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Hospital organizational strategies associated with advanced EHR adoption

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Abstract

Objective: To identify organizational complementarities of adoption and use of electronic health records (EHRs) and assess what organizational strategies were associated with more advanced EHR use.

Data Sources: Primary survey data of US hospitals combined with secondary data from the American Hospital Association Annual Survey and IT Supplement.

Study Design: In this cross-sectional study, we describe hospital organizational practices around EHR adoption and use and identify how these practices coalesce into distinct strategies. We then assess the association between those organizational strategies and adoption of advanced EHR functions.

Data Collection: Primary data collection consisted of surveys sent to 797 US acute care hospitals in 2018-2019, with 451 complete respondents.

Principal Findings: There was significant variation in hospital organizational practices for EHR adoption and use. Factor analysis identified practices in three domains: leadership engagement, human capital, and systems integration. Hospitals in the top quartile of the leadership engagement factor were 14 percentage points more likely to have adopted patient engagement EHR functions ($P = 0.01$) while hospitals in the top quartile of human capital were 14 percentage points less likely to have adopted these functions ($P = 0.02$). Hospitals in the top quartile of systems integration were 12 percentage points more likely to have adopted patient engagement functions ($P = 0.02$) and 14 percentage points more likely to have adopted EHR data analytics functions ($P = 0.02$).

Conclusions: Our findings suggest that specific organizational strategies are associated with more advanced EHR adoption. Hospital leaders interested in realizing more value from their EHR investment may find it useful to know that there is an association between adoption of more advanced EHR functions, and engaging senior leadership as well as building connectivity between clinical and administrative systems.

KEYWORDS

electronic health records, hospitals, information technology in health, organizational behavior and management, Technology Adoption/Diffusion/Use

What is Known

- Despite widespread adoption, it is unclear what is required to derive value from electronic health records (EHRs).
- Evidence from other industries shows that organizational complementarities are critical to realizing performance improvement from IT.
- Prior research has examined specific complementarities relevant to EHRs, such as frontline user training.

What This Study Adds

- Our study offers the first large-scale measures of organizational practices related to hospital EHR adoption, revealing significant variation in these practices.
- Organizational practices center around three main strategies: leadership engagement, human capital, and systems integration.
- There may be an opportunity to improve EHR value from identifying and sharing best practices, which could be supported by policy efforts such as the EHR Reporting Program.

1 | INTRODUCTION

Following the passage of the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009, electronic health records (EHR) were rapidly adopted by hospitals across the United States.¹⁻⁵ While HITECH successfully drove hospital EHR adoption,⁶ the regulations have been criticized as being overly prescriptive and constraining hospitals from moving beyond basic EHR functions to higher-value uses.⁷ As a result, hospitals digitized records but have fallen short of realizing the full potential value for patients or clinicians.⁷ Evidence from other industries reveals that substantial IT value is derived from the ability to analyze and share real-time data. However, analysis of real-time clinical data in EHRs to measure performance (eg, adherence to clinical guidelines, patient safety) and making performance transparent (eg, via dashboards) were not part of the meaningful use criteria. Another area that was underemphasized in meaningful use was EHR functions to support patient engagement, for example, by allowing patients to submit patient-generated health data or by supporting highly valued convenience functions such as online scheduling.^{1,8} Thus, while more than 80% of hospitals have adopted at least a basic EHR, there is substantial variation in the extent to which hospitals have implemented these high-value functions.¹

Prior research has shown that structural features of hospitals (eg, size, teaching status) are strongly associated with adoption of advanced EHR functions, but these findings are not actionable because the features are largely not modifiable. The problem is also more complex than simply choosing the right EHR vendor, as studies have found within-vendor performance variation on a variety of metrics, and a significant amount of hospital-level customization occurs to tailor the EHR to specific needs.⁹⁻¹² Evidence from other industries reveals that organizational decisions about complementary investments are as important as the technology itself in producing

value.¹³⁻¹⁷ Information technology adoption has often generated productivity gains after a period of organizational adaptation¹³ during which firms pursue varied complementary strategic investments.^{18,19} In the hospital context, an example of a complementary investment is the size and composition of the IT team. While including a higher proportion of clinicians on the team is more expensive, doing so may achieve better usability, workflow integration, and user satisfaction since these individuals have direct experience with frontline work. We lack evidence on how organizational strategies related to human capital or other domains apply in the hospital setting, and whether such strategies may be helpful in achieving advanced EHR adoption.^{20,21}

We collected the first national data on hospital organizational strategies for EHR adoption and their relationship to adoption of advanced EHR functions. Informed by evidence on organizational factors from health care and other industries that revealed that leadership engagement^{22,23} and IT strategy decisions⁷ were associated with performance in a variety of metrics, we surveyed a random sample of US hospital about how these domains—leadership and board of directors' involvement, human capital on the IT team including clinician engagement, workflow design, and level of EHR integration with other internal systems—were operationalized. We sought to answer three research questions. First, to what extent do hospitals vary in their organizational practices related to implementation and optimization of their EHR in these three domains? Second, do those organizational practices coalesce into strategies? That is, do approaches to operationalizing dimensions of organizational practices for EHR implementation and optimization cluster together in distinct ways? Finally, are those organizational strategies associated with greater adoption of advanced EHR functions related to patient engagement and clinical data analytics (as measured by a separate survey)? Our results provide the first national-level data characterizing hospital organizational strategies surrounding EHR adoption and

use, and identifying which strategies are associated with adoption of advanced EHR functions.

