Time-Saver

A Time-Motion Study to Evaluate the Impact of EMR and CPOE Implementation on Physician Efficiency

By Amen A. Amusan, PMP, MS; Scott Tongen, MD; Stuart M Speedie, PhD; and Andrew Mellin, MD, MBA

KEYWORDS

EMR, CPOE, time motion study.

ABSTRACT

The objective of this research is to determine the impact of EMR and CPOE implementation on physician efficiency. A time series observational study was conducted within a hospital setting at six weeks pre-implementation, six weeks post-implementation and five months post-implementation. All 19 subjects were observed twice with one patient per observation. Physician follow-up rounding times per patient were measured. Physicians demonstrated a mean total rounding time of 18.79 minutes (pre-implementation); 16.97 minutes (six weeks post-implementation); and 12.97 minutes (five months post). Overall, the results showed a statistically significant F value=8.26>1 (p=0.0011) that signifies a reduction in physician rounding time within the hospital setting following EMR implementation. Results also showed overall standard deviations of 6.96 minutes (pre-implementation); 5.13 minutes (six weeks post); and 3.69 minutes (five months post), possibly signifying a reduction in variability and a narrower distribution of rounding times with increased similarity in physicians' rounding patterns.

The objective of this research was to determine the impact of electronic medical record (EMR) and computerized physician order entry (CPOE) implementation physician efficiency at United Hospital. The focus of this research is to determine if there is reduction in physician rounds time from pre- to post-implementation of the system.

BACKGROUND

Physician resistance to EMR adoption is a major barrier to successful EMR implementation. Poissant et al., in a systematic literature review, states, "the importance of evaluating time efficiency in documentation is also related to the observation that increased time for documentation is one of the most commonly stated barriers to successful implementation of an EMR."[1]

Moving from a paper-based system to an EMR creates challenges, such as changes to the physician's workflow, processes, etc. that cannot be overlooked. The goal of this research is to examine the effects of these changes affect providers' daily activities. Current studies show that healthcare providers have several important needs—improved access to information, elimination of "chart pulls" (Bates et al.), access to decision support—that are not being met.[2]

Quality improvement through EMR depends greatly on physicians' use of the system to complete day-to-day activities.[3] It is thought that the adoption and better use of IT is essential for improved quality of care.[4] Other studies have cited the importance of EMR in reducing documentation time and enhancing efficiency.[5-10] A survey conducted by O'Brien at the JKL Healthcare System noted that 90 percent of the participating physicians affirmed that EMR made their work much easier.[11]

Galvin, et al. state that "[it] was clear from the beginning that CPOE was an initial leap in the larger revolution in health information technology necessary to achieve improved quality and efficiency."[12] Studies show that CPOE improves efficiency and medication

and order turnaround.[13-17] Some studies show a non-significant difference in time when using EMR vs. a paper-based system.[18] Though some studies show increased time spent in the CPOE system due to changes in workflow processes,[10,19] this reduced as knowledge of and experience with the system improved.[20]

Puffer, et al., state, "Perceived efficiency has been shown to have a significant impact on overall satisfaction with electronic clinical systems that, in turn, supports wider adoption of the technology."[21] We need to perform more evaluations of current systems to determine how well they enable healthcare organizations to reap the benefits of efficiency.

A pre- and post-implementation evaluation is one way of achieving this goal and finding the best ways to resolve outstanding problems and/or concerns.[22] Several studies performed in the past have focused on the impact of EMR or CPOE within the primary care, specialty clinics or outpatient settings, but very few studies have been conducted in inpatient settings.[23]

Physician resistance to EMR adoption is a major barrier to successful EMR implementation.

To evaluate the impact a new EMR/CPOE system will have on physicians' efficiency at United Hospital in St. Paul, Minn., a benefit measurement analysis was performed. Part of this analysis measured the time it took providers to perform various patient care activities, particularly rounds. The final analysis would determine if the use of EMR/CPOE reduced time spent on patient rounding.

Current workflow. The physicians at United Hospital is a private group with no residents or medical students assisting in the patient care. Generally, they work individually except when they assigned a list of patients and their location each morning. (They round an average of 15 patients per day.)

