

# The association between health information exchange and measures of patient satisfaction

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## Keywords

Hospitals; data sharing; healthcare quality assessment; propensity score; patient satisfaction, communication

## Summary

**Objective:** Health information exchange (HIE) is the interorganizational sharing of patient information and is one of many health information technology initiatives expected to transform the U.S. healthcare system. Two outcomes expected to be improved by HIE are patient-provider communication and patient satisfaction. This analysis examined the relationship between the level of HIE engagement and these two factors in a sample of U.S. hospitals.

**Methods:** Independent variables came from existing secondary sources and the dependent measures were from the Hospital Consumer Assessment of Healthcare Providers and Systems. The analysis included 3,278 hospitals. Using ordinary least squares regression, implemented HIE was positively associated with the percentage of patients reporting nurses communicated well and higher satisfaction. Due to the potential for selection bias, results were further explored using a propensity score analysis.

**Results:** Hospitals that had adopted HIE, but not yet implemented saw no benefits. Hospitals' level of HIE was not associated with the percentage of patients reporting doctors communicated well. According to propensity score corrected estimates, implemented HIE was associated with the percentage of patients who reported nurses always communicated well and who would definitely recommend the hospital.

**Conclusion:** Few studies have examined the impact of HIE at the organizational level. This examination provides some evidence that hospitals engaging in HIE are associated with higher patient satisfaction.

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## 1. Introduction

The implementation of effective health information exchange (HIE) is one of many health information technology initiatives expected to transform the U.S. healthcare system [1]. HIE is the “electronic movement of health-related information among organizations according to nationally recognized standards” [2]. HIE encompasses a host of diverse information types ranging from discharge notes to diagnostic tests to patient demographics. This process of electronically sharing patient information among organizations has the potential to make healthcare safer, foster efficiency, improve public health, support research, and generate cost savings [3–5].

However, despite these promised benefits, the literature contains few empirically demonstrated benefits. We have no shortage of expert opinions as to the benefits of HIE, but we unfortunately do not have an abundance of organizational-level and generalizable evidence of HIE effectiveness. The best evidence of cost savings comes from Overhage and colleagues’ work in emergency departments [6]. In addition, Branger and colleagues found HIE increases communication between providers [7], and Kern and colleagues reported the electronic viewing of laboratory results was associated with higher quality [8]. Further complicating HIE efforts in the U.S. HIE facilitating organizations have sustainability issues [9], a return on investment has been difficult to establish for HIE [10], and barriers exist to hospital implementation of HIE [11].

Using nationally representative datasets, this study examines the relationship between hospitals’ active HIE participation and four quality indicators. This study is part of a growing body of research examining the effectiveness of health information technologies at the organizational or institutional level [12–15]. Demonstrating or identifying the impact of new technologies at an organizational level is increasingly important in light of organizations’ massive health information technology investments as well as significant government spending.

### 1.1 Background

HIE efforts in the U.S. vary substantially in form and function. Health organizations share varying types of patient information through different types of HIE facilitating organizations, using different technical architectures, and with different types of partners [9, 16–18]. No matter the form, HIE can be considered a structural component of the organization in that it supports the provision of care [19]. While the introduction of new technology into an organization can change existing structures, the anticipated effects of HIE predominantly fall into either process or outcome improvements. Based on the existing HIE literature and commentary by HIE experts, this investigation examines the relationship between the level of a hospital’s HIE engagement and 1. patients’ perceptions of communication with providers and 2. patient satisfaction.

The suggestion that the provision of previously unavailable, relevant patient information to providers may lead to better provider-patient communication has existed for more than a decade [20]. A more recent survey demonstrates patients share this perception [21]. From commentaries and observations in the literature, HIE could act on provider-patient communication by either fostering a more informed conversation or by simply allowing the actual communication to occur. The case of the former was best articulated by Frisse[22] when he observed, in select circumstances, that HIE might create a shared “common knowledge of past medical history” on which the provider and patient can build better conversations. This better communication through better information idea also appears in the specific discussion of using personal health records as the means to, or integrated with, information exchange [23, 24]. Alternatively, provider-patient communication may be improved as a result of efficiency gains. HIE replaces information gathering activities that could interfere with patient interaction [25]. Any newfound time could be allocated to better patient communication. Lastly, one empirical study hints HIE may be related to better communication. Kern and colleagues [8] reported a large proportion of providers with access to electronic laboratory result viewing had higher than average patient communication satisfaction scores. The potential for improved patient-provider communication suggests the following hypothesis:

### Hypothesis 1

Hospitals engaged in health information exchange will have higher levels of patients reporting health professionals always communicated well.