2 | METHODS

2.1 | Data sources

We combined data from two sources. The first is a new national survey of hospitals that we developed and administered to a random sample of 797 US acute care hospitals in 2018-2019. We combined this with data from the annual American Hospital Association (AHA) Annual Survey and IT Supplement.²⁴

2.2 | Survey development

We developed, piloted, and refined our survey to capture organizational practices related to EHRs. To inform survey development, we conducted case study site visits to six hospitals and interviewed senior leaders to understand how their organization implemented and optimized their EHR. We performed a content analysis of the transcripts, which resulted in the identification of several broad domains (eg, leadership involvement, intraorganizational system integration) and how to operationalize the domains into practices that could be measured on a survey. The resulting structured survey questions were pilot tested with the Chief Information Officers (CIO) at each case study hospital. Questions were iteratively refined based on CIO feedback. Our final survey instrument consisted of 30 questions on organizational approach to EHR implementation and optimization, staffing levels and approach to support roles and functions related to IT and quality, the quality of information documented in the EHR, the extent to which specific functions were implemented, the standardization of certain practices, and the degree to which different IT systems within the organization are integrated. The full survey instrument is available in Appendix S1.

2.3 | Survey sample and administration

We partnered with the AHA to mail surveys to a national random sample of 797 acute care hospitals. Hospital CIOs were asked to complete the survey or delegate to the most knowledgeable person in the institution. Nonrespondents received a minimum of three follow-up contacts via phone, mail, and email, between June 2018 and August 2019, and the survey could be completed by mail, fax, phone, or online. Respondents were offered a \$100 gift card to complete the survey. Our final response rate was 60.1%. We calculated nonresponse weights using a propensity score model,²⁵⁻²⁷ with hospital characteristics as independent variables including size, teaching status, profit status, region, rurality, and critical access status.

This study was approved by the Institutional Review Board at the Harvard TH Chan School of Public Health.

2.4 | Measures

2.4.1 | Organizational strategies

Our primary independent variables were organizational strategies for EHR implementation and optimization. To measure strategies, as opposed to individual practices, we conducted an exploratory factor analysis on survey questions related to leadership engagement, human capital, and system integration. The factor analysis confirmed the three domains were distinct from each other and identified which questions in each domain comprised the factor.

The first factor loaded 10 survey questions: four related to how often the board of directors was presented topics related to the EHR, five related to how engaged the board of directors was in topics related to the EHR, and one question on the extent to which the organization developed a shared strategy for improving quality and reducing costs. We labeled this factor as "leadership engagement." Our second factor loaded two questions, both related to the proportion of clinicians on the IT implementation team. We labeled this factor "human capital." Our third factor loaded six survey questions: three on integration across IT systems and three on duplicate data entry. We labeled this factor "systems integration." We constructed measures of each factor by taking the mean across the individual questions that loaded onto that factor for each hospital. Full survey responses are available in Appendix S1, and factor analysis results are available in Appendix S2.

2.4.2 | Advanced EHR functions

Our outcome measures were hospital adoption of advanced EHR functions. We used questions on the 2018 AHA IT Supplement to capture advanced functions in two domains: patient engagement and clinical data analytics. First, we captured whether hospitals responded that they engaged in each of 10 uses of the EHR for patient engagement. These functions were as follows: allow patients to view, download, and electronically send their health information online; request amendments to their medical record; request refills for prescriptions; schedule appointments; pay bills online; submit patient-generated data; use secure messaging with providers; and designate family members or caregivers to access information on their behalf. Second, we captured whether hospitals responded that they engaged in each of 10 uses of EHR data for clinical data analytics. These functions were as follows: create dashboards of organizational, unit-level, and individual performance; allow clinicians to query data; assess adherence to clinical guidelines; identify care gaps for specific patient populations; generate reports to inform strategic planning; support a continuous improvement process;

monitor patient safety; and identify high-risk patients for follow-up care. Full survey questions are available in Appendix S1.

