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Time Requirements for Electronic Health Record Use in an Academic Ophthalmology Center

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← **Invited Commentary**

IMPORTANCE Electronic health record (EHR) systems have transformed the practice of medicine. However, physicians have raised concerns that EHR time requirements have negatively affected their productivity. Meanwhile, evolving approaches toward physician reimbursement will require additional documentation to measure quality and cost of care. To date, little quantitative analysis has rigorously studied these topics.

OBJECTIVE To examine ophthalmologist time requirements for EHR use.

DESIGN, SETTING, AND PARTICIPANTS A single-center cohort study was conducted between September 1, 2013, and December 31, 2016, among 27 stable departmental ophthalmologists (defined as attending ophthalmologists who worked at the study institution for ≥6 months before and after the study period). Ophthalmologists who did not have a standard clinical practice or who did not use the EHR were excluded.

EXPOSURES Time stamps from the medical record and EHR audit log were analyzed to measure the length of time required by ophthalmologists for EHR use. Ophthalmologists underwent manual time-motion observation to measure the length of time spent directly with patients on the following 3 activities: EHR use, conversation, and examination.

MAIN OUTCOMES AND MEASURES The study outcomes were time spent by ophthalmologists directly with patients on EHR use, conversation, and examination as well as total time required by ophthalmologists for EHR use.

RESULTS Among the 27 ophthalmologists in this study (10 women and 17 men; mean [SD] age, 47.3 [10.7] years [median, 44; range, 34-73 years]) the mean (SD) total ophthalmologist examination time was 11.2 (6.3) minutes per patient, of which 3.0 (1.8) minutes (27% of the examination time) were spent on EHR use, 4.7 (4.2) minutes (42%) on conversation, and 3.5 (2.3) minutes (31%) on examination. Mean (SD) total ophthalmologist time spent using the EHR was 10.8 (5.0) minutes per encounter (range, 5.8-28.6 minutes). The typical ophthalmologist spent 3.7 hours using the EHR for a full day of clinic: 2.1 hours during examinations and 1.6 hours outside the clinic session. Linear mixed effects models showed a positive association between EHR use and billing level and a negative association between EHR use per encounter and clinic volume. Each additional encounter per clinic was associated with a decrease of 1.7 minutes (95% CI, -4.3 to 1.0) of EHR use time per encounter for ophthalmologists with high mean billing levels (adjusted R^2 = 0.42; P = .01).

CONCLUSIONS AND RELEVANCE Ophthalmologists have limited time with patients during office visits, and EHR use requires a substantial portion of that time. There is variability in EHR use patterns among ophthalmologists.

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Electronic health record (EHR) systems have transformed modern medical care.[1] The transition from paper-based records to EHRs within hospitals and ambulatory practices has been aggressively promoted by federal initiatives.[2] Among all office-based clinicians in the United States, 74% had a certified EHR in 2014.[3] Adoption within nonfederal acute care hospitals is almost universal, with more than 95% possessing a certified EHR.[4]

However, physicians have raised concerns that EHR implementation has negatively affected their productivity.[5] Published studies in the surgical, intensive care, and ophthalmology settings have reported mixed outcomes with respect to physician documentation times in the EHR: some report longer times, while others report shorter times.[6-10] Additional studies have raised concerns that EHR use may negatively affect the physician-patient relationship.[11,12]

Meanwhile, these problems are exacerbated by the growing complexity and documentation associated with medical care. Physicians are pressured to see more patients in less time because of challenges involving accessibility and cost of care.[13,14] Through new programs, such as the Medicare Access and CHIP (Children's Health Insurance Program) Reauthorization Act of 2015, physician reimbursement is based increasingly on value-based purchasing models, which require additional documentation to measure quality and cost of care. These factors are increasing the documentation and time burden for physicians.

To our knowledge, few studies have rigorously examined the association of EHRs with ophthalmologists' time requirements. The purpose of our study was to address this gap in knowledge by examining the time requirements of EHR use for ophthalmologists in an outpatient setting using time-motion and data analytic methods.