Researchers, practitioners, governments, and technology vendors each expect that the organizational usage of HIE will increase patient satisfaction. Increased patient satisfaction appears in the United Hospital Fund's comprehensive HIE evaluation framework [4] and the assessment of patient or consumer satisfaction appears in additional evaluation resources [26–28]. The Kern and colleagues' [8] study noted above, also reported many providers had higher than average overall patient satisfaction scores. For practitioners, the popular healthcare press identifies improved customer satisfaction as a reason for engaging in exchange efforts [29–31] and the Health Information & Management System Society reports [32] most HIE facilitating organizations include improving patient satisfaction among their stated purposes. Potentially, individuals view the organization favorably due to their investment in HIE [33]. With researchers and those in the field expecting HIE to affect patient satisfaction, it is no surprise that state governments include satisfaction measures in HIE evaluation plans [34, 35]. Lastly, technology vendors are not immune to purporting their products will lead to improved patient satisfaction [e.g. 36, 37]. This widespread expectation suggests the following hypothesis:

### Hypothesis 2

Hospitals engaged in health information exchange will have higher levels of patient satisfaction.

## 2. Methods

Data from this study came from the 2009 HIMSSAnalytics Database™, the 2007 American Hospital Association (AHA) Survey and a review of all HIE facilitating efforts, including regional health information organizations (RHIOs), in the U.S. Using lists of exchange efforts and their characteristics from multiple sources [38, 39] the operational status of each HIE effort was determined.

Hospitals participating in efforts that were actively sharing information among partners were classified as having implemented HIE. Those hospitals identified as members of efforts that had not yet begun sharing information were classified as adopters of HIE. The presence of active information sharing was the key distinguishing feature between these two categories. Hospitals participating in an exchange effort where the information system was in use and functioning were classified as implementers. HIE adopting hospitals had agreed to join exchange efforts, but those efforts had not yet progressed from the existence of an interorganizational collaboration to actual functioning information sharing. All other hospitals were non-adopters. These definitions follow exiting management and innovation literature streams that distinguish between organizational adoption as the acquisition of technology, and implementation as a post-adoption putting the technology to use [40–42]. The process of data aggregation and classification has been described elsewhere in detail [11].

These data were linked to the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey available in Hospital Compare (<http://www.hospitalcompare.hhs.gov>) by common identifiers [43]. Select measures or composites of individual indicators from Hospital Compare have been utilized in previous investigations of EHRs and health information technology [13–15]. HCAHPS is a national survey of patients' recent inpatient hospital experiences and the current collection used in this analysis covered the period of October 2008 through September 2009. The dependent variables describing communication were measured as the percentage of patients who reported their doctors and their nurses always communicated well, respectively. The dependent variables describing patient satisfaction were: percentage of patients who would definitely recommend the hospital and the percentage of patients who gave the hospital a high global rating (a score of 9 or 10 on a 10-point scale) [44]. To ensure stable estimates, we excluded satisfaction measures based on fewer than 100 survey responses. The merged dataset included 3,278 hospitals.

The principle independent variable was level of HIE participation: implemented, adopted, or none. The relationship between the independent and dependent variables was assessed by ordinary least squares regression (OLS). We used four sources to identify potential confounding factors. First,

we considered each of the organizational variables identified in Jha and colleagues' recent analysis of hospital characteristics and HCAHPS outcome measures [44] as important factors to control. However, we did not limit ourselves to those organizational factors, but considered all other organizational characteristics available in the AHA survey where the proportion of missing responses was low enough not to substantially reduce our sample size. Third, we attempted to control for the overall level of automation within the hospital by measuring each facilities' total number of live applications as recorded in the HIMSSAnalytics Database™. Lastly, because hospitals may be influenced by the external environment we also considered factors from the environment such as the presence of state community benefit laws, state health information technology legislation, and number of Regional Health Information Organizations in the state. Best fitting models for each dependent variable were created using a backwards elimination approach looking for improvements in information criteria scores [45]. Robust standard errors were used to account for clustering if state level variables appeared in the model.

Because these data are cross-sectional in nature, and hospitals' HIE activities were not assigned through random allocation, a significant risk of self-selection bias exists. The bias may either be positive (e.g., it was the higher quality hospitals that implemented HIE to begin with) or negative (e.g., it was the lower quality hospitals that engaged in HIE to improve performance). Either way, this type of potential bias is a common threat to the statistical validity of nonrandom study designs, such as organizational level studies of secondary datasets.

We utilized propensity scores to adjust for selection bias [46, 47]. Due to the multinomial nature of our primary exposure variable, we followed the multiple propensity score method outlined by Spreuwenberg and colleagues [48]. Using multinomial probit regression we obtained the predicted probability of HIE status using factors previously associated with HIE adoption and implementation [11] and additional structural variables available in the study dataset. Exploratory analyses indicated a multinomial logistic model would not satisfy the assumption of independence of irrelevant alternatives and an ordered probit model did not satisfy the parallel regression assumption. The propensity scores were checked for areas of common support and for balance by level of HIE [49]. Corrected estimates of the effect of HIE on each of the outcome measures were determined by including the propensity scores in the regression models.

