Interventions to Increase Physician Efficiency and Comfort with an Electronic Health Record System*

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Summary
Objective: To determine comfort when using the Electronic Health Record (EHR) and increase in documentation efficiency after an educational intervention for physicians to improve their transition to a new EHR.
Methods: This study was a single-center randomized, parallel, non-blinded controlled trial of real-time, focused educational interventions by physician peers in addition to usual training in the intervention arm compared with usual training in the control arm. Participants were 44 internal medicine physicians and residents stratified to groups using a survey of comfort with electronic media during rollout of a system-wide EHR and order entry system. Outcomes were median time to complete a progress note, notes completed after shift, and comfort with EHR at 20 and 40 shifts.

Results: In the intervention group, 73 education sessions averaging 14.4 (SD: 7.7) minutes were completed with intervention group participants, who received an average of 3.47 (SD: 2.1) interventions. Intervention group participants decreased their time to complete a progress note more quickly than controls over 30 shifts (p < 0.001) and recorded significantly fewer progress notes after scheduled duty hours (77 versus 292, p < 0.001). Comfort with EHRs increased significantly in both groups from baseline but did not differ significantly by group. Intervention group participants felt that the intervention was more helpful than their standard training (3.47 versus 1.95 on 4-point scale).

Conclusion: Physicians teaching physicians during clinical work improved physician efficiency but not comfort with EHRs. More study is needed to determine best methods to assist those most challenged with new EHR rollouts.

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1. Background and Significance
Implementation of universal Electronic Health Records (EHRs) has been proposed as a solution to improve healthcare quality, safety, cost and physician efficiency [1]. In 2009, the American Recovery and Re-investment Act offered 17.2 billion USD in incentives for ‘meaningful use’ of EHRs by physicians and hospital systems [2]. Twenty-eight percent of hospital systems now use at least a basic electronic record as of January 2013 [3], up from 17% in 2009 [1]. However, physician acceptance is believed to be a significant barrier to EHR adoption [4]. Surveys note that physicians lack computer and typing skills [5, 6], computer experience [7], and are concerned with time needed to train [3, 4], as well as a perceived disruption of their workflow [8].

Education and training is critical to ensure physicians have the skills necessary to adopt EHRs [8, 9]. Although training has been shown to increase use of templates [10] and physician satisfaction [8, 11], research on best methodology of training is scant [12]. While classroom, small group, e-learning and one-on-one modalities have been utilized to teach new technologies, one-on-one training may be preferred by providers [13], and learner motivation may be higher for non-direct instructional strategies [14]. Situativity theory posits that ‘knowledge, thinking and experience are situated (or located) in experience’, and learning in the context or environment in which one performs is critical to transfer [15]. This theory posits that the social environment where a learner is taught (for instance, learning from a computer instructor in a classroom versus learning from a fellow physician on a ward during actual clinical duties) has an important impact on the degree to which the learner can apply what is learned. We hypothesized that a group of physicians randomized to receive strategies on optimal use of EHRs by a fellow physician while performing their real-time patient care duties in addition to usual training would have improved documentation efficiency over a group randomized to usual training and support. We further hypothesized that our intervention group would feel more positively about EHRs than those not receiving the intervention.
2. Materials and Methods

This study was a randomized, parallel, non-blinded controlled trial of real-time, focused educational interventions in addition to usual training and support in an intervention arm compared with usual training and support in the control arm. Primary outcomes were time to complete progress notes and number of notes completed after scheduled duty hours. Physician satisfaction was a secondary outcome. Participants from one 550-bed Academic Independent Medical Center were invited to participate if they were full-time hospitalists or residents in internal medicine with no prior experience with the EPIC EHR. The study initiation was timed to coincide with the system-wide rollout of a new inpatient EHR and ordering system (EPIC version 2010, Madison, WI). Physicians whose duties did not include regular inpatient care (including writing their own daily progress notes), those whose work was limited to teaching, and physicians with prior experience in using EPIC systems for inpatient care were excluded from the study. Physician assistants and nurse practitioners were also excluded. Physicians were recruited between January 1, 2013 and January 31, 2013 by the use of e-mails and flyers, and each provided informed consent for participation. Forty-four physicians volunteered to participate. Physicians were stratified for randomization by survey of computer literacy (▶ Appendix 1), and then allocated in a 1:1 match into each group. After ordering all participants by total score, participants were assigned sequentially to each group by two study authors (LJ, AD). The computer literacy survey asked questions regarding a participant's exposure and comfort with computer programs, social media, other EHRs, and technology in general. Questions were weighted equally, and negatively-worded questions were reverse-coded. Physicians were also asked demographic information, including age, sex, years since medical school, years in practice, years exposed to any EHR, and self-reported total time spent practicing on the hospital's EPIC e-learning 'playground'. A formal power analysis was not possible for this study, given that no prior data on progress note time (our primary outcome) was available from the literature. We therefore recruited all potential eligible providers from our facility to create the largest feasible sample. Participants were not given incentives to participate. There was no external funding for this work. The hospital's Institutional Review Board approved this research protocol (RHMC IRB Protocol number 045–12).

