Hospital adoption of interoperability functions

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A B S T R A C T

Background: The seamless transmission of patient health information across
health care settings, commonly referred to as interoperability, is a focal point of federal electronic health record (EHR) incentive programs. The objective of this study was to examine the extent to which interoperability functions outlined in Promoting Interoperability Stage 3 (PI3) requirements have been adopted by US hospitals, and barriers to interoperability.
Methods: We conducted a cross-sectional analysis of 2781 non-federal, acute-care hospitals responding to the 2015 American Hospital Association Information Technology (IT) Supplement survey. We described the percentage of hospitals that adopted PI3 functionalities, identified hospital characteristics associated with adoption, and compared barriers to interoperability between hospitals that have and have not adopted PI3 functionalities.
Results: Only 16.7% of hospitals had adopted all six core functionalities required to meet PI3 objectives. Over 70% of hospitals had implemented at least four of six functionalities, while 1.8% implemented none. Major teaching (adjusted odds ratio [aOR] = 1.66), system affiliated (aOR = 1.63), and regional health information exchange participating hospitals (aOR = 1.86) were more likely to adopt PI3 functionalities, while for-profit hospitals (OR = 0.11) were less likely. Hospitals that adopted PI3 functionalities more frequently reported experiencing barriers to interoperability, including the receiving provider's ability and interest to send/receive data.
Conclusions: While only a small proportion of hospitals had implemented all six PI3 functionalities at the time the requirements were finalized, the vast majority had already implemented most of the required functionalities. Still, several barriers stand in the way of achieving seamless interoperability, many of which lie outside hospitals' control.

1. Introduction

In April 2018, the Centers for Medicare and Medicaid Services (CMS) announced sweeping changes to their electronic health record (EHR) Meaningful Use program, which included renaming the program "Promoting Interoperability (PI)".[1] A key feature of this change was to focus PI stage 3 requirements on improving the interoperability of hospital EHRs, or the sharing of data between providers.[2] Creating more interoperable information systems allow for patient data to be shared across the fragmented health care landscape, which is critical to improving the safety and quality of patient care.[3–5] Interoperability has the potential to improve patient health and lower health care costs, and is increasingly important to hospitals as innovative models of health care delivery and payment are implemented.[2]

However, providers face substantial challenges to achieving interoperability. As recently as 2015, only 30% of hospitals have engaged in finding, sending, receiving, and integrating patient information from outside providers.[6] Barriers to increased interoperability include added

burden and inefficiencies in clinical workflow, lack of infrastructure and high costs associated with sustaining interoperable EHR systems, and limited accuracy, availability, and usefulness of shared information.[6–8] Recent evidence also suggests that community and statewide efforts to drive interoperability have declined in recent years, as most financial payments to adopt EHRs have ended.[9] The American Hospital Association (AHA) has also expressed concerns over the ability of hospitals to meet PI3 requirements – even requesting that the new administration cancel PI3 requirements altogether – citing the limited experience of hospitals with Meaningful Use Stage 2 objectives, continued interoperability limitations of most certified EHRs, and reliance on the capabilities of other providers' and facilities' to send/receive information.[10,11]

Nonetheless, CMS is moving forward with the revised six PI3 requirements for hospital eligible for Medicare payment incentives: 1. protect electronic protected health information using secure safeguards; 2. computerized physician order entry (CPOE) – generate and transmit discharge prescriptions electronically; 3. provide patients with

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electronic access to their health information and educational resources; 4. coordinate patient care by sharing information with other providers and sending patients secure messages; 5. send and receive summary of care reports; 6. public health reporting - use a clinical data registry to submit electronic reports to public health agencies. To date, there has been little investigation into the adoption of PI3 functionalities required by CMS, and how barriers to interoperability differ based on adoption of PI3 functionalities.

The objective of this study was to inform gaps in knowledge around adoption of PI3 functionalities in three ways. First, we described the percentage of hospitals that have adopted PI3 functionalities, according to 2015 AHA Annual Survey Information Technology (IT) Supplement data. Second, we identified hospital characteristics significantly associated with implementation of all PI3 functionalities. Third, we examined hospital reported barriers to interoperability, and compare whether barriers differed between hospitals that had and had not adopted all PI3 functionalities. We expected that hospitals that implemented PI3 functionalities experienced different types of barriers than those that had not. Results from this study will inform stakeholders, including hospitals and policy makers, on where to invest resources to improve success of the PI3 EHR incentive program, the types of hospitals that may require more attention for improvement, and potential barriers that limit interoperability.