### 3. Results

► Table 1 describes the study sample. Of the study hospitals 10.4% had adopted HIE and another 10.7% had progressed to HIE implementation. The sample was almost exclusively general acute care hospitals and the majority was not-for-profit. Each of the process measures and patient satisfaction measures exhibited substantial variability.

#### 3.1 Ordinary least squares regression results

The results of the OLS estimates for communication and patient satisfaction measures are presented in ► Table 2. For categorical factors, the base or comparison category is labeled as 'reference'. The difference in sample size between the adjusted models and the full dataset are due to missing responses primarily in the measure of days cash on hand. To keep the tables manageable, we do not present all associations. Instead we limited the reporting to only the measure of HIE status, the measure of automation, and those variables explored in the article by Jha and colleagues [44] to provide a contrast to the existing satisfaction literature.

The percentage of patients reporting doctors or nurses always communicated well decreased with increasing hospital size and was also higher for rural hospitals. Fewer Medicaid patients was also associated with better reported communication for both types of professionals and the higher the ratio of nurses to patient days was associated with more patients reporting better communication with nurses as well as physicians. Specific to Hypothesis 1, hospitals' implementation of HIE was positively associated with nurse communication. After adjusting for confounding factors, HIE implementation was associated with 0.75 increase (95%CI[confidence interval] = 0.13, 1.38) in the percent of patients reporting nurses always communicated well. No increase was evident for hospitals

that had adopted, but not engaged in HIE. After controlling for confounding factors, HIE status was not associated with the percentage of patients who reported doctors always communicated well.

A higher percentage of patients gave the hospital a high global rating if the hospital was not-for-profit, smaller, located in the Midwest or South, and had a lower number of Medicaid patients or higher nursing ratios. Hospital control, size, rurality, number of Medicaid patients and higher nursing ratios also were associated with the percentage of patients who would recommend the hospital. The number of total live applications in the hospital was positively associated with the global rating and the recommendation measures. Lastly, hospital implementation of HIE was associated with gains in both measures of patient satisfaction. Hospitals with implemented HIE had a 0.82 (95%CI = 0.01, 1.64) and a 1.34 (95%CI = 0.41, 2.27) increase in the percentage of patients giving a global high rating to the hospital or stating they would definitely recommend the hospital, respectively. These results provide support for Hypothesis 2. Unlike implementation, simply having adopted HIE, but not actively exchanging information, was not associated with satisfaction.

### 3.2 Propensity score adjustment results

► Table 3 displays the results of the estimated associations between level of HIE and the communication measures from the best fitting OLS regression and those corrected by propensity scores. The percentage of patients reporting doctors always communicated well was unassociated with HIE status before and after correcting by propensity score. The propensity score corrected association between implemented HIE and the percentage of patients reporting nurses always communicated well remained positive and statistically significant ( $\beta = 0.89$ ; 95%CI = 0.27, 1.51;  $p < 0.01$ ). However, the corrected model does not pass the Ramsey omitted variable test indicating even with the propensity score correction, there may be missing variables in the model.

► Table 4 contains the OLS estimates and the propensity score corrected estimates for the patient satisfaction measures. Whether from the best fitting OLS or the propensity corrected estimates, adopting HIE was not associated with higher percentages of satisfied patients. When propensity scores were included in the regression model, the positive statistically significant association between implemented HIE and the percentage of patients giving a global high rating for the hospital became non-significant. After propensity score correction, the association between implemented HIE and the percentage of patients who reported they would definitely recommend the hospital decreased to  $\beta = 0.92$  (95%CI = 0.02, 1.83), but remained statistically significant at the  $p < 0.05$  level. However, the corrected model again did not pass the Ramsey omitted variable test indicating even with the propensity score correction, there may be missing variables in the model.

## 4. Discussion

Proponents of HIE suggest the activity will foster improvements in provider-patient communication and in patient satisfaction. The results of this study provide some support for these anticipated effects as hospitals that had implemented HIE were positively associated with measures of communication and satisfaction. With the increases in public reporting of hospital statistics and pushes for increased consumer directed healthcare [50], identifying ways to improve patient experiences is an important activity for organizational leadership. In addition, the American public is generally supportive of HIE [51, 52]. This investigation is one of a small set that implies organizational level benefits from HIE implementation. Furthermore, these results highlight the challenges of organizational level evaluation, reinforce the distinction between adoption and implementation, and provide additional information on the role of automation and other factors on measures of perceived patient quality.

The OLS results indicate HIE may have some beneficial association with patient perceptions on nurse communication and satisfaction. However, the propensity score corrected estimates provided less evidence. After correction, HIE implementation was still associated with increasing percentages of patients reporting nurses always communicated well and patients reporting they would definitely recommend the hospital. However, we suspect a lingering selection bias. That suspicion is justified empirically by the omitted variable tests and conceptually because our models relied on structural

and environmental variables only. It may be that HIE engagement is an indicator of a particular culture or organizational information technology strategy that is not reflected in the measured organizational characteristics.

