Electronic medical record use in pediatric primary care

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Dr Fiks had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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ABSTRACT

Objectives To characterize patterns of electronic medical record (EMR) use at pediatric primary care acute visits.
Design Direct observational study of 529 acute visits with 27 experienced pediatric clinician users.
Measurements For each 20 s interval and at each stage of the visit according to the Davis Observation Code, we recorded whether the physician was communicating with the family only, using the computer while communicating, or using the computer without communication. Regression models assessed the impact of clinician, patient and visit characteristics on overall visit length, time spent interacting with families, and time spent using the computer while interacting.
Results The mean overall visit length was 11:30 (min:sec) with 9:06 spent in the exam room. Clinicians used the EMR during 27% of exam room time and at all stages of the visit (interacting, chatting, and building rapport; history taking; formulation of the diagnosis and treatment plan; and discussing prevention) except the physical exam. Communication with the family accompanied 70% of EMR use. In regression models, computer documentation outside the exam room was associated with visits that were 11% longer ($p=0.001$), and female clinicians spent more time using the computer while communicating ($p=0.003$).
Limitations The 12 study practices shared one EMR.
Conclusions Among pediatric clinicians with EMR experience, conversation accompanies most EMR use. Our results suggest that efforts to improve EMR usability and clinician EMR training should focus on use in the context of doctor–patient communication. Further study of the impact of documentation inside versus outside the exam room on productivity is warranted.

INTRODUCTION AND BACKGROUND

As a central feature of efforts to reform the health system, the American Recovery and Reinvestment Act (ARRA) of 2009 allocated $19 billion to promote the adoption of electronic medical records (EMRs).[1 2] These ARRA funds will likely increase the use of EMRs by office-based practices from current rates near 20%.[3 4] While this investment has the potential to increase the efficiency, coordination, and quality of healthcare,[5 6] recent findings underscore the need for additional research on the usability of these systems in order to achieve better outcomes.[7–9] In this context, the Agency for Healthcare Research and Quality (AHRQ), National Institute of Standards and Technology (NIST), and the Office of the National Coordinator (ONC) have prioritized efforts to measure and enhance EMR usability.[7 8]

Elucidating patterns of doctor–patient communication and documentation in the setting of visits using the EMR is a necessary first step for promoting the safe and efficient use of these systems. Prior research studies that have examined how EMRs affect doctor–patient communication have been limited by a reliance on surveys or interviews,[10 11] small sample sizes (<10 clinicians),[12–14] a focus on trainees,[15] or limited scope.[16] Patterns of use of the EMR at each stage of the clinical encounter and how they differ based on clinician and patient characteristics have not been well-defined. Results from studies examining the impact of EMR implementation on visit length have been mixed, with results ranging from no change in visit length to an increase of 5 min.[15 17–19] Limited evidence currently exists to guide efforts to help clinician users improve efficiency after they begin using the EMR, an increasingly important demand in practice. Finally, a fundamental advantage of the EMR over paper-based systems is the ability to deliver clinical decision support to the point of care to promote evidence-based decision making.[20] Although prior research has demonstrated that the effective use of clinical decision support systems (CDSS) depends upon understanding clinician workflows,[5 20] these workflows and their variation across primary care clinicians has not been well-characterized.

In this study, we filled these knowledge gaps by focusing on problem-oriented pediatric acute visits where efficiency is a priority and medical decisions and deliberation are common between the clinician and family.[21 22] Through direct observation, we characterized patterns of EMR use in busy primary care settings and their association with visit length and doctor–patient interaction. We focused on detailing how clinicians with EMR experience integrate the EMR into the visit flow during each component of the clinical encounter. Extending prior work in the field, we also used statistical models to examine how clinician, patient, and visit characteristics impact both doctor–patient interaction and visit length.

PATIENTS AND METHODS

Setting and electronic health record

This study was conducted at 12 practices within The Children's Hospital of Philadelphia (CHOP) Pediatric Research Consortium (PeRC), a multi-state, hospital-owned, primary care practice-based research network caring for more than 235 000 children and adolescents. PeRC includes 153 clinicians who work at 31 different practice locations.

