Electronic Prescribing at the Point of Care: A Time–Motion Study in the Primary Care Setting

Emily Beth Devine, William Hollingworth, Ryan N. Hansen, Nathan M. Lawless, Jennifer L. Wilson-Norton, Diane P. Martin, David K. Blough, and Sean D. Sullivan

Objective. To evaluate the impact of an ambulatory computerized provider order entry (CPOE) system on the time efficiency of prescribers. Two primary aims were to compare prescribing time between (1) handwritten and electronic (e-) prescriptions and (2) e-prescriptions using differing hardware configurations.

Data Sources/Study Setting. Primary data on prescribers/staff were collected (2005–2007) at three primary care clinics in a community based, multispecialty health system.

Study Design. This was a quasi-experimental, direct observation, time–motion study conducted in two phases. In phase 1 ($n = 69$ subjects), each site used a unique combination of CPOE software/hardware (paper-based, desktops in prescriber offices or hallway workstations, or laptops). In phase 2 ($n = 77$), all sites used CPOE software on desktops in examination rooms (at point of care).

Data Collection Methods. Data were collected using *TimerPro* software on a Palm device.

Principal Findings. Average time to e-prescribe using CPOE in the examination room was 69 seconds/prescription-event (new/renewed combined)—25 seconds longer than to handwrite (99.5 percent confidence interval [CI] 12.38), and 24 seconds longer than to e-prescribe at offices/workstations (99.5 percent CI 8.39). Each calculates to 20 seconds longer per patient.

Conclusions. E-prescribing takes longer than handwriting. E-prescribing at the point of care takes longer than e-prescribing in offices/workstations. Improvements in safety and quality may be worth the investment of time.

Key Words. CPOE, e-prescribing, time–motion, hardware configurations, point-of-care

The Institute of Medicine (IOM) report *Crossing the Quality Chasm* outlines a vision for the transformation of health care in the 21st century that includes the

effective use of health information technology (HIT) and the reengineering of care processes to improve quality (IOM 2001). One critical component of the HIT infrastructure is the electronic health record (EHR) with computerized provider order entry (*CPOE*) (Dick 1991, 1997; Hing, Burt, and Woodwell 2007). The 2003 vision statement of the National Alliance for Primary Care Informatics endorses this idea and argues that in order to provide United States (U.S.) citizens with good quality, affordable health care, primary care providers must have the opportunity to use a fully functional EHR with the ability to access needed clinical information at the time and place of care (Bates et al. 2003a).

Since 2006, momentum to adopt EHR/*CPOE* systems has increased, in part due to the publication of the IOM (2006) report that summarizes the role of *CPOE* systems in decreasing medication errors. Research that evaluates the impact of *CPOE* systems on safety and quality has revealed that the potential benefits outweigh the risks (Bates et al. 1998, 1999; IOM 1999; Kaushal, Shojania, and Bates 2003; Kuperman and Gibson 2003; Chaudhry et al. 2006; Ammenwerth et al. 2008; Shamliyan et al. 2008), although there is some evidence to the contrary (Koppel et al. 2005; Eslami, Abu-Hanna, and de Keizer 2007; Wolfstadt et al. 2008). Yet recent data from the National Center for Health Statistics indicate that only 12 percent of physicians surveyed reported using a comprehensive EHR in 2006; only 50 percent of these report using *CPOE* systems (Hing, Burt, and Woodwell 2007). Physicians believe that the benefits are many, but concerns still exist about the potential for decreased productivity and time inefficiency (Bates et al. 2003b; Poon et al. 2004; Ash and Bates 2005; Bates 2005; Tamblyn et al. 2006). International experts have