These results demonstrate the usefulness of the propensity score in evaluations of HIE and potentially other information technology. Historically, innovative individuals in select institutions developed technologies in-house. Currently, health information technology is dominated by vendors and is associated with substantial capital costs. Under either model, organizational level studies cannot expect randomized study designs to answer questions of effectiveness. While only one possible method to control for selection bias, the propensity score method in this study does illustrate its potential to better inform analyzes from secondary datasets.

This study's examination of HIE participation as three different levels helps illustrate that adoption of HIE is not the same as implementation of HIE. Clearly, just adoption of HIE provided no benefit. Repeatedly, no association was observed between simply adopting HIE and any of the dependent variables. Hospitals cannot expect to benefit from HIE unless it is used. Whereas these results hint HIE implementation may be associated with patient satisfaction. Although we do not know the exact level of usage within these hospitals, the use and ability to use HIE was higher than in those hospitals in the adopter category. This distinction becomes particularly important in light of the Stage 1 Meaningful Use criteria that organizations must only test their exchange capabilities. While testing is necessary to progress to actual usage, these results suggest subsequent Meaningful Criteria must ensure those capabilities are exploited and utilized to their fullest. Historically, health-care organizations have been willing to entertain the ideas of information exchange and even form the organizational relationships to facilitate sharing. However, getting past adoption to actual implementation has proven difficult [10, 11].

This study presents some additional information on the factors associated with patient satisfaction measures beyond HIE. In general, the results of this study are consistent with the existing literature on the associations between structural characteristics and satisfaction and communication [53–56]. In addition, in the best fitting OLS models, hospitals with more live and operational health information technologies were positively associated with the global high satisfaction and the definitely recommend measures. Numerous health information technology examples may improve patient experiences in the hospital and this study may provide a small degree of support for general investment in health information technology. In similar fashion, this study also supports the work of nurses within the hospital. For each measure, the more nurses there were in the hospital the higher the reported levels of patient satisfaction.

The results of this analysis must be considered in context of some important limitations. First, the propensity score method only controls for observed characteristics. Unmeasured factors may still bias results. Instrumental variable analysis would be one technique to address this potential problem; however, we were unable to identify a suitable instrument. Second, while we were able to distinguish adoption from implementation, this analysis treats HIE engagement as a uniform activity. HIE can use centralized repositories or federated architectures, users may have different software interfaces or different information availability, and each hospital might have differing types of exchange partners. The secondary dataset used in this analysis did not contain that level of detail for each hospital, nor did we know the levels of actual usage. Next, these analyses are limited in terms of generalizability: we excluded hospital with few HCAHPS survey respondents and our sample consisted of mostly general acute care hospitals. Lastly, the dependent variable reflected hospital inpatients. While HIE has application to the inpatient setting it is also applicable to emergency and ambulatory care. Given the nature and timing of the care delivered, this type of analysis might be more informative in the out-patient setting.

Each of the above findings suggests lines of future inquiry. First, the potential omitted variables may be identified by an expanded the investigation to include measures of organizational cultural or other internal hospital factors. Second, this study is also a call to identify a suitable instrumental variable for use in HIE and organizational quality investigations. However, instruments may be difficult to identify for studies that use different outcomes such as communication and satisfaction. Third, this study focuses on hospitals, but ambulatory clinics can utilize HIE and investigation could even focus exclusively on the effects of the emergency department. Finally, we can offer no conclusive explanation as to why HIE would positively affect nursing communication, but not physicians; par-

ticularly, because the level of automation within the hospital was not associated with communication for either group. As a speculation, the average level of individual acceptance of technology and routine utilization may differ between nurses and physicians even within hospitals that have implemented HIE. Much of the past and current HIE literature has focused on the role of the physician and these results suggest considering the differences between physicians and nurses as an avenue of research.

## 5. Conclusion

HIE is a national priority in the U.S., has the potential to transform the healthcare system, and is supported by the Meaningful Use criteria for EHRs. While HIE is anticipated to have numerous patient, organizational, and system level effects, few studies have examined the organizational level impact of HIE. This examination provides some evidence that implementation of HIE is associated with higher patient satisfaction and better communication in hospitals.

## 6. Implications of results for practitioners and consumers

The adoption of information systems is frequently insufficient to result in organizational benefits. Adopted systems must actually be implemented in order to benefit users, organizations and patients. Patients may be justified in expecting better communication with their providers when HIE is used by the organization.

### Conflict of Interest

The authors declare that they have no conflict of interest.

### Human Subjects Protections

Human subjects were not included in this analysis.

### Acknowledgments

The authors thank HIMSSAnalytics™ for access to their survey data.

