

Impact of electronic health record implementation on patient flow metrics in a pediatric emergency department

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ABSTRACT

Implementing electronic health records (EHR) in healthcare settings incurs challenges, none more important than maintaining efficiency and safety during rollout. This report quantifies the impact of offloading low-acuity visits to an alternative care site from the emergency department (ED) during EHR implementation. In addition, the report evaluated the effect of EHR implementation on overall patient length of stay (LOS), time to medical provider, and provider productivity during implementation of the EHR. Overall LOS and time to doctor increased during EHR implementation. On average, admitted patients' LOS was 6–20% longer. For discharged patients, LOS was 12–22% longer. Attempts to reduce patient volumes by diverting patients to another clinic were not effective in minimizing delays in care during this EHR implementation. Delays in ED throughput during EHR implementation are real and significant despite additional providers in the ED, and in this setting resolved by 3 months post-implementation.

Increasing numbers of hospitals and healthcare centers are adopting electronic health record (EHR) systems with the goal of improving healthcare quality while potentially decreasing costs.^{1–2} These systems are presently undergoing greater scrutiny as models throughout the USA can be systematically evaluated.³

Implementing EHR in healthcare settings incurs challenges in maintaining quality care, particularly in terms of efficiency, timeliness and safety of care. There are limited studies describing best practices in avoiding reduction in the quality of care.^{4–5} As EHR systems evolve from first generation computerized physician order entry or simple niche systems to large hospital-wide EHR integrated records, the risks of the implementation on impacting patient safety, efficiency and financial recovery increase dramatically.^{6–8} Given the breadth of potential negative impact, the 'success' of any implementation is colored by one's perspective, whether practitioner, administrator, or patient, resulting in little consistency in the definition of a 'successful' implementation.⁹ A variety of models in different healthcare settings managing workflow and expectations has been theorized, but there is little evidence to support any one of these models during implementation.¹⁰ It is clear that strategies employed in one setting (such as decreased scheduled visits, postponing elective surgeries, increasing office hours) cannot always be translated to another.

The emergency department (ED) faces unique challenges in an EHR implementation. EDs at baseline are an environment in which multiple barriers naturally exist for negatively impacting quality care, including job stress, limited staffing, multiple interruptions and most important, crowding. ED crowding is a well-described problem within our healthcare system, with many contributing factors, which has been shown to affect quality negatively.¹¹ Even though limited data have shown that efficiency can improve long term after an EHR implementation, provider buy-in with the ability to operate safely during the transition is a very large factor in the success of an implementation in this setting.¹² Providers in the ED environment work to maintain quality, and any potential negative impact of quality will be negatively viewed, EHR implementation being a good example. National benchmarking for quality in the ED setting places significant focus on timeliness, safety and efficiency standards, most directly reported as overall length of stay (LOS), door to doctor times and left without being seen, using them as proxies for quality measures that are difficult to collect, such as time to analgesia, antibiotics, and patient satisfaction.¹³ To date, there have been no studies that describe best practices to mitigate reduction in quality care measures in the ED during EHR implementation.

Our study describes our experience with one potential intervention to decrease delays in ED care during EHR implementation. The strategy employed was modeled after our institution's response to H1N1, an overflow clinic separate from the ED to care for low acuity patients.^{14–16} Before H1N1 we were scheduled to implement our EHR within the time frame of the expected surge of patients. Rather than delay rollout of our EHR in the ED, we opted to use the strategies developed during the H1N1 response during our EHR implementation.

GOALS OF THIS INVESTIGATION

We set out to quantify the impact of offloading low acuity visits to an alternative care site from the ED during EHR implementation. In addition, we evaluated the effect of EHR implementation on overall patient LOS, time to medical provider, and provider productivity during and after implementation of EHR.

Case setting

Cincinnati Children's Hospital Medical Center (CCHMC) ED is an urban pediatric level 1 trauma



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center that had 94 000 visits in 2009. It is a teaching hospital with residents supervised by pediatric emergency medicine providers. Care is also provided within our setting by non-emergency medicine pediatricians and advanced practice nurses (APN).

