Published in final edited form as:

Am J Med. 2014 March ; 127(3): 216–221. doi:10.1016/j.amjmed.2013.11.010.

Electronic health record utilization, intensity of hospital care, and patient outcomes

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Abstract

Background—Previous studies have suggested that weekend hospital care is inferior to weekday care and that this difference may be related to diminished care intensity. The purpose of this study was to determine whether a metric for measuring intensity of hospital care based on utilization of the electronic health record (EHR) was associated with patient-level outcomes.

Methods—We performed a cohort study of hospitalizations at an academic medical center. Intensity of care was defined as the hourly number of provider accessions of the electronic health record, termed “EHR interactions.” Hospitalizations were categorized based on the mean difference in EHR interactions between the first Friday and Saturday of hospitalization. We used regression models to determine the association of these categories with patient outcomes after adjusting for covariates.

Results—EHR interactions decreased from Friday to Saturday in 77% of the 9,051 hospitalizations included in the study. As compared to hospitalizations with no change in Friday to Saturday EHR interactions, the relative lengths of stay for hospitalizations with a small, moderate, and large decrease in EHR interactions were 1.05 (95% CI 1.00–1.10), 1.11 (95% CI 1.05–1.17), and 1.25 (95% CI 1.15–1.35), respectively. Although a large decrease in EHR interactions was associated with in-hospital mortality, these findings were not significant after risk adjustment (odds ratio 1.74, 95% CI 0.93–3.25).

Conclusions—Intensity of inpatient care, measured by EHR interactions, significantly diminished from Friday to Saturday, and this decrease was associated with length of stay. Hospitals should consider monitoring and correcting temporal fluctuations in care intensity.

Keywords

electronic health record; hospital medicine

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No Authors have conflict of interest to report. All authors participated in drafting the manuscript or revising it critically for important intellectual content.

Weekend care in hospitals has been associated with poor patient outcomes.^{1–7} Such temporal variations may reflect differences in the overall intensity of care delivered to patients on weekends as compared with weekdays. Prior studies, using surveys and detailed chart reviews, have also demonstrated that care delays are more common on weekends.^{8,9}

To measure and track global intensity of hospital care, we recently developed a metric based on utilization of the hospital electronic health record (EHR).¹⁰ We considered each opening of a patient record to represent an instance of individual patient care. Counting these accessions of the medical record, which we termed “EHR interactions”, was found to be a sensitive measure of temporal variations in care. At the level of the hospital, we observed a reduction in care intensity by two-thirds on weekends as compared to weekdays.¹⁰ To our knowledge, EHR interactions represent the first measure of global intensity of care in the contemporary hospital.

The purpose of the present study was to determine if there is an association between EHR interactions and patient level outcomes. We hypothesized that fewer EHR interactions on weekends would be associated with reduced progression in care as measured by increased length of stay and lower likelihood of weekend discharge. We further hypothesized that EHR interactions would be correlated with clinical outcomes including mortality.

Methods

We performed a retrospective cohort study of patients hospitalized at New York University Langone Medical Center (NYULMC), an urban academic institution, between January 1, 2011 and September 30, 2012, using data derived from the hospital electronic health record. Hospitalizations were included if the length of stay was greater than 48 hours and encompassed at least one consecutive complete Friday and Saturday. We excluded patients younger than 18 and those hospitalized to the obstetrical service. Only the first hospitalization was included for patients with more than one hospitalization during the study period.

As previously described, we tracked the global intensity of care delivered during each hospitalization using a measure termed “EHR interactions”, calculated as the mean hourly number of electronic health record accessions per patient by a clinical provider (physician, nurse, resident physician, pharmacist, physical therapist, etc.).¹⁰ During the study period, the majority of inpatient clinical activities were performed and documented through NYULMC’s electronic health record, Sunrise Clinical Manager (Allscripts, Chicago, IL). These activities included clinical documentation, orders, medication administration, and results of diagnostic tests.¹⁰

We measured weekday to weekend change in intensity of care by determining the difference in mean hourly EHR interactions between the first Friday and the first Saturday of each hospitalization. Differences between Friday and Saturday EHR interactions were categorized as 0.5, 0.4 to –0.4, –0.5 to –1.4, –1.5 to –2.4, and –2.5; we termed these categories increase, no change, small decrease, moderate decrease, and large decrease, respectively. We based this choice of magnitude ranges on the previously measured mean hourly number of EHR interactions at our institution.¹⁰ “No change” was used as our reference category for statistical analysis.

