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Journal of Biomedical Informatics 38 (2005) 176–188

Journal of Biomedical Informatics

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Primary care physician time utilization before and after implementation of an electronic health record: A time-motion study

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Received 6 October 2004

Available online 14 December 2004

Abstract

Despite benefits associated with the use of electronic health records (EHRs), one major barrier to adoption is the concern that EHRs may take longer for physicians to use than paper-based systems. To address this issue, we performed a time-motion study in five primary care clinics. Twenty physicians were observed and specific activities were timed during a clinic session before and after EHR implementation. Surveys evaluated physicians' perceptions regarding the EHR. Post-implementation, the adjusted mean overall time spent per patient during clinic sessions decreased by 0.5 min ($p = 0.86$; 95% confidence interval [−5.05, 6.04]) from a pre-intervention adjusted average of 27.55 min (SE = 2.1) to a post-intervention adjusted average of 27.05 min (SE = 1.6). A majority of survey respondents believed EHR use results in quality improvement, yet only 29% reported that EHR documentation takes the same amount of time or less compared to the paper-based system. While the EHR did not require more time for physicians during a clinic session, further studies should assess the EHR's potential impact on non-clinic time.

Keywords: Electronic health record; Physician satisfaction; Physician workload; Time-motion study

1. Introduction

Primary care is a fundamental component of good healthcare. Substantial evidence suggests that high quality primary care can positively affect health outcomes [1–9]. Primary care providers must deliver acute, chronic, and preventive care. This diversity in care means that these providers face the challenge of integrating and managing a tremendous amount of information and biomedical knowledge. A majority (83–95%) of primary care physicians in the United States use traditional paper records to document and process clinical data [10,11] despite the benefits of electronic medical record (EHR) systems [12–17].

As many now advocate, it is important that primary care providers adopt the use of ambulatory EHRs in order to provide the best possible care [12,18–20]. According to the National Alliance for Primary Care Informatics, widespread use of EHRs could lead to improved quality, safety, and efficiency, along with increased ability to conduct education and research [12].

Despite their benefits, many physicians are often hesitant to begin using EHRs [21–23]. A key reason for this

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1532-0464/$ - see front matter

doi:10.1016/j.jbi.2004.11.009

is that physicians are concerned that using an EHR will take longer than paper, both during the conversion and in steady state [21,24–26]. As a result, the speed and ease of use of an EHR is a key determinant of how well it will be received by physicians.

There are limited data regarding use of clinical information systems and physician time utilization [24,25,27,28]. There are even fewer studies that quantify the effect on time of an ambulatory EHR [29], suggesting that further research is needed in this area.

Time-motion studies can be used to measure the effect of an EHR on physician time utilization [30]. A time-motion study can be performed either through continuous observation or work sampling [31], with continuous observation being more accurate than work sampling [32]. In the continuous observation approach, an observer passively shadows a physician while recording the amount of time spent in each task performed by the physician. The comprehensive data collected in time-motion studies are valuable in evaluating information systems' impact on workflow and workload.

Understanding how EHRs may affect physician time utilization will be fundamental in promoting their acceptance by physicians. Since the time required to use an application is so crucial to its success, we performed continuous observation time-motion studies before and after the implementation of an electronic health record in five ambulatory primary care clinics in Boston, with the specific aim of evaluating the effect of the EHR on physicians' overall time in clinic sessions. We were also interested in analyzing how converting from a paper record to an electronic record affects the time physicians spend in direct care with patients.

2. Methods

2.1. Study setting

The time-motion observations were performed at two urban and three suburban outpatient primary care clinics in the Partners Healthcare System. These clinics included hospital-based practices, off-site community practices, and neighborhood health centers. The number of physicians observed at the different sites ranged from 2 to 7. This study was approved by the Institutional Review Board of Partners Healthcare System.

Study clinics were selected based on the fact that they were all scheduled to implement an ambulatory electronic health record (EHR) system known as the Longitudinal Medical Record (LMR) [33,34] during the study time period. The LMR is a web-based application internally designed by Partners Healthcare System and allows the provider to maintain the patient record electronically (Fig. 1). The LMR incorporates structured patient clinical data, such as medications, allergies, problem lists, and health maintenance items, and tools such as charting, results management, referral management, and order entry. The LMR also offers computerized decision support and individualized reminders for health maintenance.

Prior to LMR implementation, physicians at each clinic had the choice of writing by hand or dictating notes. Prescriptions were handwritten. Lab orders were viewed using an electronic system. A paper chart was maintained and available to the physician during clinic sessions.

Post-LMR implementation, physicians were still permitted to hand write or dictate notes and prescriptions, as well as use the LMR for these tasks. Encounter forms