Study practices included two urban teaching practices where fewer than 35% of patients have private insurance as well as 10 suburban practices, not involved in resident teaching, where over 80% of children are privately insured. All practices had used the ambulatory EMR, EpicCare (Verona, Wisconsin) for at least 19 months (mean 40 months) when this study began. The same functionality was present at each site and includes structured documentation templates, computerized order entry, electronic receipt of laboratory results, and the ability to view documentation from visits with certain hospital subspecialty departments. Each exam room at study practices was equipped with a flat panel monitor, keyboard, and mouse located on a wall-mounted desk. The configuration of a standard room is shown in figure 1 and allows the family to view information present on the screen.[23] There was little variation among exam rooms at study sites. In addition to inside exam rooms, computers at study sites could also be accessed at work areas outside of consultation rooms.

Study design and population

This direct observational study of primary care acute visits was carried out between January and April 2008. Clinicians were recruited from practices that had agreed to engage in an intervention study of EMR-based clinical decision support in the acute care setting. Since an understanding of workflows is important in designing clinical decision support systems, this study was performed before the decision support intervention was launched. Because pediatric health maintenance visits have a different flow and a substantially longer duration than sick visits, we were interested in understanding how decision support would fit within the context of sick visits, and as a prior study had focused on pediatric preventive visits, these visits were not observed. All clinicians were invited to participate. A convenience sample was formed from the first 27 clinicians who agreed to be observed. Informed consent was obtained from each participant.

Clinicians at study sites were trained to use the EMR following a standard protocol. Training began 2 months prior to implementation with an on-site presentation introducing the system. One month before implementation, clinicians received on-site training on how to abstract growth data, problem lists, medications, and allergies into the EMR. Physicians and nurse practitioners were encouraged to abstract at least 30 charts of complex patients to gain experience using the system. Once each week for the 3 weeks following implementation, clinicians received a 3 h training session covering order entry, progress notes, and tips for efficient documentation, respectively. Sessions also covered the institutional policy that charts should be completed by the clinician on the day of the visit. Each session included hands-on use of the system with supervision and each was followed by a half day spent practicing techniques learned while caring for patients using the EMR. Experienced physicians from other sites as well as nurse trainers provided on-site support for 1 month post-implementation. Then, at 2, 4, and 6 months post-implementation, additional site visits occurred to ensure that all users were able to use the system at a basic level, review tools to improve efficiency, and answer questions.

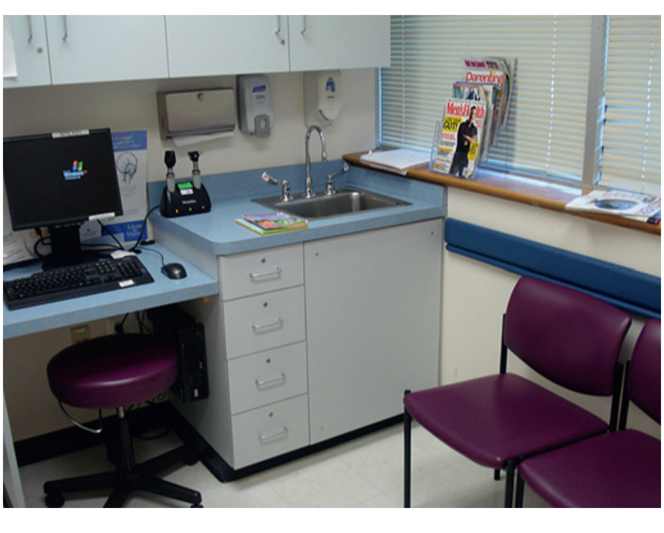

Figure 1 Exam room layout. This figure shows the layout of a typical exam room at a study site. Chairs for the patient and parent are positioned to the side of the clinical workstation. The computer monitor, keyboard, and mouse sit on a wall-mounted desk located beside the sink.