2.1 Interventions

Both groups received 12 hours of mandatory EPIC classroom training, as well as (non-mandatory) exposure to the EPIC e-learning modules and the EPIC “playground” (a test site for providers to practice using the EHR on virtual patients). All had access to 90 days of ‘at elbow’ support with an EPIC non-physician technicians, who were available on all inpatient wards, as well as access to a 24-hour, 7-day per week physician-only support line. Our initial study design called for educators to specifically direct education interventions to participants with poor performance data, but we were not able to obtain this performance data in our system until nearly the end of our study. We therefore initially targeted all intervention group participants equally, and later identified those needing more help using direct observation only. Both intervention and control participants were visited by study designers during direct patient care to observe and record the individual physician’s best tips and strategies. However intervention group participants were also given instructions on the best techniques observed in other physicians as it applied directly to the work they were currently performing. Total time with intervention participants (including observation and teaching time) was recorded by instructors in minutes, as was the subject of each teaching technique. In addition, the intervention group received weekly e-mails detailing the best techniques learned from other providers that week, including orderingatories for lab tests and medications, shortcuts to finding information, or quick texts (saved electronic phrases or templates), for the first 8 weeks of the EPIC EHR rollout. Instructors were four physicians (AD, LJ, MA, MM) who were also novices to EPIC training. Two of the four (AD, LJ) also visited a hospital with greater than 10 years’ experience in EPIC to observe physicians and learn their best techniques, which were shared with other trainers.

2.2 Outcome Measures

We chose the time to complete a progress note as our primary intervention measure. Our hospitalist program has two physicians on any day shift who perform all admissions, and twelve that care for patients already admitted. On average, the physicians work four of their 12-hour shifts per month (2 daytime, 2 night) performing admissions, and work the other 14 shifts on hospital wards. During those 14 hospital ward shifts, the vast majority of their notes are progress notes. A progress note is a daily record created by a physician on an already admitted patient that documents their status that day. For inpatient physicians at our facility, it is the most common electronic note performed on a regular basis, representing 74.1% of the electronic notes signed by a physician. This made the progress note the most feasible unit to be able to chart week-to-week improvements in physician efficiency. We postulated that as a physician gained experience, their time to complete a note should shorten, and their notes completed after the time that their shift was over should decrease. Time to completion of a note may be affected by patient factors (e.g. complexity of case, overall patient load) and physician factors (e.g. thoroughness of the physician, amount of free-texting in note, and computing skill). We attempted to balance patient factors by taking an extremely large sample; because we had only the physicians available at one institution, we controlled for comfort with computers by stratifying each arm using self-assessed comfort with computing.

Progress note start and completion times were captured electronically from the date of our hospital go-live (February 2, 2013) until June 30, 2013, at which time staff turnover made further data collection impossible for many of the participants. Time to complete a progress note was defined as the time note was time-stamped as closed minus the time the note was opened.
Notes that were addended were recorded but not counted in the analysis, because the time between the initial signing and re-opening for the addendum could not be determined. Because of the non-parametric nature of the data, the median for time to complete a note was the measure chosen for analysis. Intervention and control groups were compared by shift worked since rollout. The mean of medians of each group was compared by shift for the first thirty shifts to determine the impact of our intervention. Physicians who did not work thirty shifts in which they wrote progress notes in the study timeframe had their data eliminated from further analysis. Our second performance measure was ‘progress notes completed after scheduled duty hours’. This was defined as a progress note signed after the completion of their day shift (after 7 PM). Notes were recorded as completed before or after completion of the physician’s shift (7 PM) and analyzed dichotomously.