**Table 1** Characteristics of US hospitals included in study sample by health information exchange status.

Select hospital characteristics	Total (n = 3,278)		None (n = 2,585)		Adopted (n = 340)		Implemented (n = 351)	
	%		%		%		%	
Control								
Private	17.6		21.3		2.7		4.6	
Not-for-profit	64.8		60.5		79.4		82.6	
Public	17.5		18.4		17.9		12.8	
Service								
General acute care	98.8		98.8		99.1		98.9	
Academic affiliation	8.0		7.1		11.2		11.4	
Census region								
Northeast	15.8		14.5		9.7		31.6	
Midwest	25.5		25.9		21.5		26.2	
South	40.6		43.4		26.5		33.9	
West	18.1		16.2		42.4		8.3	
Rural county	31.8		34.3		19.4		25.6	
Beds								
<100	33.0		35.3		21.5		26.8	
100–199	26.7		27.6		23.5		23.4	
≥200	40.3		37.1		55.0		49.9	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std
Medicaid discharges	1844.7	2455.8	1661.3	2134.9	2391.0	2648.1	2666.8	3843.9
Ratio of RNs to patient days	0.6	0.4	0.6	0.4	0.6	0.3	0.6	0.3
Total live applications	53.7	12.7	52.7	13.3	57.9	10.0	56.7	11.1
% responding nurse always communicated well	74.9%	5.6	75.0%	5.7	73.5%	4.8	75.8%	4.8
% responding doctor always communicated well	79.7%	5.0	79.9%	5.2	78.3%	4.2	79.5%	4.4
% responding would definitely recommend the hospital	68.4%	9.4	67.9%	9.6	69.8%	8.5	70.2%	8.2
% rating the hospital 9 or 10 on a 10 point scale	65.8%	8.5	65.8%	8.7	65.7%	7.6	66.6%	7.5

**Table 2** Adjusted associations between health information exchange status and organizational level satisfaction & communication measures.

	Doctors always communicated well <sup>1</sup>		Nurses always communicated well <sup>2</sup>		High global rating <sup>3</sup>		Would definitely recommend <sup>4</sup>	
n	3,244		3,244		3,244		3,244	
	β	95%CI	β	95%CI	β	95%CI	β	95%CI
<b>HIE status</b>								
None	Reference		Reference		Reference		Reference	
Adopted	-0.02	-0.50, 0.47	0.09	-0.60, 0.78	0.25	-0.61, 1.12	0.79	-0.48, 2.07
Implemented	0.30	-0.16, 0.76	0.75*	0.13, 1.38	0.82*	0.01, 1.64	1.34**	0.41, 2.27
<b>Control</b>								
Not-for-profit	Reference		Reference		Reference		Reference	
For-profit	0.25	-0.21, 0.71	-1.12**	-1.75, -0.50	-1.46**	-2.28, -0.65	-2.68**	-3.99, -1.38
Public	0.36	-0.05, 0.76	-0.47	-1.07, 0.13	-1.26**	-1.97, -0.54	-1.12*	-1.99, 0.26
<b>Beds</b>								
<100	Reference		Reference		Reference		Reference	
100–199	-1.08**	-1.54, -0.62	-1.55**	-2.25, -0.84	-2.48**	-3.29, -1.66	-2.91**	-4.23, -1.60
≥200	-1.05**	-1.72, -0.38	-1.69**	-2.46, -0.84	-2.38**	-3.54, -1.21	-2.90**	-4.23, -1.58
Academic	-0.15	-0.74, 0.44	-1.13**	-2.32, -0.07	-0.37	-1.41, 0.68	-0.43	-1.79, 0.93
<b>Census region</b>								
Northeast	Reference		Reference		Reference		Reference	
Midwest	0.32	-0.15, 0.79	-0.30	-1.66, 1.05	2.43**	1.60, 3.27	0.13	-2.03, 2.30
South	2.68**	2.23, 3.13	0.54	-1.10, 2.17	2.92**	2.12, 3.73	1.73	-0.45, 3.90
West	-1.88**	-2.41, -1.35	-3.44**	-4.88, -2.02	0.21	-0.73, 1.15	0.46	-1.49, 2.42
Rural	1.53**	1.13, 1.93	1.30**	0.67, 1.94	-0.32	-1.03, 0.39	-1.85**	-3.02, -0.68
Medicaid patients (quartile)	-1.00**	-1.28, -0.72	-0.92**	-1.33, -0.51	-1.68**	-2.16, -1.20	-1.36**	-2.03, -0.69
Ratio of nurses to patient days	0.57**	0.14, 1.00	1.70*	0.40, 2.99	2.52**	1.77, 3.27	2.20*	0.14, 4.26
Total live applications	-0.01	-0.03, 0.01	0.01	-0.02, 0.03	0.07**	0.04, 0.09	0.07**	0.03, 0.11
R squared	0.37		0.35		0.30		0.32	

<sup>1</sup>Adjusted for: total number of job categories, fewer than 30 days cash on hand, ED visits, non-general acute care status, sole community provider status, uncompensated care percent, case mix index, contract managed hospital, HMO hospital, community benefit mission statement, LTC unit, critical access hospital status, AHA membership, Blue Cross contracting, JCAHO accreditation, ACS cancer program, AOA accreditation.