Data collection

A trained pediatrician or pediatric nurse observed clinicians during at least two separate half day sessions (interobserver reliability, κ=0.75 for consistency in coding of time intervals between observers using the Davis Observation Coding (DOC) system (based on five visits)). The mean number of visits observed per clinician was 20 (range 9–33). Visits involving more than one child (15 visits, 2.8% of all visits) were excluded. Observers followed clinicians as they provided care within and outside of the exam room.

Outcome measures

Doctor–patient communication

To characterize doctor–patient communication, our primary focus, we recorded during each 20 s interval whether (1) the clinician conversed with the family and patient without active computer use (solo family time), (2) communicated with the family and patient while using the computer (family with computer time), or (3) used the computer without interaction with the family (solo computer time). 'Face time' with families was defined as the sum of solo family time and family with computer time (table 1).

Visit content

To characterize the flow of the visit, we divided the encounter into distinct segments by using the DOC (see online appendix 1), a well-studied system for describing the distribution of time at medical visits.[24–26] A modified version of the DOC, retaining elements applicable to pediatric acute visits, was used to classify the activities during each 20 s block as: (1) interaction, chatting, and building rapport; (2) history taking; (3) the physical exam; (4) the diagnosis and treatment plan; (5) prevention; and (6) a category of 'other' that primarily included office-based procedures such as suture removal.

Length of visits

The overall visit length was composed of time spent in the exam room with the patient and family and time outside the exam room spent on documentation. Chart review prior to the visit, which generally is very brief if it occurs at all at pediatric acute visits, was not included in the visit length. Computer time after the visit was estimated for 46 visits because the clinician had not completed charting by the end of the observation session. Estimates were derived by asking clinicians about the time needed to complete charts for those specific visits. Through a sensitivity analysis, we found that visits with estimates were slightly longer than visits with computer time after the visit without estimates

Table 1 Components of the visit

Visit component	Definition
Solo family time	Time the clinician spends conversing with the family without active computer use during the visit
Family with computer time	Time the clinician spends conversing with the family while using the computer during the visit
Solo computer time during the patient visit	Time the clinician spends using the computer without interaction with the family inside the exam room
Computer time after the visit	Time the clinician spends using the computer to document after the visit outside the exam room
Face time	Solo family time+family with computer time
Solo computer time	Solo computer time during the visit+computer time after the visit
Patient visit length	Solo family time+family with computer time+solo computer time during the visit
Overall visit length	Solo family time+family with computer time+solo computer time

This table defines each component of the visit that we include in our analyses.

(mean of 12:22 versus 11:22 min for other visits). However, when these visits were excluded from overall analyses, main study inferences were not affected; thus, to most accurately describe patterns of care, we retained all visits in our analyses.

Independent variables

Using a self-administered 10-item questionnaire adapted from an instrument used previously by the American Medical Informatics Association,[27] we measured clinicians' self-assessed computer skills in (1) viewing patient schedules, (2) viewing lab results using electronic systems, (3) using the internet, (4) sending and receiving email, (5) advanced email tasks such as attachments, (6) loading a program onto a computer, (7) scanning a picture into a computer, (8) teaching others how to use their computer, (9) troubleshooting computer problems, and (10) creating web pages. Each item was rated on a 5-point Likert-scale (1 (this task is difficult) to 5 (this task is easy)). Out of a total possible computer skill score of 50, scores of <30 (mean item score of <3) were considered low. Other clinician variables included gender, age in years (30–39, 40–49, 50–59), years in practice (≤5, 5–15, >15), effort (full-time or part time), number of clinicians in practice (≤5, 5–15, >15), and practice type (urban resident teaching practice or a non-resident teaching practice). We also asked clinicians if they felt they needed tips on computer use to promote efficiency (yes/no). As a secondary analysis, we analyzed results with and without this variable.

Patient gender, age in years (<5, 5–11, ≥12), race (white, black, other), and diagnoses assigned were recorded at each visit. Diagnostic codes, entered into the EMR by clinicians at the end of visits as part of the billing process, were clustered into homogeneous categories using a taxonomy previously developed for acute health problems.[28] We also categorized visits based on whether or not the computer was used after the visit.