Methods

Study Institution

Oregon Health & Science University (OHSU) is an academic medical center in Portland, Oregon. The department of ophthalmology at OHSU Casey Eye Institute includes 57 attending faculty ophthalmologists who perform more than 115 000 annual outpatient examinations. In 2014, five of the top 10 physicians at OHSU with the highest annual outpatient clinical volume were ophthalmologists. This department provides primary eye care and serves as a tertiary referral center in the Pacific Northwest and nationally. In 2006, OHSU implemented an institution-wide EHR system (EpicCare; Epic Systems). This vendor is a market share leader among large hospitals.[15] All ambulatory practice management, documentation, order entry, medication prescribing, operating room management, and billing tasks are performed using components of this EHR. This study was approved by the OHSU Institutional Review Board, including waiver of consent for retrospective data analytics study of outpatient encounters.

Study Design

This study involved the following 2 parts: a time-motion study and a data analytics study. Through manual observations, the

Key Points

Question What are the time requirements for ophthalmologists' use of electronic health records?

Findings In this single-center cohort study of 27 ophthalmologists, mean total ophthalmologist examination time was 11.2 minutes per patient, of which 27% was spent on electronic health record use, 42% on conversation, and 31% on patient examination. Mean total ophthalmologist time spent using the electronic health record was 10.8 minutes per encounter, translating to 3.7 hours per day using the electronic health record (2.1 hours during patient examinations, and 1.6 hours outside the clinic session).

Meaning Although simultaneous electronic health record and conversation or examination time were not determined, this study suggests that electronic health record use requires substantial time by ophthalmologists, with variability in electronic health record use patterns.

time-motion study examined aspects of time requirements for EHR use compared with other activities during patient encounters. The data analytics study used EHR time stamps to perform larger-scale analysis of time requirements for EHR use during and after encounters.

Time-Motion Study

Five ophthalmologists from different subspecialties (comprehensive, cornea, glaucoma, pediatrics, and retina) were observed for a minimum of 5 half-day clinic sessions between September 1, 2013, and December 31, 2016. Observers used mobile devices and software (Numbers; Apple Inc) to record time-motion data of ophthalmologists starting and ending patient examinations and switching between 3 predefined activities with patients: EHR use, conversation, and examination. When EHR use or examination occurred concomitantly with conversation, the time was attributed to the nonconversation activity. Observers were trained by two of us (S.R.-B. and M.R.H.), performed parallel observation with us, and compared their observations with our observations to ensure that data collected were consistent. Time-motion data were processed to determine the duration and distribution of time spent in examination rooms with patients. The following observed encounters were excluded: encounters with incomplete timing data, additional encounters for the same patient (only the first encounter was included), and encounters that included EHR scribes (who were not widely used within the department at the time of the study).

Data Analytics Study: EHR Time Stamps

Because manual time-motion observation is cumbersome, we developed methods using EHR time stamps to broaden our analysis to all OHSU ophthalmologists. For our study, we identified "stable faculty ophthalmologists" as attending physicians who worked at OHSU for at least 6 months before and after the study period. This definition minimized bias from physicians with growing or shrinking practices. Ophthalmologists with fewer than 200 patient encounters in 2014 or who did not use the EHR were excluded. Physician demographic

characteristics (sex, age, years in practice, and ophthalmic subspecialty) were gathered using publicly available data.

We collected time stamp data for patient encounters by querying audit logs of EHR system use along with data about patient encounters. For each ophthalmologist, we counted the minutes with time-stamped events in audit log records for every encounter, both during (between patient check-in and checkout) and after the patient encounter until it was completed. We validated this approach by comparing EHR time stamp data findings against reference standard data from manual time-motion observations during 363 patient encounters.

For analysis of factors affecting EHR time requirements from January 1, 2014, to December 31, 2014, we identified the median half-day clinic volume for ophthalmologists and the primary billing code for each encounter, which was used as a proxy for complexity. Based on input from the ophthalmology departmental billing manager, we categorized the billing level as low (level 1-2 evaluation and management office visits, short preoperative and postoperative encounters, brief or intermediate cosmetic evaluations, vision examinations, and special procedures), medium (level 3 office visits, comprehensive cosmetic evaluations, intermediate or established comprehensive eye examinations, and refractive surgery consultations), or high (level 4-5 office visits, eye examinations that include treatment, and new comprehensive eye examinations).

Statistical Analysis

We analyzed factors that affected ophthalmologists' EHR use for outpatient encounters using 2 different models in R.[16] First, analyzing all encounters, we used the lme4 function[17] to perform a linear mixed effects analysis of total EHR interaction, including various fixed effects with the random effects of the ophthalmologist and the patient. We used a log normal transformation of EHR interaction time in the model. *P* values were calculated using the *glht* R function in the *multcomp* library.[18] Second, aggregating data for ophthalmologists, we created a linear model with interactions using characteristics of each ophthalmologist along with his or her typical encounter characteristics. *P* < .05 (2-sided) was considered significant.