Upon arrival to a patient's unit, the physician visits the nurses' station to review the patient's paper chart, which includes progress notes, lab results, current medications and other pertinent information. Leaving the chart at the station, the physician visits the patient. After the visit, the physician walks back to the nurses unit to update the chart. Notes are dictated via the Dictaphone system. Orders are placed within the STAR application or had written in the notes for the nurses or health unit coordinators to enter into the STAR system. Patient-related instructions are verbally discussed with nurses, peers or caregivers. The physician then moves on to the next unit and the next patient on the assigned list.

The existing system and its limitations. Allina's decision to implement an EMR system stems from its goal to have a single integrated system between the hospitals and clinics, as well as between revenue cycle and clinical systems described at Allina as "One patient. One record."[24,25]

The system at United prior to Excellian was a traditional, paper-based health record, with the exception of electronic nursing documentation in the ICU. Shortliffe (pg. 415) described the paper-based system as "highly inadequate for meeting the needs of modern medicine."[26]

It is not a very efficient system for patient information storage and retrieval; chart documentation is error-prone; and collecting patient-related information is time consuming. (For example, the medication administration record, lab results and progress notes may all be in different locations.)

NEW WORKFLOW

Physicians are added to the treatment team of each assigned patient within the application. Each provider has a provider list that contains all patients associated with the physician through the treatment team relationship and can be viewed through the system. The order of seeing patients depends on the physician's discretion and the acuity of the patient.

Upon arrival to the patient unit, the physician logs into any available workstation to retrieve and review the patient's electronic chart. He/she logs out of the system and visits the patient. After the visit, the physician walks back to the nurses' unit, logs into the system, locates the patient, and opens the chart and rounding navigator. Progress notes are written using available templates (smart text), smart list and smart phrases when necessary and filed. Orders/medication are reviewed from the same navigator and are either discontinued, modified or remain unchanged. The physician may communicate verbally with the nurse or place a communication order in the system. The physician then closes the patient chart and logs out of the system.

With EMR patient care is done through a computer, including CPOE, clinical messaging, physician documentation, results review, deficiency management and nursing documentation review. For the analysis, physicians were allowed to continue to dictate information, but all other physician documentation, including progress notes, were done through the EMR.

United Hospital mandated complete adoption of the EMR/CPOE by all providers, except those who had 12 or fewer patient contacts per year. Workflow changed for a number of individuals. For example, some physicians now round large group of patients and place orders, then complete the notes off the patient unit. Other physicians complete the H&P note directly in the computer at the patient's bedside. Some providers now also access the chart from home to follow up on information and place new orders.

METHOD

Setting. This research was performed at United Hospital. "United Hospital is one of the largest hospitals in the Twin Cities East metro area, providing a complete variety of health care services to more than 200,000 people each year."[27] This 426-bed healthcare institution has more than 1,300 healthcare professionals with a broad range of specialties. In 2006, there were 28,165 inpatient admissions and 101,196 outpatient visits. It is owned by Allina Hospitals and Clinics (a not-for-profit network of hospitals, clinics and other healthcare services, providing care throughout Minnesota and western Wisconsin). Allina has 11 hospitals, 42 clinics, 22 hospital based clinics, 14 community pharmacies and four ambulatory care centers.

Excellian is Allina's branding of the EMR implemented at United Hospital. Excellian intends to provide a quick and easy access to patient charts and improve communication between physicians treating the same patient. It also provides timelier turnaround on

Table 1: Total minutes spent on each activity and category pre and post implementation for all physicians.

		Pre_implementation	Total	Six weeks Post	Total	5 Months Post	Total	P-value
Pre rounding	Info. Gathering	21.5	76.5	18	69	0	36.5	0.0001
	Info. Review	55		51		36.5		
Seeing Patient		111.5	111.5	95.5	95.5	87	87	0.19
Post rounding	Notes	119	169	105	158	91.5	123	0.062
	Orders	3		39		26.5		
	Communication	47		14		5		

lab or radiology test results; leads to better educational opportunities for patients; and offers improved security for patient privacy.[28] To date, eight Allina hospitals and almost all of the Allina clinics have fully implemented the system in the inpatient and outpatient environment.