Statistical analysis

The time in minutes and seconds spent on each activity, both inside and outside of the exam room, as well as the proportion of the visit consisting of solo family time, family with computer time, and solo computer time were tabulated. We implemented mixed effects linear regression models with the visit as the unit of analysis and clustering of visits at the clinician level to conservatively estimate the impact of each independent variable on overall visit length, face time with families, and family with computer time.[29] Clustering visits at the practice level was explored, did not impact results, and was dropped from the final models. For unadjusted estimates, we ran models with no covariates. If two covariates were collinear, the most clinically meaningful one was modeled. Output from these models described the amount of additional time associated with a given characteristic (eg, female gender) compared to a reference category (male gender) and were reported with 95% CIs.

In all models, $p<0.05$ was considered significant. To ensure that results for models with the outcomes of face time as well as family with computer time were not biased by the overall visit length, we confirmed results with Poisson models that accounted for the overall visit length as an offset.[30]

By means of a mixed effects model, we estimated the amount of variation in the observed overall visit length, face time, and family with computer time that represented variability across physicians not explained by patient or visit characteristics. This fraction, the intraclass correlation coefficient expressed as a percent, would increase if the observed variation in overall visit length, face time, or family with computer time represented mostly variation across physicians. The fraction would be low if all physicians had about the same overall visit length, face time, or family with computer time. We refer to this measure as 'physician practice style' because it reflects otherwise unexplained differences across physicians.

All analyses were performed using Stata v 9, 10, and 11. The CHOP Institutional Review Board approved the study.

RESULTS

Clinician and visit characteristics

A heterogeneous sample of 26 pediatricians and one pediatric nurse practitioner participated in this study (table 2). Their gender and age distribution was comparable to that of clinicians in the broader network, and 25 of the 27 clinicians worked at study practices prior to the implementation of the EMR (data not shown). Most participants were full-time clinicians working outside of resident teaching practices. Their mean length of use of the EMR was 40 months (range 19–67). Eight of the 27 clinicians reported low self-assessed computer skill.

The average overall visit length, including documentation inside and outside the exam room, lasted 11 min 30 s (range 2:18 to 36:30). Visits with computer time after the visit had a mean length that was 1:12 (11%) longer than those without. Nearly half of visits were for ear, nose, throat, dental, and mouth diseases (47%), a category that includes upper respiratory infections (table 3).

Patterns of computer use

Of the 9:06 spent in the exam room during an average visit, clinicians spent 2:30 (27%) using the EMR (family with computer time+solo computer time during the patient visit) (table 4). The EMR was used throughout the visit and use occurred at all DOC stages of the visit except the physical exam. Overall, clinicians used the computer in the exam room in 81% of visits. This use spanned 29% of the time spent interacting, chatting, and building rapport, 53% of the time spent history taking, and 36% of the time spent formulating and communicating the diagnosis and treatment plan. Clinicians used the

Table 2 Clinician characteristics

Characteristic	Clinician (n=27)	Visit (n=529)
Gender		
Male	11 (41%)	240 (45%)
Female	16 (59%)	289 (55%)
Age (years)		
30–39	8 (30%)	157 (30%)
40–49	8 (30%)	142 (27%)
50–59	11 (40%)	230 (43%)
Years in practice		
≤5	2 (7%)	34 (6%)
5–15	11 (41%)	220 (42%)
>15	14 (52%)	275 (52%)
Effort		
Full-time	18 (67%)	383 (72%)
Part time	9 (33%)	146 (28%)
Self-assessed computer skill*		
Low mean=25 (range 21–28)	8 (30%)	160 (30%)
High mean=36 (range 30–42)	19 (70%)	369 (70%)
Practice size		
<5 providers (4 practices)	10 (37%)	220 (42%)
5–10 providers (5 practices)	13 (48%)	238 (45%)
≥10 providers (3 practices)	4 (15%)	71 (13%)
Months of EMR use	Mean 40 months (range 19–67 months)	

This table presents the demographic characteristics of the clinicians in the study sample as a proportion of all clinicians or all visits observed.
*Computer skill was measured with a self-administered 10-item questionnaire adapted from an instrument used previously by the American Medical Informatics Association.[27] Items assessed clinicians' self-assessed computer skills in (1) viewing patient schedules, (2) viewing lab results using electronic systems, (3) using the internet, (4) sending and receiving email, (5) advanced email tasks such as attachments, (6) loading a program onto a computer, (7) scanning a picture into a computer, (8) teaching others how to use their computer, (9) troubleshooting computer problems, and (10) creating web pages. Each item was rated on a 5 point Likert-scale (1 (this task is difficult) to 5 (this task is easy)). Out of a total possible computer skill score of 50, scores of <30 (mean item score of <3) were considered low.
EMR, electronic medical record.