Results

Study Physicians

Based on our study criteria, 27 stable ophthalmologists were identified (and are defined) (**Table 1**) at OHSU in 2014. A total of 46 519 outpatient encounters were completed in 2014 by these ophthalmologists. Overall, 10 ophthalmologists (37.0%) were female, and the mean (SD) age was 47.3 (10.7) years (median, 44; range, 34-73 years). Ten subspecialties were represented, with the largest numbers in glaucoma and retina (4 ophthalmologists each). In 2014 the mean annual volume per ophthalmologist was 1872 (range, 235-4833) patient encounters.

Time-Motion: Manually Observed Time Requirements

Five ophthalmologists were observed for 32 half-day clinics and 444 patient encounters. Eighty-one (18.2%) observed encounters were excluded (23 [5.2%] because of additional visits and

Table 1. Characteristics of 27 Stable Faculty Ophthalmologists and Their Encounters Using the EHR System in 2014[a]

Characteristic	Ophthalmologists (N = 27)
Female sex, No. (%)	10 (37.0)
Age, median (range), y[b]	44 (34-73)
Years in practice, No. (%)[b]	
1-9	11 (41)
10-19	8 (30)
≥20	8 (30)
Subspecialty, No. (%)	
Glaucoma	4 (15)
Retina	4 (15)
Oculoplastics	3 (11)
Pediatrics	3 (11)
Uveitis	3 (11)
Comprehensive	2 (7)
Cornea	2 (7)
Genetics	2 (7)
Neuro-ophthalmology	2 (7)
Oncology	2 (7)
Half-day clinic volume, median (range), No. of encounters	14 (3-22)
Encounter billing level, No./total No. (%)[c]	
Low	13 485/46 516 (29)
Medium	19 979/46 516 (43)
High	13 052/46 516 (28)

Abbreviation: EHR, electronic health record.

[a] Stable clinicians were identified based on having worked at the study institution for 6 months before and after the study period.

[b] Age and length of practice were calculated based on the beginning of the study period (January 1, 2014).

[c] Billing level was categorized as low (level 1-2 evaluation and management office visits, preoperative and postoperative encounters, brief or intermediate cosmetic evaluations, vision examinations, and special procedures), medium (level 3 office visits, comprehensive cosmetic evaluations, intermediate or established comprehensive eye examinations, and refractive surgery consultations), or high (level 4-5 office visits, eye examinations that included treatment, and new comprehensive eye examinations).

36 [8.1%] because of missing data), leaving 363 encounters for analysis. Lengths of manually observed ophthalmologist-patient encounters ranged from 2 to 60 minutes. **Table 2** summarizes the mean ophthalmologist time requirements per encounter for each of the in-examination activities (EHR use, conversation, and examination). Overall, ophthalmologists spent a mean (SD) of 11.2 (6.3) minutes per encounter (3.0 [1.8] minutes [27%] for EHR use, 4.7 [4.2] minutes [42%] for conversation, and 3.5 [2.3] minutes [31%] for examination).

Data Analytics: Validation of EHR Time Stamp Data

For each of the 363 observed encounters, we used time stamp methods to estimate EHR time use. The mean time spent using the EHR based on manually observed data was 3.0 minutes compared with 4.3 minutes for the same encounters based on EHR time stamp data. The mean difference using these 2 methods was 1.3 minutes (range, −5.7 to 9.5 minutes). Overall, time use measurements by EHR time stamps were within

Table 2. Time Requirements by Ophthalmologists During Patient Encounters for Activities During Examination[a]

Ophthalmologist by Subspecialty	EHR Use		Conversation		Examination		Total Time	
	Minutes, Mean (SD)	%	Minutes, Mean (SD)	%	Minutes, Mean (SD)	%	Minutes, Mean (SD)	No.[b]
Comprehensive	2.4 (1.7)	21	5.7 (3.4)	50[c]	3.2 (2.0)	28[c]	11.4 (4.9)	39
Cornea	2.6 (2.1)	25	5.0 (3.2)	48[c]	2.8 (2.9)	27	10.4 (6.3)	44
Glaucoma	2.6 (1.7)	26	4.0 (4.4)	40[c]	3.4 (1.1)	34[c]	10.1 (4.8)	65
Pediatrics	2.8 (1.6)	21	6.5 (4.9)	49[c]	4.0 (2.6)	30[c]	13.3 (7.3)	111
Retina	3.8 (1.9)	38	2.9 (3.0)	29	3.4 (2.5)	34	10.0 (5.9)	104
Overall	3.0 (1.8)	27	4.7 (4.2)	42[c]	3.5 (2.3)	31[c]	11.2 (6.3)	363

Abbreviation: EHR, electronic health record.