<sup>2</sup>Adjusted for: total services, total number of job categories, community benefit law state, level of state HIT legislative activity, fewer than 30 days cash on hand, ED visits, non-general acute care status, sole community provider status, uncompensated care percent, case mix index, LTC unit, critical access hospital status, AHA membership, Blue Cross contracting.

<sup>3</sup>Adjusted for: total number of job categories, fewer than 30 days cash on hand, non-general acute care status, sole community provider status, uncompensated care percent, case mix index, contract managed hospital, HMO hospital, critical access hospital status, AHA membership, JCAHO accreditation.

<sup>4</sup>Adjusted for: total services, total number of job categories, community benefit law state, total births, fewer than 30 days cash on hand, non-general acute care status, sole community provider status, uncompensated care percent, case mix index, contract managed hospital, HMO hospital, critical access hospital status, AHA membership, JCAHO accreditation. \*p<0.05; \*\*p<0.01

**Table 3** Propensity score analysis of the associations between health information exchange and organizational level communication measures.

	Doctors always communicated well				Nurses always communicated well			
	OLS		Propensity score		OLS		Propensity score	
	$\beta$	95%CI	$\beta$	95%CI	$\beta$	95%CI	$\beta$	95%CI
HIE status								
None	Reference		Reference		Reference		Reference	
Adopted	-0.02	-0.50, 0.47	-0.02	-0.51, 0.47	0.09	-0.60, 0.78	0.10	-0.59, 0.79
Implemented	0.30	-0.16, 0.76	0.30	-0.18, 0.77	0.75	0.13, 1.38*	0.89	0.27, 1.51**

Estimates adjusted for all variables in Table 2 and the propensity score based on: academic affiliation, AHA membership, total beds, benefit law state, backwards integration within the system, forward integration within the system, births, case mix index, primary care provider rate, expenses, cancer program, residency training, Medicare certification by DHHS, Federation of American Health Care Systems membership, operational regional health information organizations in the state, Medicare discharges, system membership, network membership, nursing ratio, rural referral center, sole community provider, service type, LTC unit, emergency department visits.  
\*p<0.05 \*\*p<0.01

**Table 4** Propensity score analysis of the associations between health information exchange and organizational level patient satisfaction measures.

	High global rating				Would definitely recommend			
	OLS		Propensity score		OLS		Propensity score	
	$\beta$	95%CI	$\beta$	95%CI	$\beta$	95%CI	$\beta$	95%CI
HIE status								
None	Reference		Reference		Reference		Reference	
Adopted	0.25	-0.61, 1.12	0.14	-0.73, 1.01	0.79	-0.48, 2.07	0.60	-0.58, 1.77
Implemented	0.82*	0.01, 1.64	0.55	-0.29, 1.39	1.34**	0.41, 2.27	0.92*	0.02, 1.83

Estimates adjusted for all variables in Table 2 and the propensity score based on: academic affiliation, AHA membership, total beds, benefit law state, backwards integration within the system, forward integration within the system, births, case mix index, primary care provider rate, expenses, cancer program, residency training, Medicare certification by DHHS, Federation of American Health Care Systems membership, operational regional health information organizations in the state, Medicare discharges, system membership, network membership, nursing ratio, rural referral center, sole community provider, service type, LTC unit, emergency department visits.  
\*p<0.05, \*\*p<0.01

