency department [ED], pharmacy; range = 0–29) using Lean by ownership category and the average number of Lean tools and methods employed (range = 0–15 with 1 point

allocated for each Lean tool or method for which extent of use in 2017 was designated as "high" or "very high"), and the following composite scales.

Overall Leadership Commitment

A key aspect of Lean is leadership commitment to provide the cultural transformation that is required (Becker, Huselid, & Ulrich, 2001; General Electric Co., 2015; Mann, 2015; Shook, 2008). This was measured by an eight-item index, including whether leaders clearly communicated the reason(s) for implementing Lean, the desired outcomes, the degree of employee investment in Lean, projects for early success and learning, benchmarks to assess progress, resources, team champions or sponsors, and an explicit commitment to patient-centered care. The response scale to each item ranged from "strongly disagree" to "strongly agree" with the statement. We grouped the "agree" and "strongly agree" responses and allocated 1 point to each of the eight items, so the scale ranged from 0 to 8. The Cronbach alpha reliability coefficient for the scale was 0.81.

Daily Management System

Key to Lean implementation is the use of the DMS, which supports the cultural transformation and helps to ensure sustainability over time (Becker et al., 2001; General Electric Co., 2015; Mann, 2015; Taher, Landry, & Toussaint, 2016). We developed a nine-item index, including whether managers routinely participate in daily huddles, go on gemba walks, use visual management tools for tracking priorities, use analysis tools such as scatter plots, practice A3 thinking, teach Lean methods and tools, use standard work, use value stream mapping, and use PDSA cycles. Respondents were given 1 point for each of the nine items that were checked with a "yes," so the scale ranged from 0 to 9. The Cronbach alpha reliability coefficient was 0.75.

Education and Training

Education and training in Lean philosophy, principles, and tools provide the foundation for Lean work. We measured the degree of Lean education and training by assessing the percentage of managers, nurses, and physicians that had received training in scientific approaches to problem-solving such as the use of PSDA cycles. Response categories were 0, 1%–24%, 25%–49%, 50%–74%, and 75%–100%. Respondents were grouped into the categories of 0, 1 if they were in the 1%–24% category, 2 if in the 25%–49% category, 3 if in the 50%–74% category, and 4 if in the 75%–100% category. They were then averaged across the three groups—managers, nurses, and physicians—to form an average score that could range from 0 to 4. The Cronbach alpha reliability coefficient was 0.82.

We also measured self-reported Lean maturity. Each hospital rated its progress in implementing Lean as one of four stages: (1) start-up; (2) beyond start-up, but challenged moving forward; (3) expanding to other units and getting traction throughout the hospital; or (4) mature transformational performance improvement.

We used multivariable regressions with a 1-year lag to assess the association between the adoption of Lean management by the end of 2014 and eight measures of hospital performance measured in 2015, including the following:

- **Financial performance.** Earnings before interest, taxes, depreciation, and amortization (EBITDA) margin; adjusted inpatient expense per discharge
- **Patient outcomes.** Thirty-day risk adjusted mortality index; death rate among low-mortality diagnosis-related groups (DRGs); 30-day unplanned readmission rate; severity-adjusted length of stay; percentage of ED patients who left without being seen
- **Patient satisfaction.** Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) score

Analyses were run using the statistical software Stata IC 15 and R Version 3.4.1.

For hospitals using Lean tools or methods, descriptive statistics were calculated (in each type of ownership) to identify the mean, standard deviation, and range of the number of hospital units using Lean, the number of tools or methods used, the DMS activities index, the leadership Lean commitment index, and the Lean training index. The proportion of hospitals self-reporting each level of Lean maturity was also used.

Multivariable linear regression analyses were conducted to evaluate the relationship between Lean adoption by the end of 2014 on the eight outcome variables of interest measured in 2015, controlling for seven organizational and market variables that were found in previous research to be related to both Lean adoption and outcomes: Census division (region) in which hospital is located, statistical area type (e.g., metropolitan), bed size, member of a system or network, member of the Council of Teaching Hospitals and Health Systems, Herfindahl–Hirschman Index of market concentration, and percentage of Medicaid discharges (Shortell et al., 2018). Statistical significance was defined at an alpha level of 0.10 because of the exploratory nature of this research.