Address correspondence to Emily Beth Devine, Pharm.D., M.B.A., Ph.D., Research Associate Professor, Pharmaceutical Outcomes Research and Policy Program, School of Pharmacy, University of Washington, Box 357630, Seattle, WA 98195-7630; e-mail: bdevine@u.washington.edu. Emily Beth Devine, Pharm.D., M.B.A., Ph.D., Adjunct Research Associate Professor, is also with the Biomedical & Health Informatics, School of Medicine, University of Washington, Seattle, WA. William Hollingworth, Ph.D., is with the Department of Social Medicine, University of Bristol, Bristol, UK. Ryan N. Hansen, Pharm.D., Senior Fellow, David K. Blough, Ph.D., Research Associate Professor, and Sean D. Sullivan, PhD, Professor & Director, Professor of Health Services and Medicine, are with the Pharmaceutical Outcomes Research & Policy Program, School of Pharmacy, University of Washington, Seattle, WA. Nathan M. Lawless, Ch.E., R.Ph., Clinical Pharmacist and Jennifer L. Wilson-Norton, R.Ph., M.B.A., Director of Pharmacy, are with the Strategic Health Services, The Everett Clinic, Everett, WA. Diane P. Martin, Ph.D., Professor, is with the Department of Health Services, University of Washington, Seattle, WA.

also identified integration into workflow as important to successful *CPOE* adoption (Ash, Stavri, and Kuperman 2003; Campbell et al. 2006).

The impact of *CPOE* systems on time efficiency is therefore under scrutiny. A few studies have compared the effect of *CPOE* systems on time efficiency in the inpatient (Tierney et al. 1993; Shu et al. 2001) and ambulatory (Overhage et al. 2001; Pizziferri et al. 2005; Hollingworth et al. 2007; Lo et al. 2007) settings. Results reveal that the use of *CPOE* systems in the inpatient setting can be incrementally more time intensive than paper-based systems (Tierney et al. 1993; Shu et al. 2001), although this time can be offset by reductions in time spent conducting other tasks (Tierney et al. 1993), and that the overall time spent in patient care remains the same (Shu et al. 2001). In the ambulatory setting, results have been mixed, with time efficiencies realized in primary care clinics (Overhage et al. 2001; Pizziferri et al. 2005; Hollingworth et al. 2007), but not in specialty clinics (Lo et al. 2007). All studies except Hollingworth et al. (2007) were conducted in settings affiliated with academic medical centers, and many were conducted with “home-grown” EHRs, rather than vendor solutions, which are the records that comprise the vast majority of those used in the United States.

Our time–motion research evaluates the time efficiency of using a *CPOE* system in the primary care setting during a two-phase implementation process. During phase 1, the health system added *CPOE* software to an existing EHR in physicians’ offices and at hallway workstations (offices/workstations) and explored the effect of providing laptops to providers. We have previously published these results, which compare handwritten prescriptions with those electronically prescribed (e-prescribed) using these interim hardware configurations (phase 1) (Hollingworth et al. 2007). In the current study we augment those results by comparing phase 1 with phase 2 implementation. Phase 2 represents the hardware configuration finally adopted by the health system—the same *CPOE* software delivered on desktop computers in the patient examination room (at the point of care). The implementation strategy provided us the unique opportunity to compare the time impact of using *CPOE* software with differing hardware configurations, and on prescribers and staff—both of which we provide in this report. Our two primary aims were to compare prescribing time between (1) handwritten and electronic (e-) prescriptions and (2) e-prescriptions using differing hardware configurations. Our secondary aims were to compare time spent conducting prescribing-related, major, and overall task categories. We hypothesized that prescribing using the *CPOE* software at the point of care would be time neutral for prescribers when compared with handwriting prescriptions.

METHODS

Setting

We conducted our study at The Everett Clinic, a multispecialty health system located in Everett, WA. The professional staff cares for 250,000 patients in 16 locations, logs 660,000 ambulatory visits, and writes 2.7 million prescriptions annually. The EHR was internally developed beginning in 1995. The *CPOE* software for medication ordering was rolled out beginning in 2003. During data collection clinical decision support (CDS) capabilities were limited to pediatric dosing calculations. The *CPOE* system enables prescribers to generate new or renewed prescriptions and to print or computer fax these to 200 pharmacies. Nurses and medical assistants can queue prescriptions, but authorization and signature are reserved for licensed prescribers.

