

Electronic Sharing of Diagnostic Information and Patient Outcomes

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Accurate communication of diagnostic data among medical providers is important for successful patient hand-offs and ensuring high-quality follow-up care.¹ One specific avenue of communication, the sharing of electronic health records (EHRs), has emerged as a means to quickly communicate diagnostic data among hospitals and providers and has the potential to significantly reduce patient mortality and readmissions.²⁻⁴ Despite the prospective benefits of sharing EHR diagnostic data in terms of improved patient outcomes, the lack of common standards for EHR systems across hospitals and other providers can increase the risk of communication errors that may negatively impact patients.⁵⁻⁸

Further compounding this issue, the benefits of sharing EHR data can be hard to assess given the difficulties in measuring patient outcomes. Previous studies have used the rate of medical errors,⁹ simulation tools,¹⁰ and primary data¹¹ from hospitals. In some cases, however, these studies consider unique institutions and the results may not be generalizable. Conflicting results among studies also may make it difficult to produce general conclusions about EHR data. Moreover, how hospitals pool study data may generate different results.¹² Thus, although EHR systems have the potential to improve communication among hospitals and physicians, providers face careful calculations when balancing infrastructure costs, the sharing of EHR system data, and patient outcomes.^{3,13}

By exploiting CMS Hospital Compare (HC) data and the American Hospital Association (AHA) Annual Information Technology (IT) supplement database, we sought to examine the effects on different groups of providers and hospitals within and outside of the hospital system. The CMS HC database contains useful metrics for comparing hospitals, including patient outcomes such as 30-day mortality and readmission for heart failure (HF) and pneumonia. These publicly reported quality measures have already been used to examine patient mortality and readmissions in several studies.¹⁴⁻¹⁶ We employed these data in a multivariate regression analysis to consider whether there are associations among hospital sharing of EHR diagnostic data and differences in patient mortality and readmissions.

ABSTRACT

OBJECTIVES: Hospital sharing of electronic health record (EHR) diagnostic data has the potential to improve communication across providers and improve patient outcomes. However, implementing EHR systems can be difficult for hospitals. This study uses Hospital Compare (HC) and American Hospital Association (AHA) Annual Information Technology Survey data to estimate the association between sharing EHR data and patient outcomes.

STUDY DESIGN: Descriptive and multivariate linear regression analyses.

METHODS: This study links 2 years of HC data on 30-day patient mortality and readmissions for heart failure (HF) and pneumonia with 2 years of AHA data. The sample was restricted to hospitals included in both years in both sets of data. We estimated the associations between sharing EHR diagnostic data and patient outcomes with a multivariate linear regression analysis. Results were adjusted by hospital characteristics from the AHA annual survey.

RESULTS: Hospitals' sharing of radiology report data with hospitals within their system was associated with significantly lower mortality scores for pneumonia (-0.22 ; $P < .01$). Conversely, hospital sharing of radiology report data with hospitals outside their system was associated with significantly higher HF mortality scores (0.26 ; $P < .01$). We found qualitatively similar results with sharing laboratory results through EHRs.

CONCLUSIONS: Hospital sharing of EHR data with providers within their system is associated with better patient mortality, whereas sharing data with providers outside their system is associated with worsened patient mortality. Improving communication between hospitals using different EHR systems may be more crucial than simply expanding data sharing.

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METHODS

Data

We obtained data on the sharing of hospital EHR diagnostic data from the AHA Annual IT Supplement Database for 2012 and 2013. The AHA conducts this annual survey, which gathers information on hospital sharing of EHR patient data, including diagnostic data from radiology reports and laboratory results. The AHA survey data have also been used with private healthcare claims to estimate the impact of EHR use on patient outcomes, including patient mortality and readmissions.¹⁰ Question 3 of the AHA IT Supplement asks, “Which of the following patient data does your hospital electronically exchange/share with 1 or more of the provider types listed below?” The AHA survey defines the electronic exchange of EHR data as the “exchanging of data through nonmanual means, such as EHRs and/or portals, and excludes fax/paper.”