Data Sources

Data for these analyses were compiled from several sources, including the 2017 National Survey of Lean/Transformational Performance Improvement in Hospitals, 2015 AHA Annual Survey, 2015 CMS Medicare Cost Report, 2015 Hospital Compare, 2015 CMS MedPAR (Medicare Provider Analysis and Review) files, and the 2015 CMS Hospital Service Area file. The national survey took approximately 20 minutes to complete by the chief transformation officer, chief improvement officer, chief quality officer, or equivalent position in each hospital. (This survey was considered exempt by the University of California, Berkeley Institutional Review Board.) Table 1 lists all of the independent, dependent, and control variables for the regression analyses, including the variable description, year measured, and data source.

RESULTS

A total of 1,222 hospitals completed the national survey, for a 27.2% response rate. Our analyses include the 1,210 hospitals for which we have complete data.

Extent of Lean Adoption Among Public Hospitals

Table 2 shows that 54.2% of public hospitals responded that they were currently engaged in any Lean compared to 78.3% of nonprofit hospitals and 36.5% of for-profit hospitals ($p = .0000$).

TABLE 1
Independent, Dependent, and Control Variables

Variable	Description	Year Measured	Source
Independent variable			
Started Lean by end of 2014	Binary indicator based on survey responses: Yes = hospital reported adopting Lean, Lean Plus Six Sigma, and/or Robust Process Improvement, and reported that they first began implementing it by December 2014; No = hospital reported that it had never implemented Lean, Lean Plus Six Sigma, or Robust Process Improvement, or reported that it began implementing after the end of 2014	2017	National Survey of Lean/ Transformational Performance Improvement in Hospitals
Dependent variables			
EBITDA margin	Percent: Earnings before interest, tax, depreciation, and amortization/total operating revenue	2015	Medicare Cost Reports
Adjusted inpatient expense per discharge	Cost: Cost per inpatient discharge adjusted for case mix and area wage indices	2015	Medicare Cost Reports
Severity adjusted length of stay	Days: Geometric mean length of inpatient stay, adjusted for severity of diagnosis	2015	CMS Hospital Compare
Percentage of patients who left ED without being seen	Percent: Patients who left ED without being seen/all patients	2015	CMS Hospital Compare
30-day risk adjusted mortality index	Percent: 30-day risk adjusted mortality, averaged across patients with heart failure, pneumonia, AMI, COPD, stroke	2015	CMS Hospital Compare
Death rate in low-mortality DRGs	*z*-score: Risk-adjusted in-hospital deaths per 1,000 adult discharges for low mortality DRGs (observed—expected/ standard deviation). Rates were transformed to *z*-scores to normalize the distribution	2015	AHRQ Quality Indicators (based on Medicare beneficiary population only—MedPAR)
30-day unplanned readmission rate	Percent: Patients readmitted to the hospital within 30 days of discharge/all discharges (adjusted for severity of diagnosis)	2015	CMS Hospital Compare

TABLE 1
Continued

Variable	Description	Year Measured	Source
HCAHPS score	Index: Patient responses to the question "How do you 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)	2015	CMS Hospital Compare
Control variables			
Region	Categorical dummy variable for U.S. regions: Northeast, Midwest, South, and West	2015	AHA Annual Survey
Core-based statistical area type	Categorical: Metropolitan (urban area of at least 50,000 people), micropolitan (urban areas between 10,000 and 50,000 people), or rural (nonurban area)	2015	AHA Annual Survey
Bed size	Categorical: 1–99 beds, 100–399 beds, or 400 or more beds	2015	AHA Annual Survey
Member of a system or network	Binary	2015	AHA Annual Survey
Member of council of teaching hospitals	Binary	2015	AHA Annual Survey
Market concentration	Categorical: Unconcentrated (HHI from 100 to <1,500), moderately concentrated (HHI from 1,500 to <2,500), highly concentrated (HHI ≥ 2,500)	2015	CMS Hospital Service Area File
Percentage of Medicaid discharges	Percent: Number of discharges under Medicaid/total discharges	2015	Medicare Cost Report