Until 2003, the computer configuration that provided access to the EHR consisted of a desktop in each physician's office and desktops at hallway workstations. Concurrent with rollout of the *CPOE* software, the health system made the strategic decision to enhance access to the EHR by providing each prescriber with a laptop, and to provide wireless access throughout the clinic. Partway through this process, the health system realized the wireless network was not consistently reliable, so abandoned this strategy in favor of hardwiring each of 505 patient examination rooms with a desktop. Interested readers can read about the health system's experience in our published account of this effort (Devine et al. 2008).

Study Design

We conducted a quasi-experimental, direct observation, phase 1/phase 2 time-motion study at three primary care sites: Silver Lake, Harbour Pointe, and Snohomish (Table 1). In phase 1, the *CPOE* software had not yet been implemented at Silver Lake. At Harbour Pointe, it was implemented 11 months before the start of data collection; and at Snohomish, 15 months prior. (All sites had been supported by EHR access via desktops in offices/workstations for over 5 years.) In addition, Snohomish prescribers had EHR access via wireless laptops. During phase 2 all sites accessed the *CPOE* system from desktops in patient examination rooms. Observations began 2 months (Silver Lake), 1 week (Harbour Pointe), and 1 month (Snohomish) after hardware installation in examination rooms. The *CPOE* software had been in place for over 2 years, which reflected stability; and our primary aim was to measure the effect of the software on time spent prescribing. Although handwritten prescriptions were allowed in phase 2, <5 percent were handwritten. Dates of

Table 1: Product Availability, Characteristics of Prescribers and Staff, and Time Observed

	Silver Lake		Harbour Pointe		Snohomish	
	Phase 1 Observations (Winter/Spring 2005)	Phase 2 Observations (Spring 2007)	Phase 1 Observations (Summer 2005)	Phase 2 Observations (Winter/Spring 2007)	Phase 1 Observations (Fall/Winter 2005)	Phase 2 Observations (Fall/Winter 2006)
Hardware availability and configuration at time of observation (exposure time)	*	*Desktop computers in patient examination rooms (2 months)	*	*Desktop computers in patient examination rooms (1 week)	*Prescriber laptops (4 months)	*Desktop computers in patient examination rooms (1 month)
CPOE software availability at time of observation (exposure time)	Absent	Present (> 24 months)	Present (11 months)	Present (> 24 months)	Present (15 months)	Present (> 24 months)
Prescribers	8/10 (80%)	13/14 (93%)	11/15 (73%)	16/16 (100%)	8/8 (100%)	9/9 (100%)
Specialty						
Internal medicine	2	4	3	4	2	3
Family practice	3	4	4	6	4	4
Pediatrics	1	1	4	5	1	1
Walk-in clinic	2	4	0	1	1	1
Females (%)	3 (38%)	8 (62%)	5 (46%)	7 (44%)	6 (75%)	6 (67%)
Mean hours observed	3.9	3.8	3.8	3.8	3.9	3.9
Mean number of minutes unable to observe	19.8	13.9	12.7	34.7	7.7	4.9
Staff (nurses and medical assistants)						
Consented (%)	11/17 (65%)	10/19 (53%)	21/25 (84%)	20/24 (83%)	10/11 (91%)	9/11 (82%)
% Female	11 (100%)	9 (90%)	21 (100%)	20 (100%)	10 (100%)	9 (100%)
Mean hours observed	3.5	3.8	3.7	3.7	3.8	3.7
Mean number of minutes unable to observe	1.0	2.3	1.9	1.2	0.5	1.4

*Desktop computers in prescriber offices and at hallway workstations for > 5 years.

data collection ranged from February 2005 to January 2006 (phase 1), and from November 2006 to May 2007 (phase 2).

Invited subjects were prescribers, registered nurses, and medical assistants in family practice, internal medicine, pediatric, or walk-in clinics. Each subject was observed during one 4-hour time block (morning or afternoon) in one or both phases. After training and pretesting, two observers collected the majority of data during phase 1 (R. N. H., K. L. T.); one of these two collected all data during phase 2 (K. L. T.). Four investigators were trained as back-up observers, but they were seldom used. Patients of providers were given an information sheet that explained the study and were asked to provide oral consent, although no patient data were collected. Both patients and providers could decline to be observed at any time. The analyses include only those tasks that were directly observed. The University of Washington Human Subjects Committee approved all study activities.