Separate responses to this question are collected for radiology reports and laboratory results. Within each response category, the survey lists 4 provider sharing types that a respondent may select, as well as a “Do Not Know” option. The provider sharing types are: 1) “With hospitals inside of your system,” 2) “With hospitals outside of your system,” 3) “With ambulatory providers inside of your system,” and 4) “With ambulatory providers outside of your system.” We assumed “ambulatory providers” to refer to physicians for the purposes of this study. The sample sizes varied slightly for each question category because some hospitals reported blank responses for some of the categories and because responses of “Do Not Know” for any category were removed from the analysis.

We also collected additional hospital-specific data from the full AHA Annual Survey Database for 2012 and 2013 to adjust for factors that may influence the HC scores: 1) the number of licensed beds for each hospital, 2) the number of full-time equivalent (FTE) employees for each hospital, 3) whether or not the hospital is located in a rural area, 4) whether or not the hospital is part of a network, 5) whether or not the hospital is a teaching hospital, and 6) the level of expenditures in millions for each hospital.¹⁷ The AHA determines whether a hospital is part of a network, located in a rural area, or a teaching hospital. We also included the CMS hospital case mix index and a year indicator to adjust for any unobservable trends over time that could influence patient outcomes.

The AHA survey data can be linked with the HC scores using a 1-year time lag due to a delay in data collection and reporting. CMS HC scores provide useful metrics for comparing patient outcomes among hospitals. CMS quality measures have been used to measure the relationships among hospital quality and patient mortality and readmissions.^{2,18,19} Although the scores themselves have generated some controversy, they remain a useful measure

TAKEAWAY POINTS

Hospitals that share diagnostic data through their electronic health records (EHRs) with other providers in their system are associated with better patient outcomes.

- ▶ Sharing diagnostic data through the EHRs within their system was associated with significantly lower 30-day patient mortality scores.
- ▶ Sharing diagnostic data through the EHRs outside their system was associated with significantly higher 30-day patient mortality scores.
- ▶ Sharing diagnostic data through EHRs with physicians was significantly associated with lower heart failure readmissions overall.

for comparing quality differences among hospitals. HC scores are measured at the hospital level and provide a relative comparison of patient outcomes in different hospitals across the United States. As HC includes most US hospitals, the scores also permit a more representative sample of hospitals and more generalizable results.

As our measures of patient outcomes, we used 2013 and 2014 HC scores for: 1) 30-day patient mortality from HF, 2) 30-day patient mortality from pneumonia, 3) 30-day readmissions from HF, and 4) 30-day readmissions from pneumonia. Each score represents the risk-adjusted ratio of predicted mortality or readmissions compared with expected mortality or readmissions for a hospital multiplied by the national mortality or readmission score. CMS estimates the scores using a hierarchical logistic regression model that accounts for the variance in patient outcomes within and between hospitals and adjusts for the individual hospital’s case mix index of patients.^{20,21}

Statistical Analysis

Hospital scores from the 2013 and 2014 HC scores were linked with the corresponding hospital data collected from the 2012 and 2013 AHA Annual Survey Database and the AHA IT Supplement. Descriptive statistics were calculated for all hospital data collected.

We used multivariate linear regression to examine the associations among the 4 HC outcomes scores and the responses reported on the AHA IT Supplement for Question 3. The responses were reported separately for sharing radiology reports and sharing laboratory results by each of the 4 provider sharing types. Hospitals reporting “Do Not Know” were removed from the analysis.

The multivariate regression results report the adjusted estimates for sharing radiology reports and laboratory results through hospital EHRs to different provider types on the HC scores for 30-day mortality and readmissions for patients with HF and pneumonia. The results were adjusted by the numbers of hospital beds and FTE employees, rural hospital, network hospital, teaching hospital, total expenditures, hospital case mix index, and a time trend.

Analyses were performed using SAS version 9.4 (SAS Institute; Cary, North Carolina). Two-sided *P* values < .05 were used to assess statistical significance.