TABLE 2
Lean Implementation by Hospital Ownership, 2017

Characteristic	Total *N*	Hospital Ownership *n* (column %) or *M* (*SD*); Range		
		Public (*n* = 288)	Nonprofit (*n* = 826)	For-Profit (*n* = 96)
Currently engaged in any Lean, Lean plus Six Sigma, or Robust Cap Process Improvement*	1,210	156 (54.2%)	647 (78.3%)	35 (36.5%)
Implementation of Lean components among hospitals doing any Lean *n* (%) or mean (SD); range				
Using Lean as primary process improvement approach	812	88 (57.9%)	387 (61.8%)	16 (47.1%)
Number of years doing Lean* [a < b; b > c]	769	4.58 (3.51); 0.25–22.5	5.43 (3.59); 0.25–19.1	3.74 (4.05); 0.33–21.2
Number of hospital units using Lean (0–29)* [a < b]	798	11.92 (7.48); 0–28	14.74 (7.20); 0–29	14.61 (7.04); 1–28
Number of Lean tools/ methods (0–15)* [a < b]	737	4.35 (3.70); 0–15	5.20 (3.82); 0–15	5.81 (3.05); 1–14
Lean Training Index (0–4)	727	1.80 (0.88); 0.00–3.67	1.95 (0.86); 0.00-4.00	2.06 (0.89); 0.67-3.67
Leadership Lean Commitment Index (0–8)* [a < b; a < c]	764	4.81 (2.49); 0–8	5.41 (2.36); 0–8	6.32 (1.81); 1–8
Lean Daily Management System Index (0–9)* [a < b]	742	4.98 (2.66); 0–9	5.66 (2.50); 0–9	6.06 (2.69); 0–9
Self-reported Lean maturity*	803			
New start-up stage	117	32 (21.3%)	78 (12.6%)	7 (21.2%)
Beyond start-up, but challenged moving forward	212	50 (33.3%)	156 (23.2%)	6 (18.2%)
Expanding to other units and getting traction throughout the hospital	373	59 (39.3%)	301 (48.5%)	13 (39.4%)
Have become a mature transformational performance improvement hospital	101	9 (6.0%)	85 (13.7%)	7 (21.2%)

Note. *$p < .05$ (chi-square test or *F*-test). In cases of a significant *F*-test, post-hoc comparisons (Tukey's Honest Significant Difference method) are indicated in parentheses.

Lean-adopting public hospitals had been doing Lean for an average of 4.58 years in comparison to 5.43 years for nonprofits and 3.74 years for for-profit hospitals ($p = .0002$). The percentages of hospitals using Lean as their primary performance improvement approach among for-profit, public, and nonprofit hospitals were 47.1%, 57.9%, and 61.8%, respectively, but the differences in those percentages were not statistically significant.

Extent of Lean Implementation Among Lean-Adopting Public Hospitals

Table 2 also reveals that Lean-adopting public hospitals implemented Lean in an average of 11.92 out of 29 possible hospital units, significantly lower than nonprofit hospitals ($p < .05$). Lean-adopting public hospitals used Lean most frequently in the ED (83.3%), operating room (78.5%), and medical/surgical nursing units (77.6%). Public hospitals on average used 4.35 out of 9 potential Lean tools or methods, also lower than nonprofit hospitals ($p < .05$). Public hospitals on average scored 1.80 out of a maximum of 4.0 on the Lean training index, and 4.81 out of a maximum of 8.0 on the leadership Lean commitment index, significantly lower than the average scores for nonprofit and for-profit hospitals ($p < .05$). Public hospitals had an average score of 4.98 out of a maximum of 8.0 on the Lean DMS index, significantly lower than the average score for nonprofit hospitals. The most common Lean DMS activities used were daily huddles (84.4%), PDSA cycles (75.0%), visual management (65.7%), and use of standard work (65.5%). Although public hospitals did not differ significantly from for-profit hospitals on our measures of Lean implementation (with the exception of the Lean Leadership Commitment Index), the differences in the average scores for each of these measures was in the direction predicted. Finally, public hospitals were more likely than nonprofit and for-profit hospitals to self-report that they are in the new start-up stage, and less likely to report that they have become a mature transformational performance improvement hospital ($p < .05$).

