

Assessing the relationship of the human resource, finance, and information technology functions on reported performance in hospitals using the Lean management system

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Background: Given pressures to control costs and improve quality of care, one of the most prevalent transformational performance improvement approaches in health care is Lean management. However, the roles of support functions such as human resource (HR), finance, and information technology (IT) in Lean management and the relationships of these support functions with performance are unknown.

Purpose: The aim of this study was to examine the relationships between the HR, finance, and IT functions, overall Lean implementation, and self-reported performance improvement in hospitals that have implemented Lean.

Methodology/Approach: Data from a national survey of Lean in U.S. hospitals ($N = 1,222$; 847 reported using Lean) were analyzed using multivariable regression and bootstrapped mediation analysis. The extent to which HR, finance, and IT functions support Lean management was measured using indices including six, three, and six items respectively. Lean implementation was measured by the number of units doing Lean (up to 29) and by a four-level self-reported maturity scale. Performance improvement was measured using an index of self-reported achievements (ranging from 0 to 16).

Results: There were significant positive associations between Lean HR, finance, and IT functions and self-reported performance impact (controlling for organizational and market variables). Tests of mediation indicated that the associations of HR, finance, and IT functions with self-reported performance were significantly mediated by the number of Lean units (mediated proportion ranging from 40% to 73%), and HR function was also mediated by self-reported maturity (61% mediated). There were no moderating effects.

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

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Conclusion: HR, finance, and IT functions are positively associated with self-reported Lean impact on performance and primarily explained by the overall degree of Lean implementation.

Practice Implications: Efforts to align HR, finance, and IT functions with overall Lean implementation can help to ensure that frontline caregivers and managers have the data and skills required to meet transformational improvement goals.

As the U.S. health care system attempts to respond to the growing pressures to control costs and improve the quality of care, there is increased interest in the use of transformational performance improvement initiatives. Among the most prevalent of these are the Lean management system and the related Lean plus Six Sigma and Robust Process Improvement approaches. Recent research indicates that 69% (61% adjusted for response bias) of U.S. hospitals have adopted one of these approaches, and they have been found to be positively associated with self-reported performance impact in such areas as eliminating waste in two or more departments, improved patient flow in the emergency department, and increasing employee engagement in their work (Shortell, Blodgett, Rundall, & Kralovec, 2018).

The Lean management system based on the Shingo principles (Liker, 2004) is defined as a performance improvement approach that develops a continuous improvement culture that empowers frontline workers and managers (nurses, physicians, and staff) to solve problems and eliminate waste by standardizing work to improve the value of care provided to patients. Six Sigma adds a variance reduction component to Lean, and Robust Process Improvement adds a structured change management module (Chassin & Loeb, 2013; Koning, Verver, Heuvel, Bisgaard, & Does, 2006). In health care, Lean and the related approaches have been used most directly to eliminate waste in selected departments and improve patient flow and quality of care in emergency departments, medical surgical units, the operating room, and laboratory. Although there is evidence of positive results in such applications (Bradywood, Farrokhi, Williams, Kowalczyk, & Blackmore, 2017; Ford et al., 2012; Muder et al., 2008; Vermeulen et al., 2014), systematic reviews of the Lean research evidence base suggest that overall the evidence is weak: Findings are subject to alternative explanations, and there is lack of studies on the overall organizational impact of Lean (Anderson, Røvik, & Ingebrigtsen, 2014; Deblois & Lepanto, 2016; Leggat, Bartram, Stanton, Bamber, & Sohal, 2015; Mazzocato, Savage, Brommels, Aronsson, & Thor, 2010; Moraros, Lemstra, & Nwankwo, 2016; Poksinska, 2010). Of particular note is the failure to assess the effects of three support departments suggested by some Lean thought leaders as especially important to the effective implementation of a Lean transformation initiative: human resource (HR), finance, and information technology (IT; Toussaint, 2016; Toussaint & Adams, 2015). Some of the mixed results to date may be due to the failure of those implementing Lean to redefine the roles of these functions to support frontline caregivers.

