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Changes in Electronic Health Record Use Time and Documentation over the Course of a Decade

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Abstract

Purpose: With the current wide adoption of electronic health records (EHRs) by ophthalmologists, there are widespread concerns about the amount of time spent using the EHR. The goal of this study was to examine how the amount of time spent using EHRs as well as related documentation behaviors changed 1 decade after EHR adoption.

Design: Single-center cohort study.

Participants: Six hundred eighty-five thousand three hundred sixty-one office visits with 70 ophthalmology providers.

Methods: We calculated time spent using the EHR associated with each individual office visit using EHR audit logs and determined chart closure times and progress note length from secondary EHR data. We tracked and modeled how these metrics changed from 2006 to 2016 with linear mixed models.

Main Outcome Measures: Minutes spent using the EHR associated with an office visit, chart closure time in hours from the office visit check-in time, and progress note length in characters.

Results: Median EHR time per office visit in 2006 was 4.2 minutes (interquartile range [IQR], 3.5 minutes), and increased to 6.4 minutes (IQR, 4.5 minutes) in 2016. Median chart closure time

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HUMAN SUBJECTS: Human subjects were included in this study. The human ethics committees at Oregon Health & Science University approved the study. This research adhered to the tenets of the declaration of Helsinki, and was approved by the OHSU institutional review board, which granted a waiver of informed consent for analysis of coded electronic health record data in this study.

No animal subjects were included in this study.

was 2.8 hours (IQR, 21.3 hours) in 2006 and decreased to 2.3 hours (IQR, 18.5 hours) in 2016. In 2006, median note length was 1530 characters (IQR, 1435 characters) and increased to 3838 characters (IQR, 2668.3 characters) in 2016. Linear mixed models found EHR time per office visit was $31.9 \pm 0.2\%$ ($P < 0.001$) greater from 2014 through 2016 than from 2006 through 2010, chart closure time was 6.7 ± 0.3 hours ($P < 0.001$) shorter from 2014 through 2016 versus 2006 through 2010, and note length was 1807.4 ± 6.5 characters ($P < 0.001$) longer from 2014 through 2016 versus 2006 through 2010.

Conclusions—After 1 decade of use, providers spend more time using the EHR for an office visit, generate longer notes, and close the chart faster. These changes are likely to represent increased time and documentation pressure for providers. Electronic health record redesign and new documentation regulations may help to address these issues.

Electronic health records (EHRs) have been adopted rapidly throughout the United States, with 72% of ophthalmologists using EHRs from 2015 through 2016.¹ Although adopting EHRs has many benefits, EHR adoption also is associated with a variety of unintended consequences.^{2–4} In particular, EHR adoption has raised concerns about potential negative impacts on factors including financial success, clinical efficiency, provider burnout, provider cognition, patient communication, and data accuracy.^{1,5–9} Although studies have examined whether satisfaction with EHRs improves a few years after adoption, studies over longer periods are rare.^{10,11}

A common factor in many concerns about EHRs is the amount of time providers spend using the EHR. Previous studies using EHR audit logs estimated that ophthalmologists spent on average 3.7 hours per day using the EHR for office visits,¹² and primary care physicians spent 6 hours per day.¹³ Time and motion studies in ophthalmology and other fields report approximately 33% to 40% of examination time is spent on the computer,^{14,15} and a survey study found internists self-reported 48 minutes of free time lost to EHR-related activities each clinic day.¹⁶ However, these studies used periods of 10 days to 3 years; knowing how EHR use has changed over an extended period is an important gap in knowledge.

The goal of this study was to begin to understand how ophthalmology providers' EHR use for an office visit has changed 1 decade after adoption, both in terms of time spent and documentation behavior. Studying how time spent using the EHR changes over an extended period provides additional insight into how using EHRs affects providers and how federal regulations during this decade potentially have affected provider behavior.