Table 3 Patient visit characteristics

Patient (n=529)	
Gender	
Male	264 (50%)
Female	265 (50%)
Age (years)	
<5	290 (55%)
5–11	140 (26%)
≥12	99 (19%)
Race	
White	395 (75%)
Black	93 (17%)
Other	41 (8%)
Visit (n=529)	
Primary diagnosis	
Ear, nose, throat, dental, and mouth diseases*	247 (47%)
Respiratory diseases	74 (14%)
Skin, dermatologic and soft tissue diseases	45 (8%)
Systemic states/fever alone	43 (8%)
Gastrointestinal diseases	24 (5%)
Other	96 (18%)
Number of diagnoses managed	
1	315 (60%)
≥2	214 (40%)
Computer documentation outside the exam room†	408 (77%)
Practice type	
Non-resident teaching practice (10 practices)	474 (90%)
Urban resident teaching practice (2 practices)	55 (10%)
Total visit length (min:sec)	11:30 (range 2:20–36:28)

This table presents both the demographic characteristics of the patients at study visits as well other visit level factors.
*Includes upper respiratory infections.
†Includes all visits with any computer time after the visit.

computer in the exam room during interacting, chatting and building rapport, history taking, and while formulating and communicating the diagnosis and treatment plan in 27%, 62%, and 63% of visits, respectively. Of note, the EMR was not used during any single DOC stage at more than 63% of visits.

When clinicians used the EMR, 70% of this time, on average 1:45 out of 2:30, involved simultaneous interaction with the family (family with computer time) (table 4). This pattern was consistent across clinicians and visits. Twenty-five of the 27 clinicians studied used the computer while interacting with families, and 22 of these 25 did so at more than 80% of observed visits. Of the patient visit length, face time, time spent interacting with the family either with or without EMR use, comprised 92% of the total.

Clinicians also frequently used the EMR outside of the exam room (computer time after the visit). Twelve clinicians documented outside the exam room at ≥90% of visits, 12 between 50 and 89% of visits, and only three at fewer than 10% of visits. Further, 77% of observed visits included this style of documentation. Among all study visits, the mean computer time after the visit was 2:24 (range 0 to 21:30) representing, on average, 21% of the overall visit length.

The impact of practice, clinician, and visit characteristics on visit time

Computer time after the visit was the only modifiable visit-level factor significantly associated with the overall visit length. Specifically, adjusting for covariates, out of exam room documentation (computer time after the visit) was associated with visits that were 1:51 longer (95% CI 0:46 to 2:56, p=0.001) than those with documentation limited to the exam room (table 5). Otherwise, the factors significantly associated with the overall visit length were the primary diagnosis and number of diagnoses (all p≤0.003). For example, visits with a primary diagnosis in the ear, nose, throat, dental, and mouth group were at least 2:12 shorter than those in other groups.

Clinician characteristics were not significantly associated with overall visit length or face time with families. In particular, low self-assessed computer skill was not significantly associated with either overall visit length or face time (p>0.67) and affected the overall visit length and face time by <20 s among the experienced users studied (table 5). Similarly, clinicians who reported that they would like to receive tips to improve efficiency were no different from others in terms of the overall visit length, face time, or family with computer time (all p≥0.64, data not shown). Among other factors studied, there was no impact of age or full- or part time status on the overall visit length.