Associations Between Lean Adoption by 2014 and 2015 Measures of Hospital Financial Performance, Patient Outcomes, and Patient Satisfaction

Table 3 shows the data for our control and dependent variables for public hospitals grouped by whether they adopted Lean by 2014. All of our control variables are associated with Lean adoption by 2014 at $p < .05$ significance level, justifying their inclusion in our regression analyses. Of the dependent variables, the simple bivariate measure of association with Lean adoption by 2014 is significant only for EBITDA margin ($p < .05$) and severity adjusted length of stay ($p < .05$). The results of the regression runs assessing the relationships between Lean adoption prior to the end of 2014 and the eight financial performance, patient outcome, and satisfaction indicators measured in 2015 are summarized in Table 4. Controlling for organization and market variables, only the positive association with EBITDA margin ($b = 0.0420$, $p = .020$) and the negative association with percentage of patients leaving the ED without being seen ($b = -0.610$, $p = .068$) were statistically significant. (Full regression results

TABLE 3
Control and Dependent Variable Descriptive Statistics of Public Hospitals by Lean Status at the End of 2014

Characteristic	Total *N*[a]	Public Hospitals Doing Lean by End of 2014 (*n* = 91) *n* (row %) or *M* (*SD*); Range	Public Hospitals Not Doing Lean by End of 2014 (*n* = 190) *n* (row %) or *M* (*SD*); Range
Control variables			
Region* (total *n* = 281)			
Midwest	103	27 (26.2%)	76 (73.8%)
Northeast	7	6 (85.7%)	1 (14.3%)
South	101	41 (40.6%)	60 (59.4%)
West	70	17 (24.3%)	53 (75.7%)
Core-based statistical area type* (*n* = 281)			
Metropolitan (urban area more than 50,000 people)	93	48 (51.6%)	45 (48.4%)
Micropolitan (urban area between 10,000 and 50,000 people)	57	20 (35.1%)	37 (64.9%)
Rural	131	23 (17.6%)	108 (82.4%)
Bed size* (*n* = 281)			
1–99 beds	186	37 (19.9%)	149 (80.1%)
100–399 beds	61	31 (50.8%)	30 (49.2%)
400+ beds	34	23 (67.6%)	11 (32.4%)
Member of a system or network* (*n* = 257)			
Yes	138	57 (41.3%)	81 (58.7%)
No	119	32 (26.9%)	87 (73.1%)
Member of Council of Teaching Hospitals* (*n* = 281)			
Yes	23	16 (69.6%)	7 (30.4%)
No	258	75 (29.1%)	183 (70.9%)
Market Concentration (HHI)*	280	1,056.4 (1,901.9); 151.7–10,000	1,836 (2,628.6); 151.7–10,000
Percent Medicaid Discharges*	278	12.4% (12.2); 0.0–65.4	8.59% (8.6); 0.0–46.0

TABLE 3
Continued

Characteristic	Total N^a	Public Hospitals Doing Lean by End of 2014 (n = 91) n (row %) or M (SD); Range	Public Hospitals Not Doing Lean by End of 2014 (n = 190) n (row %) or M (SD); Range
Dependent variables			
EBITDA margin*	274	0.1 (0.1); −0.4–0.3	0.1 (0.2); −2.5–0.4
Adjusted inpatient expense per discharge	131	7,874.6 (2,076.1); 4,289.6–14,555.6	8,657.0 (4,633.8); 4,888.5-30,689.5
Severity adjusted length of stay*	280	3.6 (1.3); 1.4–10.0	3.1 (1.6); 0.6–19.5
Percent of patients who left ED without being seen	144	2.3 (1.9); 0.0–9.0	2.2 (1.9); 0.0–8.0
30-day risk adjusted mortality index	75	13.9 (0.8); 12.2–15.3	14.0 (1.1); 12.4–17.6
Death rate in low-mortality DRGs	202	0.001 (0.002); 0.000–0.014	0.002 (0.007); 0.000–0.056
30-day unplanned readmission rate	250	15.7 (1.0); 13.1–18.3	15.6 (0.7); 13.8–18.3
HCAHPS score	225	264.7 (11.7); 231.0–290.0	265.3 (13.3); 211.0–291.0

Note. DRG = diagnosis-related group; EBITDA = earnings before interest, taxes, depreciation, and amortization; HCAHPS = Hospital Consumer Assessment of Healthcare Providers and Systems; HHI = Hirfindahl–Hirschman Index, NS = not significant.

[a]Column totals vary because of missing data. *$p < .05$ (t-test).