For this study, we defined length of stay, termed “study length of stay”, as the number of days from the Saturday of the first full Friday-Saturday dyad of hospitalization to the day of discharge, rather than as total hospital days. This approach ensured that the reported measure of EHR interactions was assessed prior to the outcome of length of stay. For each category of change in mean EHR interactions from Friday to Saturday, we captured study length of

stay, the proportion of patients discharged on a weekend, inpatient mortality, and the proportion of patients readmitted within 30 days. We excluded from the readmission analysis patients who died during the index hospitalization and captured only readmissions to the same medical center.

Patient characteristics included age, gender, race, insurance status, admission location, service, Charlson comorbidity score, Service Intensity Weight (SIW), and admission day of the week. SIW is a relative measure of resources used by all New York State hospitals to care for patients in each All Patient Refined Diagnosis Related Grouping.⁷ Because SIW values were not normally distributed in our study population, we converted these values to categorical data in the ranges 0 to 0.9, 1 to 1.9, 2 to 2.9, 3 to 5.9, and 6.

Statistical Analysis

We assigned each hospitalization to the appropriate category of difference between Friday and Saturday EHR interactions. Baseline characteristics were compared between groups using chi-squared tests for categorical variables and analysis of variance (ANOVA) for continuous variables. We determined the mean hourly number of EHR interactions for each day of the week, stratified by the day on which the hospitalizations began. Logistic regression was employed to weight covariates in risk adjustment modeling of the association between EHR interactions and weekend discharge, 30 day readmission, and mortality. We developed negative binomial regression models to determine the association between weekday to weekend change in EHR interactions and study length of stay.

Results

Among 9,051 hospitalizations included in the analysis, the mean (SD) hourly number of EHR interactions was 3.0 (1.5). EHR interactions were highest on the first day of hospitalization, 4.3 (1.8), and subsequently decreased to 3.5 (1.4) on hospital day two. Mean hourly EHR interactions were 3.2 (1.3) on the first Friday of hospitalization, decreased to 2.1 (1.0) on the first Saturday after admission, and increased to 3.3 (1.6) the following Monday (Figure 1).

Overall there was a mean decrease of 1.1 (95% CI 1.1 to 1.1) EHR interactions/hour between the first Friday and Saturday of hospitalization; 77% of hospitalizations showed a decrease and 3% an increase in interactions between these days. As compared with the 21% of patients for whom EHR interactions did not change from weekday to weekend, patients whose EHR interactions decreased were older and likelier to be male, had a greater comorbidity index, and were more likely to be on the medicine service (Table 1).

Mean study length of stay was 8.6 days for patients with an increase of any magnitude in weekday to weekend EHR interactions, 5.6 for patients with no change in EHR interactions, and 5.7, 6.4, and 7.0 for patients with small, moderate, and large decreases, respectively (Figure 2). After adjustment for covariates, decreases in weekday to weekend EHR interactions were associated with an increased length of stay in a dose dependent manner; as compared to patients with no change in EHR interactions, the adjusted relative rates of study length of stay for patients with a small, moderate, and large decrease in EHR interactions were 1.05 (95% CI 1.00–1.10), 1.11 (95% CI 1.05–1.17), and 1.25 (95% CI 1.15–1.35), respectively (Table 2). Similarly, decreases in EHR interactions were associated with decreased likelihood of being discharged on a weekend (Table 2). In an unadjusted analysis, 30-day readmissions were more likely among both those with a moderate and those with a large decrease in EHR interactions between Friday and Saturday, although these results did not reach statistical significance after adjusting for covariates.

In the unadjusted analysis, both an increase and a large decrease in EHR interactions were associated with in hospital mortality. However, after risk adjustment, changes in weekday to weekend EHR interactions were no longer significantly associated with mortality. (Table 3) After adjustment, patients with an increase in intensity of care had 1.81 (0.82, 4.00) times the odds of in-hospital mortality compared with patients with no change. As compared to patients with no change in EHR interactions, patients with a large decrease in EHR interactions had an associated adjusted odds ratio for mortality of 1.74 (0.93, 3.25).

Discussion

In this study, we observed that 77% of hospitalizations demonstrated a decrease in intensity of hospital care between Friday and Saturday. Decreases in Friday to Saturday EHR interactions were associated with increased length of stay and decreased weekend discharges in a dose dependent fashion. Nonetheless, changes in EHR interactions were not associated with either readmission or mortality after adjusting for covariates.