TABLE 1. AHA and HC Summary Statistics

Variable	Description	n	Mean	SD	Min	Max
Heart failure						
Mortality	30-day HC scores	4572	11.86	1.47	6.00	18.00
Readmissions	30-day HC scores	4670	22.33	1.66	15.80	31.70
Pneumonia						
Mortality	30-day HC scores	5028	11.78	1.78	6.40	22.10
Readmissions	30-day HC scores	5043	17.13	1.24	13.20	22.70
Number of beds	Number of licensed beds	4621	230.7	251.5	0	2485
Hospital FTE	Total FTE employees	5076	1190.6	1720.1	23	27,394
Rural status	= 1 if a hospital is rural, else = 0	5076	0.23	0.42	0	1
Network status	= 1 if a hospital is in a network, else = 0	5076	0.48	0.50	0	1
Teaching status	= 1 if a teaching hospital, else = 0	5076	0.08	0.26	0	1
Expenditures	Total hospital facility expenses / \$1 million	5076	196.3	309.1	2.7	4435.3
Case mix index	Hospital case mix index	3775	1.46	0.28	0.79	3.44

AHA indicates American Hospital Association; FTE, full-time equivalent; HC, Hospital Compare; max, maximum; min, minimum.

RESULTS

Between 2012 and 2013, the AHA IT Supplement surveyed 4093 hospitals, which resulted in 6575 observations. Linking these data to each hospital's HC scores and the additional data from the AHA Annual Survey produced a final sample of 3113 distinct hospitals with 5088 total observations. The total observations varied for each multivariate regression analysis based on which hospitals answered each survey question and on data for each adjustment variable. There were 7.5% to 8.3% of values missing in the responses to IT Supplement Question 3 depending on the specific question component. Of the responding hospitals, less than 4% indicated "Do Not Know" as a response.

Descriptive Statistics

Table 1 reports summary statistics for the other variables in the study. For patients with HF, the average hospital score for 30-day patient mortality was 11.86 (SD = 1.47), and for 30-day readmissions, 22.33 (SD = 1.66). For patients with pneumonia, the average hospital score for 30-day patient mortality was 11.78 (SD = 1.78), and for 30-day readmissions, 17.13 (SD = 1.24). On average, hospitals had 230.7 licensed beds and 1190.6 FTE employees. Twenty-three percent of hospitals in our sample were rural, 48% were in a network, and 8% were teaching hospitals. On average, hospitals had about \$196.3 million in expenditures, including bad debt. The average hospital case mix index was 1.46.

Table 2 reports summary statistics for hospital responses to the AHA survey. Most hospitals in the study shared EHR diagnostic data with hospitals (72% shared radiology reports; 71% shared laboratory results) and physicians (80% shared radiology reports; 81% shared laboratory results) in their system. However, fewer hospitals shared EHR diagnostic data with hospitals or physicians that were

outside their system. Only 36% shared radiology reports and 37% shared laboratory results through their EHR with hospitals outside their system. External physicians fared slightly better, with 55% of hospitals sharing radiology reports with physicians outside their system and 57% sharing laboratory results with this group. Hospital responses were also cross-tabulated by whether the hospital was part of a network (Table 2). The proportion of networked hospitals that shared EHR diagnostic data was similar to the proportion of non-networked hospitals that shared these data.

Multivariate Regression Results

Table 3 reports the estimates for sharing hospital EHR diagnostic data with HC 30-day patient mortality and readmission scores.

30-Day Patient Mortality. Hospitals sharing radiology reports through EHR systems with hospitals within their system were associated with significantly lower mortality scores for pneumonia (-0.22 ; $P < .01$). Conversely, hospitals sharing radiology reports through their EHRs with hospitals outside their system were associated with significantly higher HF mortality scores (0.26 ; $P < .01$). Hospitals sharing radiology reports through their EHRs with physicians within their system were associated with significantly lower mortality scores for pneumonia (0.24 ; $P < .05$). Sharing radiology reports with physicians, whether within or outside their system, was not associated with significant differences in HF mortality. Hospitals sharing radiology reports with either external hospitals or external physicians were not associated with significant differences in 30-day mortality for pneumonia.

Sharing laboratory results through EHRs with other hospitals in their system was associated with significant reductions in HF (-0.19 ; $P < .01$) and pneumonia (-0.24 ; $P < .01$) mortality scores,

whereas sharing with hospitals outside their system was associated with higher scores for HF (0.26; $P < .01$). Likewise, hospitals sharing laboratory results through their EHRs with physicians within their system were associated with significantly lower pneumonia mortality scores (-0.24; $P < .05$).