Data Collection

Observers collected data using a Palm PDA device. Each PDA was preloaded with software obtained from *TimerPro* (Applied Computer Services Inc., Englewood, CO). We tailored the software by loading a list of 103 individual tasks intended to represent a comprehensive picture of all tasks performed during the workday, using as a starting point the tasks used by Overhage et al. (2001). These tasks became our units of analysis, which we collapsed into a combination specific to each aim (Appendix SA1).

We had five aims. For each aim, the independent variable (intervention) was the software/hardware configuration in phase 2; the dependent variable was time spent on tasks. The time metric was specific to each aim. Covariates collected were clinic, professional type (prescriber, nurse, medical assistant), prescription type (handwritten/e-prescribed; new/renewed), number of days exposed to software within phase, number of days exposed to hardware within phase, time of day each subject was observed (morning/afternoon), and number of prescriptions written, per prescriber.

Statistical Analyses

Aim 1 comprised our comparison of primary interest and was limited to prescribers. Based on our prior work (Hollingworth et al. 2007), we calculated we had 95 percent power to identify a 20 percent difference in the number of seconds to e-prescribe (60 seconds) versus handwritten (50 seconds) a prescription. We compared the time it took to handwritten (phase 1 or phase 2) versus

e-prescribe in phase 2. The unit of analysis was the prescription event and the time metric was seconds per prescription-event. Each prescription-event describes the prescribing of a minimum of one, but potentially more than one prescription in a continuous time period. A prescription-event can be handwritten or e-prescribed, and it can reflect a new or renewed prescription. We used a linear mixed effects model that accounted for clustering of multiple prescriptions within each prescriber. We modeled all prescriptions, followed by new/renewed prescriptions separately. We did not track whether prescriptions were initiated by prescribers versus queued by staff. In all models we included a fixed effect for clinic site. In the model that compared all prescriptions, we added a fixed effect for a new/renewed prescription. We then explored models that included the number of days exposed to software/hardware, time of day each subject was observed, number of prescriptions each prescriber wrote, and an interaction term between e-prescribing and a new/refilled prescription. As these latter were not significant we did not include them in the final model.

Aim 2 was also limited to prescribers and to the two sites that used the *CPOE* system during phase 1. We compared the time spent e-prescribing, comparing phase 1 with phase 2. As in Aim 1, the unit of analysis was each prescription-event and the time metric, seconds per prescription-event. We stratified this analysis by site, as each represented a unique hardware configuration in phase 1. We used the same linear mixed effects model as in Aim 1. For all models in Aims 1 and 2 we used two-tailed tests and considered *p*-values of $<.005$ as significant. We conducted both unpaired and paired analyses, including subjects followed in either or both phase 1 and phase 2, respectively. These results were similar. To err conservatively, we report our unpaired results.

Aim 3 included all professional types. We evaluated the time spent in prescribing-related *tasks*, comparing phase 1 with phase 2. The unit of analysis was one of the prescribing-related tasks (handwriting, e-prescribing, conducting prescription-related telephone calls, and faxing). The time metric was minutes/hour. We stratified this analysis by clinic and by professional type (prescriber or nurse/medical assistant combined). We conducted both paired and unpaired *t*-tests and the corresponding nonparametric tests (Wilcoxon signed-rank tests for matched pairs and Wilcoxon rank-sum tests). As results were similar, we report the results of the unpaired *t*-tests. Aim 4 again included all professional types. We evaluated time spent conducting major tasks, comparing phase 1 with phase 2. The unit of analysis was one of the 12 major tasks (computing, examining/reading charts, examining patients, looking for

objects or information, phoning colleagues, phoning patients, completing procedures, talking to colleagues, talking to patients, walking, writing, and other). The time metric, stratification variable, and statistical tests used were the same as in Aim 3. Because of the number of categories, we adjusted for multiple comparisons by applying the Bonferroni correction and consider p -values of $<.001$ of significance.