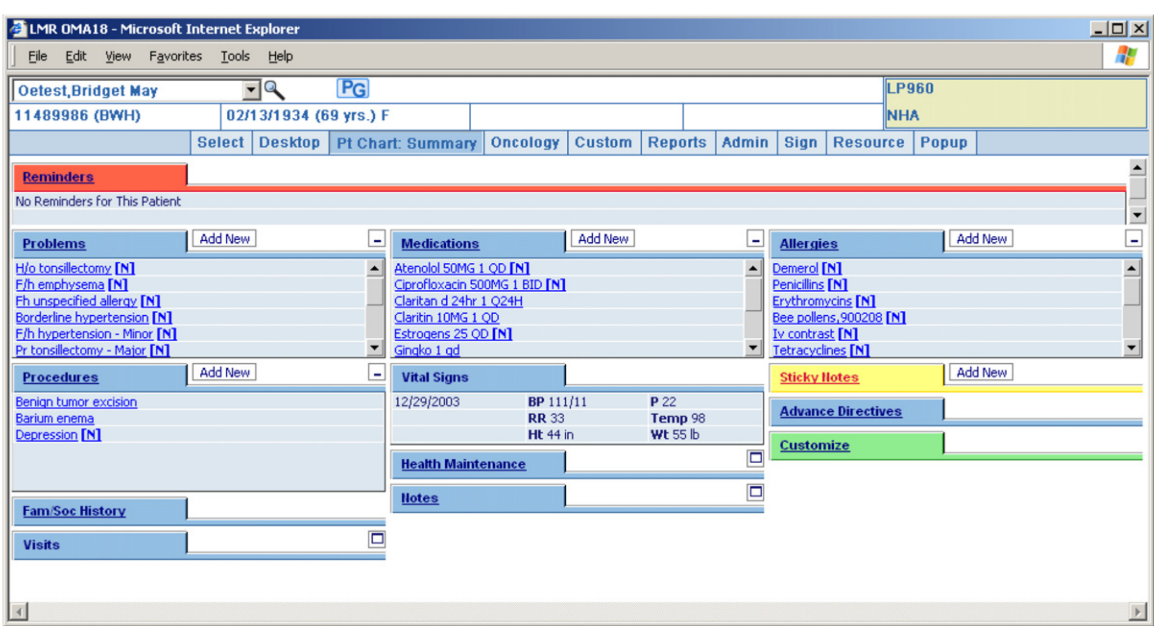

Fig. 1. Patient chart summary sheet for longitudinal medical record (LMR).

and test order requisitions continued to only be available in a paper-based form. Chart pulls could still be performed.

2.2. Study design

In preparation for LMR implementation, a hardware evaluation was performed to upgrade any computers that were below the application's minimum system requirements. A 1-hour personal training session was offered for each physician but was not mandatory.

This study design was modeled after a time-motion study performed at the Regenstrief Institute for Health Care [29]. Continuous time-motion observations were performed with physicians at the five study clinics both before and after LMR implementation. Post-observations were performed when the clinics were judged to be in a steady state of routine LMR use. Observers followed physicians during their entire clinic session and directly timed specific physician activities.

Primary care physicians (all general internists) were invited to participate. Residents and fellows were not invited because of the possibility they would not all be practicing at the clinic once the LMR was implemented. Physicians were invited to participate via email and were requested to suggest possible observation dates. Physicians who agreed to participate were observed once before and after implementation for a half day (1 session) or a full day (2 sessions) depending on their schedule on the day of the observation.

Twenty physicians were observed prior to implementation. Sixteen of these physicians were subsequently observed post-implementation. Four physicians were lost to follow-up because they left the practice or were on leave. Four additional physicians, who had not participated in a pre-observation, were recruited for a post-observation for a total of 20 physicians.

Observations began just before the first patient appointment, and continued until onsite care was completed for the last scheduled patient of that session or day. The physician or clinic staff was instructed to explain to the patient that the physician was the subject of the study, and that declining participation would in no way affect patient care. If a patient did not wish to participate, or if the physician declined participation due to the nature of the patient case, the observer did not enter the examining room or collect data until the physician completed the visit with the patient. If patient consent was obtained, the physician introduced the observer to the patient. After this point, the observer's role was restricted to passive observation only, involving no interaction with the patient or the physician. No patient identifiers were collected during the observation and the data were identified by a physician number rather than the physician name. The key linking physician number to name was kept in a separate file.

2.3. Task categories

Physician activities were documented using a predetermined set of tasks, which were arranged into categories useful for data collection and analysis. Each task needed to be visually identified when the activity was being started, without explanation of what the physician was doing by the physician or patient.

The tasks and categories were adapted from Overhage's categorization scheme [29]. Pilot observations were performed to test the relevance of the activities and categories within Partners HealthCare System. As a result of the pilot, several activities were added (e.g. "Procedures—Examining Patient" and "Personal—[Using a] Palm/Diary"), deleted or collapsed into another activity (e.g. "Talking—Patient History" was collapsed into "Talking—Patient").

Individual tasks were categorized into "Major Categories" (Appendix A) which served as main headings in the data entry tool (Fig. 2). The Major Categories emphasized the medium used to accomplish the task (i.e., paper, computer, and phone), facilitating identification of performed tasks. For example, the Major Category "Phone" was followed by "Minor Categories" (Patient, Dictating Notes, etc.). The combination of the Major and Minor Categories comprised the full description of the task. For example, "Phone—Patient" denoted that the physician was talking to a patient on the phone.

Major Categories were also restructured to suit the study setting. Post-LMR implementation, physicians could still perform some tasks using the older paper-based system and some tasks such as test requisitions and encounter forms (commonly known as a "superbill") were still only performed using paper forms. Consequently, the Major Categories were differentiated by whether the task was computer or paper-based.

For analysis, the individual tasks (the combination of Major and Minor Categories) were grouped into Direct Patient Care, Indirect Patient Care—Write, Indirect Patient Care—Read, Indirect Patient Care—Other, Administrative, and Miscellaneous categories. Direct Patient Care included examining the patient, talking to the patient, or talking to a colleague regarding patient care. Indirect Patient Care categories included tasks such as writing or reading notes or lab results, or getting results via the phone ("reviewing data and recording data in support of an individual patient") [29]. The Administrative category was comprised of reviewing the schedule and talking to a colleague about non-patient matters. The Miscellaneous category consisted of tasks such as eating, walking, and personal conversation. The analysis categories and associated Major and Minor Categories are listed in Appendix A.