Subjects. The target population was the hospitalists at United Hospital. The hospitalists group at United is made up of highly trained "board-certified physicians."[29] This group collaborates with primary care providers to provide seamless continuity of patient care. They work on a weekly rotation, which posed some challenges during the initial phase of this research as it was difficult to recruit physician subjects.

The intent was to recruit 20 to 30 hospitalists for this research to increase the statistical power and precision of the data analysis. After obtaining approval from both the Allina's Health System IRB and University of Minnesota IRB, the principal investigator went to different hospital units and personally approached providers, explained the purpose of the study and handed a copy of the consent forms to these providers. Due to busy and varying schedules, only 11 United physicians were recruited. At the end of the recruiting period, five additional hospitalists from the ASPEN Medical group agreed to participate in the study. There were also two specialty physicians from the St. Paul Heart Clinic and one from the St. Paul Lung Clinic who agreed to participate in the study. All of these providers do rounds on patients at United Hospital within the same units, using the same EMR and CPOE applications. The final sample size was a total of 19 physicians.

Study design. A time series observational time-motion study was performed at six weeks pre-implementation; six weeks post-implementation; and five months post-implementation. The observations focused primarily on the physicians' rounding workflow processes per patient. The time (in minutes) of each of the three workflow tasks was measured within each observation session. It was measured for the following tasks:

***Pre rounding*:**

- Information gathering time
- Information review time.
- Seeing patient
- This study does not include detailed observation of processes involving direct patient care because of privacy considerations. However, the time in minutes spent by the physician within the patient's room was recorded and included in this research.

Post rounding

- Time taken to write patient notes
- Time to place orders (written and/or verbal)
- Communication time (time spent in discussing with the nurse or other healthcare providers directly involved in the patient care).

For each session, a start and end time (signifying physician arrival and departure time) was recorded.

Data collection. Data was collected over a period of two weeks for the pre-implementation and the six-week and five-month period post-implementation. Data for six weeks pre-implementation was collected from April 2 through April 14, 2007, between the hours of 8:30 a.m. and 12:30 p.m. Data for the six weeks post go-live was collected from June 16 through June 29 2007, between the hours of 8:30 a.m. and 12:30 p.m. For five months after go-live, observation sessions were done from September 11 to October 8, 2007, between the hours of 8:30 a.m. and 12:30 p.m.

An observer followed each provider as they rounded. A minimum of two complete sessions with one patient per session were recorded in minutes (rounding seconds to the nearest minute) on an Excel spreadsheet. Zero times were recorded for less than 30 seconds and in cases where no activity was performed. Times recorded for 30 seconds and above were rounded to the nearest minute. Rounding times for admissions and discharge were not included in this analysis as it took providers longer times to perform these activities.

Data analysis. The SAS (Statistical Analysis Software) version 9.1 TS level 1M3 and Microsoft 2003 Excel was used for data analysis. Alpha (type I error) was set to 0.05. The SAS GLM (General Linear Model) procedure was used to analyze the rounding time (minutes). The decision to use the SAS GLM procedure was due to the longitudinal (multiple measures on one person) nature of the data collected during this study. Proc UNIVARIATE was also used to perform analysis on the data collected and the following statistical results: mean and standard deviation was reported.

Table 1 shows the total time spent on each activity pre- and post-implementation by all physicians.

The information gathering activity showed a 3.5-minute reduction in time at six weeks post-implementation and a 100 percent time reduction five months post-implementation. The 100 percent reduction was due to zero times recorded for periods less than 30

Table 2: The average total times in minutes and standard deviations for all categories.