In contrast to the overall visit length and face time, clinician characteristics were associated with family with computer time, the time spent interacting with families while using the computer. In adjusted models, females spent 1:06 longer interacting with families while using the computer than males (95% CI 0:22 to 1:50, p=0.003) (table 5). In addition, clinicians between 40 and 49 years of age used the computer while interacting more commonly than others. Use of the EMR while conversing with families was also more common at visits with children at least 5 years of age, who could actively participate in discussions. The above associations were all confirmed using Poisson models that accounted for the overall visit length.

Table 4 Computer use in exam room during acute pediatric visits* (N=529)

Davis category	Face time: Solo family time (min:sec) (row%)	Face time: Family with computer time (min:sec) (row%)	Solo computer time during patient visit (min:sec) (row%)	Total contribution to patient visit length (min:sec) (column%)
Interaction, chatting, rapport	0:26 (71%)	0:09 (24%)	0:02 (5%)	0:37 (7%)
History	0:52 (47%)	0:50 (46%)	0:08 (7%)	1:50 (20%)
Physical	2:23 (100%)			2:23 (26%)
Diagnosis and treatment plan	2:05 (62%)	0:40 (20%)	0:32 (16%)	3:22† (37%)
Prevention	0:18 (71%)	0:05 (21%)	0:02 (7%)	0:25† (5%)
Other‡	0:14 (48%)	0:01 (4%)	0:01 (4%)	0:29† (5%)
Total contribution to patient visit length	6:18 (69%)	1:45 (19%)	0:45 (8%)	9:06† §

This table describes the distribution of clinician time at included visits according to the modified Davis Observation Code.
*Solo family time is defined as time the clinician spends conversing with the family without active computer use. Family with computer time is time the clinician spends conversing with the family while using the computer during the visit. Solo computer time during the patient visit is the time the clinician spends using the computer without interaction with the family inside the exam room. All times are in minutes:seconds.
†Unclassified interaction times (visit interruptions such as talking to a nurse) are not shown in the table and do contribute to these totals. On average there were 18 s of unclassified time per visit.
‡Other refers to any additional activities inside the exam room such as procedures.
§Overall visit length = patient visit length (9:06) + computer time after visit (2:24) = 11:30.

Clinician impact on variability in visit length

We found that 20% of the variability in overall visit length and face time was related to physician practice style as defined in the Methods section. In contrast, 40% of the variability in family with computer time was related to physician practice style.

DISCUSSION

Main discussion

With the growing emphasis on EMR implementation and 'meaningful use,' the field of clinical informatics should provide evidence to guide the design and implementation of these systems to enhance usability. Optimizing these systems to

Table 5 Impact of clinician, patient, and visit, characteristics on overall visit length, face time, and family with computer time*