2.4.3 | Hospital characteristics

To obtain measures of hospital characteristics, we used AHA Annual Survey and IT Supplement data. 93% of hospitals who responded to our survey had also responded to the AHA Annual Survey and IT Supplement. Specifically, we captured a variety of hospital characteristics that previous studies found to be associated with IT adoption in hospitals. These included size (<100 beds, 100-399 beds, >400 beds), teaching status, profit status, rurality, census region, and system membership. We measured the extent of hospital EHR adoption using the Basic and Comprehensive definitions developed by Jha et al²⁷

2.5 | Statistical analysis

Our sample consisted of 479 hospitals who responded to our survey and to the AHA Annual Survey and IT Supplement. 28 hospitals did not respond to 5 or more of the questions included in our factor analysis and were excluded from our analyses, leaving 451 hospitals. We compared characteristics of hospitals that responded to the survey to nonrespondents, using chi-squared tests to identify statistically significant differences.

To answer our first research question, we reported response distributions to each survey question on organizational practices included in our factors, plotted as stacked bar graphs.

For our second research question, we conducted the exploratory factor analysis across our measures of organizational practices to identify distinct organizational strategies. For questions included in the factor analysis, the small number of missing responses to individual items was imputed with the mean response. We identified three factors with eigenvalues greater than one and created new variables for each factor by keeping variables that loaded above 0.4 on each factor after varimax rotation, averaging the responses that loaded onto each factor.

Next, we calculated the mean score of each factor stratified by each hospital characteristic using univariate linear models, with Wald F tests for statistical significance. Since the factor value is not directly interpretable, we present the specific practices that comprised the strategy by identifying and reporting the median response for each individual question for hospitals in the top quartile and hospitals in the remaining three quartiles of the respective factor. For example, in the leadership engagement domain, factor scores ranged from 0 to 1, with scores of 0.70 and greater representing the top quartile. For the practice in this domain—board engagement with the selection of a specific EHR—the median hospital in the top quartile reported the board was engaged “to a great extent” while the median hospital in the remaining three quartiles reported the board was engaged “to a small extent/not at all.” We then report the specific

practices where top quartile hospitals and other quartile hospitals in each factor differ.

To answer our third research question, we created two multivariate logistic regression models. The dependent variable for the first was whether a hospital engaged in at least 8 of 10 patient engagement EHR functions, and the second was whether a hospital engaged in at least 8 of 10 EHR data analytics functions. We chose to use the any 8 out of 10 definition of advanced EHR function adoption for two reasons: first, to be consistent with previously published literature that used this measure.¹ Second, we wished to capture hospitals that had broadly adopted advanced EHR functions but did not want to exclude those that purposefully chose not to adopt certain functions. Our independent variables were whether a hospital was in the top quartile of scores on each of the three factors and our set of hospital characteristics. Both models included robust standard errors, and we report average marginal effects (AME) and 95% confidence intervals on a forest plot.

We ran robustness tests for both models with nondichotomized dependent variables (ie, the count of patient engagement or data analytics functions adopted) using ordinary least squares and Poisson models. We also ran robustness tests for both logistic regression models using the factor score rather than the dichotomized top quartile results and report the average marginal effects. Finally, we ran a robustness test including controls for EHR vendor choice. All analyses used our nonresponse weights to create nationally representative results.

3 | RESULTS

60.1% of hospitals responded to our survey. Respondent hospitals ($n = 479$) were more likely than nonrespondent hospitals ($n = 318$) to be major teaching hospitals, nonprofit or government owned, rural, small, or large compared to medium-sized, in the Northeast or Midwest, not a member of a hospital system and have implemented at least a basic EHR. (Appendix S3).

3.1 | Organizational strategies

Figures 1-3 report the response distribution for each question that loaded on our factors. Ten specific practices loaded on the first factor: leadership engagement (Figure 1). The first practice was the extent to which the hospital developed and communicated a shared strategy for improving quality and reducing costs related to EHR adoption, the second practice that loaded on the factor captured the level of Board engagement on the following EHR-related topics: decision to implement an EHR, selecting a specific EHR, the quality committee, EHR implementation approach, and EHR optimization approach. The final set of practices loading on the leadership engagement factor captures how often EHR-related topics were presented to the Board.