Aim 5 included all professional types. We evaluated the proportion of total time spent in overarching activity types, comparing phase 1 with phase 2. The unit of analysis was one of the six categories that represent these overarching activity types (administrative, direct patient care, indirect patient care: read, indirect patient care: write, indirect patient care: other, and miscellaneous). The time metric was the proportion of time spent. We stratified by professional type (prescriber or nurse/medical assistant combined). We used the two-sample test of proportions and designated a p -value of .01 as significant. All data were analyzed in *Stata* 10.1 (StataCorp LP, College Station, TX).

RESULTS

We conducted 146 observations, out of a possible 179 observation times had each subject consented to be observed in either phase, for an 82 percent observation rate. In 45 percent (65/146) of observations, the subjects were prescribers; in 29 percent (43/146), nurses; and in 26 percent (38/146), medical assistants. Twenty-five prescribers, 10 nurses, and 13 medical assistants were followed in both phases; for a total of 77 percent (50/65) of prescriber observations, 47 percent (20/43) of nurse observations, and 68 percent (26/38) of medical assistant observations that were paired. One walk-in clinic prescriber was a physician's assistant; two pediatric prescribers were advanced registered nurse practitioners. The remaining providers were physicians (Table 1).

Sixty-five prescribers handwrote or e-prescribed 582 prescriptions; 372 (64 percent) were new prescriptions. When combining phase 1 and phase 2, 450 (77 percent) of prescriptions were e-prescribed. For Aim 1, the average number of seconds/prescription-event (new/renewed combined) it took to e-prescribe in phase 2 was 69, an adjusted 25 seconds longer than it took to handwrite (99.5 percent confidence interval [CI] 12.38). New prescriptions took significantly longer (29 seconds; 99.5 percent CI 14.44), while renewed prescriptions did not (13 seconds; 99.5 percent CI -13.39) (Table 2). When comparing prescribers with staff, 30 nurses queued 233 prescriptions—less

Table 2: Time Spent Handwriting and E-Prescribing for Prescribers

	<i>Mean Seconds per Prescription-Event (Number of Prescriptions)</i>	<i>Mean Seconds per Prescription- Event Adjusted Difference; Unpaired Analysis (99.5% CI)</i>	
Aim 1 [¶]			
	Handwritten (phases 1 and 2 combined)	E-prescribed on desktops in examination rooms (phase 2)	
All sites—all prescriptions [†]	47 (132)	69 (312)	25 (12, 38)*
All sites—new prescriptions [‡]	47 (111)	75 (181)	29 (14, 44)*
All sites—renewed prescriptions [‡]	46 (21)	60 (131)	13 (– 13, 39)
Aim 2 [¶]			
	E-prescribed from desktops in offices/ workstations (phase 1)	E-prescribed on desktops in examination rooms (phase 2)	
Harbour Pointe—all prescriptions [§]	44 (79)	69 (147)	24 (8,39)*
Harbour Pointe— new prescriptions	45 (37)	74 (84)	29 (6, 53)*
Harbour Pointe— renewed prescriptions	42 (42)	63 (63)	19 (– 3, 41)
Snohomish—all prescriptions [§]	73 (59)	73 (69)	3 (– 18, 24)
Snohomish—new prescriptions	75 (43)	83 (38)	8 (– 20, 35)
Snohomish— renewed prescriptions	68 (16)	61(31)	– 4 (– 37,30)

Note. Linear mixed effects models—random effect: prescriber.

†Fixed effects: clinic, new/renewed prescription.

‡Fixed effects: clinic.

§Fixed effects: new/renewed prescription.

*Variables not included in final model due to nonsignificance were number of days exposed to software/hardware, time of day each subject was observed, number of prescriptions written by each prescriber, and the interaction between e-prescribing and a new/refilled prescription.

**p* < .001

CI, confidence interval.

than half the number of prescriptions prescribers wrote—and 25 medical assistants queued less than one-third (133). The proportion of prescriptions queued by nurses was equally distributed between phases, whereas for medical assistants the proportions were 40 percent (phase 1) and 60 percent (phase 2). Eighty-one percent of prescriptions written by nurses were renewals (189/233);

90 percent for medical assistants (120/133). Ninety-one percent of prescriptions written by nurses were e-prescribed (211/233); 97 percent for medical assistants (129/133). On average, it took nurses less time to prescribe than it did medical assistants (handwritten: 83 versus 114 seconds; e-prescribed in phase 2: 76 versus 134 seconds) (data not in table).