Variable	Overall visit length Adjusted difference in time (min:sec) (95% CI)	Face time Adjusted difference in time (min:sec) (95% CI)	Family with computer time Adjusted difference in time (min:sec) (95% CI)
Clinician characteristics (N=27)			
Female gender	1:17 (−0:41 to 3:18)	1:14 (−0:29 to 2.34)	1:06† (0:22 to 1:50)
Age (years)			
30−39	Baseline	Baseline	Baseline
40−49	1:48 (−0:29 to 4:06)	1:07 (−0:52 to 3:07)	1.11† (0:20 to 2:01)
50−59	−0:36 (−2:40 to 1:26)	−0.28 (−2:15 to 1:17)	0:15 (−0:30 to 1:00)
Practicing full-time (vs part time)	0:36 (−1:18 to 2:30)	0:53 (−0:46 to 2.32)	0:34 (−0:08 to 1:16)
Low self-assessed computer skill	0:19 (−1.19 to 1:57)	−0.30 (−1:43 to 1.07)	−0:26 (−1:02 to 1:41)
Patient characteristics (N=529)			
Female gender	0:56 (−0:34 to 2:26)	0:17 (−0:19 to 0:52)	−0:13 (−0:26 to 0:01)
Age (years)			
<5	Baseline	Baseline	Baseline
5−11	0:02 (−0:55 to 0:59)	0:04 (−0:37 to 0:46)	0:20† (0:04 to 0:37)
≥12	0:17 (−0:48 to 1:23)	0:07 (−0:40 to 0:54)	0:22† (0:03 to 0:41)
Race			
White	Baseline	Baseline	Baseline
Black	0:55 (−0:34 to 2:26)	0:13 (−0:53 to 1:11)	0:13 (−0:13 to 0:40)
Other	−0:05 (−1:39 to 1:29)	0:03 (−1:05 to 1:11)	0:13 (−0:13 to 0:41)
Visit characteristics (N=529)			
Primary diagnosis			
Ear, nose, throat, dental, and mouth diseases§	Baseline	Baseline	Baseline
Respiratory diseases	3:56† (2:43 to 5:09)	3:01† (2:07 to 3:53)	0:29† (0:08 to 0:50)
Skin, dermatologic and soft tissue diseases	2:22† (0:53 to 3:50)	1.21† (0:08 to 2:18)	−0:17 (−0:43 to 0:08)
Systemic states	2:12† (0:47 to 3:49)	2:06† (1.09 to 3.29)	0:21 (−0:05 to 0:47)
Gastrointestinal diseases	4:53† (2:57 to 6:50)	2:55† (1:30 to 4:20)	0:24 (−0:09 to 0:58)
Other	2:27† (1:19 to 3.36)	1:34† (0:44 to 2:24)	−0:04 (−0:23 to 0:16)
Number of diagnosis ≥2 (vs 1)	1:39† (0:50 to 2.29)	0:49† (0:13 to 1:25)	0:05 (−0:10 to 0:19)
Computer time after the visit (vs none)	1:51† (0:46 to 2:56)	‡	‡
Non-resident practices (vs urban resident teaching practices)	−1:57 (−4:40 to 0:43)	−0:15 (1:20 to 9:23)	−1:17 (−0:25 to 2:58)

This table presents the impact of clinician, patient, and visit characteristics on the overall visit length and the allocation of time during the visit.
*Time is shown as minutes:seconds. Negative values indicate less time (negative difference).
†Variables significantly associated with time ($p<0.05$).
‡Not included in the model.
§Includes upper respiratory infection.

improve outcomes depends upon understanding patterns of use during primary care visits. We characterized these patterns and their implications for usability and productivity. In addition, we consider how workflows might impact the implementation of clinical decision support.

For EMRs to be optimally used in practice, they must complement doctor–patient communication.[31–36] Since the EMR, room configuration, and training were consistent across sites, we were able to focus on the impact of clinician, patient, and visit characteristics on EMR use. Our results indicate that experienced EMR users in the setting of pediatric primary care acute visits, trained with an approach that incrementally introduced and reinforced features of the system over a period of months, integrate this technology into the flow of their interaction with families. By directly observing pediatric acute visits, brief, problem focused encounters ideal for the study of how time pressures might compromise interaction between clinicians and families, we found that clinicians spent 27% of the patient visit length using the EMR and that 70% of this time clinicians were actively communicating with the patient and family. Overall, clinicians and families spent 92% of the patient visit length interacting. In addition, even though computer skill differed, we found limited (20%) variability related to physician practice style as defined in the Methods section either in the overall visit length or in face time. These results suggest that variation in time is largely explained by patient and visit characteristics. In contrast, the much larger 40% variability in family with computer time attributable to physician practice style suggests a need to further explore how the EMR is used differently by individual clinicians as they interact with families.

In designing this study, we aimed to better understand how EMRs are used in primary care visits in order to inform efforts to improve usability. Our finding that the EMR is most often used while clinicians interact with families underscores the importance of designing systems that facilitate doctor–patient communication.[3 34] While national reports have highlighted the importance of clinician–EMR interaction,[8] our results indicate that the ideal context to evaluate EMR usability in primary care practice may be the setting of clinician–patient/family–EMR interaction. As usability increasingly becomes a standard for judging EMRs,[7 8] our findings suggest that usability metrics such as error and task completion rates, efficiency, as well as satisfaction should be measured in this context.[37]

Our results also suggest that efforts to improve EMR design for primary care should examine the reasons for clinician style differences. Although visits with female clinicians tend to be longer,[38] this study demonstrated that female clinicians spend significantly more time using the EMR while speaking to families, even controlling for the overall length of the visit and in the absence of a significant association between clinician gender and face time. Since the ability to talk and listen, maintain eye contact, and remain oriented toward the patient all improve communication during EMR use,[12 14 39–41] female clinicians might be more adept at these skills. Further study in informatics is needed to understand this association and its implications for EMR design, training, and clinical practice.