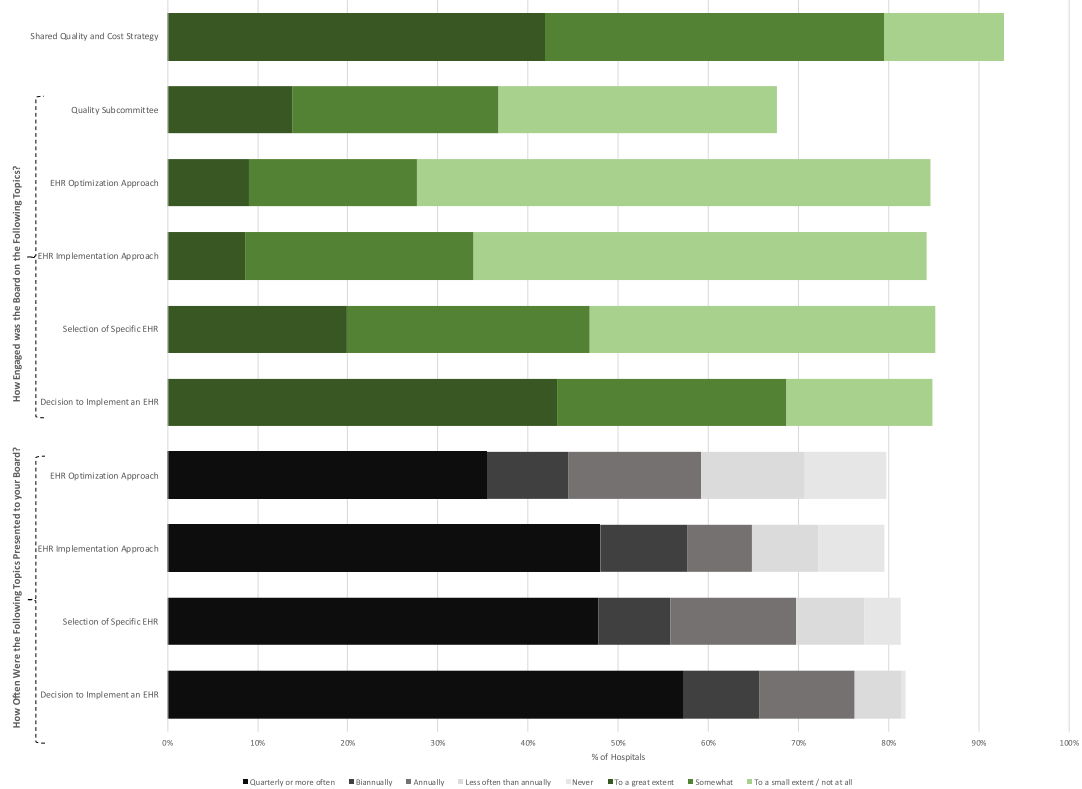


FIGURE 1 Factor 1: Hospital organizational practices for leadership/board engagement. *Source:* Authors' analysis of hospital survey data. *Notes:* N = 451 hospitals [Color figure can be viewed at wileyonlinelibrary.com]

Two factors loaded on the second factor, human capital (Figure 2). The first was the proportion of the IT team comprised of clinicians, and the second was the proportion of the IT team comprised of clinicians with patient experience *at the hospital*. For both questions, the median response for hospitals in the top quartile of the factor was more than 50%, while the median response for other hospitals was 10%-20%.

Our third factor, systems integration, included six practices (Figure 3). The first three practices captured the amount of time staff spent doing duplicative data entry, and the next three practices captured the extent that IT systems across the organization are integrated. Table 1 summarizes the different practices for each factor and reveals practices with the *greatest differences* between top quartile hospitals and other hospitals.

3.2 | Organizational strategies and hospital characteristics

In our comparison of organizational strategy factors by hospital characteristics, we found that for leadership engagement, urban hospitals had higher scores (mean of 0.56 compared to 0.50, $P = 0.01$), as did hospitals who were members of a health care system (0.58 compared to 0.51, $P < 0.001$) and hospitals who had at least eight patient engagement advanced EHR functions (0.60 compared to 0.51, $P < 0.001$) and eight clinical data analytics functions (0.60 compared to 0.51, $P < 0.001$). (Appendix S4).

For human capital, large (0.52) and medium (0.46) sized hospitals scored higher than small (0.39) hospitals ($P = 0.05$). Hospitals with a comprehensive EHR (0.46) or basic EHR (0.39) scored higher than those with a less than basic EHR (0.39, $P = 0.03$), and hospitals with at least eight clinical data analytics EHR functions scored better (0.50 compared to 0.38, $P < 0.001$).

For systems integration, hospitals with a comprehensive (0.53) EHR had higher scores than hospitals with a basic (0.44) or less than basic (0.50) EHR ($P = 0.05$). Hospitals with at least eight patient engagement (0.56 compared to 0.48, $P < 0.001$) and eight clinical data analytics (0.56 compared to 0.48, $P < 0.001$) EHR functions had higher scores than those without.

3.3 | Organizational strategies to enable advanced EHR functions

In our regression models, hospitals in the top quartile of the leadership engagement factor were 14 percentage points more likely to have adopted at least 8 patient engagement functions, (AME = 0.14, $P = 0.01$). Hospitals in the top quartile of human capital were 14% less likely (AME = -0.14, $P = 0.02$) to have at least eight patient engagement functions. Finally, those in the top quartile of the systems integration factor were 12 percentage points more likely to have at least eight patient engagement functions (AME = 0.12, $P = 0.02$) and 14 percentage points more likely to have eight or more clinical data analytics advanced EHR