[a] Data are displayed per patient encounter for 5 ophthalmologists and were obtained using manual observation time-motion methods.

[b] Number of unique patients observed.

[c] $P < .05$ (2-sided) when comparing time spent in conversation and examination with time spent using the EHR.

Figure 1. Mean Electronic Health Record (EHR) Time per Patient Encounter vs Median Half-Day Clinic Volume by Mean Billing Level
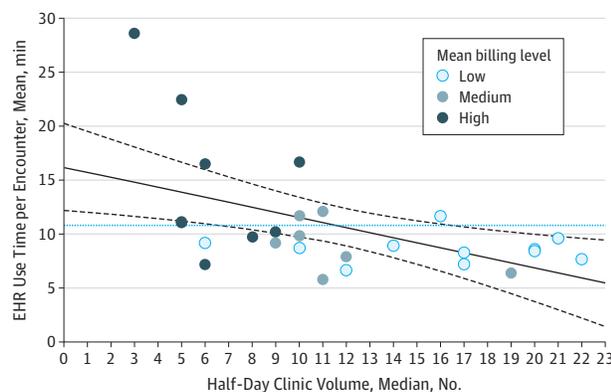
Mean EHR use time per encounter was 10.8 minutes (dotted horizontal line) (range, 5.8-28.6 minutes). Linear regression fits and 95% CIs are displayed. Low billing level was defined as level 1-2 evaluation and management office visits, preoperative and postoperative encounters, brief or intermediate cosmetic evaluations, vision examinations, or special procedures. Medium billing level was defined as level 3 office visits, comprehensive cosmetic evaluations, intermediate or established comprehensive eye examinations, or refractive surgery consultations. High billing level was defined as level 4-5 office visits, eye examinations that included treatment, or new comprehensive eye examinations.

3 minutes of the reference standard manually observed time-motion data in 278 of 363 encounters (76.6%).

EHR Use Analysis

We created the following 2 models of the data: one focusing on encounters and another on ophthalmologists. For both models, we considered various effects, but the only significant ones were encounter billing level and clinic volume.

Model 1 was a mixed linear model of all encounters, with random effects (encounter's ophthalmologist and patient) combined with interacting fixed effects (encounter's session volume and billing level). This model showed that increasing the billing level of an encounter was associated with an increase in EHR use in that encounter, but that the outcome was mitigated by clinic volume. For example, at the median clinic volume (14 encounters), EHR use time increased by 26% at medium billing levels compared with low billing levels, by 64%

at high billing levels compared with low billing levels, and by 30% at high billing levels compared with medium billing levels ($P < .001$ for all comparisons). However, increases in clinic volume were associated with decreases in EHR use and were affected by billing level. For low–billing level encounters, clinic volume was associated with a minor influence of clinic volume on EHR time per encounter (0.01% per additional encounter; $P < .001$). Clinic volume for high-billing level encounters was associated with a greater influence (−0.64% per additional encounter; $P < .001$), while medium level encounters were associated with the greatest influence (−1.10% per additional encounter; $P < .001$).

Model 2 used data aggregated by ophthalmologist. **Figure 1** displays the mean EHR use time per encounter for each ophthalmologist as a function of clinic volume. The mean (SD) total time spent by ophthalmologists for EHR use was 10.8 (5.0) minutes per encounter (range, 5.8-28.6 minutes per encounter). As shown in Figure 1 and **Table 3**, increases in ophthalmologists' median half-day clinic volume were associated with decreases in EHR use time per encounter. Furthermore, **Figure 2** displays the influence of mean billing level on mean EHR use time per encounter for each ophthalmologist. Overall, ophthalmologists with the highest half-day clinic volumes had the lowest mean billing levels, while ophthalmologists with high mean billing levels had the lowest half-day clinic volumes and their clinic volume was associated with the biggest influence on their EHR use. The influence of volume on EHR time ranged from near zero for ophthalmologists with lower mean billing levels (Figure 2A) to −1.7 minutes (95% CI, -4.3 to 1.0) per additional encounter for ophthalmologists with higher mean billing levels (Figure 2B) (adjusted R^2 = 0.42; $P = .01$ for high mean billing level).