Satisfaction was measured at intervals at 20 and 40 shifts since rollout, using a 3-question survey (Appendix 2). Total time spent training each intervention group member was recorded in minutes. Total cost of the study was estimated by calculating total hours spent training and multiplying by typical hourly rate of a hospitalist, estimated at $150/hour.

2.3 Statistical Analysis

Basic demographics between groups (age, sex, years since medical school, number of years as a practicing physician, time using EPIC playground training, prior experience with EMRs) were analyzed using Chi-square and t-tests as appropriate. Answers to pre-test questions were reverse-coded if negative, weighted equally and summed for a total score to randomize participants. Results of individual questions on the survey were analyzed by group using t-tests (Appendix 3). Subjects with less than 30 shift performance data during the study period were excluded. Experience for each provider was normalized by calculating each day’s data sequentially (for instance, a provider working on the first day, and then not again until the eighth day of the rollout had that data marked as ‘day 1’ and ‘day 2’ of experience). Regression analysis was conducted for each group for using the
mean of all subject medians for a particular day. Regression analysis used days 1–30 as the x-axis variable and the median time of all subjects’ data for that day. Once the slope and intercept for each group was calculated the slopes of intervention and control groups were compared using methods described by Snedecor and Cochran [16]. In addition, Chi-square analysis was conducted comparing intervention and control groups for progress notes that were completed before and after completion of their shift that day for each day within subject entry. The predictive validity of the pre-test score was analyzed by Pearson correlations of pre-test score to the mean of medians of time to close a progress note for each individual provider over the 30-shift period. Post-hoc analysis of our findings, using one of the two primary outcomes (‘comfort with EPIC’), suggested that we would have needed 63 participants per arm to detect a moderate difference (effect size > 0.5) with 80% power. However, given our hospital

### Table 1 Baseline characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Control</th>
<th>Intervention</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>37.7</td>
<td>40.1</td>
<td>.17</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>11 (50)</td>
<td>6 (27)</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Male</td>
<td>11 (50)</td>
<td>16 (73)</td>
<td></td>
</tr>
<tr>
<td>Training status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resident</td>
<td>3 (14)</td>
<td>4 (18)</td>
<td>.68</td>
</tr>
<tr>
<td>Physician</td>
<td>19 (86)</td>
<td>18 (82)</td>
<td></td>
</tr>
<tr>
<td>Time since medical school graduation, y</td>
<td>11.5</td>
<td>12.6</td>
<td>.40</td>
</tr>
<tr>
<td>Years using an Electronic Health Record, y</td>
<td>6.4</td>
<td>4.5</td>
<td>.05</td>
</tr>
<tr>
<td>Time spent on EPIC playground [e-learning site] before go-live [hours]</td>
<td>6.9</td>
<td>3.6</td>
<td>.06</td>
</tr>
<tr>
<td>Pre-Test computer experience/comfort score</td>
<td>23.3</td>
<td>22.9</td>
<td>.92</td>
</tr>
</tbody>
</table>

No: number, %: percentage

### Table 2 Results

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Control Mean (SD)</th>
<th>Intervention Mean (SD)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort with EPIC EHR (4-point scale)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-study</td>
<td>2.14 (.88)</td>
<td>2.05 (.79)</td>
<td>.46</td>
</tr>
<tr>
<td>At 20 shifts</td>
<td>2.94 (.66)</td>
<td>2.78 (.81)</td>
<td>.25</td>
</tr>
<tr>
<td>At 40 shifts</td>
<td>3.37 (.68)</td>
<td>3.10 (.92)</td>
<td>.84</td>
</tr>
<tr>
<td>Change in comfort from baseline to 40 shifts</td>
<td>1.23</td>
<td>1.05</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Learner satisfaction standard EHR training/preparation (class, e-learning, playground) (4-point scale)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 40 shifts exposure</td>
<td>2.32 (.82)</td>
<td>1.95 (1.0)</td>
<td>.22</td>
</tr>
<tr>
<td>Learner satisfaction with intervention (intervention group only) (4-point scale)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 20 shifts</td>
<td>3.17 (.85)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 40 shifts</td>
<td>3.47 (.62)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*paired t-tests were used to compare baseline data versus 40 week data for each group. SD: standard deviation.