Case report

Our ED was fully live (nursing and physician documentation, computerized physician order entry, tracking, registration) with a niche EHR system (EMSTAT) for approximately 1.5 years when our institution began the implementation of a system-wide EHR-Epic 2008. The implementation in the hospital was phased in over 2 years with the ED portion set for 11 November 2009. The H1N1 flu pandemic began in our region in the late summer of 2009, causing a surge in patient volumes to the ED in September 2009.

To cope with the large volume of non-acute patients because of influenza, an overflow clinic was started to divert patients presenting to the ED with flu-like illnesses to an onsite clinic staffed by non-ED providers. Patients who met specific triage criteria were sent to an alternative care site within the hospital where care was provided by non-ED providers. Within 2 weeks, the overflow clinic was seeing approximately 50–60 patients a day, approximately 10–20% of the daily ED volume. By early November 2009, volumes of flu patients declined to pre-surge averages.

The overflow clinic remained open for an additional time during implementation of our new EHR in the ED in an attempt to offload the volume of low acuity patient visits during implementation. Nursing and medical provider staffing were also increased during implementation, increasing the number of providers by approximately 10–15%, and nursing staff by approximately 15–20%. ‘Superusers’ were deployed in the department as well as a staffed call center. ‘Superusers’ were physicians and nursing providers on site who had no patient care responsibilities and functioned only to support staff in using the EHR. Staffing increased for 2 weeks immediately following implementation.

Data review methods

We reviewed the electronic visit data of patients presenting to the CCHMC ED during 2-week blocks around implementation, and again 1 year later. De-identified metrics data were examined for ED patients who presented for care before, during and after implementation of the new EHR. Pooled data for physician and APN productivity immediately preceding implementation, 2 months following, and 1 year after were studied.

Blocks studied included a baseline block, a period the overflow clinic was operational before EHR rollout, the time immediately following rollout both with the overflow clinic and without, and a new steady state period 9 months later with similar volumes. The following were calculated for each period: total number of patient visits (overflow clinic and ED), average LOS for discharged and admitted patients, time to first provider

(resident, doctor, or APN) and time to room placement. CI were calculated for all mean metrics, and the unpaired t-test were performed on the LOS data to quantify that differences seen were significant.

We report provider efficiency data (patients per hour) by provider type before, during, and after implementation.

RESULTS

The timeline of events is depicted in figure 1.

Table 1 outlines the 2-week time blocks and reports the patient flow data throughout the timeline. Each 2-week block was similar in terms of the number of patients seen (mean 3281, range 3154–3333), and numbers of discharged and admitted patients. When compared with pre-implementation levels, on average, admitted patients’ LOS was 6–20% longer during EHR implementation and for discharged patients, LOS was 12–22% longer.

During the overflow clinic activation, and before EHR implementation nearly 10% of patients were diverted to the overflow clinic; however, only 5% were diverted during EHR implementation.

The overflow clinic during H1N1 surge did appear to reduce the overall LOS before the implementation (95% CI showed decreased LOS 24 to 53 min for admissions, and by 9 to 19 min for discharges with the clinic in place, comparing time 1 with time 2). However, during EHR implementation, the overall LOS for both groups exceeded both the H1N1 pre-overflow clinic block as well as the H1N1 overflow clinic block (95% CI showed increased LOS 32 to 62 min for admissions and by 35 to 44 min for discharges compared with the clinic in place before rollout). Both LOS dropped back to pre-H1N1 average LOS after 3 months.

Figure 2 reveals that it took approximately 3 months to get to the previous steady state level for visit metrics, and a new improved LOS steady state was achieved approximately 6 months post-implementation. Using the new steady state data to calculate proportions, the ED system operated at 80% efficiency in terms of LOS during the first 2 weeks of implementation, and recovered to 90% by weeks 3–4. This included additional patients who were diverted to an overflow clinic. Despite consistency during all blocks in time to room placement, there was a significant increase in time to doctor in the first 2 weeks after EHR implementation from 47 min to 70 min ($p<0.001$).