Extrapolating our findings from half-day clinics, study ophthalmologists spent a mean 3.7 hours using the EHR for a full-day clinic session: 2.1 hours during encounters, and 1.6 hours outside the clinic session. High-volume ophthalmologists spent the most time using the EHR outside of clinic sessions, with a mean 2.3 hours of EHR use per full-day clinic.

Discussion

The key findings from the manual time-motion observation and data analysis of EHR time stamps were that ophthalmolo-

Table 3. Time Requirements for EHR Use per Encounter and per Median Half-Day Clinic[a]

Median Clinic Volume for Ophthalmologist[b]	No.	Mean (SD) [Range], min	
		EHR Use Time per Encounter	EHR Use Time per Median Half-Day Clinic
Low	10	13.5 (6.9) [7.2-28.6]	75.7 (22.6) [43.0-112.1]
During encounter[c]		6.5 (3.2) [3.0-12.7]	39.3 (18.2) [9.0-63.5]
After encounter		7.0 (7.0) [0.8-25.6]	36.4 (20.9) [4.2-76.8]
Medium	9	9.8 (3.3) [5.8-16.7]	107.4 (31.4) [64.1-166.9]
During encounter		6.3 (1.7) [3.8-8.5]	69.3 (18.4) [42.0-96.2]
After encounter		3.5 (2.1) [1.4-8.5]	38.1 (19.9) [17.2-85.5]
High	8	8.5 (1.6) [6.4-11.7]	160.2 (28.9) [121.2-200.2]
During encounter		4.8 (1.2) [3.2-6.3]	90.5 (24) [61.8-132.8]
After encounter		3.7 (1.9) [1.4-7.8]	69.7 (31.3) [23.1-124.7]
Total	27	10.8 (5.0) [5.8-28.6]	111.3 (43.9) [43.0-200.2]
During encounter		5.9 (2.3) [3.0-12.7]	64.5 (28.9) [9.0-132.8]
After encounter		4.8 (4.7) [0.8-25.6]	46.8 (27.7) [4.2-124.7]

Abbreviation: EHR, electronic health record.

[a] Data are displayed for 27 ophthalmologists divided among 3 categories based on their median half-day clinic volume.

[b] Median clinic volume per half-day clinic was categorized as low (3.0-9.2 patients), medium (9.3-15.6 patients), and high (15.7-22.0 patients).

[c] Electronic health record use during encounter was defined as use that occurred while the patient was physically in the clinic; EHR use after the encounter was defined as EHR use that occurred after the patient had left and before medical record closure.

gists have limited time with patients, time requirements associated with EHR use are significant, and ophthalmologists differ in their patterns of EHR use.

The first key finding is that ophthalmologists have limited time to spend with patients. Manual observation showed that ophthalmologists spent a mean of 11.2 minutes per encounter (Table 2). Although physicians report feeling pressured for time, studies show that the length of patient visits has increased in all primary care specialties except ophthalmology and psychiatry.[19-22] Physicians face growing time pressures as care of chronic medical issues becomes more complex[23] and as increasing emphasis is placed on reporting patient satisfaction and quality of care metrics.[24] During patient visits, physicians are expected to address acute and chronic issues, provide preventive care, and form a relationship with the patient.[25] These time pressures may have negative consequences for patients, as research suggests that physician performance suffers under time pressure.[26]

The second key finding is that EHR use requires significant time by ophthalmologists. In this study, EHR use accounted for 27% of ophthalmologist time during encounters, representing a mean of 10.8 minutes per encounter and 1.9 hours per half-day clinic session (Table 3). Although there were statistically significant differences between the time for EHR use and times for conversation and examination (Table 2), it is not clear if this is a clinically relevant difference. The magnitude and proportion of time spent using the EHR are consistent with previous research.[7,19,27] The time requirements for a full day of clinic (2.1 hours during examinations and 1.6 hours outside the clinic session) are consistent with a similar study outside ophthalmology[28] and represent a significant time burden. Finally, there were 2 ophthalmologists who appeared to be outliers for the time spent per encounter (Figure 1). Removing these 2 ophthalmologists did not result in a significant change in mean (SD) EHR use time (9.6 [2.7] minutes). We included all ophthalmologists in the analysis to represent the inherent variability in EHR use time among different clinicians. Overall, these quantitative study findings support physicians' reports of using EHRs during and after work hours for excessive lengths of time.[29,30]

