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The Combined Effect of the Electronic Health Record and Hospitalist Care on Length of Stay

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Abstract

Objectives: To assess the combined impact of electronic health record (EHR) adoption and hospitalist care on length of stay (LOS).

Study Design: Retrospective cohort study using data from the Healthcare Information and Management Systems Society and a 5% national sample of Medicare beneficiaries. Patients included 20,862 admissions for respiratory disease cared for by hospitalists, and 28,714 admissions for respiratory disease cared for by nonhospitalists in 2985 general and surgical hospitals in the United States.

Methods: The interaction effect of EHR and hospitalist care on LOS was evaluated using generalized linear models with log-link normal distribution after controlling for patient and hospital characteristics.

Results: In multivariable analyses controlling for patient and hospital characteristics, we found that the reduced LOS associated with complete EHR was 0.166 days and was statistically significant in the hospitals in which 50% or less of patients were cared for by hospitalists. Moreover, we found that reductions in LOS associated with hospitalist care were greater in hospitals that had not adopted a complete EHR. LOS was 0.599 days shorter for patients cared for by hospitalists versus nonhospitalists in hospitals with incomplete EHR adoption; in hospitals with complete EHR adoption, the stay was 0.433 days shorter.

Conclusions: The reduced LOS associated with hospitalist care is greater than that associated with EHR adoption. However, the combined reduction in LOS with both EHR adoption and hospitalist care may be substantial.

The percentage of hospitalized patients cared for by hospitalists—physicians who specialize in the care of this type of patient—jumped from 5.9% in 1995, to 19% in 2006.[1] The

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justification for the increased use of hospitalists stems from both the growing complexity of inpatient care and its increasing costs. A physician specializing in hospital medicine should be more efficient, and also perhaps more effective in initiating rapid and appropriate treatment, as well as in recognizing and preventing complications of hospitalization.[2–4] Hospitalists can also participate in multidisciplinary teams that address patient safety, quality, and early discharge planning.[5,6]

Another approach to improving efficiency is the electronic health record (EHR). EHR use grew in US hospitals during the same time period that the use of hospitalists increased. A complete EHR contains tools to increase efficiency and to increase communication among providers. Some studies have found that the EHR is associated with lower length of stay (LOS),[7,8] and the EHR has also been reported to improve the quality of care by increasing adherence to guideline- or protocol-based care, identifying adverse drug events, reducing medical error, and providing decision support.[7] In addition, the EHR allows tracking of therapy in detail, enabling the physician to address adherence and compliance issues.[9–11] Thus, the EHR can improve efficiency by improving continuity in information transfer and in communication among health providers.

We know of no prior studies examining the interaction of the EHR and hospitalists on LOS. We had 2 closely related hypotheses: 1) that the effect of EHR on LOS would be greater in hospitals with few hospitalists; and 2) that the effect of hospitalists on LOS would be less in hospitals with a complete EHR. We examined the association of EHR and hospitalist care on LOS, focusing on 49,576 admissions with respiratory disease from a 5% national sample of Medicare data in 2009, linked to data on EHR adoption from the Healthcare Information and Management System Society (HIMSS).

METHODS

Sources of Data

Claims from a 5% national sample of Medicare beneficiaries in 2009 were used, as well as Medicare enrollment files, Medicare Provider Analysis and Review (MEDPAR) files, Outpatient Statistical Analysis files, Medicare Carrier files, Provider of Services (POS) files, diagnosis-related group (DRG) weight files, and HIMSS data files.

Establishment of the Study Cohort

Beneficiaries enrolled in health maintenance organizations or those without both Medicare Parts A and B for the entire 12 months before admission were excluded. Because the study focused on hospitalist care, and more than 95% of hospitalists treating adult patients are generalist physicians, admissions not involving an evaluation and management charge by a general internist, family physician, general practitioner, or geriatrician were excluded.

We selected respiratory disease because continuity of care is very important for chronic pulmonary diseases such as chronic obstructive pulmonary disease, pneumonia, and bronchitis.[12,13] We selected 34 DRGs related to respiratory disease using the DRG codes from 175 to 208. Patients with respiratory disease accounted for 20,862 admissions cared for by hospitalists and 28,714 admissions cared for by nonhospitalists.