2. Materials and methods

2.1. Data sources and sample

We analyzed data from the 2015 AHA Annual Survey and IT Supplement questionnaires. The AHA Annual Survey contains information on structural, service, and staffing characteristics of hospitals. The AHA IT Supplement surveys hospitals on details related to meaningful use implementation, adoption of specific computerized systems, interoperability capabilities, and EHR vendor information. From the n = 6125 hospitals participating in the AHA Annual Survey, we limited our sample to n = 4390 non-federal, acute care hospitals in the United States, as these hospitals are eligible for incentive payments through the HITECH Act. Since these data contain only hospital-level information, it was deemed to be human subjects exempt research.

2.2. Promoting interoperability stage 3 functionalities

The IT Supplement data contains information on the six core PI3 objectives originally outlined by CMS for incentive payments, including protecting electronic patient health information (PHI), generate and transmit prescription information at discharge (ePrescribe), patient electronic access (eAccess), care coordination, health information exchange (HIE), and public health reporting. We created binary indicators (yes vs. no) to indicate whether or not a hospital implemented each of the six core functionalities required to meet PI3 objectives. For a hospital to have implemented a core functionality, they had to respond that the specific function was "fully implemented across all units", otherwise the hospital was considered to not have implemented the core functionality. Additionally, we tallied the number of core objectives implemented, and created a binary indicator (yes vs. no) categorizing hospitals as having implemented all six core objectives. Details on the PI3 core objective measures, along with the corresponding data field from the AHA IT Supplement data, can be found in Supplementary Table 1.

2.3. Barriers to interoperability

We also used data from the IT Supplement to identify barriers hospitals reported in interoperability: 1. Receiving providers do not have EHR, 2. Receiving providers have EHR, but cannot receive data, 3. Recipients find care summary information not useful, 4. Cumbersome

workflow to send info, 5. Difficult to match or identify patient between systems, 6. Lack receiving provider address, 7. Challenges exchanging data across vendors, 8. Typically do not share patient data outside system, and 9. Additional costs to exchange data outside system. For each of the nine barriers surveyed in the IT Supplement data, we categorized hospitals as having reported or not reported the barrier. We then categorized hospitals as having reported any barrier (yes vs. no), and estimated the total number of barriers reported. Details on the barriers to interoperability, along with the corresponding data field from the IT Supplement data, can be found in Supplementary Table 2.

2.4. Hospital characteristics

We used the AHA Annual Survey data to describe the characteristics of hospitals in our sample, including bed size categories (< 100 beds, 100–300 beds, and 300+ beds), major (residency program + Council of Teaching Hospital membership) or minor (residency program only) teaching hospital vs. non-teaching hospital, ownership status (for-profit, not-for-profit, or publicly owned), urban vs. rural location, US region (Northeast, Midwest, South, West), health system affiliation (yes vs. no), critical access hospital (yes vs. no), and regional HIE participation (yes vs. no).[6,12] We also used the 2015 Medicare Impact File to obtain data on the disproportionate share (DSH) index for each hospital, which represents the extent to which hospitals treated socioeconomically disadvantaged patients. We classified hospitals in the highest quartile of DSH index were classified as safety net hospitals.

2.5. Statistical analysis

Similar to previous research, we attempted to account for non-response bias in the IT Supplement questionnaire.[12] To accomplish this, we used multivariable logistic regression to estimate the predicted probability that each hospital in our sample (n = 4442 hospitals) completed the IT Supplement survey (yes vs. no). These predicted probabilities were used to weight subsequent logistic regression models through inverse probability weighting. We also estimated the adjusted relative odds (OR) (with 95% confidence intervals [CI]) of completing the AHA IT survey by bed size category, hospital teaching status, ownership status, urban/rural location, system affiliation, critical access hospital status, safety net status, and regional HIE participation

We then limited our sample to hospitals with AHA IT survey data, and described the extent to which these hospitals implemented the six PI3 functionalities. Specifically, we estimated the distribution and average number of functionalities implemented, the percentage of hospitals implementing all six functionalities, and the percentage of hospitals that implemented each functionality. Next, we compared the percentage of hospitals that implemented and did not implement all PI3 functionalities across hospital characteristics. Rao-Scott chi-square tests were used to test for bivariate differences by hospital characteristic. Using multivariate logistic regression, we estimated the adjusted relative odds (OR) and 95% confidence intervals (CI) of implementing all PI3 functionalities (yes vs. no) for each hospital characteristic, holding all other characteristics constant.