Table 2 shows the total number of clinical hours worked by all medical care providers in our ED by month. Despite a consistent total number of clinical work hours from October to December 2009, the patients/h seen fell between October and December as the total number of patient visits dropped. Staffing levels remained elevated the following year compared with 2009, resulting in an overall lower patients/h seen in the last quarter of 2010 (total provider hours increased by 6% and total patients decreased by 16%).

Figure 1 Timeline of events. H1N1 surge includes greater than 20% above normal volume attributed to flu-like illness, overflow clinic includes all days clinic saw patients, electronic health record rollout includes 14 days that extra staffing was employed, starting with rollout day. EHR, electronic health record.

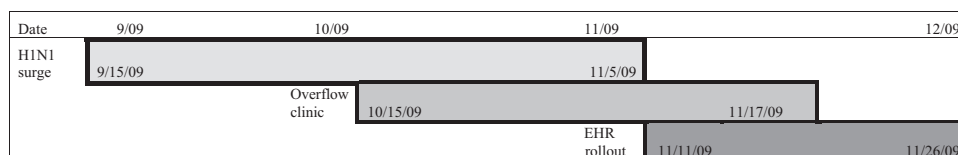


Table 1 Patient visit metrics before/during/after implementation

	Time 1 9/28/09–10/11/09	Time 2 10/28/09–11/10/09	Time 3 11/11/09–11/24/09	Time 4 11/25/09–12/8/09	Time 5 8/27/10–9/10/09
Total ED visits	3328	3311	3333	3154	3279
No of OC visits (% of total)	0	299 (10%)	165 (5%)	0	0
No of ED patient visits, admissions	460	456	470	460	451
No of ED patient visits, discharges	2577	2776	2660	2577	2530
No of elopements	69	59	56	31	32
Mean time to room, min (95% CI)	29 (28 to 30)	35 (34 to 36)	27 (26 to 28)	33 (32 to 34)	28 (27 to 29)
Mean time to MD, min (95% CI)	42 (41 to 43)	47 (46 to 48)	70 (68 to 72)	60 (59 to 61)	41 (40 to 42)
Mean LOS admissions, h (95% CI)	5:28 (5:24 to 5:32)	4:50 (4:46 to 4:54)	5:36 (5:32 to 5:40)	5:20 (5:16 to 5:24)	4:35 (4:31 to 4:39)
Mean LOS discharges, h (95% CI)	2:59 (2:56 to 3:02)	2:45 (2:42 to 2:48)	3:25 (3:22 to 3:28)	3:05 (3:02 to 3:08)	2:33 (2:30 to 2:36)

Time (1) overflow clinic absent, before new EHR implementation during similar patient volumes to time period 3, previous steady state.

Time (2) overflow clinic present, before new EHR, end of surge + overflow clinic.

Time (3) overflow clinic present, new EHR rollout.

Time (4) overflow clinic absent, new EHR active without additional staffing.

Time (5) 9 months after EHR active, new steady state.

ED, emergency department; LOS, length of stay; MD, doctor; OC, overflow clinic.

DISCUSSION

Patient visit metrics appear to be negatively impacted in the ED during EHR implementation despite additional staffing and availability of the overflow clinic. Time to physician, left without being seen numbers, and overall LOS for both admitted and discharged patients were significantly higher during the initial EHR implementation phase. The effect appeared to be

temporary; LOS was back at pre-implementation baselines within 3 months of implementation, when corrected for patient volumes.