These findings further support the use of EHR interactions as a tool for quantifying intensity of care. We have previously shown that this approach, the first attempt to measure global intensity of services using the electronic health record, varies between weekdays and weekends in the overall hospital.¹⁰ We again show a significant decline in intensity between Friday and Saturday, but now at the patient level. Additionally, we demonstrate important associations between this decline and patient-level outcomes. The strong associations of EHR interactions with both length of stay and likelihood of weekend discharge suggest that EHR interactions are correlated with progression of patient care and hospital throughput, both of which are related to intensity of care. It remains to be seen whether tracking and reducing variations in care intensity will result in improved hospital efficiency and patient care.

Multiple studies have suggested that clinical outcomes may be worse on weekends as compared to weekdays.¹⁻⁷ Such differences have been hypothesized to be partly related to differences in the care delivered on weekdays versus weekends.¹¹ However, prior studies examining weekday to weekend differences in care delivery have not consistently demonstrated weekend care to be a factor that contributes to any differences in weekday to weekend outcomes. Additionally, prior studies have typically focused on a single specific marker for a difference in care delivery, such as revascularization for acute myocardial infarction.^{5-7,12,13} To our knowledge, this is the first study to examine variations in global intensity of care. We found that intensity of care differed from weekends to weekdays and was associated with important process measures such as time a patient spends in the hospital. Nonetheless, EHR interactions were not associated with readmission or mortality in our sample, suggesting that high acuity patients may be receiving sufficient care to prevent adverse outcomes.

Both increased and decreased intensity from Friday to Saturday were associated with increased length of stay. This finding of poor outcomes among patients with an increase in EHR interactions may reflect individuals who suffered a clinical deterioration on Saturday. Typically, such patients are transferred to an intensive care setting, where intensity of care increases and the likelihood of increased length of stay and mortality increases. The apparently anomalous finding of increased length of stay and a trend towards increase mortality among patients with increased EHR interactions is therefore, we believe, a validation of the sensitivity of our intensity measurement.

To help promote adoption of electronic health records to improve patient care, Medicare and Medicaid have offered financial incentives to hospital for deployment of electronic health

records that satisfy requirements for “meaningful use.”¹⁴ The requirements for meaningful use include process measures and reporting of clinical quality metrics, with the goal of improving patient-level outcomes.¹⁴ EHR interactions could be considered a potential metric of meaningful use, as a process measure that appears to be related to temporal variations in care. Furthermore, findings that EHR interactions were associated with length of stay and had a nonsignificant association with mortality suggest that tracking and reducing variations in this metric as part of quality improvement efforts may have a meaningful impact on patient care and outcomes.

Several limitations deserve mention. First, while we adjusted for many potential confounders in our analysis, residual confounding may account for some of the results in this observational study. For instance, a provider may have decided on Friday that weekend discharge was unlikely for a certain patient and, as a result, reduced activity related to that patient on Saturday. This patient would have a large difference in Friday to Saturday interactions and a low likelihood of weekend discharge; in this case the associated relationship between EHR interactions and weekend discharge would be related to unmeasured confounders. Second, our study took place at a single institution and findings may not be generalizable to other contexts. Third, EHR interactions may not always reflect actual patient care or clinical documentation, although this measure has been shown to be well correlated with patient orders.¹⁰ Fourth, variations in the amount of care associated with each accession of a patient’s electronic health record may limit the validity of EHR interactions as a perfect measure of care intensity. Finally, readmissions were measured only if they occurred at the same institution which may have led to misclassification if patients were readmitted to other hospitals.

We found that a weekend decline in intensity of care, typical of many hospitals, is associated with hospital processes and patient outcomes. Using EHR interactions as a global measure of intensity, length of stay was adversely associated with a decrease in care intensity from Friday to Saturday. Taken together with previous work, these results suggest that hospitals should consider measuring and mitigating temporal fluctuations in the intensity of their services with a view to improve efficiency and, most likely, patient outcomes as well.

Acknowledgments

Dr. Blecker was supported in part by National Center for Advancing Translational Sciences (NCATS) grant KL2TR000053.