Methods

This study was approved by the institutional review board at Oregon Health & Science University (OHSU). This research adhered to the tenets of the Declaration of Helsinki, and was approved by the OHSU institutional review board, which granted a waiver of informed consent for analysis of coded electronic health record data in this study.

Study Institution and Department

The OHSU Casey Eye Institute includes more than 50 faculty providers who conduct more than 130 000 outpatient examinations annually. The department provides primary eye care

and is a tertiary referral center for the Pacific Northwest and nationally. The department adopted its current EHR in February 2006 with a vendor that is a market share leader among large hospitals (EpicCare; Epic Systems, Verona, WI).¹⁷ Ambulatory practice management, documentation, electronic communication, order entry, medication prescribing, operating room management, and billing tasks currently are completed using the EHR.

Meaningful Use

We reviewed internal documents to determine periods characterizing OHSU's compliance with federal Meaningful Use (MU) regulations: before MU (EHR use before compliance with MU), MU stage 1 adoption (EHR use in the process of complying with MU), MU stage 1 attestation (compliance with MU stage 1), and MU stage 2 attestation (compliance with MU stage 2). These periods were used to categorize office visits according to their visit date. Additionally, we acquired data about which years study providers attested for MU.

Electronic Health Record Office Visit Timing and Use Data

The period of this longitudinal study was from January 1, 2006, through December 31, 2016. Attending ophthalmologists or optometrists were included in this study if they met the following criteria per year: (1) for the first year only, conducted office visits in January and February; (2) conducted more than 200 office visits; and (3) either conducted office visits in November and December or conducted more than 200 office visits the following year. For 2006, February and March were used instead of January and February, because the EHR was not fully in use until February. These criteria were chosen to minimize bias from providers with growing or shrinking practices and from providers not regularly seeing patients.

Provider audit logs, office visit data, and progress note data were gathered via OHSU's clinical data warehouse (EpicCare). We collected relevant audit log entries for each office visit that were recorded by the provider for the office visit and that occurred between patient check-in time and chart closure time. Then, using previously published methods, which also account for instances when multiple charts are open at once,^{12,18} we calculated the provider's EHR time per office visit as the number of distinct minutes in that provider's relevant audit log entries for each visit. If multiple office visits were accessed in the same minute, the minute was divided proportionally between all office visits according to the number of audit logs associated with each visit recorded in that minute. Time spent using the EHR did not include any time from ancillary staff, providers, or trainees. Note length was taken as the sum of the characters of all progress notes associated with an office visit, and chart closure time was calculated as check-in time subtracted from close date time. Time spent using the EHR, chart closure time, and note length were chosen as our study metrics because they provided insight into provider EHR use and the nature of the notes produced during this work and because they could be tracked over a long period and on a large scale.

Office visits were excluded if they were missing check-in times, chart closure times, or note length data. We also excluded office visits with incorrect chart closure times—less than 10 minutes or more than 4 weeks—based on recommendations from Casey Eye Institute's billing manager.

Statistical Analysis

Processing of data, creation of summary statistics and models, and calculation of P values were conducted in R software version 3.5.0 (R Foundation for Statistical Computing, Vienna, Austria). We constructed linear mixed models in which the dependent variable was 1 of 3 metrics (time spent using EHR per office visit, chart closure time, or note length), the fixed effect was MU period, and the random effects were providers and patients. We constructed an additional note length mixed model in which the fixed effect was years and the random effects were providers and patients. Electronic health record use time was not normally distributed, so we used the natural log transformation in the model, which reports model effects in percentages. Models were constructed in lme4 version 1.1–17. (<https://cran.r-project.org/web/packages/lme4/citation.html>).¹⁹ The model effects of MU periods on the dependent variable were compared using the Tukey test with the multcomp package version 1.4–8²⁰ (<https://cran.r-project.org/web/packages/multcomp/citation.html>) and were adjusted using the Holm-Bonferroni method. A type II Wald chi-square test was used to calculate the P value for the year model. Significance was defined as $P < 0.05$.