Lastly, we estimated the percentage of hospitals that reported any barriers to interoperability, and the average number of reported barriers for hospitals that implemented and did not implement PI3 functionalities. Additionally, we estimated the percentages for each individual barrier to interoperability for hospitals that implemented and did not implement all PI3 functionalities. We used Rao-Scott chi-square tests and weighted *t*-tests to test for any significant bivariate differences in percentages and averages, respectively. We deemed p-values less than 0.05 to be statistically significant. All analyses were conducted with SAS version 9.4 (SAS Institute Inc., Cary, NC).

Table 1
Characteristics of non-federal, acute care hospitals responding to 2015 American Hospital Association Information Technology Supplement survey (n = 4390).

Hospital Characteristics	Sample Size, n	Responded to Survey (%)		Adjusted OR* (95% CI)	p-value
		Yes	No		
Total	4390	76.1	23.9	–	–
Bed Size					
300 +	753	75.8	24.2	2.25 (1.73–2.93)	< 0.001
100–300	1426	64.6	35.4	1.60 (1.34–1.91)	< 0.001
< 100	2211	56.8	43.2	1 [Ref]	–
Teaching Status					
Major	234	81.6	18.4	1.62 (1.08–2.42)	0.019
Minor	1000	68.5	31.5	1.14 (0.95–1.38)	0.160
Non-Teaching	3156	59.3	40.7	1 [Ref]	–
Ownership Status					
For-Profit	721	46.9	53.1	0.51 (0.41–0.64)	< 0.001
Not-for-Profit	2686	66.9	33.1	0.92 (0.78–1.09)	0.325
Public	983	62.8	37.2	1 [Ref]	–
Location					
Urban	2542	65.0	35.0	1.04 (0.88–1.22)	0.651
Rural	1848	59.3	40.7	1 [Ref]	–
Region					
Northeast	540	65.9	34.1	1.10 (0.87–1.39)	0.437
Midwest	1334	74.2	25.8	2.15 (1.77–2.60)	< 0.001
South	1653	55.6	44.4	0.95 (0.80–1.13)	0.528
West	863	58.3	41.7	1 [Ref]	–
System Affiliated					
Yes	2774	63.3	36.7	0.99 (0.86–1.15)	0.920
No	1616	61.4	38.6	1 [Ref]	–
Critical Access Hospital					
Yes	1307	60.2	39.8	0.93 (0.77–1.12)	0.430
No	3083	63.6	36.4	1 [Ref]	–
Safety Net Hospital					
Yes	765	62.1	37.9	0.87 (0.72–1.04)	0.125
No	3625	62.7	37.3	1 [Ref]	–

* Odds ratios (OR) were adjusted for all other hospital characteristics.

3. Results

Among the 4390 non-federal, acute care hospitals in our sample, 2781 hospitals completed the AHA IT questionnaire for a response rate of 63.3%. Hospitals responding to the survey were more likely to have 300+ beds or 100–300 beds compared to 100 beds, be major teaching compared to non-teaching hospitals, and be located in the Midwest (Table 1). They were also less likely to be for-profit compared to publicly owned hospitals and safety-net hospitals.

For the 2781 hospitals completing the AHA IT survey, 18.3% of hospitals implemented all six PI3 functionalities (Fig. 1). Over 70% of
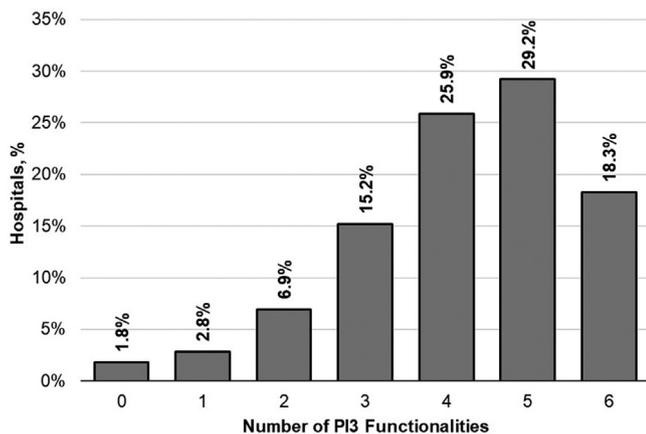
hospitals had implemented at least four of six functionalities, and 1.8% of hospitals implemented none. Hospitals implemented 4.2 (standard deviation = 2.6) of six functionalities on average. There was wide variation in implementation across functionalities, with 94.9% of hospitals implementing functions to protect electronic PHI and 31.0% of hospitals implementing functions for care coordination (Fig. 2). Comparison of unweighted and inverse-probability weighted percentages of PI3 functionality implementation can be found in Supplemental Figures 1 and 2.