References

1. Aujesky D, Jimenez D, Mor MK, Geng M, Fine MJ, Ibrahim SA. Weekend versus weekday admission and mortality after acute pulmonary embolism. *Circulation*. 2009; 119(7):962–968. [PubMed: 19204300]
2. Bell CM, Redelmeier DA. Mortality among patients admitted to hospitals on weekends as compared with weekdays. *N Engl J Med*. 2001; 345(9):663–668. [PubMed: 11547721]
3. Crowley RW, Yeoh HK, Stukenborg GJ, Medel R, Kassell NF, Dumont AS. Influence of weekend hospital admission on short-term mortality after intracerebral hemorrhage. *Stroke*. 2009; 40(7): 2387–2392. [PubMed: 19461030]
4. Horwich TB, Hernandez AF, Liang L, et al. Weekend hospital admission and discharge for heart failure: association with quality of care and clinical outcomes. *Am Heart J*. 2009; 158(3):451–458. [PubMed: 19699870]
5. Becker DJ. Do hospitals provide lower quality care on weekends? *Health Serv Res*. 2007; 42(4): 1589–1612. [PubMed: 17610439]

6. Kostis WJ, Demissie K, Marcella SW, Shao YH, Wilson AC, Moreyra AE. Weekend versus weekday admission and mortality from myocardial infarction. *N Engl J Med*. 2007; 356(11):1099–1109. [PubMed: 17360988]
7. Magid DJ, Wang Y, Herrin J, et al. Relationship between time of day, day of week, timeliness of reperfusion, and in-hospital mortality for patients with acute ST-segment elevation myocardial infarction. *JAMA*. 2005; 294(7):803–812. [PubMed: 16106005]
8. Selker HP, Beshansky JR, Pauker SG, Kassirer JP. The epidemiology of delays in a teaching hospital. The development and use of a tool that detects unnecessary hospital days. *Med Care*. 1989; 27(2):112–129. [PubMed: 2918764]
9. Carey MR, Sheth H, Braithwaite RS. A prospective study of reasons for prolonged hospitalizations on a general medicine teaching service. *J Gen Intern Med*. 2005; 20(2):108–115. [PubMed: 15836542]
10. Blecker S, Austrian JS, Shine D, Braithwaite RS, Radford MJ, Gourevitch MN. Monitoring the pulse of hospital activity: Electronic health record utilization as a measure of care intensity. *J Hosp Med*. 2013; 8(9):513–518. [PubMed: 23908140]
11. Aylin P, Alexandrescu R, Jen MH, Mayer EK, Bottle A. Day of week of procedure and 30 day mortality for elective surgery: retrospective analysis of hospital episode statistics. *BMJ*. 2013; 346:f2424. [PubMed: 23716356]
12. Reeves MJ, Smith E, Fonarow G, Hernandez A, Pan W, Schwamm LH. Off-hour admission and in-hospital stroke case fatality in the get with the guidelines-stroke program. *Stroke*. 2009; 40(2): 569–576. [PubMed: 18988914]
13. Shaheen AA, Kaplan GG, Myers RP. Weekend versus weekday admission and mortality from gastrointestinal hemorrhage caused by peptic ulcer disease. *Clin Gastroenterol Hepatol*. 2009; 7(3):303–310. [PubMed: 18849015]
14. Blumenthal D, Tavenner M. The "meaningful use" regulation for electronic health records. *N Engl J Med*. 2010; 363(6):501–504. [PubMed: 20647183]
15. Centers for Medicare & Medicaid Services. [Accessed October 15, 2013] EHR Incentives Programs Meaningful Use. Available at: https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/Meaningful_Use.html

Clinical significance points

- Intensity of care, as measured by electronic health record interactions, decreased for three-fourths of hospitalized patients.
- A decrease in electronic health record interactions on weekends was associated with increased length of stay in a dose dependent manner.
- Electronic health record interactions were not associated with readmissions or mortality after adjusting for covariates.

Figure 1. Mean hourly number of Electronic Health Record (EHR) Interactions per patient per day of the week, by weekday of admission. Lines represent weekday of admission.

Figure 2. Study length of stay from first Saturday of hospitalization to discharge day, by change in hourly number of Electronic Health Record (EHR) Interactions from first Friday to Saturday. Boxplot graphs are truncated at 20 days; diamonds represent means.

Table 1

Baseline characteristics of 9,051 hospitalized patients, by change in Friday to Saturday Electronic Health Record (EHR) Interactions.