Results

Provider Overview

Summary data for the 70 ophthalmology providers who met inclusion criteria are displayed in Table 1. A plurality (16/70 [23%]) were comprehensive providers, 27 of 70 (39%) were women, and 43 of 70 (61%) were men. On average, study providers worked at OHSU for 5.9 ± 3.8 years. On average, 88% of providers successfully attested for MU each year of the program. In all, study providers conducted 692 984 office visits during the study period. After applying exclusion criteria, 685 361 visits were analyzed.

Meaningful Use

The periods corresponding to OHSU's MU compliance were before MU, January 1, 2006 through November 2, 2010, when the first e-mail about complying with MU was sent to OHSU providers²¹; MU stage 1 adoption, November 2, 2010, through August 7, 2011, when more than 95% of providers had attested for MU stage 1²²; MU stage 1 attestation, August 7, 2011, through December 31, 2013; and MU stage 2 attestation, January 1, 2014, through December 31, 2016.

Changes in Electronic Health Record Time per Office Visit

Figure 1 shows how time spent using the EHR per office visit changed between 2006 and 2016, along with MU periods. In 2006, the median was 4.2 minutes (interquartile range [IQR], 3.5 minutes; also the overall minimum median). In 2016, the median was 6.4 minutes (IQR, 4.5 minutes). The maximum median EHR use time per office visit was 8.1 minutes (IQR, 7.5 minutes) in 2014.

Results from the mixed model of time spent using the EHR per office visit are displayed in Table 2. The latter periods 2010 through 2011 (MU stage 1 adoption), 2011 through 2013 (MU stage 1 attestation), and 2014 through 2016 (MU stage 2 attestation) showed significantly larger effects on time per office visit than the initial period 2006 through 2010

(before MU) by $8.9 \pm 0.3\%$ to $39.8 \pm 0.2\%$ ($P < 0.001$), but the effect of the period 2014 through 2016 (MU stage 2 attestation) was smaller than that of 2011 through 2013 (MU stage 1 attestation) by $7.9 \pm 0.2\%$ ($P < 0.001$).

Changes in Chart Closure Time

Changes in chart closure time between 2006 and 2016 are displayed in Figure 2, along with the MU periods. In 2006, median chart closure time was 2.8 hours (IQR, 21.3 hours), whereas in 2016, it was 2.3 hours (IQR, 18.5 hours). Between the 2 end points, the time varied from the minimum median chart closure time of 2.2 hours (IQR, 22.1 hours) in 2015 to the maximum of 20.8 hours (IQR, 117.0 hours) in 2010. Results of the mixed model of chart closure time are displayed in Table S3 (available at www.aaojournal.org). There was a significant increase in the effect of the period 2010 through 2011 (MU stage 1 adoption) compared with the initial period 2006 through 2010 (before MU): 18.5 ± 0.4 hours ($P < 0.001$). After that, the effects were significantly smaller. Both periods 2011 through 2013 (MU stage 1 attestation) and 2014 through 2016 (MU stage 2 attestation) showed significantly smaller effects compared with 2010 through 2011 (MU stage 1 adoption) by 10.9 ± 0.5 hours and 25.1 ± 0.5 hours, respectively ($P < 0.001$), and the effect of the period 2014 through 2016 (MU stage 2 attestation) was significantly smaller than the period 2011 through 2013 (MU stage 1 attestation) by 14.2 ± 0.3 hours ($P < 0.001$).

Changes in Note Length

Median note length increased every year from 1530 characters (IQR, 1435 characters) in 2006 to 3838 characters (IQR, 2668.25 characters) in 2016, an increase of 151%. Each successive period showed significantly greater note length than the previous one in the first mixed model (Table S4, available at www.aaojournal.org). Unlike time spent using the EHR per office visit and chart closure time, median note length seemed to increase more or less linearly regardless of MU period (Fig 3). Taking this into account, we created a linear model of note length and calculated an increase of 264.9 ± 0.9 characters per year ($P < 0.001$).