When the analysis was limited to sites with the *CPOE* software in phase 1 (Aim 2), the number of seconds it took to e-prescribe in phase 2 at Harbour Pointe was again 69, an adjusted 24 seconds longer than it took to e-prescribe in phase 1 (99.5 percent CI 8.39). As in Aim 1, time spent was significantly longer for new, but not for renewed prescriptions. It took 73 seconds to e-prescribe in phase 2 at the Snohomish site, although this was not an increase over time spent in phase 1. Of note is that it took longer to e-prescribe in phase 1 at Snohomish using laptops, than at Harbour Pointe using desktops in office/workstation (Table 2).

When evaluating the number of minutes/hour spent conducting prescribing-related tasks (Aim 3), the average number of minutes spent for prescribers (2–3 minutes) and staff (< 1–5 minutes) was low, and it did not change between phases. When the comparison was further limited solely to tasks that involve writing (or e-prescribing) a prescription, the average number of minutes spent was the same for prescribers, while the number of minutes spent writing prescriptions comprised only a portion of prescribing-related tasks for nurses and medical assistants (0–4 minutes) (not shown in graph).

For Aim 4, the transition at Silver Lake, from using a paper-based prescribing system (phase 1) directly to e-prescribing using desktops at the point of care (phase 2), was associated with a significant increase in the average time prescribers spent on computing tasks (7 minutes/hour; 99.9 percent CI: 1.13). This time was partially offset by a 2-minute/hour reduction in the amount of time spent on writing tasks. The net increase in combined time (5 minutes/hour) was not statistically significant (99.9 percent CI: –2.12). Similar increases in time spent computing, and combined computing and writing, were noted at Harbour Pointe and Snohomish; neither were these significant. There were no other notable differences in time spent on any task (Figure 1a). Neither did the transition from phase 1 to phase 2 change significantly the time spent on tasks for nurses and medical assistants (Figure 1b). Overall, prescribers spent more time talking with patients and colleagues, examining patients, computing, and writing than conducting other tasks. When compared with prescribers, nurses and medical assistants spent less time talking to and examining patients, and more time examining charts, telephoning, and computing.

Figure 1: Major Task Categories, Comparison of Phase 1 with Phase 2 (Aim 4)

When comparing the proportion of time spent conducting overarching activity types (Aim 5), there were no significant differences between phases for prescribers, who spent 47–48 percent of their time in direct patient care (Figure 2). Staff experienced a statistically significant 6 percent increase (27–33 percent; 99 percent CI 4.8) in time spent in direct patient care in phase 2, with a corresponding decrease in indirect patient care—other and miscellaneous tasks.

DISCUSSION

For prescribers, e-prescribing took longer than did handwriting a prescription (Aim 1). Each prescriber handwrote between 1 and 18 prescriptions in phase 1, but did not exceed 3 in phase 2. In either phase, the number of prescriptions each prescriber e-prescribed ranged from 1 to 22. These numbers reflect one-half day observation times. Using the adjusted mean difference of 25 seconds to e-prescribe one prescription-event, and multiplying by two to reflect a full day's work, the additional amount of time spent e-prescribing can range between 50 seconds ($1 \times 2 \times 25$) and 1,100 seconds (18 minutes; $22 \times 2 \times 25$) per prescriber. The mean number of prescriptions e-prescribed over all prescribers was 8 per observation period. This totals just over 6 minutes per day, per prescriber ($8 \times 2 \times 25$). Seeing 20 patients per day, this increase is

Figure 2: Overarching Activity Types for Prescribers and Staff, Proportion of Time Spent (Aim 5)

20 seconds per patient. Comparing the results of the present study with our earlier work (Hollingworth et al. 2007) reveals an important finding: overall prescribing time doubled—from 12 seconds when comparing handwriting with e-prescribing at offices/workstations in our earlier study, to 25 seconds when comparing handwriting with e-prescribing at desktops in examination rooms in the present study.