	Change in EHR interactions				p-trend
	Increase (n=241)	No change (n=1883)	Small decrease (n=4232)	Moderate decrease (n=2068)	
Age, Mean(SD)	64.5 (17.6)	58.4 (20.1)	61.7 (19.6)	65.5 (18.6)	<0.0001
Female Gender	45.2	53.4	53.5	51.2	0.02
Race					
White	61.8	69.0	69.2	67.3	0.15
Black	13.7	9.3	9.3	10.8	10.5
Other	24.5	21.7	21.5	21.9	20.0
Insurance					
Medicaid	13.3	18.1	17.3	17.4	16.8
Self pay / Null	1.2	1.0	1.1	0.6	0.3
Other	85.5	80.9	81.6	82.0	82.9
Service Intensity Weight (SIW)					
0-0.9	33.8	44.2	44.5	45.8	46.5
1-1.9	24.5	29.1	28.5	27.7	28.3
2-2.9	8.0	7.6	9.4	10.0	10.7
3-5.9	22.3	15.1	13.9	13.3	11
6	11.4	4.0	3.7	3.2	3.5
Charlson Index					
0	16.5	38.1	32.7	23.6	20.3
1	18.2	16.6	17.5	17.8	18.9
2	19.5	18.4	17.6	17.9	19.7
3	12.3	9.3	10.2	12.2	10.1
4	33.5	17.6	22.0	28.5	31
Admission Source					
ER	31.1	32.0	40.9	51.0	60.0
Other Hospital	8.7	5.8	5.7	7.9	5.7
Skilled Nursing Facility	0.4	0.5	0.1	0.3	0.3
Home/Other	59.8	61.7	53.3	40.8	34.0

	Increase (n=241)	No change (n=1883)	Change in EHR interactions			p-trend
			Small decrease (n=4232)	Moderate decrease (n=2068)	Large decrease (n=627)	
Service						
Medicine	32.8	25.7	35.0	48.0	56.8	<0.0001
Surgery	51.9	42.3	40.2	34.3	27.3	
Other	15.3	32.0	24.8	17.7	15.9	
Hospitalist Service	10.6	8.7	12.6	17.9	25.0	<0.0001
Day of Admission						
Saturday	2.5	4.0	3.6	2.5	1.3	<0.0001
Sunday	4.6	5.3	4.6	4.6	2.7	
Monday	15.3	18.8	16.6	13.8	11.1	
Tuesday	22.0	22.4	20.1	14.8	11.8	
Wednesday	26.1	26.0	25.5	22.8	22.2	
Thursday	29.5	23.5	29.6	41.5	50.9	

Values are in percents unless otherwise noted

Association of change in Friday to Saturday Electronic Health Record (EHR) Interactions with outcomes related to progression of care.

Table 2

Change in EHR interactions	N	Study Length of Stay		% Weekend Discharge	
		Unadjusted RR	Adjusted RR	Unadjusted OR	Adjusted OR
Increase	241	1.43 (1.27, 1.62)	1.28 (1.14, 1.44)	0.78 (0.54, 1.13)	0.86 (0.59, 1.26)
No change	1,883	1 (Reference)		1 (Reference)	
Small decrease	4,232	1.05 (0.99, 1.10)	1.05 (1.00, 1.10)	0.88 (0.77, 1.02)	0.92 (0.79, 1.07)
Moderate decrease	2,068	1.12 (1.06, 1.19)	1.11 (1.05, 1.17)	0.58 (0.48, 0.69)	0.66 (0.55, 0.80)
Large decrease	627	1.30 (1.19, 1.41)	1.25 (1.15, 1.35)	0.66 (0.51, 0.85)	0.76 (0.58, 1.00)

RR represents rate ratio, OR represents odds ratio

Association of change in Friday to Saturday Electronic Health Record (EHR) Interactions with clinical outcomes of 30 day readmission and in-hospital mortality.

Table 3

Change in EHR interactions	N	30 Day Readmission		Mortality	
		Unadjusted OR	Adjusted OR	Unadjusted OR	Adjusted OR
Increase	241	1.49 (1.05, 2.12)	1.25 (0.87, 1.80)	2.88 (1.38, 6.04)	1.81 (0.82, 4.00)
No change	1,883	1 (Reference)		1 (Reference)	
Small decrease	4,232	0.99 (0.84, 1.16)	0.89 (0.76, 1.06)	1.14 (0.73, 1.79)	0.99 (0.62, 1.57)
Moderate decrease	2,068	1.33 (1.11, 1.59)	1.08 (0.90, 1.30)	1.39 (0.85, 2.27)	1.03 (0.61, 1.72)
Large decrease	627	1.39 (1.08, 1.78)	1.09 (0.84, 1.41)	2.20 (1.23, 3.96)	1.74 (0.93, 3.25)

OR represents odds ratio