The inverse-probability weighted percentages and adjusted odds of hospitals implementing PI3 functionalities by hospital characteristics can be found in Table 2. In our bivariate analysis, we found statistically
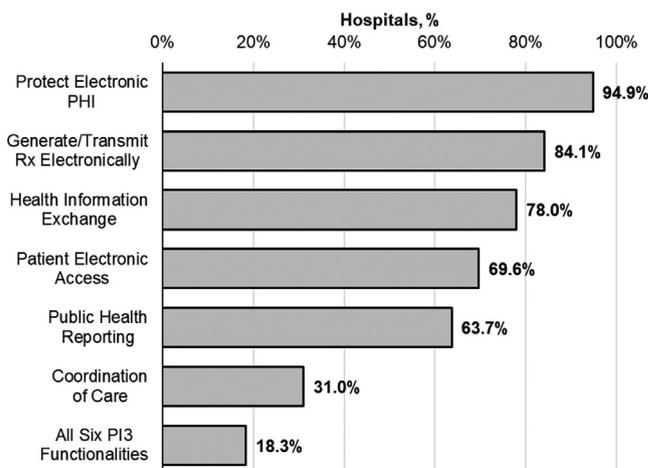

Fig. 1. Distribution of number of Promoting Interoperability Stage 3 (PI3) functionalities adopted (n = 2781), including protecting electronic patient health information, generating/transmitting prescriptions electronically, health information exchange, patient electronic access, public health reporting, and coordination of care.

Fig. 2. Percentage of hospitals adopting specific Promoting Interoperability Stage 3 (PI) functionalities (n = 2781).

Table 2
Weighted percentage and adjusted odds of hospitals implementing functionalities required for Promoting Interoperability – Stage 3 (PI3) by hospital characteristics (n = 2768).

Hospital Characteristics	Sample Size, n	All PI3 Functionalities (%)		Crude p-value[*]	Adjusted OR[†] (95% CI)	p-value
		Yes	No			
Total	2768	18.3	81.7	–	–	–
Bed Size						
300 +	573	25.3	74.7	< 0.001	1.17 (0.77–1.80)	0.459
100–300	934	17.9	82.1		1.05 (0.75–1.48)	0.769
< 100	1261	12.6	87.4		1 [Ref]	–
Teaching Status						
Major	191	31.4	68.6	< 0.001	1.66 (1.01–2.71)	0.044
Minor	695	20.2	79.8		0.98 (0.72–1.35)	0.121
Non-Teaching	1882	14.4	85.6		1 [Ref]	–
Ownership Status						
For-Profit	346	2.3	97.7	< 0.001	0.11 (0.05–0.24)	< 0.001
Not-for-Profit	1801	21.8	78.2		1.31 (0.93–1.85)	0.182
Public	621	12.3	87.7		1 [Ref]	–
Location						
Urban	1670	21.5	78.5	< 0.001	1.25 (0.90–1.73)	0.182
Rural	1098	11.9	88.1		1 [Ref]	–
Region						
Northeast	356	17.5	82.5	0.212	0.61 (0.41–0.91)	0.016
Midwest	990	19.5	80.5		0.94 (0.60–1.31)	0.719
South	919	15.7	84.4		0.84 (0.65–1.17)	0.300
West	503	19.6	80.4		1 [Ref]	–
System Affiliated						
Yes	1760	21.6	78.4	< 0.001	1.63 (1.22–2.19)	0.001
No	1008	12.0	88.0		1 [Ref]	–
Critical Access Hospital						
Yes	787	11.2	88.8	< 0.001	0.79 (0.55–1.14)	0.210
No	1981	20.5	79.5		1 [Ref]	–
Safety Net Hospital						
Yes	476	20.7	79.3	0.210	1.04 (0.75–1.44)	0.831
No	2292	17.8	82.2		1 [Ref]	–
Regional HIE Participation						
Yes	1770	22.0	78.0	< 0.001	1.86 (1.39–2.49)	< 0.001
No	998	10.7	89.3		1 [Ref]	–