The purpose of this study was to analyze the amount of time clinicians spent using the EHR, not to determine its positive or negative outcomes. Although studies have shown that the nature of EHR documentation is different from paper documentation,[31] the overall association of EHRs with quality of care warrants further study. That said, adoption of EHRs has altered the nature of the physician-patient relationship.[32,33] Although EHRs have enormous potential to improve quality of care,[34-36] they also create clerical and cognitive burdens, bloated records with copied and pasted text, and frequent interruptions that threaten the potentially beneficial outcomes.[37-39] Physicians have expressed concern about pressures from the competing demands of patient care and EHR requirements.[40] Furthermore, 57% of physicians display 1 or more signs of burnout and 45% report dissatisfaction with work-life balance.[41] Several surveys have shown a correlation between EHR use and physician burnout due to EHR-related stress and significant EHR time spent outside traditional work hours.[29,42,43] Future research should investigate ways to lessen these burdens.

The final key study finding is that there is significant variation among ophthalmologists regarding time requirements and EHR use patterns (Figures 1 and 2). In general, higher clinic volumes are associated with less EHR time per encounter and more total EHR time (Table 3). Billing level, a reflection of the complexity of the patient encounter and documentation, also affects the variability of EHR use among ophthalmologists.[44] Encounters billed at a higher level were associated with longer EHR use times, but this outcome was mitigated by clinical volume. Ophthalmologists with medium and high mean billing levels had lower clinic volumes and their EHR use was the most affected by changes in clinic volume. In addition, there was greater variability in EHR use per patient encounter among ophthalmologists within the medium and high mean billing levels. Ophthalmologists with low mean billing levels saw the most patients, displayed a wide variety of clinic volumes, and were not affected by the influence of clinic volume on EHR use. Future studies should focus on understanding the differences in EHR use among similar physicians, not only for identifying habits that improve efficiency but also for ensuring that shortcuts (eg, copying and pasting text) are not detrimental to patient care.

Figure 2. Mean Electronic Health Record (EHR) Time per Patient Encounter vs Clinic Volume by Mean Billing Level

A Low mean billing level

B Medium mean billing level

C High mean billing level
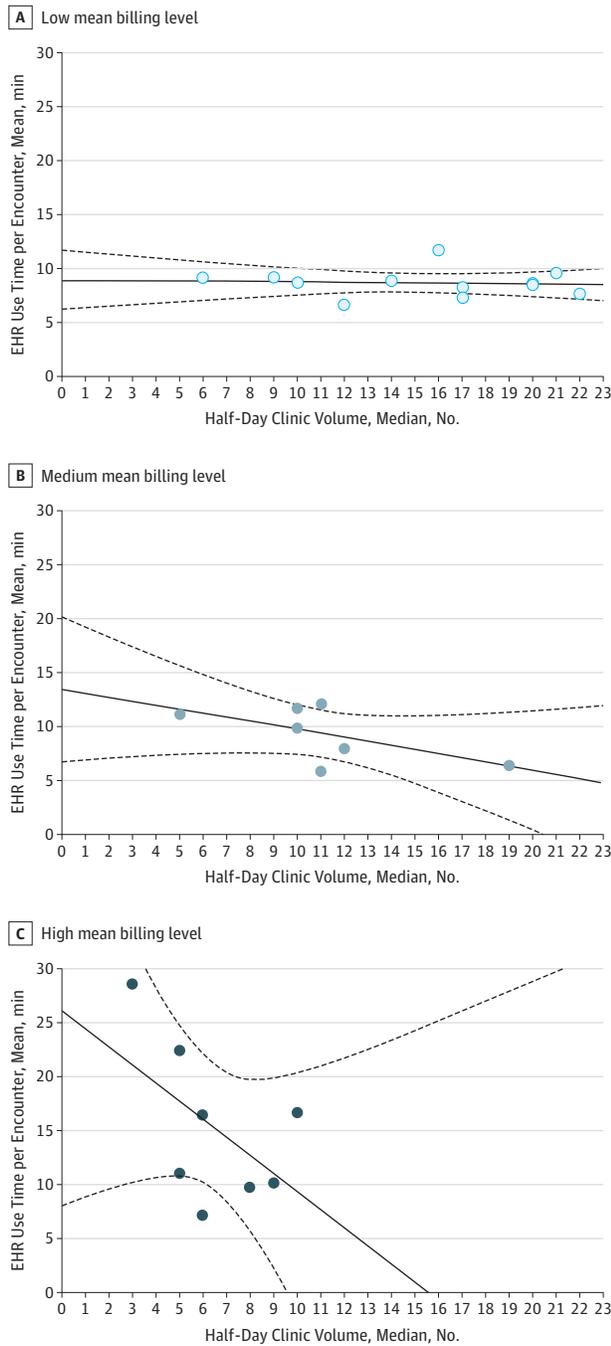
A, Low billing level, defined as level 1-2 evaluation and management office visits, preoperative and postoperative encounters, brief or intermediate cosmetic evaluations, vision examinations, or special procedures. B, Medium billing level, defined as level 3 office visits, comprehensive cosmetic evaluations, intermediate or established comprehensive eye examinations, or refractive surgery consultations. C, High billing level, defined as level 4-5 office visits, eye examinations that included treatment, or new comprehensive eye examinations. Linear regression fits and 95% CIs are displayed.