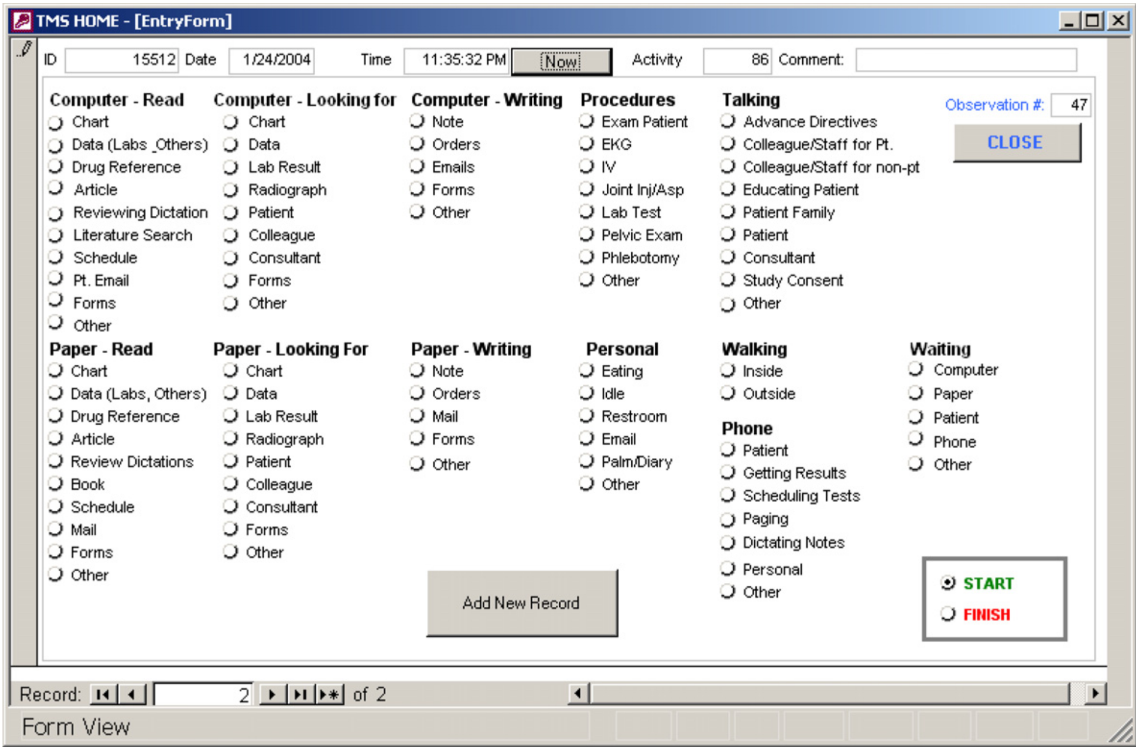

Fig. 2. Screenshot of time-motion study data entry form. The form lists Major Categories and associated Minor Categories. After selecting "Now" to halt current time (the start of an activity), the activity is chosen by clicking radio button. "Add New Record" is selected to save each activity entry.

2.4. Data entry tool

We used a Microsoft Access database installed on Fujitsu Lifebook touchscreen computers for data collection. Observers used a stylus to log activities on an Access form (Fig. 2). The observer could only categorize an activity into one category at any point in time. Therefore, the observer needed to judge the primary activity of the physician at each instant. For example, if the physician was writing notes and the patient was talking, the "writing notes" category would be primary. However, if at any time the physician stopped writing and only appeared to be listening to the patient, "talking to the patient" was selected. In general, fleeting activities, where the physician went back and forth between two different tasks, occurred more often than a physician taking part in two tasks at the same time. The observer could accurately capture fleeting activities using the data entry tool.

Observers selected "Now" at the start of each activity to log the time and then selected the activity. If an activity was mistakenly chosen, the observer could select another one to replace the first. The particular activity was not logged until the observer selected "Add Record." In this way, observers had time during the activity to identify the task performed. The stop time for each activity was the start time of the following activity. The date and a unique observation number were also automatically generated and collected by the data entry form. The internal clock of the computer was used for task timing with second precision. After completion of the observation, the number of patients observed was recorded in the Access database. Patient-related information was not collected. All data were backed up to the network and then transferred to a master Access database.

2.5. Observer training

Observers were seven research assistants (six non-clinicians and one physician) that had trained for the time-motion observations by receiving instruction from an experienced observer and by doing practice observations with non-study physicians. Prior to performing any observations, observers studied the categories and became familiar with their definition and placement on the data entry form. Observers also received training on using the Microsoft Access database and form, and on how to operate the computer. The training observations of actual clinic sessions ranged from 4 to 8 h. Data derived from training observations were not used in the study. After and during the training sessions, observers had the opportunity to ask questions of the observed physician, experienced observers, and the senior investigator (DWB). Results of training observations were reviewed to ensure proper data collection.

One observer performed a majority (22/40) of observations (Table 1). Several of the observers performed only pre-observations (2) or only post-observations (4). With the exception on the physician observer (Observer

Table 1
Number of observations performed by each observer, pre- and post-implementation of LMR

Observer	Pre-LMR	Post-LMR	Total
A	2	0	2
B	4	0	4
C	0	1	1
D	0	2	2
E	0	4	4
F	2	3	5
G	12	10	22
Total	20	20	40

B), all observers performed additional observations in specialty care settings. The data derived from specialty care observations are not reported in this paper.