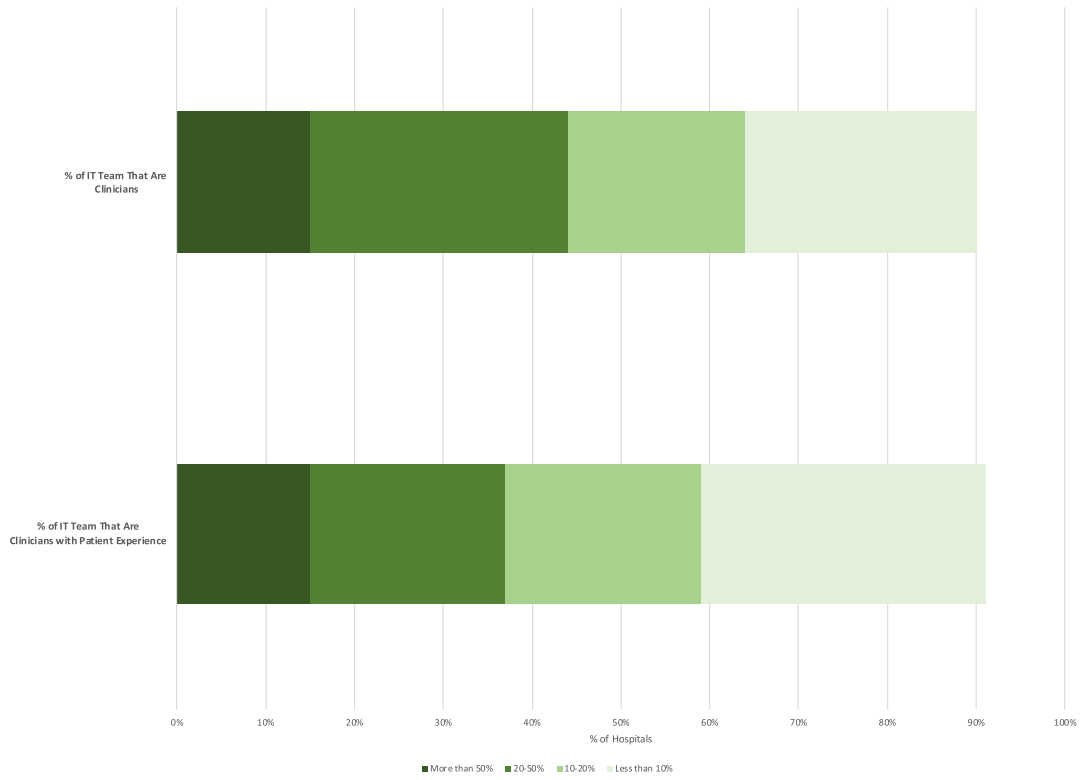


FIGURE 2 Factor 2: Hospital organizational practices for human capital. *Source:* Authors' analysis of hospital survey data. *Notes:* N = 451 hospitals [Color figure can be viewed at wileyonlinelibrary.com]