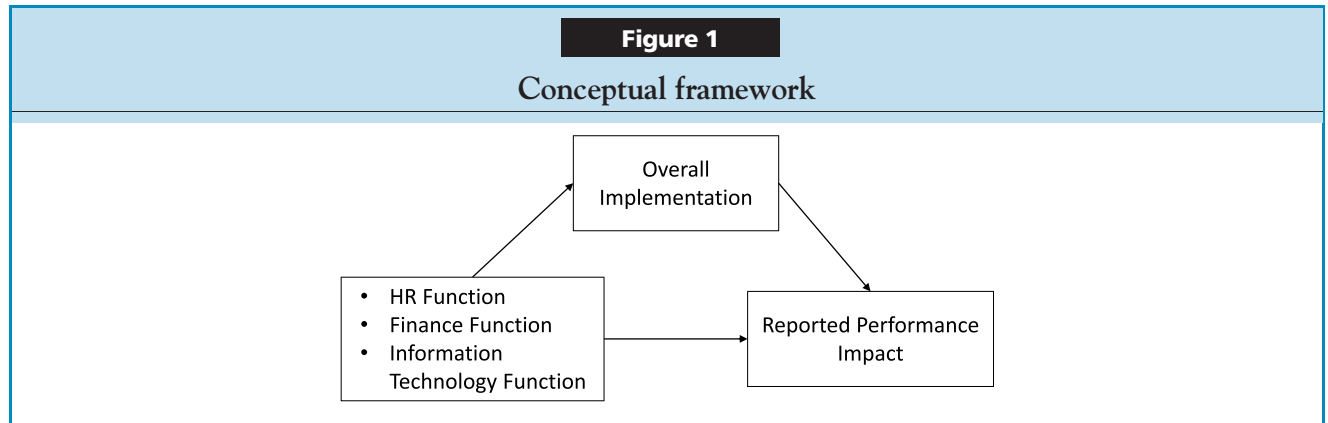
In turn, this might be influenced by the overall degree of Lean implementation in the organization. This article addresses those gaps in the literature and, potentially, in practice.

Theory

A key Shingo principle is the empowerment of frontline workers and managers; in the case of hospitals, this means those who directly provide, assist, or oversee the provision of care to patients. This requires training them in the skills and tools needed for problem solving and continuous improvement of their work—a major responsibility of the HR function of the organization. It also means developing position descriptions and having a recruitment process that aligns with the Lean management philosophy. At the same time, it requires workers to be provided with data and feedback to improve their performance. These data come largely from the finance and IT functions of the organization. The finance department partners with frontline caregivers and managers by regularly providing key financial performance indicators for each unit and helping to interpret those data. They also develop standard work for forecasting purposes (Barnas, 2014). Similarly, the IT function must be reorganized to not only provide data for external quality reporting purposes but also for internal quality improvement related to the everyday work of those managing and providing care. The focus is to provide data for problem solving and to provide ready access to quality, safety, and patient experience scores at the unit level (Toussaint, 2016; Toussaint & Adams, 2015). Lean hospitals with strong support functions in HR, finance, and IT should have a higher likelihood of having a positive impact on performance. Thus, our first hypothesis:

H1: Hospitals that have implemented Lean in their HR, finance, and IT functions to support frontline empowerment of managers and caregivers to solve problems will have higher reported impact on performance.

The ability of a hospital to transform their HR, finance, and IT functions, however, may also be influenced by how far along they are in their Lean performance improvement journey. As a hospital spreads Lean management over time, it is likely to influence the relationship that the three support functions have on performance (see Figure 1). The extent of overall Lean implementation may mediate or moderate the relationship between these support functions and reported performance.



H2A: The relationship between the HR, finance, and IT functions and reported performance will be mediated by the hospital's overall degree of Lean implementation.

H2B: The relationship between the HR, finance, and IT functions and reported performance will be moderated by the overall degree of Lean implementation, with a stronger relationship the greater the degree of overall Lean implementation.

Methods

Data Sources

The data for the present analysis comes from the National Survey of Lean/Transformational Performance Improvement in Hospitals fielded by the American Hospital Associations' Survey Data Center between May and September 2017, with a completion rate of 27% ($N = 1,222$ hospitals). The survey was sent to all 4,500 acute, general medical/surgical and pediatric hospitals in the United States and was completed by the Chief Transformational Officer, Continuous Performance Improvement Officer, Chief Quality Officer, Chief Medical Director, or similar position title in each hospital. The responding hospitals were somewhat more likely to be not-for-profit; to be a member of the Council of Teaching Hospitals; to be larger in size; and less likely to be located in the South and more likely to be located in the West. The survey was approved by the institutional review board of the University of California, Berkeley. Further details on the survey are available in Shortell et al. (2018).