For hospitals, we selected only general and surgical hospitals (n = 3452). However, 467 of these were excluded because they could not be merged with POS and MEDPAR files. This left 2985 general and surgical hospitals in 2009 for study.

Measures

Hospitalists were defined as generalist physicians who had more than 5 Medicare evaluations and management claims and generated more than 90% of these claims from care provided to hospitalized patients in the year studied. This definition was validated at 7 hospitals, and had a sensitivity of 84.2% and a specificity of 96.5%.[1] The effect of hospitalist care was examined at the individual patient level and at the hospital level as the percent of patients cared for by hospitalists in a hospital.

Medicare enrollment files were used to categorize patients according to age, sex, and race (ie, white, black, and other). A Medicaid indication in the enrollment file was used as a proxy for low socioeconomic status. Information regarding origin of admission (emergency department vs other), weekend versus weekday admission, admission with intensive care unit (ICU) stay, and discharge DRG were obtained from the MEDPAR files. DRG weight reflects the average amount of resources used for each DRG and was used to adjust severity across different hospitals/patients.

Elixhauser comorbidity measures were generated using inpatient and physician claims from the MEDPAR, Out-patient Statistical Analysis files, and Carrier files.[14] The total number of hospitalizations and total number of out-patient visits in the year before the index hospitalization were generated from the MEDPAR and Carrier files. Hospital information (ie, zip code, county, state, total number of hospital beds, type of hospital, and medical school affiliation) was obtained from the POS file. Metropolitan area size was generated from 2010 Census data. Metropolitan area size and total number of hospital beds were categorized into quartiles; states were grouped by census region; type of hospital was categorized as nonprofit, for-profit, or public; and medical school affiliation was categorized as none, minor, or major.

The EHR adoption information was generated using HIMSS data, which provide the adoption information for health information technology (HIT) systems. The EHR was defined as including a clinical decision support system, clinical data repository, computerized physician order entry, and physician document.[6,15–17] Hospitals that adopted these 4 HIT systems were regarded as adopting the complete EHR system.

Statistical Analyses

The study outcome was hospital LOS for admissions with respiratory disease, obtained from the MEDPAR files. The relationship of EHR use and hospitalist care on LOS was evaluated using generalized linear models (GLMs) with log link and normal distribution. GLMs are commonly used to analyze outcomes that are not normally distributed; they apply a transformation, known as the link function, to the mean of data. Furthermore, rather than assume that a transformation of the data leads to normally distributed data to which standard linear modeling techniques can be applied, GLMs take the distribution of the data into account.[18] To adjust for patients clustering within hospitals, the parameters were estimated

by generalized estimating equation with an exchangeable working correlation matrix. In the GLM models, we included the interaction between EHR and hospitalist care, and controlled for patient characteristics (ie, age, sex, race, socioeconomic status, DRG group, emergency department [ED] admission, admission with ICU stay, weekend admission, comorbidity, DRG weight, and total number of hospitalizations and provider visits in the 12 months before the index admission) and hospital characteristics (ie, region, metropolitan area size, total number of beds, type of hospital, and teaching affiliation). We reported the difference on adjusted average LOS associated with EHR and hospitalist care by taking exponential to the predicted LOS from the GLM models. Analyses were performed using STATA version 10.1 (StataCorp LP, College Station, Texas).[19]

RESULTS

Tables 1A and 1B provide patient and hospital characteristics stratified according to whether patients received care from a hospitalist or a nonhospitalist and by whether or not hospitals had a complete EHR in 2009. The 4 groups differed by socioeconomic status, number of comorbidities, average number of hospitalizations in the year before index admission, average number of doctor visits in the year before index admission, DRG weight, percentages with ED admission, ICU use, hospital teaching status, hospital size, hospital ownership, size of the metropolitan area, and geographic region (all P values <.001). Seventeen percent of the 2985 hospitals had adopted a complete EHR by 2009.