30-Day Readmission. Hospitals sharing radiology reports through their EHRs with physicians outside their system were associated with significant reductions in 30-day readmission scores for patients with HF (-0.15; $P < .05$), as were those that shared laboratory results with physicians outside their system for these patients (-0.19; $P < .05$). Sharing radiology reports with hospitals was not associated with significant differences in HF readmissions. Sharing laboratory results with physicians within their system was associated with lower pneumonia readmission scores (-0.16; $P < .05$).

DISCUSSION

Our results suggest that hospitals that share diagnostic data through EHRs with other providers in their system are associated with better patient outcomes. Hospitals sharing diagnostic data through their EHRs with other hospitals and physicians within their system were associated with significant reductions in 30-day patient mortality scores. In contrast, electronic sharing of diagnostic data with hospitals outside their system was significantly associated with higher patient mortality scores for HF. It is possible that hospitals within a system share EHR data more effectively due to team dynamics.²² Further, as hospitals in different systems may have different EHR systems, there may be unique difficulties with sharing data across systems.⁹ Sharing of some diagnostic data, such as radiology reports, may also be limited in that EHR records often do not contain the radiology images, causing a mistake made before the data are entered into an EHR system to be transmitted across systems that cannot validate the original information. This may partially account for the differential between sharing with providers within and outside of systems because physicians within the system may be able to access the source images through other means when necessary. Hospitals that solve the communication challenges associated with EHR data may be able to significantly reduce patient readmissions and mortality.

Overall, fewer hospitals shared data with hospitals outside their system, which may reflect the concerns about communicating across EHR systems: 72% of hospitals shared radiology reports with hospitals within their system compared with 36% that shared radiology reports with hospitals outside their system, with similar percentages for laboratory results. For both types of diagnostic data, we found that more hospitals shared data with physicians within their own system than with physicians outside their system. If hospital sharing is limited by communication or compatibility among different EHR systems, the ability of EHRs to improve patient outcomes or access to care may be limited in the long run.

TABLE 2. Summary Statistics for AHA IT Supplement Question 3 Categories

	n	Mean	SD	
Share Radiology Reports^a				
Hospitals within system	4697	0.72	0.45	
Hospitals outside system	4697	0.36	0.48	
Physicians within system	4698	0.80	0.40	
Physicians outside system	4697	0.55	0.50	
Share Laboratory Results^a				
Hospitals within system	4730	0.71	0.45	
Hospitals outside system	4730	0.37	0.48	
Physicians within system	4731	0.81	0.39	
Physicians outside system	4730	0.57	0.49	
	Networked Hospital		Nonnetworked Hospital	
	n	%	n	%
Share Radiology Reports				
Hospitals within system	1753	37.4	1604	34.2
Hospitals outside system	831	17.7	867	18.5
Share Laboratory Results				
Hospitals within system	1753	37.2	1597	33.8
Hospitals outside system	865	18.3	861	18.3

AHA indicates American Hospital Association; IT, information technology.
^aEach question could have a response of either 0 or 1.

Sharing diagnostic data through hospital EHRs with physicians was found to be significantly associated with lower HF readmissions. These results may be partially driven by overall lower readmission rates of patients with pneumonia relative to HF²³ that may provide more opportunities for shared diagnostic data to influence care. Others have indicated that physicians may have more influence over readmissions than mortality.²⁴ Thus, readmission reductions from sharing EHR diagnostic data with physicians may also reflect how EHR data can increase physician productivity.²⁵⁻²⁷

Limitations

Like all studies, ours has limitations. First, hospitals face significant penalties for what CMS determines to be “excessive” mortality and readmission rates.²⁸ It is therefore possible that HC and sharing EHR diagnostic data simultaneously improve patient outcomes. Hospitals may also be cherry-picking patients to influence their HC scores for hospital-acquired conditions.²⁹ The HC scores may therefore provide a representative but overly positive sample of hospital rates for 30-day patient mortality and readmissions. It is also possible that hospital culture or other factors not captured in the data could influence the sharing and use of other hospitals’ EHR data. Given the evolution of EHR interoperability and shifting