This analysis focuses on the 847 responding hospitals that reported that they were doing Lean at the time of the survey. The sample size varies for different analyses due to missing data.

Measures

The measures of Lean implementation in the three functional areas were based on a review of the Shingo principles underlying Lean (Liker, 2004) and the work of Toussaint and Adams (2015), Toussaint (2016), and Barnas (2014). All of the measures are shown in Table 1. HR was measured

by a composite index including six items ($\alpha = .85$) with the response categories being *strongly disagree*, *disagree*, *neither agree nor disagree*, *agree*, and *strongly agree*. The composite index was based on the number of responses rated "agree" or "strongly agree."

The finance function was measured by a composite index (calculated using the methods described above), including three items shown in Table 1 ($\alpha = .74$):

The IT function was measured by a composite index (calculated using the methods described above), including six items shown in Table 1 ($\alpha = .80$).

The overall degree of Lean implementation was measured both by the number of hospital units doing Lean and by a self-reported degree of maturity measure that involved selecting one of four categories: We are in a start-up stage; we are beyond start-up, but challenged moving forward; we are expanding to other units and getting traction throughout the hospital; or we have become a mature transformational performance improvement hospital. The number of units doing Lean measured the breadth of Lean implementation, while the self-reported maturity level also considered the depth of implementation.

The self-reported performance index was a composite measure equal to the count of performance improvements up to 16 that the respondent indicated could be primarily due to Lean. Examples included eliminating waste in two or more processes or departments, reducing expenditures in two or more departments, and improving employee engagement in their work (see Table 1 for the full list).

Data Analysis

Descriptive statistics on the study variables are reported using the mean and standard deviation. The relationships among the measures of the support function indices and hospital characteristics of ownership, member of a system/network, location, member of Council of Teaching Hospitals, and size are assessed using t tests or analysis of variance with post hoc comparisons using Tukey's honestly significant difference method. The hypotheses were examined using

Table 1
Composite measures

Composite	Items included
HR function ^a alpha = .85	<ol style="list-style-type: none"> 1. Our hospital's HR department is an important partner in achieving our Lean goals and objectives. 2. Our HR team's primary role is to act as advisors to managers. 3. Our hospital's HR department provides managers with the data and analysis they need to achieve their goals. 4. Our hospital's HR department works with hospital leaders to redefine job roles and responsibilities to ensure alignment with Lean operating philosophy and management principles. 5. Our hospital's personnel recruitment process takes into account candidate's preparation to work in a Lean environment. 6. The people in the hospital are well trained in Lean management philosophy and principles.
Finance function ^a alpha = .74	<ol style="list-style-type: none"> 1. Our organization's finance department is an important partner in achieving our Lean goals and objectives. 2. Our finance team's primary role is to act as advisors to managers. 3. Our hospital's finance department provides managers with the data and analysis they need to achieve their goals.
IT function ^a alpha = .80	<ol style="list-style-type: none"> 1. Our hospital's IT department is an important partner in achieving our Lean goals and objectives. 2. Our IT team's primary role is to act as advisors to managers. 3. Our hospital's IT department provides managers with the data and analysis they need to achieve their goals. 4. Our hospital has ready access to data that integrates its clinical and operational processes. 5. Our managers receive very timely data from our IT department. 6. Our managers receive very accurate data from our IT department.
Self-reported performance improvement ^b alpha = .89	<ol style="list-style-type: none"> 1. Eliminated waste in two or more processes or departments. 2. Reduced expenditures in two or more departments. 3. Improved employee engagement in their work. 4. Reduced average length of stay. 5. Reduced medical errors. 6. Improved patient satisfaction scores. 7. Reduced employee turnover. 8. Reduced one or more types of hospital-acquired infections. 9. Reduced ambulatory care sensitive admissions. 10. Reduced hospital re-admissions within 30 days of discharge. 11. Reduced risk adjusted 30-day mortality. 12. Increased throughput in the emergency department. 13. Increased throughput in the operating rooms. 14. Increased throughput in the cardiac care unit. 15. Increased throughput in med/surg nursing units. 16. Other significant achievement.

Note. HR = human resource; IT = information technology.

^aItems were rated on a 5-point scale (strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree). The composite index is the number of items rated "agree" or "strongly agree."