## References

1. President's Council of Advisors on Science and Technology. Report to the President. Realizing the full potential of health information technology to improve healthcare for americans: The path forward. Washington, DC: Executive Office of the President, 2010.
2. The National Alliance for Health Information Technology. Report to the Office of the National Coordinator for Health Information Technology on Defining Key Health Information Technology Terms. Department of Health & Human Services; 2008 [updated April 28, 2008March 3 2010]; Available from: [http://healthit.hhs.gov/portal/server.pt?open=18&objID=848133&parentname=CommunityPage&parentid=5&mode=2&in\\_hi\\_userid=10741&cached=true](http://healthit.hhs.gov/portal/server.pt?open=18&objID=848133&parentname=CommunityPage&parentid=5&mode=2&in_hi_userid=10741&cached=true).
3. Institute of Medicine. Fostering rapid advances in health care: learning from system demonstrations. Corrigan J, Greiner A, Erikson S, editors. Washington, D.C.: National Academy Press; 2003.
4. Hripcsak G, Kaushal R, Johnson KB, Ash JS, Bates DW, Block R, et al. The United Hospital Fund meeting on evaluating health information exchange. *Journal of Biomedical Informatics* 2007; 40(6 S1): S3-S10.
5. Walker J, Pan E, Johnston D, Adler-Milstein J, Bates DW, Middleton B. The value of health care information exchange and interoperability. *Health Aff* 2005; 24(hlthaff.w5.10): w10-w18.
6. Overhage J, Deter P, Perkins S, Cordell W, McGoff J, McGrath R. A randomized, controlled trial of clinical information shared from another institution. *Ann Emerg Med* 2002; 39(1): 14–23.
7. Branger P, van'tHooft A, van der Wouden HC. Coordinating shared care using electronic data interchange. *Medinfo* 1995; 8 (Pt 2): 1669. Epub 1995/01/01.
8. Kern LM, Barron Y, Blair AJ, Salkowe J, Chambers D, Callahan MA, et al. Electronic result viewing and quality of care in small group practices. *Journal of General Internal Medicine* 2008; 23(4): 405–410.
9. Adler-Milstein J, Landefeld J, Jha AK. Characteristics associated with regional health information organization viability. *J Am Med Inform Assoc* 2010; 17(1): 61–65. Epub 2010/01/13.
10. Vest JR, Gamm LD. Health information exchange: persistent challenges & new strategies. *Journal of the American Medical Informatics Association* 2010; 17(3): 288–2894.
11. Vest JR. More than just a question of technology: Factors related to hospitals' adoption and implementation of health information exchange. *International Journal of Medical Informatics* 2010; 79(12): 797–806.
12. Menachemi N, Chukmaitov A, Saunders C, Brooks RG. Hospital quality of care: Does information technology matter? The relationship between information technology adoption and quality of care. *Health Care Management Review* 2008; 33(1): 51–59. doi:10.1097/01.HMR.0000304497.89684.36.
13. Jones SS, Adams JL, Schneider EC, Ringel JS, McGlynn EA. Electronic health record adoption and quality improvement in US hospitals. *The American Journal of Managed Care* 2010; 16 (12 Special issue): SP64-SP71.
14. Kazley AS, Ozcan YA. Do hospitals with electronic medical records (EMRs) provide higher quality care? *Medical Care Research and Review* 2008; 65(4): 496–513.
15. McCullough JS, Casey M, Moscovice I, Prasad S. The effect of health information technology on quality in U.S. hospitals. *Health Aff* 2010; 29(4): 647–654.
16. Wilcox A, Kuperman G, Dorr DA, Hripcsak G, Narus SP, Thornton SN, et al. Architectural strategies and issues with health information exchange. *AMIA AnnuSymp Proc* 2006: 814–818. Epub 2007/01/24.
17. Adler-Milstein J, McAfee AP, Bates DW, Jha AK. The state of regional health information organizations: current activities and financing. *Health Aff* 2008; 27(1): w60-w69.
18. eHealth Initiative. The state of health information exchange in 2010: connecting the nation to achieve meaningful use. Washington, DC: 2010.
19. Donabedian A. Evaluating the quality of medical care. *Milbank Mem Fund Q*. 1966; 44(3 Suppl): 166–206. Epub 1966/07/01.
20. Department of Health & Human Services. Information for health: a strategy for building the national health information infrastructure. Washington, DC: 2001 Nov 15.
21. Patel V, Dhopeswarkar R, Edwards A, Barrón Y, Sparenborg J, Kaushal R. Consumer support for health information exchange and personal health records: a regional health information organization survey. *Journal of Medical Systems* 2010: 1–10.
22. Frisse ME. Health information exchange in Memphis: Impact on the physician-patient relationship. *The Journal of Law, Medicine & Ethics* 2010; 38(1): 50–57.
23. Kaelber DC, Bates DW. Health information exchange and patient safety. *Journal of Biomedical Informatics* 2007; 40(6, Suppl. 1): S40-S45.
24. Dixon BE, Miller T, Overhage JM. Assessing HIE stakeholder readiness for consumer access: lessons learned from the NHIN trial implementations. *J HealthcInfManag* 2009; 23(3): 20–25. Epub 2009/08/12.