In a multivariable model, we found a significant interaction between whether a hospital had a complete EHR and whether it was a high versus a low user of hospitalists in terms of patient LOS. Therefore, in the analyses, we stratified hospitals by those 2 characteristics. Table 2 shows the differences in adjusted LOS between hospitals with ≤ or >50% of patients cared for by hospitalists. Hospitals in which ≤50% of patients receive hospitalist care have slightly longer LOS than those in which more patients receive hospitalist care (4.97 vs 4.61 days, not reported). In hospitals in which ≤50% of patients receive hospitalist care, a complete EHR was associated with an average LOS 0.17 days shorter than that of similar hospitals without a complete EHR, a statistically significant result. However, a complete EHR was not associated with reduced LOS in hospitals in which most patients received hospitalist care. Moreover, hospitals in which ≤50% of patients received care by hospitalists are more likely to be smaller (222 vs 272 beds), nonprofit (63.1% vs 39.9%), and nonteaching hospitals (71.1% vs 39.9%) than those in which >50% of patients were cared for by hospitalists.

Second, we tested the hypothesis that reductions in LOS associated with hospitalist care would be greater in hospitals without a complete EHR. Table 3 presents the differences in adjusted LOS between patients cared for by either hospitalists or nonhospitalists in hospitals with or without EHR adoption. LOS was 0.60 days shorter for patients cared for by a hospitalist versus a nonhospitalist in hospitals without a complete EHR adoption. In hospitals with a complete EHR, the patient stay was 0.43 days shorter for patients cared for by a hospitalist versus a nonhospitalist. The difference of LOS decrease between those receiving nonhospitalist and hospitalist care in a hospital without and with a complete EHR is 0.17 days, which is significantly different from zero (P ≤.01).

Our definition of complete EHR is less restrictive than the EHR adoption model used in another study.[9] In a sensitivity analysis, we also defined EHR more restrictively, including clinical decision support system, clinical data repository, computerized physician order entry, physician notes, Electronic Medication Administration Record, and nursing notes to test our hypothesis. The regression results were similar to previous ones and are reported in eAppedix Tables 1 and 2 (available at www.ajmc.com).

DISCUSSION

Many studies report shorter LOS associated with hospitalist care[1–3,20]; moreover, the EHR has been reported to lower LOS by increasing physician efficiency and communication of medical information. However, to our knowledge, no study has been done on the combined impact of EHR and hospitalist care on efficiency. We found that EHR adoption improves efficiency in hospitals in which fewer patients were cared for by hospitalists. Thus, EHR adoption may complement hospitalist care in hospitals that have a relatively small number of hospitalists among its physicians. Hospitals with fewer patients cared for by hospitalists are more likely to be small, nonprofit, and/or nonteaching hospitals. While these hospitals might benefit most from EHR in improving efficiency, they may have limited access to capital and infrastructure,[21] which makes adoption more difficult. The incentive program of the Health Information Technology for Economic and Clinical Health (HITECH) Act may increase EHR adoption in those hospitals, resulting in improved efficiency.

We found a significant interaction of EHR and hospitalists in terms of length of stay, such that the presence of one lessened the effect of the other. Prior studies of the impact of EHR or of hospitalists on length of stay have studied just one of those in isolation. What this means, is that the magnitude of the impact of hospitalist on length of stay found in studies in hospitals without an EHR would not translate to a similar impact in hospitals with an EHR. Even though the reduced LOS associated with hospitalist care in hospitals with a complete EHR was smaller than that in hospitals without a complete EHR, the total reduction in LOS associated with both hospitalists and a complete EHR was 0.61. A change of 0.61 days translates to 613 bed days saved for 1000 discharges.

Limitations

First, hospital costs were not analyzed. Medicare claims data provide information on charges only. The correlation between total charges and LOS was 0.65 in our sample. However, we focused on LOS because it was a more direct measure of resource use than charge. Second, a hospitalist was defined as a doctor who derived 90% or more of evaluation and management charges from hospitalized patients.[1] Previous studies have defined hospitalist differently[22–25]—our definition of hospitalist does not include the physician's years of EHR and medical subspecialty experience. Third, we included only patients admitted with respiratory disease, so caution should be used when generalizing the results of this study. Fourth, payer mix may be associated with LOS and should be included in our model; however, that information is not available in our data, and so our results may be biased. Fifth, we looked at only cross-sectional data. The effect of EHR adoption on reduced LOS associated with hospitalist care could be larger if we consider longitudinal data, because

EHR adoption has a learning spillover effect.[26,27] Last, the combined effect of EHR and hospitalist care on outcomes, such as readmission rates, was not addressed. Future study in this area is needed.