		Pre Implementation	6 weeks post	5 Months Post
Pre Rounding	Mean	4.03	3.63	1.92
	Standard Deviation	1.84	1.88	1.40
Seeing Patient	Mean	5.87	5.03	4.58
	Standard Deviation	3.36	2.90	2.44
Post Rounding	Mean	8.89	8.32	6.47
	Standard Deviation	3.67	4.32	2.18
Rounding (Overall)	Mean	18.79	16.97	12.97
	Standard Deviation	6.96	5.13	3.69

seconds and in cases where no task was performed. The information review activity had a four-minute reduction in time six weeks post, and then had an 18.5-minute reduction five months post. Although a reduction in the time a provider spent with a patient was not anticipated, there was a 16-minute reduction six weeks after, and a 24.5-minute reduction five months post. In notes activity, there was a 14-minute reduction six weeks post and a 28.5-minute reduction five months post. Time spent in the orders activity increased from three to 39 minutes six weeks post and then approximately 27 minutes five months post. Communication activity declined drastically six weeks post by 33 minutes and 42 minutes five months post. A possible reason for this is a reduction in physician dictation time and increased use of electronic communication.

This is the total time spent on rounding activities (pre-rounding, seeing patient and post-rounding). Pre-rounding had a 7.5-minute reduction in total time at six weeks and a 40-minute reduction five months after go-live. Seeing patients had a 16-minute reduction in total time at six weeks and a 24.5-minute reduction in total time five months after go-live. Table 1 also shows that post-rounding had an 11-minute reduction in total time six weeks after go-live and a 46-minute reduction in total time five months after go-live.

The GLM Procedure Repeated Measures Analysis of Variance simply called Repeated Measures ANOVA analysis was performed on the time motion dataset for pre-rounding, seeing patients and post-rounding.[30] There were a total of 38 observations with the 19 subjects. Analysis also was performed on the average total time spent rounding on patients per provider for the periods of pre-implementation, six weeks post and 5 months post implementation. A test for normality was performed to verify that the data was normally distributed. Shapiro-Wilk test is the most commonly used test for this analysis. A p-value greater than alpha signifies a normal distribution of data. SAS recommends using Shapiro-Wilk test for small sample size not greater than 2000.

Before proceeding with a GLM procedure using univariate or multivariate analysis, a test for sphericity was performed. The Mauchly's sphericity assumption (spherical matrix equals zero with equal variances and covariance) must be met to perform univariate analysis.

In order to evaluate the impact of rounding to zero minutes, we tried the alternative of rounding to 0.5 minutes and did the analysis.

RESULTS

Results from the ANOVA analysis showed that the data from six weeks post-implementation was normally distributed while data from six weeks pre-implementation and five months post-implementation did not appear to be normally distributed but rather skewed to the right.

Results from the Shapiro-Wilk's test of normality for six weeks pre-implementation was non-significant (p=0.081) meaning that the dataset is normally distributed. Similarly results were observed for the period of six weeks post-implementation (p-value=0.72) and five months post-implementation (p-value=0.56).

Table 2 shows average total times per physician and standard deviations for the pre-rounding, seeing patients and the post-rounding categories for each of the three time periods.

The analysis shows that the sphericity assumption was violated with a chi-square of 10.41 with 2 degrees of freedom which has a p-value=0.0055. This means that the univariate test would likely yield invalid results. Accordingly, the repeated measures analysis of variance was employed. The multivariate F-test for

time (pre, six weeks post and five months post) had a significant F value=15.66 with a corresponding p-value of 0.0001.

For the pre-rounding analysis, the sphericity assumption was met with a chi-square of 1.47 and an associated p-value of 0.4801 which is greater than alpha (=0.05). The univariate test used for this analysis showed a significant result with a p-value of 0.0001. This shows a considerable change in physician pre-rounding time across the trials. Similarly for the seeing patient category, the sphericity assumption was met (chi-square=0.86 and a p-value=0.65) and we proceeded with the Univariate test that showed a non significant F=1.72 with a p-value=0.19. In the post-rounding category, the sphericity assumption was also met with a chi-square of 4.06 and an associated p-value=0.13. The univariate test showed a significant F=3.01 with a p-value of 0.062. This result demonstrates a downward trend that approached significance.

The overall results from rounding to 0.5 minutes was statistically significant with p=0.0034. This did not show any considerable difference from the result obtained from previous analysis.