Additional evidence is also needed to guide clinicians seeking to maximize productivity through efficient EMR use, a component of usability. Our finding that use of the computer after the visit was significantly associated with an increased overall visit length, controlling for the primary diagnosis and number of diagnoses as well as clinician, patient, and other visit characteristics, has not been previously described. There are multiple possible explanations for the observed finding. In certain circumstances, use of the computer after the visit may slow down clinicians who need to log on and off different computers and, as a result, increase the overall visit length. Alternatively, for certain complex visits that require lengthy documentation, it may be more efficient to release the patient so that the clinician can complete charting without interruption. This also allows clinic staff to move the next patient/family into the exam room while the clinician does work elsewhere. Variables in our statistical models may not have fully accounted for this complexity. Further research is warranted in order to better understand under what circumstances clinicians should complete documentation in the exam room and what tools within the EMR most enhance efficiency.

Automated clinical decision support systems (CDSS) are a primary benefit of computer versus paper-based records and a centerpiece of efforts to use EMRs to improve the quality of care.[5 20] However, they depend upon the clinician receiving alerts at the right point in the workflow.[20 42] Consistent with results from prior physician surveys, we found extensive EMR use in the exam room.[10] Since clinicians must be using the EMR during the visit to receive alerts, our finding suggests that patterns of use are consistent with the implementation of CDSS designed to impact care and decision making within the exam room. We also documented that computer use was most common during the early (interacting, chatting, and building rapport or history taking) and later stages of the visit (formulation and communication of the diagnosis and treatment plan), indicating time points when alerts are most likely to be noticed. However, designers of CDSS should also note that while the EMR was used in the exam room at over 80% of visits, clinicians at most used the computer during any individual stage (eg, history taking) at 63% of visits. As others have suggested,[43 44] study is needed to examine patterns of response to actual reminders when presented with different timing and approaches during primary care encounters.

Limitations

Our study population was a convenience sample of clinicians from 12 practices which all used the same EMR. Nonetheless, the finding that variability across clinicians explained only 20% of visit length and face time indicates that clinician practice style is consistent in this setting even among those with varying experience and self-assessed computer skill. This finding might be generalizable to other clinicians who have similar training and work in settings with similar room layouts and equipment. Future research in settings with distinct EMR systems, patient populations, and room configurations should be conducted to confirm our findings. This is especially important since our study focused on pediatric primary care acute visits which may differ from those with other groups such as the elderly. In these studies, it would also be worthwhile to assess whether primary care clinicians use existing functionality to enhance efficiency and avoid errors, an area beyond the scope of our study. In addition, because clinicians studied were not randomly selected, it is possible that participants in our study had different patterns of computer use compared to non-participants, a potential source of bias. Furthermore, the Hawthorne effect, where clinicians change their behavior while being observed, might have impacted results. However, as has been recommended for direct observational studies,[45] we did not present the clinicians being observed with any specific hypothesis that would have changed their behavior, which also mitigates the potential effects of selection bias. Finally, we did not consider the impact of patterns of computer use on parent or patient satisfaction with the encounter. Additional study will be needed to assess how families respond to different patterns of computer use.

CONCLUSIONS

Accompanying efforts to expand the use of EMRs, the Agency for Healthcare Research and Quality, the National Institute of Standards and Technology, and the Office of the National Coordinator have prioritized efforts to measure and enhance the usability of these systems.[7 8] By studying pediatric primary care acute visits conducted with EMRs, we characterized patterns of EMR use at each stage of the visit, contributing to the foundation for future work to optimize usability. We found that most EMR use is accompanied by conversation between clinicians and families and that completing documentation in the exam room was associated with shorter visits. Findings suggest that studies to promote EMR usability should focus on use in the context of doctor−patient communication and that further study is needed to understand how best to design EMRs and train clinicians to maximize productivity.

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