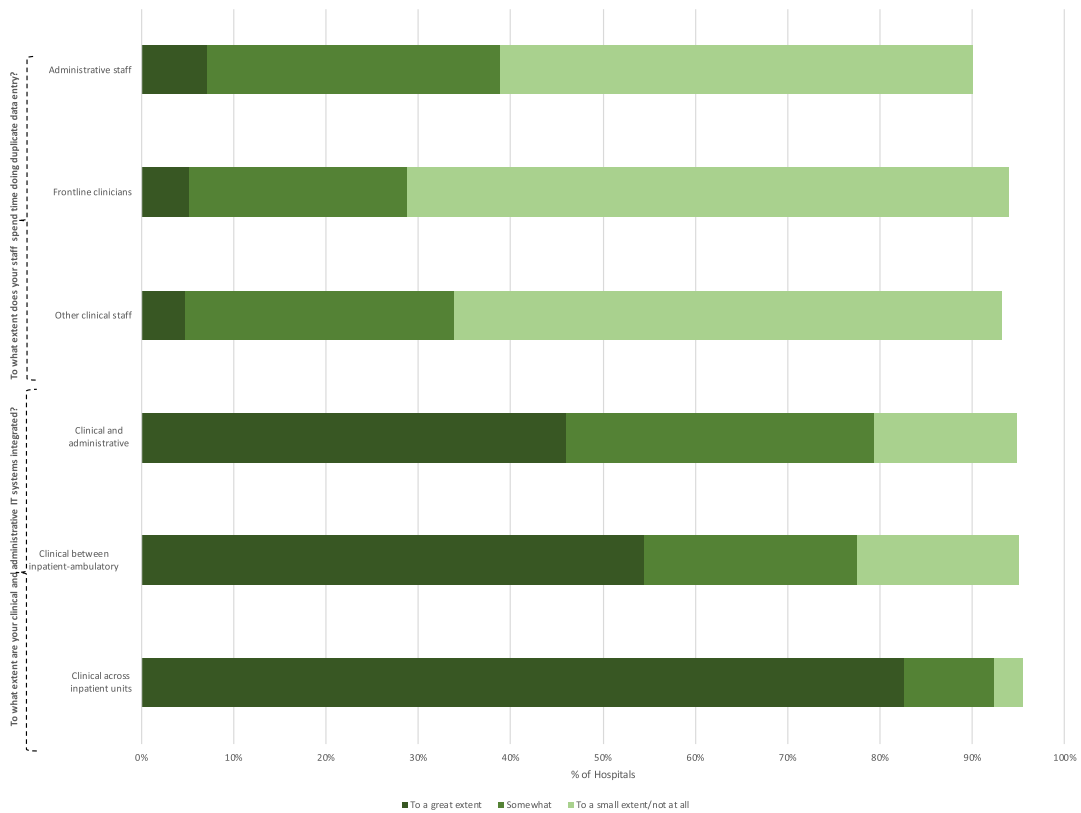


FIGURE 3 Factor 3: Hospital organizational practices for systems integration. *Source:* Authors' analysis of hospital survey data. *Notes:* N = 451 hospitals [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 1 Strategies from top quartile of each factor hospitals versus other three quartiles

	Top quartile hospitals (Median response)	Other hospitals (Median response)
Leadership		
Shared quality and cost strategy	To a great extent	Somewhat
How engaged was the board on the topic?		
Quality subcommittee	To a great extent	To a small extent / not at all
EHR optimization approach	Somewhat	To a small extent / not at all
EHR implementation approach	Somewhat	To a small extent / not at all
Selection of specific EHR	To a great extent	To a small extent / not at all
Decision to implement EHR	To a great extent	Somewhat
How often were the topics presented to the board		
EHR optimization approach	Quarterly or more often	Annually
EHR implementation approach	Quarterly or more often	Biannually
Selection of specific EHR	Quarterly or more often	Biannually
Decision to implement EHR	Quarterly or more often	Quarterly or more often
Human capital		
Proportion of IT team that are clinicians	More than 50%	10%-20%
Proportion of IT team that are clinicians with Patient experience at your hospital	More than 50%	10%-20%
Systems integration		
To what extent does your staff spend time doing duplicate data entry?		
Administrative staff	To a small extent/not at all	Somewhat
Frontline clinicians	To a small extent/not at all	To a small extent/not at all
Other clinical staff	To a small extent/not at all	To a small extent/not at all
To what extent are your clinical and administrative IT systems integrated?		
Clinical and administrative systems	To a great extent	Somewhat
Clinical between inpatient and ambulatory	To a great extent	Somewhat
Clinical across inpatient units	To a great extent	To a great extent

Abbreviations: HER, Electronic Health Records; IT, Information Technology.

Source: Authors' analysis of hospital survey data. N = 451 hospitals.

functions (AME = 0.14, P = 0.02). (Figure 4) For hospital structural characteristics, we found private, nonprofit hospitals were 27% more likely to have adopted at least eight advanced patient engagement functions (P < 0.01) and 26% more likely to have adopted eight clinical data analytics functions (P < 0.01) compared to private, for-profit hospitals. Other characteristics associated with advanced patient engagement adoption include public, nonfederal hospitals (AME = 0.28, P < 0.01) compared to private, for-profit hospitals, and hospitals who are members of health systems (AME = 0.24, P < 0.01). Similarly, public, nonfederal hospitals (AME = 0.22, P = 0.01) compared to private, for-profit hospitals, and hospitals who are members of health systems (AME = 0.26, P < 0.01) were more likely to have at least 8 advanced clinical data analytics functions.

Our robustness tests using alternative operationalizations of our dependent variable with continuous and count model specifications were consistent with these results, though with wider confidence

intervals. (Appendix S5) Using an alternative operationalization of our independent variable, with continuous factor scores, also produced results consistent with our main specification. (Appendix S6) Including additional controls for EHR vendor found similar results to our primary specification, with the exception that the negative association between patient engagement functions and hospitals in the top quartile of the human capital factor was not statistically significant. (Appendix S7).

4 | DISCUSSION

Our study offers the first national data on hospital organizational strategies for EHR implementation and optimization. Our results may partially help to explain why a range of studies have shown an inconsistent relationship between EHR adoption and outcomes.^{1,9,14,28} Our study looks upstream to reveal substantial heterogeneity in