DISCUSSION

The purpose of this study was to determine the impact of an EMR & CPOE implementation at United Hospital on physician hospitalists' efficiency. Our finding shows a statistically significant result with a p-value of 0.0011, which signifies a reduction in the time spent on rounding by physicians per patient.

There were initial concerns of possible bias to the study due to the three additional specialty physicians added to the subjects. The decision was made to include these physicians given that the intent of the analysis was not to target the specialty, but rather the tasks being performed. Hospitalists and specialists performed similar tasks at the time of observation and used the same EMR and CPOE within the United Hospital.

The significant difference in pre-rounding compared to the other rounding categories was due to the fact that the providers had to spend less time looking for charts or patient information from disparate systems. Some of the providers said that they did all their pre rounding activities consisting of information gathering and review prior to coming to the patient's units. This made the process much faster for them. However, in this research, all participants performed all the activities while rounding on patients and as a result of that the outcome of this study was not biased in this respect.

The zero times seen in Table 1 above for order (pre-implementation) and information review (five months post) were due to physicians possibly handwriting patient orders while writing patient notes or communicated this verbally to other clinical staff (e.g., nurses). Very few physicians logged in to the Allina STAR system (used pre-Excellian implementation) at the time of observations. The observer had no way of knowing what was being written. It is likely that some of the order times in the pre implementation may have been added to the note taking time. As a result of that, the amount of time in minutes recorded for the notes activity may have been over estimated.

The final data analysis above also shows no significant difference in times through the trials for the category seeing patient. The time a provider spent in the patient room was considered as time spent seeing patient. The actual time the physician spent directly on patient care while inside the patient's room may have been lesser than the time reported. The observer did not go into the patients' rooms and hence was unable to tell from the observation the amount of time spent directly on patient care. This is subject to further study.

The results shows that the highest standard deviation six weeks post-implementation for pre-rounding and seeing patients (Table 2). Seeing patients and post-rounding saw the highest standard deviation during the pre-implementation phase. A possible reason for that could be increased variability or wide distribution of rounding times among physicians. Physicians had dissimilar rounding patterns as there was no standardized method of rounding. The overall standard deviations showed a declining trend signifying a reduction in variability and a narrower distribution of rounding times with increased similarity in physicians rounding pattern. There was no control over the acuity of the cases which could possibly have influenced how the physicians spent their time.

The post-rounding category evidences a declining trend in average time which approached statistical significance. The lack of a significant decline may have been due to some providers having to spend more time entering procedure, lab and communication orders in the CPOE system as this was mandatory with the new system. In the previous paper world, these orders were mostly communicated to the nurse verbally or through patient notes.

The hypothesis that the implementation of the EMR and CPOE will result in an increase in physician's efficiency was accepted.

One likely but unknown impact on this study is the Hawthorn effect (which is the awareness of the presence of the observer by the physicians). However in this research, this effect became minimal with increased number of observations.

CONCLUSION AND FUTURE DIRECTIONS

In conclusion, the hypothesis that the implementation of the EMR and CPOE will result in an increase in physician's efficiency with a reduction in the time spent on rounding patients was accepted. This research only observed physicians when they were rounding on the floor and the focus was on hospitalists. It did not however include admissions and/or discharges. The results might be different if these categories of patients been included.

For future studies, it is recommended that a larger physician sample size be needed and the number of trials be increased in order to improve the precision and accuracy of the analysis. Another consideration for future research is to randomly select a large number of providers, send out a survey to selected providers to further group them by work life style. Some providers prefer reviewing patients' information in batches of three or four prior to seeing patients. Others prefer seeing patients in batches and go back to the physicians' lounge to write all the notes, place orders,

etc. Varying work styles can be a form of bias to the research if not taken into consideration. These physicians' natural rounding workflow processes were changed in order to capture data more accurately. In the future it will be beneficial to track the time physicians spend on rounding over some observational period rather than per patient to determine the impact the EMR/CPOE will have on natural workflow processes.