### 3. Results

Eighty-five physicians (36 internal medicine resident physicians, 49 hospitalists) were assessed for eligibility to participate in the study. Of these, 44 physicians (7 internal medicine resident physicians, 37 hospitalists) were eligible and volunteered to participate (Figure 1). Participants were randomized in the study after being stratified by computer experience and comfort, as ascertained by survey. Average pre-test score was 23.1 (SD: 4.4). While both groups were similar in survey score, including at the level of the individual question, physicians in the control group were significantly more likely to be female, had used an EHR in practice longer, and spent more hours practicing in EPIC playground (Table 1). Baseline self-described comfort with use of the EPIC EHR was not significantly different (2.1 vs 2.0 on 4-point scale).

In the intervention group, a total of 73 real time micro-skill education sessions were carried out with intervention group participants receiving an average of 3.47 (SD: 2.1) interventions (range: 0 – 8). One intervention group physician refused to be observed or instructed; that participant’s data was kept for analysis of performance in their assigned group. Sessions lasted 14.4 (SD: 7.7) minutes, which included both observation and teaching. Two instructors (AD, LJ) performed > 90% of the sessions (77% for the former and 14% for the latter). The estimated total cost of the face-to-face micro-skills interventions was $2437 USD (16.25 hours × $150 per hour of physician teacher time). An additional 1 hour was needed per week for creation of the EPIC Quick Tips e-mails and coordination of schedules for 12 weeks of the interventions, and an additional 2 hours per week for 12 weeks for developing quick texts, and preference lists for the group (12 total weeks × $150/hr, total of $5400 USD).
or with satisfaction at 40 shifts (r = –0.21, p = 0.18).

4. Discussion

In this study, participants assigned to real-time, focused educational interventions in addition to usual training improved their performance (time to completion of a progress note, rate of completion of progress notes during scheduled work hours) at a faster rate than volunteers not receiving this intervention. Self-described comfort with EHRs was not different between groups following intervention. Pre-test assessment of computer comfort was not associated with later performance or satisfaction with the EHR. As found by others [13], one-on-one teaching was preferred in the intervention group over their standard pre-rollout training (3.47 vs. 1.95 on 4-point scale). This study adds to what is known by detailing a method to acclimate physicians to EHRs that appeared to improve performance significantly compared with our standard training methods (classroom, e-learning, and non-physician technician support). We also demonstrated two potentially reproducible measures of performance efficiency for physicians. Docu-

Topic areas for the teaching sessions are listed in Table 3.

Physicians produced 5500 progress notes that were addended (2318 (42.2% of total addended)) from intervention group and 3181 (57.8%) in the control group, p < .001 which were excluded from further analysis. Physicians in the study also produced 20,510 progress notes for analysis of performance. Participants averaged 476 progress notes over the study period (Interquartile range: 259, 695). Three physicians (1 in intervention group, 2 in control group) had not worked 30 shifts in which they generated progress notes by completion of the study, and their data was eliminated from further analysis. While median times to complete progress notes decreased in both groups over 30 shifts of experience with the EHR, there was a statistically significant difference in the slope of median time to complete progress notes between groups (p < 0.001) (Figure 2). Control group participants had 292 notes recorded after scheduled duty hours versus 77 for the intervention group (p < 0.001). Comfort with EPIC EHR was measured at 20 and 40 shifts. Response rates were 80% and 89% respectively. Comfort with EHRs increased in the control group on a 4-point scale on average from 2.1 at baseline to 2.9 at 20 shifts and 3.4 at 40 shifts. Comfort with EHRs increased in the control group from 2.0 at baseline to 2.8 at 20 shifts and 3.1 at 40 shifts (Table 2). Scores did not differ significantly from each other, but did increase significantly from baseline in both groups (p < .001). Participants in the intervention group felt that the intervention was more helpful than their standard training in helping them function using the EMR at 40 shifts (3.47 versus 1.95 on 4-point scale). Pre-test comfort with electronic media scores did not significantly correlate with mean of medians of time to complete a progress note (r = 0.11, p = .50) or with satisfaction at 40 shifts (r = – 0.21, p = 0.18).