^bThe composite index is the total number of improvements that could be primarily attributed to Lean.

multivariable regression, and we calculated the bootstrapped average causal mediated effect and 95% confidence interval using the R package Mediation and 1,000 simulations (Tingley, Yamamoto, Hirose, Keele, & Imai, 2014).

Results

Table 2 presents the descriptive statistics on the study variables. Table 3 shows the differences in the three support

function composite measures by the hospital background characteristics. As shown, there are no differences by ownership or location. HR function is significantly higher for hospitals that are members of a system or network but lower for those who are members of Council of Teaching Hospitals and those of 400 beds or more. Finance function is also lower for those who are members of the Council of Teaching Hospitals. There are no differences for the IT function.

Table 2
Descriptive statistics of control, independent, dependent, and mediation variables

	<i>n</i>	% or mean (<i>SD</i>)
Ownership		
Public	156	18.53%
Not-for-profit	651	77.32%
Investor-owned	35	4.16%
Member of a system or network?		
Yes	678	82.68%
No	142	17.32%
Core-based statistical area type		
Metro (urban area at least 50,000 people)	576	68.41%
Micro (urban area between 10,000 and 50,000 people)	136	16.15%
Rural	130	15.44%
Member of Council of Teaching Hospitals?		
Yes	96	11.40%
No	746	88.60%
Bed size		
1–99 beds	303	35.99%
100–399 beds	387	45.96%
400 or more beds	152	18.05%
HR function (0–6)	741	2.55(1.77)
Finance function (0–3)	744	1.99(1.07)
IT function (0–6)	738	2.73(1.99)
Number of units using Lean (0–29)	807	14.25(7.31)
Self-reported maturity		
New start-up stage	120	14.81%
Beyond start-up, but challenged moving forward	212	26.17%
Expanding to other units and getting traction throughout the hospital	376	46.42%
Have become a mature transformational performance improvement hospital	102	12.59%
Number of self-reported achievements attributed to Lean (0–16)	731	9.07(3.99)

Note. Total *N* varies because of missing data. HR = human resource; IT = information technology.

Regression Model 1 (see Table 4) shows significant positive direct associations of the HR, finance, and IT functions with the self-reported performance index, supporting H1. The regression coefficients show that one-unit increases in the HR, finance, and IT scales are associated with 35%, 33%, and 20% increases in the number of performance impact items, respectively. In Model 2, the number of units using Lean was added to the model producing a significant and positive coefficient, while the coefficients for the three support functions were reduced and no longer significant. The bootstrapped average causal mediated effect of number of units was significant for each of the support functions, and the proportion mediated for HR, finance, and IT was 73%, 40%, and 41%, respectively. This supports H2A. Model 3 substitutes a second measure of degree of overall implementation, the self-reported maturity level. As shown, self-reported maturity is significantly and positively associated with self-reported performance. In Model 3, the support function coefficients are no longer significant at the .05 level, again suggesting a significant mediating effect supporting H2A. However, the bootstrapped average causal mediated effect indicated significant mediation by self-reported maturity

on HR function only (mediating 61% of the effect) and non-significant mediation of the effect of finance and IT function.

To test our moderating Hypothesis H2B, we conducted additional analyses including interaction terms for each of the HR, finance, and IT scales with the number units using Lean and self-reported maturity, respectively. None of the interactions was significant (data not shown), providing no support for H2B.

Discussion

This study is the first to our knowledge to empirically examine the important role that the HR, finance, and IT support functions play in transformational performance improvement, such as that represented by the Lean management system. Central to Lean implementation is the empowerment of frontline workers and managers by providing them with the information, skills, and resources to prevent and solve problems as they arise and to continuously improve their work (Barnas, 2014; Liker, 2004; Toussaint & Adams, 2015). This requires the HR, finance, and IT functions of the organization to become partners and advisers to frontline managers and caregivers to provide them with data and analyses to