CONCLUSIONS

We tested the association of hospitalist care and EHR adoption on LOS using a 5% national sample of Medicare beneficiaries and HIMSS in 2009. We used a retrospective cohort study and found that the reduced LOS associated with hospitalist care is greater than that associated with EHR adoption. However, the combined reduction in LOS with both EHR adoption and hospitalist care may be substantial (0.61 days). Thus, the interaction effect of EHR adoption and hospitalist care may be of interest to hospital administrators.

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eAppendix Table 1.: Average LOS for Patients in Hospitals With Lower vs Higher Use of Hospitalists and Advanced vs Incomplete EHRa

	Incomplete EHR		Advanced EHR			
Percent of patients cared for by a hospitalist	**Admission**	**Predicted average LOS (SE)[b]**	**Admission**	**Predicted average LOS (SE)[b]**	**Difference**	***P***
50% or Less	25,669	4.99 (0.002)	4309	4.84 (0.003)	0.15	<.01
Higher 50%	15,908	4.62 (0.002)	3690	4.58 (0.004)	0.04	.278

EHR indicates electronic health record; LOS, length of stay.

[a]Advanced EHR includes clinical data repository; clinical decision support; computerized physician order entry; physician documents; Electronic Medication Administration Record (eMAR); nursing documents.

[b]Adjusted for age, sex, race, low socioeconomic status, comorbidity, Major Diagnosis Category (MDC) group, diagnosis-related group weight, number of hospitalizations in the year before admission, number of doctor visits in the year before admission, emergency department admission, weekend admission, admission with subsequent intensive care unit use, geographic region, metropolitan-area size, type of hospital, hospital size, and medical school affiliation.

The main difference between Table 2 and eAppendix Table 1 is the definition of EHR. eAppendix Table 1 defines an Advanced EHR to include 6 applications. Table 2 defines a Complete EHR to include 4 applications.

eAppendix Table 2.: Average LOS for Patients Cared for by a Hospitalist vs a Nonhospitalist in Acute Care Hospitals With and Without Advanced EHRsa (2009)

	Incomplete EHR				Advanced EHR					
	Admission	Predicted average LOS (SE)[b]	Difference (1)	*P*	Admission	Predicted average LOS (SE)[b]	Difference (2)	*P*	Difference (1–2)	*P*
Nonhospitalist	24,474	5.09 (0.005)			4240	5.03 (0.013)				
Hospitalist	17,103	4.50 (0.006)	0.59	<.01	3759	4.53 (0.012)	0.50	<.01	0.09	<.01

EHR indicates electronic health record; LOS, length of stay.

[a]Advanced EHR includes clinical data repository; clinical decision support; computerized physician order entry; physician documents; Electronic Medication Administration Record (eMAR); nursing documents.

[b]Adjusted for age, sex, race, low socioeconomic status, comorbidity, Major Diagnosis Category (MDC) group, diagnosis-related group weight, number of hospitalizations in the year before admission, number of doctor visits in the year before admission, emergency department admission, weekend admission, admission with subsequent intensive care unit use, geographic region, metropolitan-area size, type of hospital, hospital size, and medical school affiliation.

The main difference between Table 3 and Appendix Table 2 is the definition of EHR. eAppendix Table 2 defines an Advanced EHR to include 6 applications. Table 3 defines a Complete EHR to include 4 applications.

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Take-Away Points

The electronic health record (EHR) and hospitalist care were associated with reduced length of stay (LOS).

- Complete EHR adoption was associated with lower LOS only in hospitals in which ≤50% of patients were cared for by hospitalists.
- The reduced LOS associated with hospitalist care in hospitals without a complete EHR was higher than that for hospitals with a complete EHR. A complete EHR may slightly lessen the relative advantage in efficiency of the use of hospitalists over nonhospitalists.
- The overall impact of hospitalists on LOS is modest, but the effect of hospitalists in facilities with complete EHR is substantial.