That it took 24 seconds longer to e-prescribe using desktops in examination rooms than it did using desktops in offices/workstations (Aim 2—Harbour Pointe) was an unexpected finding. The mean number of prescriptions e-prescribed in this clinic in phase 2 was again 8, for an estimated daily increase in time spent e-prescribing of 6 minutes. This increase was not noted at the Snohomish site that transitioned from using laptops to desktops—both at the point of care.

Our comparisons of prescribing-related task categories (Aim 3) reveal that, for prescribers, the majority of time spent on prescribing-related tasks is spent on writing prescriptions; while for staff, a portion of this time is spent on prescribing-related telephoning and faxing. Our comparisons of 12 major task categories (Aim 4) reveal that none of the hardware and software combina-

tions was associated with a dramatic shift in tasks for prescribers or staff. Only at the site that implemented the *CPOE* software between phase 1 and phase 2 (Silver Lake) was implementation associated with an increase in mean time spent computing for prescribers, but less time spent writing offset this. As expected, our comparisons reveal differences in task types between types of professionals. At all sites, the amount of time prescribers spent conducting prescribing-related tasks was smaller than time spent in many other task types, specifically those that involve the patient. Although implementation did not result in a task shift for prescribers, it did for staff (Aim 5), resulting in increased time spent in direct patient care. One possible explanation for this centers on the fact that, concurrent with computer installation in examination rooms, medical assistants were given a new charge—after rooming patients, queue patient profiles, and take histories, recording these in the computer at the point of care.

Our results are comparable to those of others. In the inpatient setting, Tierney found that e-prescribing took 33 minutes longer per shift than did handwritten prescribing (Tierney et al. 1993). However, 62 percent of this time was spent on computer-intensive order sets. This was offset by a 5.7-minute reduction in other record-keeping tasks. Shu et al. (2001) found that the proportion of interns' time spent conducting *CPOE*-related tasks increased from 2.1 percent before *CPOE* implementation to 9.0 percent after, but this was offset by less time spent looking for charts and walking. Overhage found that experienced physicians saved 3.73 minutes per patient when e-prescribing from workstations in the ambulatory setting of internist's practices. There were no computers in examination rooms during his study (Overhage et al. 2001). Pizziferri found the use of the EHR decreased the adjusted mean time spent per patient by 0.5 minute in the primary care setting. The amount of time spent talking to or examining patients did not change significantly. Both before and after implementation, 50 percent of the time was spent in direct patient care and 20 percent in writing activities that supported patient care (Pizziferri et al. 2005). Lo et al. (2007) compared the time efficiency of a paper-based system with an EHR in four types of specialty clinics and found that following EHR implementation, the average adjusted total time spent per patient increased by 0.94 minutes. All five studies were conducted at health systems that have years of experience in developing and implementing internally developed systems. Our results are similar to Tierney et al.'s (1993) and Shu et al.'s (2001) in that our EHR/*CPOE* system increased time spent in computing tasks, but was offset by a reduction in other types of tasks. This was similar to Pizziferri et al.'s (2005) results in that the overall distribution of time spent talking to or

examining patients did not change, and in that the proportions of prescriber time spent in direct patient care and indirect patient care-writing tasks were similar. In contrast to Overhage et al.'s (2001) study, we found that e-prescribing does significantly increase time spent prescribing, but our increase was in the context of e-prescribing in the examination room.

There are several plausible explanations as to why e-prescribing took longer at the point of care. First, our phase 2 observations followed closely after desktop installation in examination rooms and could have left prescribers with insufficient time to develop efficient work patterns. If this were the case, we would have expected time spent e-prescribing in phase 2 at Snohomish would have increased over phase 1; it did not. E-prescribing at Snohomish in phase 1 took longer than at Harbour Pointe. This suggests that no increase in time was necessary when transitioning from a laptop to a desktop when both were used at the point of care. Second, we note that there were no significant enhancements made to the *CPOE* software during the study, ruling out this as an explanation. Third, we ruled out a slow network connection as the cause of the increased time spent e-prescribing in the examination room. Our most plausible explanation is that e-prescribing at the point of care is a more dynamic process because the clinician is simultaneously interacting with the patient. This notion is supported not only by the increase in time spent at Harbour Pointe but also the greater amount of time spent in phase 1 at Snohomish. Because phase 2 implementation we have received anecdotal feedback from prescribers indicating they feel that optimizing hardware configurations on a room-specific basis is paramount to efficiency and that the importance of addressing this dynamic was underestimated. Our results suggest that e-prescribing is a complex task that involves optimization of both software features and hardware configurations.