TABLE 4
Regression Results: Implemented Any Lean by 2014 and Financial, Patient Outcome, and Patient Satisfaction Measures, Controlling for Organizational and Market Variables

Dependent Variable	Sample Size for the Regression Analysis[a]	*b* for Independent Variable: Started Lean by End of 2014	Significance of *b*
EBITDA margin	250	0.042	<0.05
Adjusted inpatient expense per discharge	126	−730	NS
Severity-adjusted length of stay	254	−0.191	NS
Percentage of patients who left ED without being seen	138	−0.610	<0.10
30-day risk adjusted mortality index	74	0.158	NS
Death rate in low-mortality DRGs	184	1.11	NS
30-day unplanned readmission rate	227	−0.102	NS
HCAHPS score	205	1.12	NS

Note. DRG = diagnosis-related group; EBITDA = earnings before interest, taxes, depreciation, and amortization; HCAHPS = Hospital Consumer Assessment of Healthcare Providers and Systems; NS = not significant.
[a]Sample size varies because of missing data.

are provided as Appendix A to this article, published online as Supplemental Digital Content at http://links.lww.com/JHM/A35).

DISCUSSION AND IMPLICATIONS

The majority of U.S. public hospitals have adopted some form of Lean. In comparing the rate of Lean adoption for public hospitals with the rates of for-profit and nonprofit hospitals, our first hypothesis receives partial support. As predicted, public hospitals have a lower rate of adoption than nonprofit hospitals, but contrary to our prediction, they have a higher adoption rate than for-profit hospitals. We also found that the mean length of time public hospitals have been doing Lean also falls between the means for nonprofit and for-profit hospital groups. One possible explanation for these unexpected findings is that for-profit hospitals may tend to have stronger "hierarchical" and "command and control" dimensions to their organizational cultures that must be changed to be more accepting of Lean, which emphasizes employee empowerment and decentralized decision-making.

We explored whether Lean-adopting hospitals tend to use Lean in conjunction with other performance improvement initiatives. In analyses not shown here, we found that substantial proportions of Lean-adopting hospitals also used other performance improvement approaches, including benchmarking (88%), Focus PDCA (Plan Do Check Act) (59%), high-reliability organization (52%), and the Model for Improvement (35%). In fact, the percentage of Lean-adopting public hospitals that used each of these additional performance improvement approaches was higher than the corresponding percentage for nonadopting public hospitals, which suggests that Lean-adopting public hospitals may share cultural beliefs, leadership, and other characteristics that support multiple

and multifaceted performance improvement initiatives.

Hypothesis 2, which predicts lower extent of Lean implementation in public hospitals than either nonprofit or for-profit hospitals, is supported across multiple measures. The average score on the Lean Leadership Commitment Index for public hospitals is lower than the score for either nonprofit or for-profit hospitals. Also, on the self-reported Lean maturity measure, public hospitals are more likely than nonprofit or for-profit hospitals to report that they are in the "new start-up" stage and less likely to report they "have become a mature transformational performance improvement hospital." With respect to the number of hospital units using Lean, number of Lean tools and methods used, and the number of Lean DMS activities routinely used, the scores for public hospitals are significantly lower than for nonprofit hospitals. With respect to for-profit hospitals, the public hospital scores on these measures are lower, as predicted, but do not achieve statistical significance, probably due to the relatively small sample of for-profit hospitals.

These results show that Lean-adopting public hospitals fall well short of full implementation of Lean and lag behind nonprofit hospitals, and possibly for-profit hospitals as well. It appears that although for-profit hospitals are less likely than public hospitals to adopt Lean, those that do adopt Lean have the resources and capabilities to implement Lean more extensively than public hospitals. The challenges public hospitals experience in implementing Lean may be the result of relatively fewer resources to invest in expanding Lean and other contextual factors such as the extent of experience with quality improvement, the capabilities of the information infrastructure, and the abilities of human resources departments to recruit and develop staff with skills to support Lean management.

Our results provide partial support for our third hypothesis, which reveals that among public hospitals, adoption of Lean by 2014 was favorably associated with 2015 measures of financial performance, patient outcomes, and patient satisfaction. Based on multivariable linear regression models for each of the eight dependent variables, controlling for market, regional, and organizational characteristics, Lean adoption by 2014 was significantly associated with two of four measures of hospital efficiency: an increase in EBITDA margin and reduction in the percentage of patients who left the ED without being seen. These results are consistent with the findings of a small number of Lean evaluation studies, which indicates that Lean has reduced hospital costs and decreased ED left-without-being-seen rates (Holden, 2011; Moraros et al., 2016). By means of eliminating steps that do not add value and standardization of care processes, Lean may be reducing unnecessary hospital spending and increasing ED process efficiency, thus increasing the number of ED patients who can be seen by a doctor.