Abbreviations: HIE = Health Information Exchange.
[*] Crude p-values were estimated using Rao-Scott chi-square tests.
[†] Odds ratios (OR) were weighted and adjusted for all other hospital characteristics.

significant differences in implementation across most hospital categories (all p < 0.001), except for region (p = 0.202) and safety net hospitals (p = 0.210). Major teaching hospitals had the highest rate of implementing required PI3 functionalities (31.4%), while for-profit hospitals had the lowest rate (2.3%). After adjustment, major teaching hospitals (OR = 1.66; 95% CI: 1.01–2.71), system affiliated hospitals (OR = 1.63; 95% CI: 1.22–2.19), and hospitals participating in a regional HIE (OR = 1.86; 95% CI: 1.29–2.49) had higher relative odds of implementing all PI3 functionalities, while for-profit hospitals (OR = 0.11: 95% CI: 0.05–0.24) had significantly lower relative odds (Table 2). Unweighted percentages and adjusted logistic regression findings are located in Supplementary Table 3, which were not substantively different from the weighted results.

Hospitals that implemented all PI3 functionalities more frequently reported any barrier to interoperability (96.8% vs. 90.3%) (Fig. 3). These hospitals also reported more barriers on average (3.9 vs. 3.2 of 9, p < 0.001). Hospitals implementing all PI3 functionalities more frequently reported that receiving providers did not have an EHR (71.3% vs. 51.9%) or were unable to receive data through their EHR (70.2% vs. 52.1%). They also reported greater challenges in exchanging data across vendors (53.0% vs. 46.7%) and additional costs when exchanging data outside their system (37.2% vs. 25.4%). Interestingly, hospitals implementing all PI3 functionalities were more likely to report that recipients of care summaries found that the information was not useful (45.9% vs. 30.5%). We found no significant differences between hospitals who have and have not implemented PI3 functionalities in barriers related to identifying patients between systems, cumbersome

workflow to send info, and patterns around sharing patient data outside systems.

4. Discussion

While only a small proportion of hospitals had implemented all six PI3 functionalities at the time the requirements were finalized, the vast majority had already implemented most of the required functionalities. With almost three years to begin attesting to PI3 requirements, our study finds that most hospitals are well positioned to improve interoperability in order to continue receiving federal funding. Overall, our findings suggest that hospitals may be more capable of achieving these requirements than previously thought. It will be critical to examine how hospitals respond to the evolving PI3 requirements.

Our findings also highlight specific areas that can be targeted to improve overall PI3 achievement. Adoption of care coordination PI3 goals, which require exchanging secure messages with patients, incorporating patient generated data in the EHR, and allowing patients to view, download, and transmit their health information, lags behind the other core PI3 objectives. Fewer than a one in three of hospitals reported meeting care coordination these objectives in 2015. Policy makers and administrators should focus efforts around facilitating care coordination goals in order to drive increases in the adoption of PI3 functionalities, which are necessary to improve patient care quality and outcomes.

Furthermore, major teaching and system affiliated hospitals may be better positioned to attest to the upcoming PI3 requirements compared
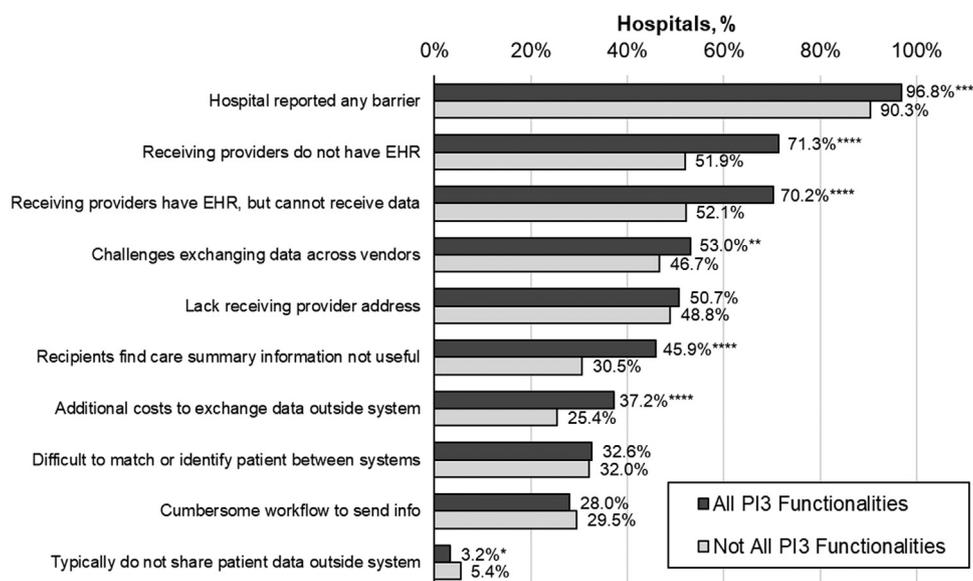
Fig. 3. Percentage of hospitals reporting barriers and interoperability, stratified by adoption of PI3 functionalities (n = 2781) (note: *p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001).