Table 3

Comparison between background characteristics and departmental indices

	HR function	Finance function	IT function
Ownership			
Public	2.36 (1.83)	2.04 (1.09)	2.71 (2.05)
Not-for-profit	2.56 (1.75)	1.97 (1.06)	2.70 (1.95)
Investor-owned	3.16 (1.66)	2.32 (1.05)	3.35 (2.35)
	F = 2.69	F = 1.77	F = 1.59
Member of system or network?			
Yes	2.64 (1.76)	2.03 (1.06)	2.69 (1.97)
No	2.17 (1.79)	1.83 (1.10)	3.02 (2.03)
	t = 2.65**	t = 1.91	t = -1.63
Core-based statistical area type			
Metro (urban area at least 50,000 people)	2.58 (1.77)	1.98 (1.08)	2.73 (2.03)
Micro (urban area between 10,000 and 50,000 people)	2.55 (1.73)	2.02 (1.08)	2.77 (1.94)
Rural	2.41 (1.81)	2.03 (1.00)	2.70 (1.87)
	F = 0.41	F = 0.11	F = 0.038
Member of Council of Teaching Hospitals?			
Yes	2.16 (1.61)	1.61 (1.10)	2.76 (1.94)
No	2.60 (1.78)	2.04 (1.05)	2.73 (2.00)
	t = -2.29*	t = -3.38**	t = 0.13
Bed size			
a. 1–99 beds	2.50 (1.77)	2.06 (1.03)	2.74 (1.96)
b. 100–399 beds	2.69 (1.79)	2.00 (1.08)	2.72 (2.00)
c. 400 or more beds	2.26 (1.66)	1.85 (1.10)	2.76 (2.03)
	F = 3.06*	F = 1.70	F = 0.02
	b > c		

Note. Results are presented as mean (standard deviation) and test statistic. Significant *F* and *t* values are boldfaces. Significant ($p < .05$) post hoc comparisons (Tukey's honestly significant difference method) are listed under significant overall *F* statistics. HR = human resource; IT = information technology.

* $p < .05$. ** $p < .01$. *** $p < .001$.

accomplish their daily work (Barnas, 2014; Toussaint, 2016). Furthermore, it requires the HR function to redesign job roles and responsibilities to align with Lean operating philosophy and management principles and develop recruitment processes that take into account people's motivation and preparation to work in a Lean culture and environment.

The present findings link these support functions to greater reported performance impact. But this is only part of the story. The significant mediating effects of the degree of overall Lean implementation suggests that the association of the support functions with performance is largely due to the hospital's overall use of and experience with Lean. Based on related research, these hospitals had strong leadership commitment that provided needed resources; consistently implemented a daily management system involving daily huddles, structured problem solving, use of plan, do, study, act (PDSA) cycles, and value stream mapping; and also engaged in greater training of nurses, staff, and physicians in Lean philosophy, principles, and tools (Shortell et al., 2018). These appear to be the main pathways and behaviors associated with greater reported Lean performance impact. The support functions compliment

these behaviors but are not a substitute for them. They likely coevolve over time as hospitals gain experience in implementing the Lean management system. This is supported by data (not shown) indicating that hospitals not implementing Lean in the HR, finance, and IT areas scored significantly lower on the overall indices in each functional area than those hospitals in which Lean was being implemented and used in the three support function areas.

The above findings need to be considered within the context of a number of limitations. Responses to the survey are based on a single informant at a given point in time. The study was not funded to collect data from multiple respondents to assess interrater reliability or directly observe Lean implementation in these functional areas. Although we identified the most knowledgeable person to answer the questions, it is possible that others in the organization may have responded differently. The findings may also be subject to "common method" bias in that the data on self-reported performance were collected on the same survey that asked about the degree of Lean implementation (Podsakoff, MacKenzie, & Podsakoff, 2012). However, the survey was designed to mitigate such bias by separating

Table 4

Regression models and bootstrapped mediation analysis results (dependent variable: self-reported performance improvement)