I also recommend that future research address the following questions: Would it have been better to record times to the second? Were the results skewed by primarily following heavy users of the EMR and CPOE like hospitalists? How would surgeons or different specialists do? Is there a difference in the kind of visit, i.e. regular rounding vs. admission or discharge? What would the numbers look like after a year? If we included time on the computer in the patient's room, what effect would this have? Will grouping of physicians by gender change the results? And, finally, will general computer proficiency make any difference in the final result? Future research should also consider comparing the results from this analysis to previous research.

ACKNOWLEDGEMENTS

This research was funded by the United Hospital Foundation. Our appreciation goes to Dr. Don Connelly and Dr. Bonnie Westra. We would like to acknowledge the United Hospital Services hospitalists for participating in this study. The hospitalists from the ASPEN Medical group, St. Paul Heart Clinic and St. Paul Lung Clinic for participating in this research. Thank you Jennifer Raiter for helping with the physician schedules. Thanks to Jane Tobias (Allina Excellian Support-Lead) and Sharon Bresnahan (Manager-Allina Excellian support). Thanks to Susan Telke (Instructor Division of Biostatistics University of Minnesota) for the statistical advice provided. Thanks to Linda Fletcher and Beverly Collins for reviewing this research literature. Finally we would like to acknowledge the entire staff and student of the University of Minnesota Health Informatics Division. Thanks to Tola, Samuel and John Amusan for all their understanding and support throughout this research. **JHIM**

Amen A Amusan, PMP, MS, is a member of the Health Informatics Division, University of Minnesota.

Scott Tongen, MD, is Excellian Medical Director, United Hospital, St. Paul, Minnesota.

Stuart M Speedie, PhD, is a member of the Health Informatics Division, University of Minnesota.

Andrew Mellin, MD, MBA, was Excellian Director (former), Allina Hospitals and Clinics, Minnesota.

REFERENCES

1. Poissant L, Pereira J, Tamblyn R, Kawasumi Y. The impact of electronic health records on time efficiency of physicians and nurses: a systematic review. *J Am Med Inform Assoc*. 2005;12(5):505–516.

2. Bates DW, Ebell M, Gotlieb E, Zapp J. A proposal for electronic medical records in US primary care. *J Am Med Inform Assoc.* 2003;10(1):1-10.

3. Miller RH, Sim I. Physicians' use of electronic medical records: barriers and solutions.]*Health Aff.*2004;23(2):116-126.

4. Preparing for implementation. Available at: http://www.emrtoolkit.ca/view_section.php?section=3. Accessed on December 8, 2007.

5. Sujansky WV. The benefits and challenges of an electronic medical record: much more than a 'word-processed' patient chart. *West J Med.* 1998;169(3):176-83.

6.Chaudhry B, Wang J, Wu S, Maglione M, Mojica W, Roth E, Morton SC, Shekelle PG. Systematic review: impact of health information technology on quality, efficiency and costs of medical care. *Ann Intern Med.* 2006;144(10): 742-752.

7. Toward a high-performing EMR health system. EMR vs. EHR: is there a difference? Available at: http://www.emrworld.net/emr-research/ehr.php. Accessed on December 8, 2007.

8. Ford EW, Menachemi N, Phillips MT. Predicting the adoption of electronic health records by physicians: when will health care be paperless. *J Am Med Inform Assoc*. 2006;13(1):106–112.

9. Khan SA, Payne PRO, Johnson SB, Bigger JT, Kukafka R. Modeling clinical trials workflow in community practice settings. *AMIA Annu Symp Proc.* 2006;2006:419–423.

10. Overhage JM, Perkins S, Tierney WM, McDonald CJ. Controlled trial of direct physician order entry: effects on physicians' time utilization in ambulatory primary care internal medicine practices. *J Am Med Inform Assoc.* 2001;8(4):361-71.

11. O'Brien MS. Implementation of the EPIC electronic medical record/physician order-entry system. *JHIM*. 2006:FELLOW PROJECT:1-2.

12. Galvin RS, Delbanco S, Milstein A, Belden G. Has the Leapfrog Group had an impact on the health care market? *Health Aff.* 2005;24(1):228-33.