2.6. Physician survey

Once all post-observations had been completed, all physicians in study clinics were sent a survey (Appendix B) via email regardless of whether they were observed. The surveys were administered in March and April 2003 and assessed physician estimates of the amount of time they spent in patient documentation outside of the clinic session and perceptions relating to the impact of the EHR.

2.7. Statistical analysis

The main outcome of interest was time spent per patient during clinic sessions after the LMR was implemented. The outcome variable of time was operationalized by summing the total seconds spent in each activity during the observation period and then dividing the number of patients seen during that observation period. Therefore, "overall time spent per patient" is not reflective of only face to face time with the patient.

Our main outcome measure, time spent per patient, was used as the outcome variable in a repeated measures linear regression model. Because each physician contributed multiple patient observations in both the pre- and post-intervention periods, usual linear regression would not have been adequate to account for the correlated observations. Instead we used the GENMOD procedure in the SAS statistical package to empirically estimate the correlation between patients within physician and to adjust the standard errors of the effect estimates for the correlation [35]. Our primary predictor was a binary indicator for the pre- versus post-intervention time period. In addition, we included indicator variables for the observers and the clinics because we found that these covariates confounded the effect estimate for intervention. The amount of time a physician had been in practice was also examined as a potential confounder but it was not found to affect the results and it was therefore left out of the final regression model. Results from these repeated measures models are presented as adjusted means (i.e., demonstrating the effect of the intervention on a patient at an average clinic, measured by an average observer), along with standard errors and p values. Two-sided p values less than 0.05 were considered to be statistically significant.

In addition to the primary analysis of all physicians, as described above, we checked the robustness of our result by limiting the analyses to the 16 physicians who contributed data in both the pre- and post-intervention periods. While this reduced our sample size and power, we wanted to be sure that any effects we found were not due to intrinsic differences in the physicians who participated in the pre-intervention data collection compared to the physicians who participated post-intervention. Since these analyses produced results consistent with the all-physician analyses, we chose not to present them separately. The repeated measures linear regression model described above was also run for each of our secondary outcomes, representing the time spent on the analysis categories.

A power calculation based on the actual accrued sample sizes and observed standard deviations shows that our study had, at worst (assuming no correlation between observations in the pre- and post-periods), 80% power to find a 10 min reduction in total patient time and, more realistically (assuming a correlation of 0.5 between observations in the pre- and post-periods), 80% power to find an 8 min reduction.

3. Results

Observations took place between May 2001 and December 2003. The implementation date for each of the clinics varied. Across the 5 clinics, 43% (20/47) of the physicians contacted about the study agreed to participate in a pre-observation. A majority of the sample was female. The mean years in practice as calculated by medical school graduation and observation date was 15.1 (SD = 7.9) years for physicians observed pre-implementation and 13.5 (SD = 8.4) years among those observed post-implementation (Table 2).

Twenty physicians had one observation session pre-LMR implementation for a total of 82.7 h. Post-observations were performed over a total of 84.5 h across 20 physicians (16 of these physicians were also observed pre-implementation). Pre-observations lasted an average of 4.1 h (SD = 1.7) vs. 4.2 h (SD = 1.3) post-implementation. The average number of patients seen was 8.6 (SD = 3.6) during pre-observations and 9.6 (SD = 2.0) during post-observations. Across both pre- and post-observations, 97% patients consented to being observed (pre-observation 171/179 patients consented; post-

Table 2
Physician characteristics, pre- and post-implementation of LMR

	Pre-LMR	Post-LMR
Total number of Physicians	20	20
Females No. (percent)	14 (70%)	15 (75%)
Physicians in Clinic No. (percent)		
A	4 (20%)	4 (20%)
B	7 (35%)	6 (30%)
C	3 (15%)	3 (15%)
D	2 (10%)	3 (15%)
E	4 (20%)	4 (20%)
Years in practice		
Mean	15.1	13.4
Standard deviation	7.9	8.4
Median	16.5	13.5
Range	24	33
Minimum	4.0	4.0
Maximum	28.0	37.0
<10 years No.	6	8
10–19 years No.	9	9
>19 years No.	5	3

Physician characteristics are comparable between the pre and post-periods, primarily because 16 of the physicians participated in both periods. No formal statistical testing was carried out.

observation 191/196 patients consented). Physicians were observed a mean of 3.3 months prior to LMR implementation and 7 months after implementation. The minimum amount of time physicians were observed post-implementation was 4.5 months.

Post-implementation, the adjusted mean overall time spent per patient during clinic sessions decreased by 0.5 min ($p = 0.86$; 95% confidence interval [−5.05, 6.04]) from a pre-intervention adjusted average of 27.55 mins (SE = 2.1) to a post-intervention adjusted average of 27.05 min (SE = 1.6).

3.1. Analysis categories

Table 3 presents the mean minutes per patient in each of the analysis categories after adjustment for clinic, observer, and analysis category. The distribution of time spent in the different analysis categories was similar pre- and post-implementation. There were no statistically significant differences in time spent in any of the analysis categories except for a 0.88 increase post-LMR in Indirect Patient Care—Read ($p = 0.029$). Both before and after implementation a majority of the time was spent in Direct Patient Care (approximately 50% of the total observation) and Indirect Patient Care—Write (approximately 20% of the total observation).