	Model 1 B (SE) N = 706	Model 2 B (SE) N = 699	Model 3 B (SE) N = 699
(Intercept)	4.77 (0.59)***	2.64 (0.53)***	3.36 (0.60)***
Ownership (ref: public)			
Not-for-profit	1.42 (0.39)***	0.45 (0.35)	0.86 (0.36)*
Investor-owned	0.30 (0.78)	-0.19 (0.69)	0.28 (0.73)
Member of a system or network?	0.97 (0.40)*	0.99 (0.35)**	0.94 (0.37)*
Core-based statistical area type (ref: rural)			
Metro (urban area at least 50,000 people)	-0.01 (0.50)	0.35 (0.44)	-0.19 (0.46)
Micro (urban area between 10,000 and 50,000 people)	-0.20 (0.53)	0.00 (0.46)	-0.13 (0.49)
Member of Council of Teaching Hospitals?	-0.07 (0.56)	-0.50 (0.50)	-0.28 (0.52)
Bed size (ref: 1–99 beds)			
100–399 beds	0.48 (0.39)	0.35 (0.34)	0.52 (0.36)
400 or more beds	0.86 (0.57)	0.68 (0.49)	0.85 (0.52)
HR function^a	0.35 (0.10)***	0.09 (0.09)	0.15 (0.09)
Finance function^b	0.33 (0.16)*	0.22 (0.14)	0.20 (0.15)
IT function^c	0.20 (0.08)*	0.13 (0.07)	0.13 (0.08)
Number of units using Lean		0.27 (0.02)***	
Self-reported maturity (ref: new start-up stage)			
Beyond start-up, but challenged moving forward			1.80 (0.45)***
Expanding to other units and getting traction throughout the hospital			3.71 (0.41)***
Have become a mature transformational performance improvement hospital			5.61 (0.54)***
R²	0.124	0.34	0.269
F	8.94***	29.41***	17.96***

Note. HR = human resource; IT = information technology; ACME = average causal mediated effect; CI = confidence interval.

^aThe effect of the HR index was significantly mediated by the number of units (ACME = 0.241, 95% CI [0.140, 0.340], 73% mediated) and by self-reported maturity (ACME = 0.221, CI [0.040, 0.430], 61% mediated).

^bThe effect of the finance index was significantly mediated by the number of units (ACME 0.154, 95% CI [0.001, 0.31], 40% mediated) and not by self-reported maturity.

^cThe effect of the IT index was significantly mediated by the number of units (ACME = 0.090, 95% CI [0.015, 0.170], 41% mediated) and not by self-reported maturity.

* $p < .05$. ** $p < .01$. *** $p < .001$.

the questions about the three support functions and the self-reported performance items by between 12 and 20 questions and from the overall Lean implementation questions by 53 and 54 questions, respectively, far exceeding the six-question separation recommended in the literature (Weijters, Geuens, & Schillewaert, 2009). Furthermore, the questions used different response formats and scales ranging from 5-point Likert scales to yes/no checklists (Weijters, Cabooter, & Schillewaert, 2010). Also, some of the questions were subjective assessments, whereas others were objective counts. An unrotated exploratory principal components factor analysis of all of the study items explained only 34% of the variance providing some empirical evidence for the lack of “common method” variance. The findings, of course, are based on cross-sectional associations, and causal inferences cannot be drawn. The self-reported

performance impact measure should be validated by examining independent objective performance measures, an important area for ongoing research. Finally, given the difference between responding and nonresponding hospitals, the results cannot be strictly generalized to all U.S. hospitals.

Practice Implications

There are a number of actions that hospital leaders and managers could take to enhance functional support of Lean. The HR, finance, and IT support functions provide frontline and middle managers with the data and training to engage in effective problem solving and continuous improvement work (Fryer, Tucker, & Singer, 2018). Given the high degree of interdependent work in providing patient care, leaders

might also develop cross-functional advisory teams that include staff from HR, finance, and IT working with frontline managers and caregivers (Barnas, 2014). Regular meetings of support staff and frontline caregivers might be established to review performance indicators. The finance function might move away from traditional budgeting to developing rolling real-time information contained in quarterly forecasting reports (Toussaint, 2016). These can be used for quicker adjustment of gaps in financial performance and to take remedial action as needed. Furthermore, the IT and finance functions can work more closely together to link safety and quality data with cost data at the unit level so that return on investment calculations can be made for comparing alternative continuous improvement interventions. For example, what is the return on investment on reducing central line infections by purchasing an automated surveillance system versus making increased investments in staff training? The overarching recommendation for hospital leaders and managers is to align the HR, finance, and IT functions with the organization's overall continuous improvement goals as experience is gained in implementing the Lean management system (Toussaint & Adams, 2015).

Conclusion

The Lean management system and related transformational performance improvement approaches are being increasingly adopted in U.S. hospitals. Implementing Lean requires associated changes in the HR, finance, and IT functions. Transforming these functions to become partners and advisers to operating units and frontline caregivers is associated with greater performance improvement impact. However, this relationship is largely explained by the hospital's overall degree of Lean implementation suggesting that, as Lean is diffused throughout the hospital, changes in the HR, finance, and IT functions take place to support overall alignment. There are a number of actions that hospital leaders and managers can take to further such alignment.

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