All ophthalmologists in this study spent more than 5.8 minutes on average using the EHR per patient encounter, suggest-

ing that there is a minimum amount of EHR time needed per encounter. Ophthalmologists differed in when they used the EHR: among study physicians, 8 of 27 (30%) completed more than half of their EHR use after the encounter, and high-volume ophthalmologists spent the most time using the EHR after the clinic session. It was not possible to discern why these ophthalmologists used the EHR after the clinic session and whether those reasons consisted of examination time constraints, work flexibility, comfort level with the EHR, preservation of the physician-patient relationship, or other factors. Future studies will further investigate physician work patterns, including which parts of the patient encounter documentation and communication are completed during vs after the examination.

In summary, these findings highlight the importance of developing EHRs to meet the needs of patients and physicians and to develop appropriate training programs to improve the quality and efficiency of care.[45,46] Addressing EHR usability through user-centered design methods will be an important step toward improving EHR workflow and data accessibility.[47] Professional groups have long advocated for improved EHRs designed in collaboration between clinicians and vendors, yet the efficiency of current EHRs continues to be a challenge.[40,48-50] We hope that this study will inspire clinicians and system designers to collaborate on improving EHR systems.

Limitations

Several study limitations should be noted. This study was limited to the manual observation of 5 ophthalmologists and the EHR time stamp analysis of 27 ophthalmologists at 1 institution and the findings may not be generalizable to other specialties, clinical settings, or EHRs. However, the consistency between EHR time stamp data and manual observation findings and between the quantitative results of this study and previously published qualitative findings suggests that these methods are generalizable. Although we believe ophthalmology is a representative domain for other fields because it is a fast-paced specialty with both medical and surgical components, additional studies are needed. This study did not investigate the association between EHR use and satisfaction. Further research is needed to determine if the time requirements for EHR are correlated with positive or negative feelings about EHRs. Time-saving practices such as copying and pasting text were not included in the analysis. We imagine that the use and effect of these practices would vary by clinician and believe that future studies will be important to address the association of such practices with EHR use time. For simplicity, we used only the primary office visit billing code as a proxy for encounter complexity. Future studies are needed to investigate the influence of additional procedures on encounter complexity. At the study institution, ancillary staff and trainees perform and record intake examinations (history, medications, and preliminary examination findings) and the clinician completes the examination. Although this is a fairly standard workflow in ophthalmology, our findings may not apply to alternative workflows without this initial examination. This study inferred EHR use from

time stamps with a coarse (1-minute) granularity that may have led to the overestimation or underestimation of ophthalmologist EHR use. Although time-motion studies reveal more precise information from a smaller number of encounters, we found that it was impractical given the large number of physicians involved. In practice, ophthalmologists often talk with patients while simultaneously examining them or using the EHR. We recorded this multitasked time as the nonconversation activity, which may have caused a bias of decreased conversation time. Without recording multitasked time in this way, a time-motion study would have been impractical.

Conclusions

Overall, these study findings support anecdotal reports that EHRs create significant time burdens for ophthalmologists both during and after clinics. Ophthalmologists varied with regard to their time requirements and EHR use, suggesting that there may be approaches to address these challenges through training and experience. These findings have important implications for all practicing physicians regarding clinical efficiency, patient and physician satisfaction, design of improved EHR systems, and quality of care.

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