Several investigators have studied the impact of EHRs at the point of care. Poissant et al. (2005) conducted a systematic review of EHRs on time efficiency and found that using EHRs at the point of care increased documentation time by 17.5 percent, whereas documentation at central workstations increased time spent by 8.2 percent, each compared with paper-based systems. Makoul used videotapes and questionnaires to compare physician-patient interactions in examination rooms with and without EHRs. He noted that physicians using the EHR spent less time exploring patient issues, and more time checking/clarifying information and ensuring completeness of patient issues. Physicians noted the orientation of the computer in the exam room detracted from interacting with patients (Makoul, Curry, and Tang

2001). Hsu captured information from patient questionnaires that reported their satisfaction with physician's use of computers in examination rooms. Their results revealed positive effects on physician-patient interactions related to medical communication, without significant negative effects on time available for patient concerns or psychosocial issues (Hsu et al. 2005).

We suggest that an increase of 20 seconds per patient, in time spent to e-prescribe, may be a worthwhile investment of time, if it improves the safety and quality of care provided to patients. That *CPOE* systems can reduce medication errors by 55–86 percent, and preventable adverse drug events by 17 percent has been highlighted in a recent systematic review (Kaushal, Shojania, and Bates 2003). In conducting a return on investment for a home-grown *CPOE* system, Kaushal et al. (2006) noted that *CPOE* system elements that contributed the greatest cost savings were renal dosing guidelines, specific drug guidance, adverse drug event prevention, and nursing time utilization. Wang et al. (2003) has estimated that the net benefit of using an EHR for a 5-year period was \$86,400 per provider. Another key benefit to EHRs is increased access to patient information. And the increased time spent at the point of care may also enhance patient communications. Certainly, determining optimal hardware configurations will be important to increase adoption.

Our study has several limitations. Generalizability is limited because The Everett Clinic was using an internally developed EHR and *CPOE* system, without CDS capabilities; and we limited our study to three primary care clinics. Importantly, we observed subjects during clinic hours only. We know that prescribers also use the *CPOE* system on their own time. We have not captured this. We were also limited in our ability to capture simultaneously occurring tasks, although our research assistants received extensive training in correct identification and classification of tasks. We did not capture the total amount of time each prescriber worked per day, and thus we are not able to determine whether using the *CPOE* system lengthened their day. Finally, our study illustrates the challenges inherent in evaluating the impact of a *CPOE* system in the real-world setting. Because The Everett Clinic made a midcourse adjustment in their implementation strategy, we had to revise our initial study design, which was simply to conduct a pre-post evaluation of *CPOE* software implementation. As a result, we had the opportunity to capture data that represent additional hardware configurations. Configurations that, in retrospect, were intermediate in the implementation process of The Everett Clinic may be of interest to other health systems as their configurations of choice. Despite these limitations, our study is one of a few that have focused

specifically on the length of time it takes to write a prescription using four different methods, handwriting, e-prescribing from offices/workstations, from portable laptops, and e-prescribing at the point of care. As such, it sheds light on the complexity of the e-prescribing process and the multiple aspects that contribute to time spent.

CONCLUSION

E-prescribing took 25 seconds longer per prescription-event than handwritten prescriptions. E-prescribing at the point of care took 24 seconds longer than did e-prescribing in offices and at workstations, and it likely reflects the increased time spent interacting with the patient. Overall, implementation of the *CPOE* system did not change the time spent at task categories for prescribers or staff, although there was a slight increase in the proportion of staff time spent in direct patient care, again likely due to having computers in examination rooms. Implementation of EHRs and *CPOE* systems continues, but the results of their impact on time efficiency may vary with the heterogeneity of the systems and settings involved. Further efforts to identify optimal software and hardware configurations will be beneficial to speed adoption.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.

Appendix S1. Task Categories.

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