25. Biondich PG, Grannis SJ. The Indiana network for patient care: an integrated clinical information system infomed by over thirty years of experience. *J Public Health Management Practice* 2004; November(Suppl): S81-S86.
26. Cusack CM, Poon EG. Health information exchange toolkit. Rockville, MD: Agency for Healthcare Research & Quality, 2007 Contract No.: 08-0026-EF.
27. Ash JS, Guappone KP. Qualitative evaluation of health information exchange efforts. *Journal of Biomedical Informatics* 2007; 40 (6 Suppl. 1): S33-S39.
28. Dixon BE, Zafar A, Overhage JM. A Framework for evaluating the costs, effort, and value of nationwide health information exchange. *Journal of the American Medical Informatics Association* 2010; 17(3): 295-301.
29. Freedman I, Diamond J. Strategies for success. *Health Management Technology* 2007; 28(7): 30-31.
30. EMRDaily News. Health information technology enhances exchange capabilities. 2011 [cited 2011 6/18/2011]; Available from: <http://emrdailynews.com/2011/01/11/health-information-technology-enhances-exchange-capabilities/> Archived at <http://www.webcitation.org/5zZUboX0f>.
31. Restuccia M. Get ready for a national network. *InformationWeek Healthcare* [Internet]. 2010. Available from: <http://www.informationweek.com/news/healthcare/EMR/227800022> Archived at <http://www.webcitation.org/5zZW0xGAE>
32. Healthcare Information & Management Systems Society. Health information exchanges: similarities and differences. HIMSS HIE Common Practices Survey Results White Paper Chicago, IL: 2009.
33. Pevnick JM, Claver M, Dobalian A, Asch SM, Stutman HR, Tomines A, et al. Provider stakeholders' perceived benefit from a nascent health information exchange: a qualitative analysis. *Journal of Medical Systems* 2010.
34. California Health & Human Services Agency. California health information exchange cooperative agreement program. Sacramento, CA2009.
35. Oregon Health Authority and Health Information Technology Oversight Council. Health information exchange: an operational plan for Oregon. Salem, OR2010.
36. Greenway Medical Technologies I. Health information exchange: interoperability and data liquidity for HIE Success. Carrolton, GA2011 [cited 2011 6/18/2011]; Available from: <http://www.greenwaymedical.com/solutions/greenway-hie/> Archived at: <http://www.webcitation.org/5zZU1sAF7>.
37. Accenx. Solutions for Hospitals. 2011 [cited 2011 6/18/2011]; Available from: <http://accenxtechnologies.com/Solutions/Hospitals.php> Archived at <http://www.webcitation.org/5zZUslzKT>.
38. Adler-Milstein J, Bates DW, Jha AK. U.S. regional health information organizations: progress and challenges. *Health Aff* 2009; 28(2): 483-492.
39. eHealth Initiative. Results of 2009 survey on health information exchange. Washington, DC2009 [cited 2009 Aug 21]; Available from: <http://www.ehealthinitiative.org/HIESurvey/>.
40. Klein KJ, Sorra JS. The challenge of innovation implementation. *The Academy of Management Review* 1996; 21(4): 1055-1080.
41. Tornatzky LG, Klein KJ. Innovation characteristics and innovation adoption-implementation: a meta-analysis of findings. *IEEE Transactions on Engineering Management* 1982; 29(1): 28-45.
42. Rogers EM. Diffusion of innovations. 5th ed. New York: Free Press; 2003.
43. Department of Health & Human Services [Internet]. Note to Hospitals. 2001 [cited 1/25/2011]; Available from: <http://www.hospitalcompare.hhs.gov/staticpages/help/Note-Hospitals.aspx>.
44. Jha AK, Orav EJ, Zheng J, Epstein AM. Patients' perception of hospital care in the United States. *New England Journal of Medicine* 2008; 359(18): 1921-1931.
45. StataCorp. Stata base reference manual: Release 11. College Station, TX: StataCorp LP; 2009.
46. Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. *Biometrika* 1983; 70(1): 41-55.
47. Rosenbaum PR, Rubin DB. Reducing bias in observational studies using subclassification on the propensity score. *Journal of the American Statistical Association* 1984; 79(387): 516-524.
48. Spreuuenberg MD, Bartak A, Croon MA, Hagenaaers JA, Busschbach JJV, Andrea H, et al. The multiple propensity score as control for bias in the comparison of more than two treatment arms: an introduction from a case study in mental health. *Medical Care* 2010; 48(2): 166-174. doi:10.1097/MLR.0b013e3181c1328f.
49. Caliendo M, Kopeinig S. Some practical guidance for the implementation of propensity score matching. Bonn, Germany: Institute for the Study of Labor 2005. Report No.: IZA DP No. 1588.
50. Elliott MN, Lehrman WG, Goldstein EH, Giordano LA, Beckett MK, Cohea CW, et al. Hospital survey shows improvements in patient experience. *Health Aff (Millwood)* 2010; 29(11): 2061-2067.

51. O'Donnell H, Patel V, Kern L, Barrón Y, Teixeira P, Dhopeswarkar R, et al. Healthcare consumers' attitudes towards physician and personal use of health information exchange. *Journal of General Internal Medicine* 2011; 1–8.
52. Markle Foundation. Attitudes of Americans regarding personal health records and nationwide electronic health information exchange. New York, NY: 2005.
53. Young GJ, Meterko M, Desai KR. Patient satisfaction with hospital care: effects of demographic and institutional characteristics. *Medical Care* 2000; 38(3): 325–334.
54. Kutney-Lee A, McHugh MD, Sloane DM, Cimiotti JP, Flynn L, Neff DE, et al. Nursing: a key to patient satisfaction. *Health Aff (Millwood)* 2009; 28(4): w669-w677.
55. Centers for Medicare & Medicaid Services. <http://www.hcaphpsonline.org>. Baltimore, MD2010 [cited 2011 March 1 2011].
56. Lehrman WG, Elliott MN, Goldstein E, Beckett MK, Klein DJ, Giordano LA. Characteristics of hospitals demonstrating superior performance in patient experience and clinical process measures of care. *Medical Care Research and Review* 2010; 67(1): 38–55.