3.2. Direct patient care

Overall there was no significant change (13.4 min vs. 13.6 min; $p = 0.86$) in the time spent in Direct Patient Care post-implementation. The majority of time within Direct Patient Care was spent examining and talking to the patient. Time spent generally talking to the patient or patient's family and educating the patient was essentially the same pre- and post-LMR: the mean time per patient was 8.75 min pre-implementation and 8.58 min post-implementation. Examinations and procedures of the patient performed in clinic took slightly less time post-implementation: 4.23 min vs. 3.51 min post-implementation.

3.3. Indirect patient care

Post-implementation, physicians still needed to perform some tasks using paper because encounter and test requisition forms, for example, were not yet part of the LMR. Also, physicians were not prohibited from performing tasks using the old paper-based methods. The mean time per patient spent in computer-based Indirect Patient Care activities increased post-implementation, from 0.95 to 5.11 min per patient. Indirect Patient Care activities performed on paper took a mean of 7.60 min per patient pre-LMR and 3.72 min post-LMR. Time spent on the phone in Indirect Patient Care decreased post-implementation (1.21 min per patient vs. 0.38 min per patient). While the distribution of time spent in Indirect Patient Care activities performed via computer, paper, and phone computer, paper, and phone activities changed post-implementation, the total amount of time spent per patient to perform these activities combined was similar (Fig. 3).

3.4. Miscellaneous

A 1.32 min decrease ($p = 0.21$) in mean per patient post-implementation was observed in the Miscellaneous

Table 3
Time spent in analysis categories: pre- and post-LMR

Analysis Categories	Adjusted average time pre-LMR (SE)	Adjusted average time post-LMR (SE)	*p* value	Estimate of change (difference)	Lower CI	Upper CI
Direct Pt. Care	13.4 (1.1)	13.6 (.70)	0.86	−0.21	−2.55	2.13
Indirect Pt. Care—Write	5.6 (.84)	5.7 (.62)	0.95	−0.07	−2.26	2.12
Indirect Pt. Care—Read	2.2 (.36)	3.1 (.23)	0.029	−0.88	−1.66	−0.09
Indirect Pt. Care—Other	2.2 (.49)	1.5 (.29)	0.10	0.73	−0.13	1.59
Administration	0.3 (.33)	0.6 (.22)	0.51	−0.32	−1.26	0.62
Miscellaneous	3.9 (.84)	2.6 (.54)	0.21	1.32	−0.76	3.39

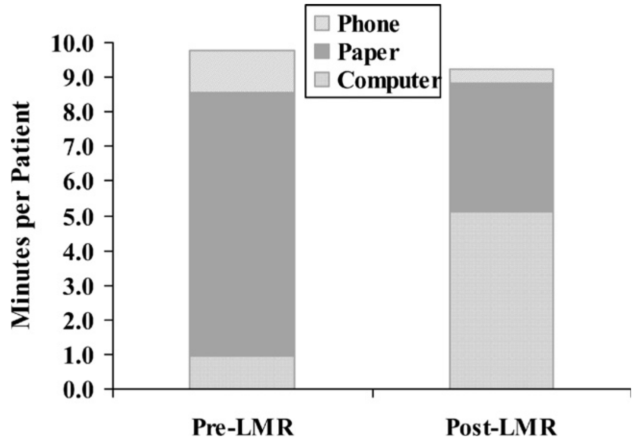

Fig. 3. Unadjusted minutes per patient spent during clinic session in Indirect Patient Care activities performed via computer, paper, and phone pre- and post-LMR implementation. Time spent "waiting" within Indirect Patient Care was not included with the exception of time spent waiting for paper or the computer.

analysis category. Two tasks that had the greatest post-implementation decrease were: "Walking—Inside" (0.38 min/patient decrease) and "Personal—Other" (0.35 min/patient decrease).

3.5. Survey

There was a 43% (23/54) response rate to the survey. Fourteen of the survey respondents had also been observed for the study. Fifteen of the 23 respondents reported that documentation was performed outside of the clinic session for a mean of 66% of patients (ranged from 20 to 100%). Physicians reported a mean of 9.9 min/established patient to complete documentation post-LMR versus 6.9 min pre-LMR. For the 13 physicians reporting more time for documentation after implementation, the median percent increase as calculated by the reported time to complete documentation before and after implementation, was 80% (ranged from 43 to 200%). However, seven respondents reported documentation took the same amount of time or less with LMR use.

Respondents also rated the LMR on a scale from 1 to 5, with 1 being the worst and 5 being the best (Appendix B). Making comparisons to the paper-based system, physicians assessed the LMR's impact on communication, access, efficiency, workload, and quality of care. The scores indicated that the physicians believed the LMR resulted in an improvement in many domains relating to quality, access, and communication (all means were greater than 4.1). The only item rated below neutral was the LMR's impact on workload with a mean rating of 2.9. Whether or not the observed post-LMR time per patient decreased was not associated with the workload rating using a chi-squared test of proportions ($p = 89$). The mean overall satisfaction score was 3.5.

4. Discussion

This study evaluated how EHR use affected time utilization by physicians. We found that compared to a paper-based system, the EHR did not require additional physician time during a primary care clinic session. Overall, physicians took slightly less time (0.5 min) per patient during clinic sessions after the EHR was implemented. This difference in time utilization between pre-and post-EHR observations was not statistically significant ($p = 0.86$).