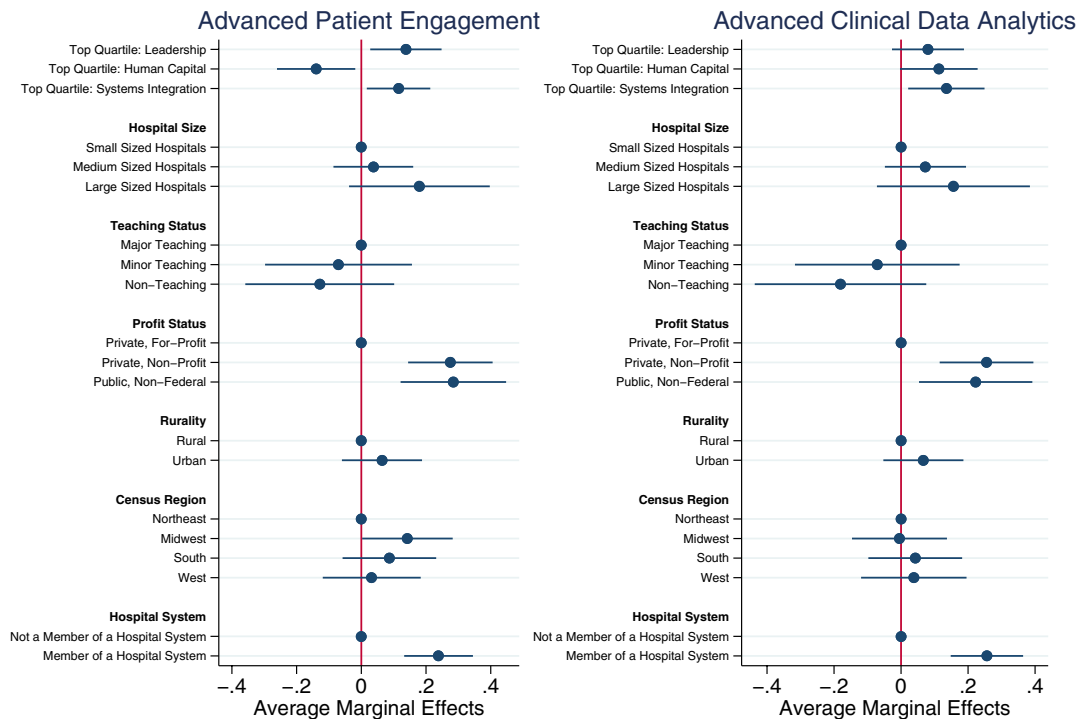


FIGURE 4 Association between hospital characteristics and adoption of advanced EHR Functions in two domains. *Source:* Authors' analysis of hospital survey and American Hospital Association Annual Survey data.

Notes: N = 451 hospital [Color figure can be viewed at wileyonlinelibrary.com]

how hospitals approach EHR implementation and optimization, focusing on three key domains. Using factor analysis, we are able to operationalize the specific practices that differentiate hospitals that are “top performers” within each domain, such that our results offer concrete evidence of variation. Finally, we examine how these strategies relate to adoption of advanced EHR functions for patient engagement and clinical data analytics.

We found significant variation across organizational practices related to EHR adoption between hospitals in the top quartile of the factor score and other hospitals. First, related to leadership engagement, while top quartile hospitals regularly engaged their Board on a range of EHR topics, other hospitals engaged to a lesser extent, especially on more complex topics such as EHR optimization. While Board engagement during the implementation decision likely reflects the large financial cost associated with initial EHR adoption, it is likely important for Boards to remain engaged in the ongoing process of optimizing IT systems. This is supported by previous studies that have found a relationship with Board engagement on a topic and performance in that area.²⁹ EHR optimization involves making important decisions about where to focus organizational resources as well as priorities after establishing baseline functionality and meeting minimum federal requirements. Boards are likely to be helpful in aligning these choices with broader strategic goals.

Additional practices with substantial variation were the degree of systems integration and the resulting need for duplicate data entry. Hospitals in the top quartile of the systems integration factor reported both better integration across technology systems and less administrative time doing duplicative entry. This offers a clear target

for improving administrative efficiencies. While significant effort has focused on clinical system integration, our results suggest that administrative systems, such as billing, financial, quality reporting, and personnel management systems, may be overlooked. There has been little investigation of the impact of lack of clinical-administrative connectivity, and the resulting data silos that limit the usability of data.^{30,31} If data cannot be extracted from integrated clinical and administrative systems, hospitals are unable to use that data for new and innovative purposes, such as building algorithms to identify at-risk patients or automating processes such as quality metrics reporting.^{32,33} Hospitals looking to invest organizational resources into IT should consider reducing administrative staff duplicative work and integrating clinical and administrative technology systems, and working to engage their Board in the ongoing optimization of the EHR.

Two strategies were associated with adoption of advanced EHR functions. Hospitals with more engaged leadership and more integrated IT systems were more likely to have advanced patient engagement functions. Given that greater hospital Board engagement has been associated with better performance in other dimensions of quality such as clinical care,^{22,23} our results are consistent with the hypothesis that senior leadership involvement translates into broader advanced EHR investment. The system integration finding is consistent with the hypothesis that integration between clinical and administrative systems supports implementation of many patient engagement functions—paying bills online requires integration with financial and billing systems, while scheduling appointments online requires integration with scheduling and workforce management systems. One surprising finding is that hospitals in the top quartile

of our human capital factor were less likely to have advanced patient engagement functions. This negative association is puzzling considering human capital is positively associated with advanced clinical data analytics, and the two advanced EHR functions are positively correlated with each other in the overall data. One hypothesis is that having an IT team predominantly composed of clinicians translates into a focus on clinical use cases, or perhaps more resistance to patient engagement functions because of the potential for increasing workload associated with EHR-induced burnout.^{34,35} It may also be that among resource-constrained hospitals, clinicians on the IT team perceive internal-facing functions as more valuable.