While two of four efficiency metrics were significantly associated with Lean adoption, no statistically significant associations were found across the patient outcome and patient satisfaction measures. It is possible that the primary interest in Lean implementation at public hospitals has been on improving efficiency, with lesser attention given to improving patient outcomes. Also, improving patient outcomes is likely

to be more challenging than improving financial performance because patient outcomes are linked to complex care processes, hard-to-change clinical cultures, and care provided by multiple caregivers across the continuum of care. The lack of patient engagement in Lean transformation work may also be hindering efforts to improve patient outcomes. Previous research has shown that although Lean performance improvement efforts frequently focus on patients and patient care pathways (Crema & Verbano, 2017), typically there is little patient input into care redesign (Glasgow et al., 2010; Holden, 2011).

Study Limitations

Our study had several limitations. Although the 27% response rate to the national survey is slightly above that of most AHA special topic hospital surveys (P. Kralovec, personal communication, February 4, 2017), it raises concern that there may be a response bias in our study sample. In analyses not shown here, we did find relatively small but statistically significant differences between responding and nonresponding hospitals by ownership, bed size, teaching status, and region. Although our analyses controlled for the possible confounding effects of these and other organizational and market characteristics, there might be 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.

Unfortunately, we were not able to assess the effects of different types of organizational changes that hospital leaders made in implementing Lean in their organizations prior to the end of 2014. The implementation of organizational changes to streamline and improve key work processes may take a number of years. Although we investigated the relationship between hospital performance and the number of years that Lean had been implemented (analyses not shown), the results were not significant, suggesting that in at least some cases Lean implementation over time does not progress linearly.

Future research using longer lag times between Lean implementation and performance assessment and interviews, observations, and related qualitative methods are needed to address these issues. The findings, of course, are restricted to the public hospital sector of healthcare and do not address the ambulatory/primary care or post-acute care sectors. Future research should address the Lean implementation–performance relationship in these sectors.

CONCLUSION

This research reported here provides the first in-depth analysis of Lean in U.S. public hospitals. The findings provide public hospital leaders and policymakers with improved data to benchmark Lean implementation and explore opportunities for improvement. Further research regarding Lean is needed in public and safety-net hospital settings. Quantitative, large-sample studies using longitudinal designs in combination with case studies of individual public hospitals undergoing Lean transformation could identify factors that would help public hospitals more effectively use their limited resources for performance improvement.

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REFERENCES

Barnas, K. (2014). *Beyond heroes: A Lean management system for healthcare*. Appleton, WI: ThedaCare Center for Healthcare Value.

Becker, B. E., Huselid, M. A., & Ulrich, D. (2001). *The HR scorecard: Linking people, strategy, and performance*. Boston, MA: Harvard Business School Press.

Centers for Medicare & Medicaid Services. (2017a, June 10). Hospital-acquired condition reduction program. Retrieved from www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/HAC-Reduction-Program.html

Centers for Medicare & Medicaid Services. (2017b, June 10). Hospital value-based purchasing program. Retrieved from www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/Value-Based-Programs/HVBP/Hospital-Value-Based-Purchasing.html

Centers for Medicare & Medicaid Services. (2018a, May 5). Medicare Access and CHIP Reauthorization Act. Retrieved from www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/Value-Based-Programs/MACRA-MIPS-and-APMs/MACRA-MIPS-and-APMs.html

Centers for Medicare & Medicaid Services. (2018b, May 5). Readmissions reduction program. Retrieved from www.cms.gov/medicare/medicare-fee-for-service-payment/acuteinpatientpps/readmissions-reduction-program.html

Chassin, M. R., & Loeb, J. M. (2013). High-reliability health care: Getting there from here. *The Milbank Quarterly*, *91*(3), 459–490. doi.org/10.1111/1468-0009.12023

Crema, M., & Verbano, C. (2017). Lean management to support choosing wisely in healthcare: The first evidence from a systematic literature review. *International Journal for Quality in Health Care*, *29*(7), 889–895. doi.org/10.1093/intqhc/mzx135

Felland, L. E., & Stark, L. (2012). Local public hospitals: Changing with the times. *Research Brief*, (*25*), 1–13.