Time spent in direct patient care activities such as talking to and examining the patient did not change significantly post-EHR implementation. However, there was an increase (0.88 min; $p = 0.029$) post-implementation in the amount of reading performed in support of patient care. We did not observe a significant time shift in physicians' administrative duties during post-implementation clinic sessions. These findings are relevant in terms of maintaining the quality of patient care, as well as physician satisfaction levels, since a majority of physicians are already dissatisfied with the amount of hours spent on administrative activities compared with patient care [36].

The observational data also confirmed that the EHR was being used by physicians. Activities that were once done only via paper methods were performed via the EHR after implementation. Time spent dictating also decreased. Some tasks, however, continued on paper (such as ordering writing). Whether more paper tasks could have been performed efficiently on the computer is unclear. For example, certain tasks may either be more quickly performed using paper, or result in a time savings once transitioned to the EHR. Still, the combination of computer and paper tasks within indirect patient care (reading, writing, and looking for data in support of patient care) took the same amount of time pre- and post-implementation.

The literature contains conflicting data regarding the workflow effects of computerizing processes such as prescribing and ordering. Physician fears that EHR usage may slow work processes are not surprising in light of some of these data. Unsuccessful implementations are well known, from work strikes in the early 1990s at a major academic medical center [22,23], to more recent decisions to pull a computerized physician order entry system from a large medical center [26]. In one study of computerized order entry at our institution, interns were found to use 5% more of their time ordering after the process was computerized [25]. This increase in intern time was counterbalanced by the decreased time spent by nursing and pharmacy personnel and by improvements in quality and efficiency, although these counterbalancing factors are not likely to be visible to those physicians actually spending more time ordering. Another study at the Regenstrief

Institute for Health Care examined the effects of computerizing inpatient order entry on resource utilization, and found that although patient charges and hospital costs were significantly reduced by computerizing, more physician time was required [24]. Qualitative studies in the outpatient setting also report physicians' perceptions that the computer system is too time-consuming [37,38].

However, there are also data suggesting that computerizing may facilitate time savings. Keshavjee et al. [39] found that physician charting time increased by 50% at 6 months post-EHR but found a return to original levels by 18 months. In a study from the Regenstrief Institute for Health Care [29], researchers again examined the time utilization effects of a computerized physician order entry system and concluded that little to no extra physician time was required to use computerized order entry. Their findings even suggest that with experience, physicians may be able to save time by using a computerized system.

Rodriguez et al. [40] also found no difference in overall time to complete typical physician tasks using an EHR. The average physician completed orders in the same amount of time as a paper system. Documentation took longer with the computerized system, but was offset by a time savings achieved in viewing tasks. These findings parallel our own study findings with respect to observed ordering time and documentation time as reported via the survey.

Perceptions of increased time to perform patient documentation were reported for a majority (71%) of the survey respondents. While self-report is not always accurate [41], clearly perceptions of increased workload are relevant to physician satisfaction levels [37,42,43]. For the 66% of physicians who reported performing documentation outside of clinic hours, it may be that LMR use within the clinic resulted in needing additional time for documentation during non-clinic time. While the increased access and flexibility allowing physicians to work outside the clinic can be considered a benefit, it represents an infringement on personal time and, such time should ideally be included in the physician's overall time, though this is hard to study. However, it is clear, that for a third of physicians, the LMR appears to have improved their workload.

Consistent with the literature [15,21,44,45], we found that EHR users recognized improvements in quality of care, access, and communication compared to the paper-based system. Also, physicians acknowledged that the efficiency of general practice operations had improved overall. While the survey ratings indicated that the LMR's impact resulted in slightly more work, overall satisfaction with the LMR was reported by 18/23 respondents with a rating of 3 or higher. This suggests that many physicians found the time expense was a manageable tradeoff for other LMR benefits.

4.1. Implications

The results suggest that for most physicians, the benefits of the LMR can be realized without sacrificing time with patients or overall clinic time. However, a majority of the physicians perceived at the time they were surveyed that the LMR increased workload. This suggests that, at least initially, some physicians require more time for EHR use that may impact time spent on documentation outside of clinic sessions. Identifying which physicians will need more time to use EHRs will help in applying strategies to improve use and minimize time burdens. At this stage, further research is required to predict intrinsic and extrinsic factors associated with increased time utilization by physicians.

Some patient care tasks that are possible with electronic data could not be easily achieved using paper-based systems. For example, physicians might be able to use the EHR to easily query panels to identify patients due for health maintenance tests and then send out patient letters to schedule tests. There is also facilitated access to clinic information which may result in more data, presented in support of patient care, for physicians to review. Time in these tasks may increase, not because a particular task takes longer but because there are more features, clinical decision support, and clinically important data available that will support better quality of care. The enhanced or new data and features may explain why the study physician read more post-implementation observations.

Yet while patients, institutions, and payers [46] stand to benefit from EHRs, some physicians are paying with time. For example, cost savings as a result of decreased dictation, chart pulls, or medication ordering may financially benefit the institution and payers but not the physician. Since the time demands on physicians are high, a perception of increased demands, represents a major stumbling block in EHR implementation. Therefore, good design, implementation support, financial incentives to increase use, or pay-for-performance programs are critical strategies to drive EHR usage by physicians.

Financial incentives to providers, proposed by the Bridges to Excellence Program [47], the Center for Medicare and Medicaid Services, the Leapfrog Group, and the National Alliance for Primary Care, may help increase widespread usage of EHRs. Pay-for-performance programs, which reward physicians based on quality outcomes, go hand-in-hand with EHRs since electronic systems can practically demonstrate quality measures and physicians' adherence to practicing evidenced-based medicine.