Using the model of input/throughput/output to describe ED flow in our setting,¹¹ the input (number of visits, time to room placement) and output (numbers of admitted and discharged patients) measures were consistent between each of the 2-week

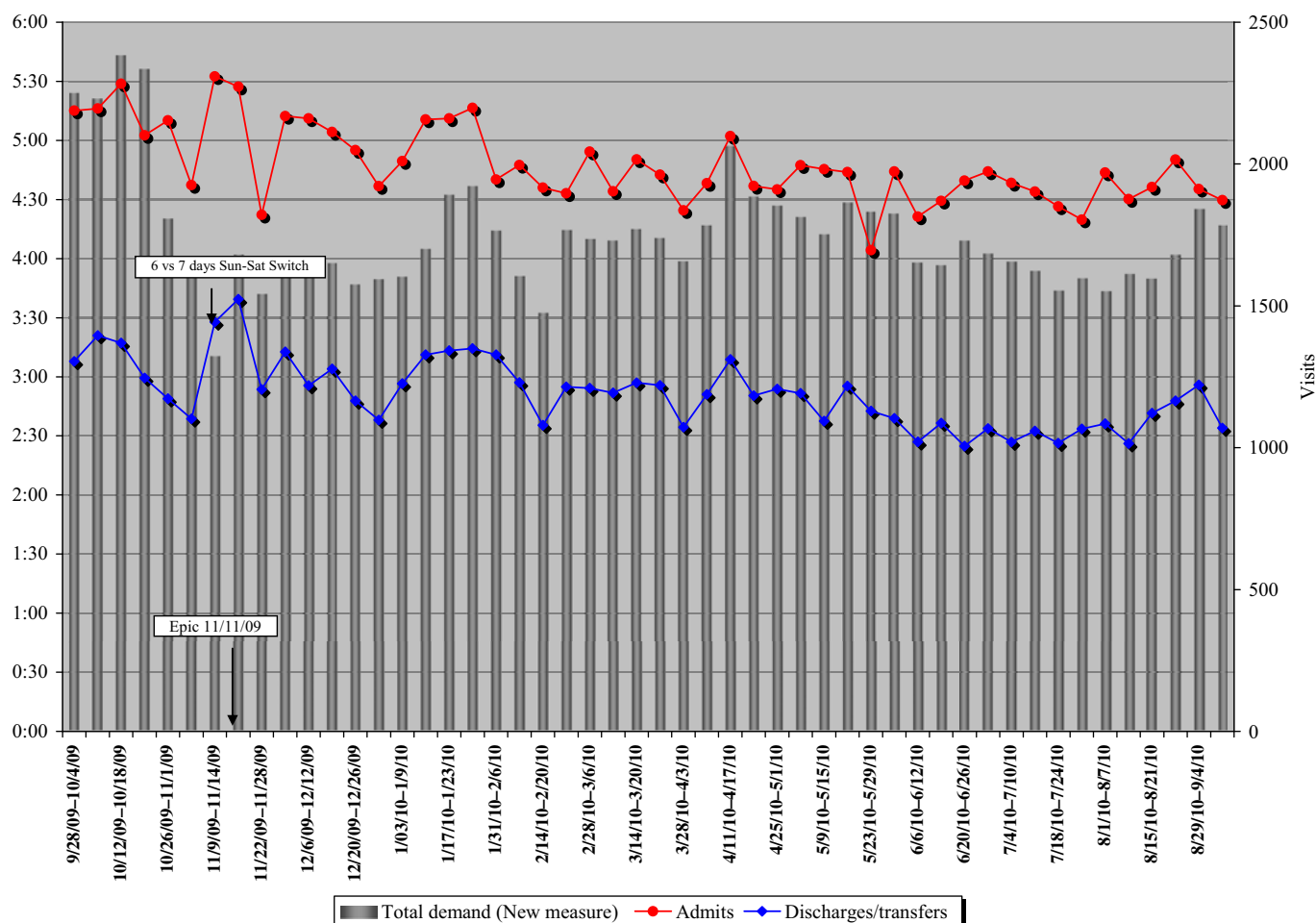
**Figure 2** Average lengths of stay.