to their counterparts, while for-profit hospitals lag behind. These findings are largely in line with other studies on the adoption of interoperability functionalities.[12,13] The same studies have also shown that for-profit hospitals consistently lag in the adoption of EHR technology. This is concerning and suggests that late-adopters continue to lag in meeting interoperability goals. Policy makers should target smaller, non-teaching, for-profit, non-system affiliated, and critical access hospitals with interventions and resources to encourage the adoption of advance EHR functions and interoperability. Similarly, although not statistically significant, targeting rural and critical access hospitals may be important to ensure that these hospitals do not fall behind in adopting interoperability goals.

Health information exchange participation has increased substantially since the passage of the HITECH Act in 2009, where hospitals who reported reporting sharing data through an HIE to 76% in 2015.[12] Our study found that participation in a regional HIE was associated with increased likelihood of implementing PI3 functions. However, we also found that nearly every hospital reported significant barriers with interoperability with outside providers, and these barriers were reported more frequently in hospitals that have already implemented PI3 functionalities. This finding is in contrast with a previous study of Meaningful Use Stage 2 objectives, where hospitals that achieved these objectives reported fewer challenges.[12] A likely explanation is that once a hospital is capable of carrying out interoperability functions, or performing tasks enabled by interoperable systems, they may experience these barriers more frequently. Indeed, most of the barriers reported by hospitals were outside of the hospital's control, such as barriers related to a receiving provider's ability and interest to send/receive data. These findings support purported concerns over a hospital's ability to meet PI3 requirements.[10] It may also be that differences in barriers reported by hospitals are the product of the local hospital markets in which those hospitals are located, and not directly related to implementing interoperability functions.

A particularly concerning finding from our study is that nearly half of all hospitals that implemented PI3 functionalities reported that recipients of electronic care summaries do not find them useful. The quality of data captured in EHRs have long been cited as a challenge to interoperability. One study suggests that only 18% of physicians' notes captured in EHRs were manually entered, with the remaining notes copied or imported from other sources.[14] In-depth interviews suggest that physicians and nurses may not fully trust EHR data.[15] The assumed

benefit of interoperability is that shared data between hospitals and outside providers is meaningful and reliable. If shared data is neither meaningful nor reliable, then the benefits and investments made in interoperability may be squandered.

There are limitations to our study that should be considered. First, while we attempted to control for nonresponse bias for the hospitals that did not complete the IT Supplement survey, these hospitals may be different in ways not accounted for in our analysis. Second, our measures of PI3 core objective implementation reflect survey responses to whether certain capabilities were implemented in a hospital EHR, but do not represent the extent to which those capabilities were functional or actively utilized by providers. Thus, our estimates do not capture the extent to which hospitals have fully achieved PI3 requirements according to federal guidelines. Third, information on perceived barriers were captured at the hospital level, and may not reflect the barriers experience by staff within hospitals. Fourth, the data was collected in 2015, before the release of the PI3 requirements. However, changes in the adoption of interoperable systems have been slow, and we do not expect that barriers to interoperability have changed during this time.[6] Future studies should examine more recent trends in interoperability as newer data become available. Finally, the cross-sectional observational nature of this analyses does not allow us to interpret the direction of the relationship or causality.

Ultimately, our study demonstrates that while few hospitals had fully implemented PI3 requirements at the time of this study, the majority of hospitals have implemented most of the requirements, and may be well positioned to meet PI3 requirements. Focused efforts on improving implementation of certain functionalities and within specific hospital subgroups could lead to significant improvements in overall PI3 achievement. However, several barriers stand in the way of achieving seamless interoperability, many of which lie outside hospitals' control.

Funding source

Appendix A. Supporting information

Supplementary data associated with this article can be found in the

online version at doi:10.1016/j.hjdsi.2018.12.001.

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