Discussion

This study has 4 key findings: (1) providers spent more time using the EHR per office visit in 2016 than in 2006, (2) chart closure time was less in 2016 than in 2006, (3) progress note length increased from 2006 to 2016, and (4) trends in time spent using EHR per office visit and chart closure varied over this time, in a pattern related to adoption of federal MU regulations.

The first key finding is that providers spent more time using the EHR per office visit in 2016 than in 2006. Because this study examined all providers working at OHSU throughout the study period, not just those consistently present from 2006 to 2016, the increase could be the result of inexperienced providers who simply take longer. However, of the 14 providers working in the department continuously from 2006 to 2016, 11 of 14 showed a higher median EHR time per office visit in 2016 than in 2006, with an overall increase of 43% (data not shown), suggesting that this was not the case. We also note our study measured time spent using the EHR per office visit and omitted non-EHR clerical work related to office

visits. One study examining provider behavior before and after EHR adoption found no significant difference in the time providers spent on paper-based activities during patient examinations before EHR adoption and 6 months after.¹⁴ Thus, some of the increase between 2016 and 2006 may be the result of increased activities performed on the EHR, particularly the review of old notes. Still, 2 previous studies showed that ophthalmologists spent more time documenting on the EHR as compared with paper charts,^{5,23} and a systematic review of longitudinal studies found physicians spent more time documenting after adopting an EHR, implying that overall time spent on clerical work also increased, at least in the short term.²⁴

Other studies of providers with such mature EHR systems are limited. Although one recent study focusing on productivity showed that providers at community health centers with more EHR experience contributed more to the center's clinic volume, we suggest providers with more experience may contribute more to clinic volume while also using the EHR more.²⁵ A qualitative study interviewing clinicians in the process of preparing for MU stage 3 highlighted persistent concerns about interoperability, patient communication, and managing the vast amount of data in the EHR, as well as the prevalence of workarounds.²⁶ Usability issues likely are reflected in increased EHR use. Several studies have raised concerns about how use of EHRs affects providers' burnout rates, although none explicitly have linked office visit EHR use time and burnout.^{6,27–29} Additional studies to understand how increased EHR use is related to burnout would be worthwhile.

Even if the EHR were a perfect system, we might expect providers to spend more time on the EHR in 2016 versus 2006, simply because so much more data were contained in the EHR in 2016 than in 2006. However, the still recent reporting of usability issues^{26,28} combined with our study findings suggest that some of this increase is attributable to other factors and that more drastic changes to EHR design and regulation may be warranted.

The second key finding is that chart closure time was less in 2016 than in 2006. In contrast to time spent using the EHR, median chart closure time peaked in 2010, after which it decreased and became less variable starting in 2014 (Fig 2). An earlier study reported that chart closure time at OHSU was an increasing trend 3 years after EHR adoption,²³ and it is notable that this trend subsequently has reversed. Stage 1 of MU required providers to make patient records available to 50% of patients who requested their record within 3 business days, whereas stage 2 required providers to make patient records available to 50% of all patients within 4 business days.^{30,31} Although we cannot establish causation, the alignment of these requirements with declining trends in chart closure time and significant decreases in the effects of our mixed model (Fig 2; Table S3, available at www.aaojournal.org) is evidence of the power of federal regulations to change providers' behavior. That chart closure time decreased much sooner than EHR time per office visit may mean providers were spending more time on the EHR each day to close their charts faster. Additional analysis of our data shows that for 38.4% of stage 1 MU office visits, the provider used the EHR outside of 8 AM to 5 PM, as compared with 36.6% of visits before MU, and median EHR time per office visit outside of 8 AM to 5 PM was 2.4 minutes (IQR, 2.6 minutes) for office visits before MU and 3 minutes (IQR, 4 minutes) for stage 1 MU office visits (data not shown). Mixed-model analysis in which patients and providers were the random

variables, MU time was the independent variable, and the log of EHR time per office visit outside of 8 AM to 5 PM was the dependent variable showed that time spent using the EHR per office visit outside of 8 AM to 5 PM was 28.8% longer during stage 1 of MU as compared with before MU ($P < 0.001$, data not shown), suggesting providers worked more outside of business hours to close charts faster.