Table 1A.

Patient Characteristics Stratified by Electronic Health Record (EHR) Completeness and Treatment by Hospitalist

		Incomplete EHR		Complete EHR		
Patient Characteristics (n = 49,576)		**Nonhospitalist (n = 23,883)**	**Hospitalist (n = 16,472)**	**Nonhospitalist (n = 4831)**	**Hospitalist (n = 4390)**	***P***
Age (years)	<65, %	14.8%	16.8%	13.4%	17.2%	
	65–74, %	25.6%	25.5%	23.8%	23.7%	
	75–84, %	34.5%	33.8%	36.0%	33.1%	
	≥85, %	25.1%	23.9%	26.8%	26.0%	
	Mean (SD)	75.6(12.2)	75.1 (12.6)	76.4(12.3)	75.3(13)	<.001
	Median (25th, 75th percentiles)	77 (69,85)	77 (68,84)	79 (70,85)	77 (68,85)	
Sex, %	Male	38.3%	40.1%	37.5%	39.6%	
	Female	61.7%	59.9%	62.5%	60.4%	.61
Race, %	White	84.2%	84.0%	83.9%	82.0%	<.001
	Black	9.3%	9.3%	10.7%	10.6%	
	Other	6.5%	6.7%	5.5%	7.3%	
Low socioeconomic status, %	32.7%	33.6%		27.7%	31.3%	<.001
Emergency admission, %	73.0%	81.9%		75.9%	79.6%	<.001
Weekend admission, %	26.7%	27.0%	27.3%	26.4%	.84	
Number of comorbidities	Mean (SD)	3.2 (1.2)	3.1 (1.3)	3.2(1.2)	3.1 (1.3)	<.001
	Median (25th, 75th percentiles)	4 (2,4)	4 (2,4)	4 (2,4)	4 (2,4)	
Number of hospitalizations in year before index admission	Mean (SD)	1.6(2.1)	1.6(2.2)	1.6(2.2)	1.5 (2.0)	<.001
	Median (25th, 75th percentiles)	1 (0,2)	1 (0,2)	1 (0,2)	1 (0,2)	
Number of doctor visits in year before index admission	Mean (SD)	11.4(9.9)	10.3(9.7)	11.2(9.8)	10.9 (9.8)	.011
	Median (25th, 75th percentiles)	9 (4,16)	8(3,15)	9(4,16)	9(4,15)	
Admission with intensive care unit stay, %	No	75.0%	73.4%	75.4%	75.2%	<.001
	Yes	25.0%	26.6%	24.7%	24.9%	
DRG weight	Mean (SD)	1.2 (0.6)	1.3 (0.6)	1.2 (0.6)	1.3 (0.6)	<.001
	Median (25th, 75th percentiles)	1.0(0.8,1.4)	1.2 (0.9,1.4)	1.0 (0.9,1.4)	1.2 (0.9,1.4)	

DRG indicates diagnosis-related group; EHR, electronic health record.

Patients admitted with respiratory disease in 2009, from a 5% national Medicare sample. They included 20,862 cared for by hospitalists and 28,714 cared for by nonhospitalists in 2985 general and surgical hospitals.

Table 1B.

Hospital Characteristics Stratified by Electronic Health Record Completeness and Percentage (high/low) of Hospitalists