General Electric Co. (2015). *CAP toolkit 2015 change acceleration process (CAP) workshop: Leading effective change*. Retrieved from https://uscan.gehealthcarepartners.com/Upload/Results/636273614909214859.pdf

Glasgow, J. M., Scott-Caziewell, J. R., & Kaboli, P. J. (2010). Guiding inpatient quality improvement: A systematic review of Lean and Six Sigma. *The Joint Commission Journal on Quality and Patient Safety*, *36*(12), 533–540. doi.org/1016/S1553-7250(10)36081-8

Holden, R. J. (2011). Lean thinking in emergency departments: A critical review. *Annals of Emergency Medicine*, *57*(3), 265–278. doi.org/10.1016/j.annemergmed.2010.08.001

Hussey, P. S., Liu, J. L., & White, C. (2017). The Medicare Access and CHIP Reauthorization Act: Effects on Medicare payment policy and spending. *Health Affairs*, *36*(4), 697–705. doi.org/10.1377/hlthaff.2016.0559

Lee, J. Y., McFadden, K. L., & Gowen, C. R.III (2016). An exploratory analysis for Lean and Six Sigma implementation in hospitals: Together is better? *Health Care Management Review*, *43*(3), 182–192. doi.10.1097/HMR.0000000000000140

Mann, D. (2015). *Creating a Lean culture: Tools to sustain Lean conversations*. 3rd ed. Boca Raton, FL: CRC Press.

Moraros, J., Lemstra, M., & Nwankwo, C. (2016). Lean interventions in healthcare: Do they actually work? A systematic literature review. *International Journal for Quality in Health Care*, *28*(2), 150–165. doi.org/10.1093/intqhc/mzv123

Rosenthal, M. B., Fernandopulle, R., Song, H. R., & Landon, B. (2004). Paying for quality: Providers' incentives for quality improvement. *Health Affairs*, *23*(2), 127–141. doi.org/10.1377/hlthaff.2016.0559

Ryan, A. M., & Damberg, C. L. (2013). What can the past of pay-for-performance tell us about the future of value-based purchasing in Medicare? *Healthcare*, *1*(1–2), 42–49. doi.org/10.1016/j.hjdsi.2013.04.006

Shook, J. (2008). *Managing to learn: Using the A3 management process to solve problems, gain agreement, mentor and lead*. Cambridge, MA: Lean Enterprise Institute.

Shortell, S. M., Blodgett, J. C., Rundall, T. G., & Kralovec, P. (2018). Use of Lean and related transformational performance improvement systems in hospitals in the United States: Results from a national survey. *Joint Commission Journal on Quality and Patient Safety*, *44*(10), 574–582. doi.org/10.1016/j.jcjq.2018.03.002

Spear, S. J. (2004). Learning to lead at Toyota. *Harvard Business Review*, *82*(5), 78–86.

Taher, D., Landry, S., & Toussaint, J. (2016). Breadth vs. depth: How to start deploying the daily management system for your Lean transformation. *Journal of Hospital Administration*, *5*(6), 90–96. doi: 10.5430/jha.v5n6p90

Toussaint, J., & Gerard, R. A. (2010). *On the mend: Revolutionizing healthcare to save lives and transform the industry.* Cambridge, MA: Lean Enterprise Institute.

Vest, J. R., & Gamm, L. D. (2009). A critical review of the research literature on Six Sigma, Lean and Studer Group's Hardwiring Excellence in the United States: The need to demonstrate and communicate the effectiveness of transformation strategies in healthcare. *Implementation Science*, *4*(1), 35. doi.org/10.1186/1748-5908-4-35

PRACTITIONER APPLICATION: Lean Management and U.S. Public Hospital Performance: Results From a National Survey

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Po, Rundall, Shortell, and Blodgett have faced the challenge of determining if implementation of Lean practices makes a significant impact on hospital finances, national health outcome, and patient satisfaction data. They developed scoring mechanisms to measure the level and reach of implementation, including key areas that affect the success of Lean practices at a hospital such as leadership commitment to Lean and staff understanding of Lean principles.

The authors noted that some hospitals might use other performance improvement techniques along with Lean practices, which would indicate that they are committed to improving operations. Even though implementing various performance initiatives complicated the determination of how much Lean implementation itself leads to any improvement, the process improvement techniques that hospitals reported using—including Lean practices—involve similar core steps. Lean or not, these techniques assess the ways in which a process can be adjusted to measure and maintain the improvement.

Po et al. hypothesized that Lean implementation results in better financial performance, patient outcomes, and patient satisfaction. Emergency departments (EDs) showed the greatest extent of Lean adoption. This is understandable, as increasingly efficient triage, treatment, and discharge processes lead to more patients being seen and more

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