Table 3

<table>
<thead>
<tr>
<th>Topic area</th>
<th>n</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop or share quick texts</td>
<td>63</td>
<td>37.5%</td>
</tr>
<tr>
<td>Share preference lists</td>
<td>19</td>
<td>11.3%</td>
</tr>
<tr>
<td>Demonstrate screens/quickest way to find clinical information</td>
<td>48</td>
<td>28.6%</td>
</tr>
<tr>
<td>Demonstrate buttons</td>
<td>24</td>
<td>14.3%</td>
</tr>
<tr>
<td>Build filters</td>
<td>7</td>
<td>4.2%</td>
</tr>
<tr>
<td>Build personal order panels</td>
<td>7</td>
<td>4.2%</td>
</tr>
</tbody>
</table>

*sessions frequently covered >1 topic. n: no of sessions, %: percentage

Figure 2

Median times to complete progress note in minutes in the intervention group (black) compared to the control group (grey) over 30 shifts
mentation time in our study (15 patients/day × average of 7.5 minutes per note = 1.87 hours) was similar to that from other authors, who noted documentation times of 0.33–2.2 hours. [17] While our instructional method will likely be costly to a facility hoping to replicate this intervention ($7837 USD for 22 physicians, or $356.22/physician), this cost is dwarfed by overall costs of information systems and the downstream loss of productivity from inadequately trained providers. The fact that instructing physicians in actual practice was both feasible and effective reinforces the tenets of situativity theory, which posits that learning is most effective when it occurs in authentic, meaningful contexts [15].

Techniques to train end users in applying new technology vary in significantly in method (classroom, small-group, one-on-one), and no one method has been proven to be superior [5, 13, 18]. As we also found, hands-on exercises in which users can problem-solve on their own appears to be critical to learning new technology[19], and exercises that mimic workflow and increase authenticity have been cited as key to acceptance in successful rollouts [20]. Personal relations with EHR champions who understand a physician’s workflow may increase physician acceptance of EHRs [21], which may have played a role in the success of our peer-to-peer instruction strategy.

This study had several significant limitations. We used ‘time to complete progress note’ as our primary outcome. However, proficiency in working with the EHR is not the only variable that determines the time to complete progress note. Other variables that may influence time to complete progress note include patient factors (e.g. complexity of case, overall patient load) and physician factors (e.g. thoroughness of the physician, amount of free-texting in note, and computing skill). We believe that large sample of notes (> 20,000 datapoints) would likely have balanced patient-related factors in each arm. We attempted to control the physician factors in this study by stratifying our groups with self-assessed computer comfort. However, we believe our small sample size and our use of a previously non-validated tool for randomization are significant limitations to the results that our specific interventions improved physician efficiency, since the differences between group performance may be related to unmeasured differences between practitioners. Whether the difference between the numbers of added notes (significantly more in control group) reflects a difference in physician effort in documentation between groups or difference in efficiency is unclear from this study, but could have affected physician performance and acceptance of our EHR. While we were able to demonstrate faster completion of notes, we cannot comment on the quality of those notes as it pertains to safety or patient care. We also cannot determine the unique contributions of our e-mail reminders versus 1-on-1 teaching sessions on their unique contribution to improvements in efficiency, as they were given simultaneously as a multimodal intervention to the intervention group. We cannot determine whether the effects of the instructors’ attitudes toward EHRs had an impact on the overall comfort with EHRs by the intervention group. Because this was a single-center trial with a small number of participants, we could not separate out the effects of the instructional method from the instructors, the physical plant (availability of computers, workspace, and voice recognition software) or the participants on the outcome in order to say this method alone resulted in our improvement. While we controlled for computer comfort in our groups, our sample size was too small to balance differences in prior use of EHRs and self-reported time in the playground (both favoring the control group) and sex (more males in intervention group), both of which may have affected both the speed of improvement and the overall impressions of the intervention’s efficacy. Whether this intervention would have the same impact on non-volunteers is also unknown, since volunteers may have been much more receptive to accepting and implementing the teachings than a similar group who did not volunteer.

5. Conclusions

With incentives for electronic records going away after 2014 and penalties for non-implementation to follow [2], many health systems are likely to be transitioning to electronic systems over the next 36 months. More study is needed to address the needs of physicians with more limited computer exposure, older age, and those who fail to improve with clinical practice on an EHR, and study populations should be broadened to include non-volunteers. Whether one-on-one determination of individual needs as identified by valid measures of performance may be a cost-effective approach to targeting training resources where they are most needed is an important next step for this field.

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