13. Foster RA, Antonelli PJ. Computerized physician-order entry: are we there yet? *Otolaryngol Clin North Am*. 2002;35(6):1237-43.

14. Ali NA, Mekhjian HS, Kuehn PL, Bentley TD, Kumar R, Ferketich AK, Hoffmann SP. Specificity of computerized physician order entry has a significant effect on the efficiency of workflow for critically ill patients. *Crit Care Med.* 2005;33(1):110-4.

15. Cordero L, Kuehn L, Kumar RR, Mekhjian HS. Impact of computerized physician order entry on clinical practice in a newborn intensive care unit. *J Perinatol*. 2004;24(2):88-93.

16. Lehman ML, Brill JH, Skarulis PC, Keller D, Lee C, "Physician Order Entry impact on drug turn-around times", Proc AMIA Symp. 2001;359-63.

17. La Cour V, Hellstern-Hauerslev C. Evaluating the implementation and use of a computerized physician order entry system: a case study. *Stud Health Technol Inform.* 2007;130:75-9.

18. Newmarka L, Kittlera A, Lippincotta M, Volk LA, Honour MM, Gupta S, Wang SJ, Bates DW. Does using an electronic health record require more time for primary care physicians? *J I Med Inform Assoc.* 2004;1776.

19. Cheng CH, Goldstein MK, Geller E, Levitt RE. The effects of CPOE on ICU workflow: an observational study. *AMIA Annu Symp Proc.* 2003;150-4.

20. Hollingworth W, Devine EB, Hansen RN, Lawless NM, Comstock BA, Wilson-Norton JL, Tharp KL, Sullivan SD. The impact of e-prescribing on prescriber and staff time in ambulatory care clinics: a time motion study. *J Am Med Inform Assoc.* 2007;14(6):722-30.

21. Puffer MJ, Ferguson JA, Wright BC, Osborn J, Anshus AL, Cahill BP, Kamath J, Ryan MJ. Partnering with clinical providers to enhance the efficiency of an EMR". *JHIM*. 2007;21(1):24-32.

22. Optimizing your EMR (Practice efficiency & ongoing improvement). Available at: http://www.emrtoolkit.ca/view_section.php?section=7. Accessed on December 8, 2007.

23. Pizziferri L, Kittler AF,Volk LA, Honour MM,Gupta S, Wang S, Wang T, Lippincott M, Li Q, Bates DW. Primary care physician time utilization before and after implementation of an electronic health record: a time-motion study. *J Biomed Inform*. 2005;28(3):176-188.

24. HIStalk Interviews Kim Pederson, VP of Excellian, Allina Hospitals & Clinics. Posted May 23, 2007. Available at: http://histalk.blog-city.com/histalk_interviews_kim_pederson_vp_of_excellian_allina_hos.htm. Accessed December 8, 2007.

25. Pederson K, Truitt J, Mellin A, Henry S, Heichert S, Nueske K, Buhr K, Aldrich T, Aarness P, Lambert M, Scott L, Boyd T, Hirsch C, Bresnahan S, Schneider K. Allina Hospitals & Clinics EMR implementation. 2007; HIMSS Davies award:4-5.

26. Shortliffe EH. The evolution of electronic medical records. *Acad Med.* 1999:74(4):414-419.

27. Allina Medical Clinic-United Hospital. Available: http://www.unitedhospital.com/ahs/united.nsf/page/aboutus. Accessed on December 8, 2007.

28. Allina launches electronic medical record system at Abbott Northwestern Hospital. MINNEAPOLIS, July 26, 2007. Available at: http://www.allina.com/ahs/news.nsf/newspage/anw_7_26_05. Accessed on December 8, 2007.

29. Allina Medical Clinic- United Hospitalist Service, http://www.allina.com/ahs/AMC.nsf/page/AMC_UHS. Accessed on December 8, 2007.

30. Repeated Measures ANOVA Using SAS PROC GLM, 31 July 1997, Usage Note: Stat-40, Copyright 1995-1997, ACITS, The University of Texas at Austin, http://www.ats.ucla.edu/stat/sas/library/repeated_ut.htm. Accessed on December 8, 2007.