Table 2 Provider productivity before/during/after implementation

Month	Clinical hours, totals for month by job title			Total hours	Total patients	Patients/h
	Faculty	Clinical staff	APN/fellows			
Sep 2009 pre-EHR	1548	1425	916	3889	8431	2.17
Oct 2009 pre-EHR	1359	1166	914	3439	8573	2.49
Nov 2009 implementation	1575	1130	954	3659	8166	2.23
Dec 2009 post-EHR	1282	1135	1063	3480	6388	1.84
Totals 2009	5764	4856	3847	14467	31558	2.18
Sep 2010	1656	1340	1103	4099	7249	1.77
Oct 2010	1403	1082	1200	3685	6895	1.87
Nov 2010	1341	1093	1336	3769	6306	1.67
Dec 2010	1333	1195	1163	3691	5955	1.61
Totals 2010	5732	4710	4802	15244	26405	1.73

APN, advanced practice nurse; EHR, electronic health record.

blocks. Given that no other interventions were employed either in the ED or within the hospital during this time (other than increasing staffing in the ED), we conclude that the impact for delays in care were directly related to the implementation of EHR.

The difference in LOS was seen in the time to provider, and was not reflected in time to room placement. Time to room placement is a proxy for the amount of time doing rapid nursing assessments and triage. Before implementation, there was a concern that this process, designed to take less than 10 min per patient, would be affected greatly by the new EHR, but that was not the case. All staff experienced the same change in system, but more ‘bottlenecks’ appeared to be attributable to provider slowdown. This is clearly in keeping with previous research, in which loss of physician efficiency was recognized to be a potential drawback to EHR systems.⁹ This effect might be more pronounced in our setting, where the frequent rotation of residents (involved in approximately 50% of visits) increased ‘new’ provider users to the system. Whether this is offset by improving revenues with increased charting or capturing of charges was not addressed by our study.

A critical question was whether the overflow clinic model could be quickly adapted to offload the ED for the implementation of EHR. The clinic was successful at decreasing LOS during our flu surge, but it was not effective in diverting patients during EHR implementation, perhaps partly due to fewer patients being diverted to the clinic. The clinic was designed to divert patient with ‘flu’ symptoms, and once that specific population declined, the process for triaging patients to the clinic did not work well, and fewer patients were diverted. It is unclear from our data whether increasing the specific number of patients diverted would have made a difference in decreasing LOS during the implementation.

We saw continued improvement in LOS from 3 to 6 months after implementation, leading to an overall improvement compared with baseline. It appears from productivity data that the total number of hours worked by all providers has remained constant since H1N1 and implementation, despite an overall reduction in patient visits, which probably explains this continued drop. The drop in total ED visits was unexpected in the following year, and probably impacts the perceived loss of provider ‘productivity’ seen 1 year after implementation.

Provider productivity was included to determine how much an effect was due to increasing provider and patient services staffing during the go live. Initial decreased productivity seen in December 2009 could be due to the product, but it is interesting that this effect was not seen in the month of implementation. Due to the structuring and reporting of these data, it was not possible to segment it further.

Limitations

As this was an observational study, no causality can be formally attributed from our data. No effort was made to control between the groups, but as there were no other major operational changes during this time, it would appear that the EHR rollout was the largest contributing factor to the slowdown.

CONCLUSIONS

Patient flow delays occur during the implementation of EHR in a busy pediatric ED. It is difficult to know how much benefit was gained through our interventions of increased staffing and limited diversion of low acuity patients. However, despite these interventions, we found patient metrics returned to baseline levels by 3 months. This should help other hospital/ED groups recognize potential needs when planning an EHR implementation. Further study is needed to identify potential safeguards to ensure patient safety during such a period of operational change.

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Competing interests None.

Ethics approval This study was approved by Cincinnati Children’s Hospital Medical Center.

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Data sharing statement The data we used for our metrics are available for review upon request.

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