Further advances in technology and a continued emphasis on design will likely produce clinical systems that are efficient and easy to use. The decrease in the cost of hardware and high-speed processors allow for better overall speed in clinical systems. The web-based version of the LMR did not deplete processing resources compared to an older visual basic system. Operating system upgrades have also improved system response times and reliability. Usability engineering has the potential to further improve EHRs with respect to speed, ease of use, and improved user satisfaction [48–50]. A focus on usability began early in LMR development, evident in the consistent user interfaces across a wide variety of screens. In 2002, an experienced usability engineer with graphic design skills was hired to contribute to the continued design of the LMR and other clinical systems implemented at Partners. Involving actual users in the design and modification of the EHR system and conducting usability testing are also critical parts of EHR development.

There are still other significant barriers to EHR implementation and use. The costs of implementation, support, and maintenance, a lack of standards to support data exchange, and the challenges in selecting and evaluating vendor systems [12] make it difficult for institutions or smaller practices to adopt EHRs. Financial incentives for EHR adoption as well as National infrastructure (federal or industry) as called for by IOM and NAPCI would address these EHR barriers [12,51].

4.2. Limitations

This study has several limitations. The observations were performed in clinics associated with one institution and may not be fully generalizable to other settings. The physicians in the study were all general internists and have different practice patterns than specialists. The salary of physicians in the institution is primarily productivity-based and this may motivate them to see more patients despite time pressures. Also, since the observed physicians volunteered to be observed, it is possible that some were more or less positive about using the LMR. However, physicians had no experience with the system when they were initially recruited for pre-implementation observations. Another limitation of the study is that we did not conduct inter-rater reliability estimates for the observers.

The LMR system is unique to Partners and therefore may not represent how other EHRs effect time. The results suggest that a well-designed system does not require more time during an overall clinic session and the time spent reading, looking for, or writing notes is at least time neutral during clinic sessions. However, further evaluation is needed to determine the usability principles or system properties that are characteristic of efficient EHRs.

The effect of continued experience is not evaluated in this study. The LMR may affect time differently depending on the level of experience with the system. As the post-observations were performed at least 4.5 months after initial implementation, we did not assess the potential time it took to learn the system. Overhage et al. [29] found whereas initially physicians took 2.2 min longer per patient, further experience with a physician order entry system resulted in a time savings of 3.73 min per patient.

5. Conclusion

This study focused on the physician time barrier to EHR adoption. We conclude that the EHR does not require more time than a paper-based system during a primary care session. This study demonstrates that the benefits of using an EHR can be achieved without physicians sacrificing time with patients or other activities during clinic sessions. Physicians recognize the quality improvements achieved by EHRs, indicating that small increases in perceived overall workload may be an acceptable tradeoff. Further studies should evaluate the impact of EHRs on time spent outside of the clinic session. The development of methods to identify or predict physicians who are likely to have greater challenges in integrating EHRs into their workflow will be important in assisting the transition from paper-based records.

Acknowledgments

The authors wish to acknowledge Pat Carchidi, Alison Gersten, Michelle McGibbon, and Allison Benoit for assistance in coordinating the study. They also thank Tony Yu, MD, MPH, and John Orav, PhD, for their suggestions and advice during data analyses and Karen Burk for development of the data collection tool. The authors would also like to thank and recognize the physicians, patients, and clinic staff who participated in the study.

Appendix A. Activity categories (adapted from Overhage et al.)

Major Category	Minor Category	Analysis Category
Computer—Looking For	Consultant	Indirect Patient Care: Other
Computer—Looking For	Chart	Indirect Patient Care: Read
Computer—Looking For	Data	Indirect Patient Care: Read
Computer—Looking For	Lab Result	Indirect Patient Care: Other
Computer—Looking For	Radiograph	Indirect Patient Care: Other

Appendix A (*continued*)