Only the systems integration factor was associated with adoption of advanced EHR data analytics functions. This is consistent with the hypothesis that better integration supports advanced data analytics functions, as combined data may better support creating performance dashboards, identifying high-risk patients using algorithms, and generating reports to inform strategic planning.

4.1 | Implications for policy and practice

Understanding which organizational strategies are associated with adoption of advanced EHR functions is a first step to suggest hypotheses about where to conduct further investigation of how to help hospitals increase the benefit from health IT. Unlike identifying structural characteristics associated with IT adoption, organizational strategies can be broadly disseminated and enacted. Health system leaders interested in developing IT-enabled patient engagement may find it useful to know of the association between a more involved Board of Directors and advanced patient engagement EHR functions. Similarly, our results show an association between investing in systems integration and advanced data analytics that requires data from multiple sources. This is consistent with the hypothesis that when there are disparate systems used in clinical units or across clinical and administrative systems, it is difficult to aggregate data across care settings, which limits the usefulness of data analytics.

Advanced EHR functions may require specific organizational approaches, which to-date have not been part of federal policy efforts. While the government is not an appropriate entity to mandate organizational strategy, policymakers could play a role in identifying and disseminating best practices. Specifically, dissemination through mechanisms such as the EHR Reporting Program included in the 21st Century Cures Act.³⁶ While the focus of this Program is on reporting provider experiences with health IT, complementing these with context about IT strategy could help understand differences in experiences as well as make such strategies more transparent to facilitate learning and benchmarking. Finally, the Cures Act prohibition of gag clauses, contractual limitations on sharing data such as screenshots of EHRs, may remove a significant barrier for organizational best practice dissemination.³⁷

Policymakers should consider supporting future research examining how organizational practices contribute to adoption of advanced EHR functions and ultimately outcomes, especially the

difficult task of identifying causal relationships. While randomizing organizational practices is not feasible, researchers in other domains have randomized specific types of organizational support.³⁸ Quasi-experimental studies may be possible, for example, leveraging geographic variation in the availability of informatics-trained clinicians. Rapid-cycle randomized trials within hospitals could be used to identify how managerial practices impact the success of IT projects.³⁹ Given the importance of the topic and the difficulty of generating strong evidence, funders should consider prioritizing these projects to generate actionable strategies for hospitals to maximize EHR performance.

4.2 | Limitations

Our study has important limitations. First, while we received a 60.1% response rate, hospitals responding to the survey differed from non-respondents on observable characteristics. While we adjusted for these differences with nonresponse weights, adjustments may not fully account for differences and our results may not be representative of all US hospitals. Second, we rely on self-reported survey data that we are unable to independently verify. Several of our survey questions rely on the respondent's subjective perceptions of organizational practices where different hospitals may have interpreted the questions and response options in different ways. While we did not conduct cognitive testing, we followed a similar approach to prior organizational health IT surveys by conducting in-depth pilot testing with potential respondents. Other surveys following this approach, including the AHA IT Supplement, have been found to be reliable and valid in measuring hospital information technology adoption and use. We attempted to minimize the impact of respondent subjectivity on key measures by designing questions and associated answer choices to capture objective dimensions, such as frequency of presentations to the Board and proportion of clinicians involved in the IT team. However, some of our measures did ask for respondent perception and are therefore more subjective and potentially biased in nature.⁴⁰ Third, we made several choices in the way that we constructed our measures of organizational strategies and advanced EHR functions, and it is possible that they may not fully capture the underlying concepts. We performed robustness tests of alternative constructions of both measures and found consistent results. Fourth, while our robustness tests show that hospital organizational strategies are significant even when controlling for EHR vendor choice, the effect size of choosing Epic as an EHR vendor is much larger than our organizational strategies. While our goal was to evaluate associations with vendor-agnostic organizational practices, it is important to note these differences as they should be factored into hospital decisions. Finally, our study is cross-sectional and we are unable to assess the causal relationships between hospital organizational strategies and advanced EHR function adoption. While a key strength of our approach is that it offers the first nationally representative data on hospital organizational strategies and how they may explain some of the variation in advanced EHR

capabilities, we do not know to what extent, if at all, the strategies directly contributed to adoption of these capabilities. Instead, our formative findings could inform future research to test causal relationships between organizational strategies, EHR adoption, and care outcomes.^{41,42}

5 | CONCLUSION

Our results reveal that EHR implementation and optimization practices vary significantly across hospitals in the United States. These organizational practices coalesce around three main strategies related to greater engagement of the board of directors, greater reliance on clinicians within the IT team, and greater integration across systems, particularly clinical-administrative systems. For hospitals seeking to drive adoption of more advanced EHR functions, our results are consistent with the hypothesis that engagement from leadership and integration across systems may help in the patient engagement domain, and systems integration may help in the clinical analytics domain. This new evidence on how organizational strategies are associated with advanced EHR functions is an important first step in understanding how hospital management can work toward realizing the potential of electronic health records.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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