TABLE 3. Association of 30-Day Patient Scores With Sharing of Hospital EHR Data^a

	Sharing Radiology Reports		Sharing Laboratory Results	
	Change (95% CI)	P	Change (95% CI)	P
30-Day Patient Mortality Scores				
Patients With Heart Failure				
Hospitals within the system	-0.12 [-0.25 to 0.01]	.07	-0.19 [-0.32 to -0.06]	<.01
Hospitals outside the system	0.26 [0.15-0.38]	<.01	0.26 [0.14-0.37]	<.01
Physicians within the system	-0.13 [-0.29 to 0.03]	.10	-0.10 [-0.27 to 0.06]	.21
Physicians outside the system	0.04 [-0.08 to 0.16]	.53	0.01 [-0.12 to 0.13]	.93
Patients With Pneumonia				
Hospitals within the system	-0.22 [-0.36 to -0.07]	<.01	-0.24 [-0.39 to -0.09]	<.01
Hospitals outside the system	0.11 [-0.02 to 0.24]	.11	0.12 [-0.01 to 0.25]	.07
Physicians within the system	-0.24 [-0.42 to -0.06]	.01	-0.24 [-0.43 to -0.06]	.01
Physicians outside the system	-0.06 [-0.20 to 0.08]	.40	-0.07 [-0.21 to 0.07]	.34
30-Day Patient Readmission Scores				
Patients With Heart Failure				
Hospitals within the system	-0.01 [-0.16 to 0.14]	.90	0.04 [-0.11 to 0.18]	.62
Hospitals outside the system	0.01 [-0.12 to 0.14]	.86	-0.02 [-0.15 to 0.11]	.71
Physicians within the system	-0.14 [-0.32 to 0.04]	.13	-0.17 [-0.36 to 0.01]	.07
Physicians outside the system	-0.15 [-0.29 to -0.01]	.04	-0.19 [-0.33 to -0.05]	.01
Patients With Pneumonia				
Hospitals within the system	0.00 [-0.11 to 0.12]	.95	0.04 [-0.07 to 0.15]	.46
Hospitals outside the system	-0.06 [-0.16 to 0.04]	.25	-0.04 [-0.14 to 0.06]	.40
Physicians within the system	-0.09 [-0.23 to 0.04]	.18	-0.16 [-0.30 to -0.02]	.02
Physicians outside the system	0.01 [-0.10 to 0.12]	.85	0.03 [-0.08 to 0.13]	.60

EHR indicates electronic health record.

^aMultivariate regression estimates were adjusted for the number of licensed beds, full-time equivalent employees, total expenditures, rural or nonrural setting, whether a hospital is part of a network, teaching or nonteaching hospital, hospital case mix, and a time trend.

incentives by payers since these study data were collected, these findings are best interpreted as a baseline association between EHR sharing and HC outcomes.^{30,31} Future work is needed to assess whether these associations have changed with the evolution of EHR systems' interoperability and usage.³² Hospitals removed from the study sample for missing values in the AHA IT Supplement were found to be significantly smaller, more rural, and less likely to be networked or academic, which could influence the generalizability of the findings. Finally, these results are associations and further research is required to determine whether the effects described are causal.

CONCLUSIONS

Of high policy interest is the overall low rate at which hospitals share diagnostic data through their EHRs with out-of-system hospitals and physicians. EHR data sharing has the largest potential for benefit when it accurately informs providers on patient conditions and avoids duplicative medical utilization. Our study

found some evidence that when hospitals do share EHR data with hospitals outside their system, patient mortality has the potential to increase. Therefore, although there may be benefits to sharing EHR data, it may be that hospitals are not yet able to effectively use EHR data from other hospitals as well as would be desired. Thus, the best approach for increasing patient outcomes through better provider communication of diagnostic information may not be simply expanding the degree of EHR data sharing among providers, but rather developing common standards when using different EHR systems to ensure that providers can share diagnostic information in ways that are easy for other providers to access and accurately interpret. ■

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