Major Category	Minor Category	Analysis Category
Computer—Looking For	Colleague	Indirect Patient Care: Other
Computer—Looking For	Forms	Indirect Patient Care: Other
Computer—Looking For	Other	Miscellaneous
Computer—Looking For	Patient	Indirect Patient Care: Other
Computer—Read	Reviewing Dictation	Indirect Patient Care: Other
Computer—Read	Chart	Indirect Patient Care: Read
Computer—Read	Data (Labs and Others)	Indirect Patient Care: Read
Computer—Read	Pt. Email	Indirect Patient Care: Read
Computer—Read	Forms	Indirect Patient Care: Read
Computer—Read	Drug Reference	Indirect Patient Care: Other
Computer—Read	Schedule	Administration
Computer—Read	Article	Miscellaneous
Computer—Read	Literature Search	Miscellaneous
Computer—Read	Other	Miscellaneous
Computer—Writing	Note	Indirect Patient Care: Write
Computer—Writing	Orders	Indirect Patient Care: Write
Computer—Writing	Emails	Indirect Patient Care: Write
Computer—Writing	Forms	Indirect Patient Care: Write
Computer—Writing	Other	Indirect Patient Care: Write
Paper—Looking For	Lab Result	Indirect Patient Care: Other
Paper—Looking For	Radiograph	Indirect Patient Care: Other
Paper—Looking For	Patient	Indirect Patient Care: Other
Paper—Looking For	Colleague	Indirect Patient Care: Other
Paper—Looking For	Consultant	Indirect Patient Care: Other
Paper—Looking For	Forms	Indirect Patient Care: Other
Paper—Looking For	Chart	Indirect Patient Care: Read
Paper—Looking For	Other	Miscellaneous
Paper—Looking For	Data	Indirect Patient Care: Read
Paper—Read	Other	Miscellaneous
Paper—Read	Book	Miscellaneous
Paper—Read	Drug Reference	Indirect Patient Care: Other
Paper—Read	Forms	Indirect Patient Care: Read
Paper—Read	Mail	Indirect Patient Care: Read
Paper—Read	Chart	Indirect Patient Care: Read
Paper—Read	Schedule	Administration
Paper—Read	Article	Miscellaneous
Paper—Read	Data (Lab & Others)	Indirect Patient Care: Read
Paper—Read	Review Dictations	Indirect Patient Care: Other
Paper—Writing	Forms	Indirect Patient Care: Write
Paper—Writing	Note	Indirect Patient Care: Write
Paper—Writing	Mail	Indirect Patient Care: Write
Paper—Writing	Other	Indirect Patient Care: Write
Paper—Writing	Orders	Indirect Patient Care: Write
Personal	Other	Miscellaneous
Personal	Palm/Diary	Miscellaneous
Personal	Email	Miscellaneous
Personal	Restroom	Miscellaneous
Personal	Idle	Miscellaneous
Personal	Eating	Miscellaneous
Phone	Patient	Direct Patient Care
Phone	Dictating Notes	Indirect Patient Care: Other
Phone	Getting Results	Indirect Patient Care: Other
Phone	Personal	Miscellaneous
Phone	Other	Miscellaneous
Phone	Scheduling Tests	Indirect Patient Care: Other
Phone	Paging	Indirect Patient Care: Other
Procedures	Phlebotomy	Direct Patient Care
Procedures	Other	Direct Patient Care
Procedures	Pelvic Exam	Direct Patient Care
Procedures	Lab Test	Direct Patient Care
Procedures	Exam Patient	Direct Patient Care
Procedures	Joint Inj/Asp	Direct Patient Care

(*continued on next page*)

Appendix A (*continued*)

Major Category	Minor Category	Analysis Category
Procedures	IV	Direct Patient Care
Procedures	EKG	Direct Patient Care
Talking	Study Consent	Miscellaneous
Talking	Consultant	Direct Patient Care
Talking	Other	Miscellaneous
Talking	Patient	Direct Patient Care
Talking	Patient Family	Direct Patient Care
Talking	Educating Patient	Direct Patient Care
Talking	Colleague/Staff for Pt.	Direct Patient Care
Talking	Advance Directives	Direct Patient Care
Talking	Colleague/Staff for non-pt	Administration
Waiting	Phone	Indirect Patient Care: Other
Waiting	Other	Indirect Patient Care: Other
Waiting	Paper	Indirect Patient Care: Other
Waiting	Computer	Indirect Patient Care: Other
Waiting	Patient	Indirect Patient Care: Other
Walking	Inside	Miscellaneous
Walking	Outside	Miscellaneous

Appendix B. Physician survey

QUESTIONS ABOUT THE LMR	**Mean (N=23)**
1. Thinking about your most recent typical clinic day:	
(A) How many sessions (4 hour slots) did you do in one day:	**1.3** *Sessions*
(B) How many established (est.) patients did you see (**do not include new patients**):	**10.3** *Established Patients*
2. Documentation for patient visits may include notes or adding other new data to the patients' record, such as new diagnoses, medications and health maintenance information. It may include dictating or entering information directly into the LMR.	
Of the **established (est.) patients** you reported in 1B:	
(A) **How many** patients did you complete documentation **during the same clinic session**:	**6.2** *Established Patients*
(B) **How many** patients did you complete documentation **during non-clinic time** (i.e. evenings and weekends):	**4.7** *Established Patients*
(C) **How many** patients did you complete documentation **during another clinic session**:	**0.5** *Established Patients*
3. Since the clinic began using the LMR, **how many minutes** on average does it take you to complete documentation **per established patient**?	**9.9** *Minutes*
4. Before the clinic began using the LMR, **how many minutes** on average did it used to take to complete documentation **per established patient**?	**6.9** *Minutes*
5. How many **sessions** (4 hour slots) do you **average per week**:	**5.2** *Sessions*
6. **With the LMR**, compared to how you did things before, please rate the following on a scale from 1-5:	
(A) Access of patient information is (1= Impeded, 5=Enhanced):	**4.7**
(B) Finding specific information within a patient's medical record is (1=Harder, 5=Easier):	**4.1**
(C) Communicating patient information within the practice is (1=Harder, 5=Easier):	**4.8**
(D) Communicating patient information to other practices is (1=Harder, 5=Easier):	**4.6**
(E) LMR's impact on my workload results in (1=More Work, 5=Less Work):	**2.9**
(F) Efficiency of general practice operations has (1=Declined, 5=Improved):	**3.8**
(G) Quality of care is (1= Impeded, 5=Enhanced):	**4.1**
(H) Overall satisfaction with LMR is (1=Low, 5=High):	**3.5**

7. Any other comments regarding how the LMR has affected workflow/workload and/or quality of care?
Sample Responses:
"Quality is great but has slowed me down"
"I am at a health center and the link to ____ is a little slow. If it were just a bit faster I would be 100% satisfied. As it is, it is a little annoying."
"I think it works best for me because I type my own free-form notes and I type fast, so I include a lot of personalized data in the notes as well as in the lists. I find it very flexible."

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