		Incomplete EHR		Complete EHR		
		Percent of Patients Cared for by a Hospitalist		Percent of Patients Cared for by a Hospitalist		
Hospital Characteristics (n = 2985)		**≤50% (n = 1587)**	**>50% (n = 891)**	**≤50% (n = 285)**	**>50% (n = 222)**	***P***
Geographic region, %	New England	2.5%	6.3%	3.2%	12.6%	<.001
	Mid-Atlantic	12.6%	8.9%	19.6%	12.2%	
	East north central	16.8%	10.8%	24.6%	10.8%	
	West north central	6.8%	6.6%	14.7%	9.9%	
	South Atlantic	17.5%	22.8%	11.9%	18.9%	
	East south central	12.1%	7.9%	9.5%	3.6%	
	West south central	15.8%	14.5%	8.1%	8.6%	
	Mountain	4.8%	9.8%	2.8%	8.1%	
	Pacific	11.1%	12.6%	5.6%	15.3%	
Population of metropolitan area, %	<100,000	35.1%	41.9%	48.8%	52.7%	<.001
	100,000–249,999	16.6%	23.1%	16.8%	25.2%	
	250,000–999,999	10.9%	9.1%	11.6%	9.9%	
	≥1,000,000	37.4%	25.8%	22.8%	12.2%	
Medical school affiliation, %	None	73.4%	68.5%	58.3%	45.5%	<.001
	Minor	17.5%	18.9%	17.9%	25.2%	
	Major	9.1%	12.6%	23.8%	29.3%	
Number of beds in hospitals, %	<200	59.2%	52.2%	44.6%	35.1%	<.001
	200–349	22.1%	22.5%	23.2%	22.5%	
	350–499	11.2%	12.5%	15.1%	13.9%	
	≥500	7.6%	12.9%	17.2%	28.4%	
	Mean (SD)	211.7(166.7)	252(205.1)	279.3 (215.6)	352.7 (273.7)	
	Median (25th, 75th percentiles)	166(88,296)	186(100,343)	229 (106,378)	276 (142,523)	
Type of hospital, %	Nonprofit	60.7%	64.5%	76.5%	77.9%	<.001
	For-profit	18.2%	19.6%	8.4%	5.9%	
	Public	21.2%	15.8%	15.1%	16.2%	

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EHR indicates electronic health record.

Patients admitted with respiratory disease in 2009, from a 5% national Medicare sample. They included 20,862 cared for by hospitalists and 28,714 cared for by nonhospitalists in 2985 general and surgical hospitals.

Table 2.

Average LOS for Patients in Hospitals With Lower vs Higher Use of Hospitalists and Complete vs Incomplete EHR[a]

	Incomplete EHR		Complete EHR			
Percent of Patients Cared for by a Hospitalist	Admission	Predicted Average LOS (SE)[b]	Admission	Predicted Average LOS (SE)[b]	Difference	*P*
≤50%	24,996	5.00 (0.000)	4982	4.83 (0.000)	0.17	<.01
>50%	15,359	4.63(0.001)	4239	4.56 (0.002)	0.07	.251

EHR indicates electronic health record; LOS, length of stay.

[a]Complete EHR includes clinical data repository, clinical decision support, computerized physician order entry, physician documents.

[b]Adjusted for age, sex, race, low socioeconomic status, comorbidity, Major Diagnosis Category (MDC) group, diagnosis-related group weight, number of hospitalizations in the year before admission, number of doctor visits in the year before admission, emergency department admission, weekend admission, admission with subsequent intensive care unit use, geographic region, metropolitan area size, type of hospital, hospital size, and medical school affiliation.

Table 3.

Average LOS for Patients Cared for by a Hospitalist vs a Nonhospitalist in Hospitals With and Without Complete EHRs[a]

	Incomplete EHR				Complete EHR					
	Admission	Predicted Average LOS (SE)[b]	Difference (1)	*P*	Admission	Predicted Average LOS (SE)[b]	Difference (2)	*P*	Difference (1–2)	*P*
Nonhospitalist	23,883	5.11 (0.001)			4831	4.92 (0.002)				
Hospitalist	16,472	4.51 (0.001)	0.60	<.01	4390	4.49 (0.002)	0.43	<.01	0.17	<.01

EHR indicates electronic health record; LOS, length of stay.

[a]Complete EHR includes clinical data repository, clinical decision support, computerized physician order entry, physician documents.

[b]Adjusted for age, sex, race, low socioeconomic status, comorbidity, Major Diagnosis Category (MDC) group, diagnosis-related group weight, number of hospitalizations in the year before admission, number of doctor visits in the year before admission, emergency department admission, weekend admission, admission with subsequent intensive care unit use, geographic region, metropolitan area size, type of hospital, hospital size, and medical school affiliation.