The third key finding is that progress note length increased more or less consistently since EHR adoption in 2006. Some of the increase may be the result of providers adapting to a new medium, because one study found ophthalmology notes in the EHR have come to rely more on structured textual descriptions.³² Given prior research noting the phenomenon, another possibility is that some of the increase in length is the result of so-called note bloat caused by imported text (e.g., copy and paste, all normal).^{28,33} Two recent studies found copy and pasted or templated text made up the vast majority of notes in internal medicine and ophthalmology (Henriksen et al. *Invest Ophthalmol Vis Sci.* 2018;59:ARVO E-Abstract 4155).³⁴ Another study comparing sequential examination notes in ophthalmology found that most progress note text is identical to the previous note.³⁵ This has implications for patient safety and regulatory compliance,³⁶ but also likely makes reviewing progress notes more difficult, increasing the time providers must spend reviewing information in the EHR. This seems to be the experience of physicians, because a 2014 national survey of physicians found that 70% believed that reviewing information took more time with the EHR,³⁷ although there are a number of other possible factors that could influence this finding.³⁸ A few studies have attempted educational interventions that successfully have increased the quality of progress notes while decreasing note length.^{39,40} These studies show promise, but more direct changes in regulation and EHR design may be desirable in the long term.

The final key finding is that trends in EHR time per office visit and chart closure varied over the years studied herein, in a pattern related to adoption of federal MU guidelines. Figure 1 shows relatively stable EHR time per office visit until a marked increase between 2011 and 2014, followed by a decrease in 2015 through 2016. Chart closure time peaked in 2010 and generally decreased thereafter (Fig 2). The increase in EHR time per office visit and decrease in chart closure time in 2011 coincides with OHSU's campaign to comply with the federal MU program, which incentivized hospitals to purchase and use EHRs.^{21,22,30} Our models also show that different MU periods affected our metrics significantly (Table 2; Tables S3 and S4, available at www.aaojournal.org), meaning the MU periods were associated with changes in provider behavior. Oregon Health & Science University was diligent in complying with MU regulations, and used (and continues to use) an EHR found to be supportive of MU compliance.⁴¹ Establishing causation was beyond the scope of this study, and other factors may be partially responsible, but our findings imply that the MU program impacted how long providers used the EHR and how quickly they completed their notes. This may indicate that the MU program succeeded in encouraging providers to use EHRs in positive, productive ways. It also may indicate that MU forced providers to use the EHR in ways that were not beneficial and were time consuming. A recent study evaluating the benefits and burdens of each MU requirement for family physicians found that 18 of 31 criteria had high benefit, whereas 13 did not, meaning the program may have done both.⁴² It is noteworthy that, even while complying with MU stage 2, providers' EHR time per office

visit decreased significantly by $7.9 \pm 2\%$ as compared with MU stage 1, because it suggests providers may become faster at using the EHR over time.

Unlike EHR time per office visit and chart closure time, note length increased linearly from 2006 to 2016 (Fig 3). It is possible that the use of templates and copy and paste contributed to this increasing trend. Meaningful Use did not seem to affect note length as it did for EHR time per office visit and chart closure time because there were no MU guidelines for how notes were structured, merely what went into them and how quickly they were completed. Overall, the fourth key finding suggests that federal regulations successfully changed how providers used the EHR. Regulation reform based on minimizing unnecessary documentation and prioritizing provider time with patients may be equally effective at decreasing note length and ultimately improving quality and efficiency of clinical care.

This study had several limitations. First, this study was conducted retrospectively and cannot establish causation. Second, we were unable to evaluate providers' compliance with individual MU requirements. However, on average, 88% of study physicians successfully attested for MU each year of the program, suggesting that overall compliance was high. Third, the method used to calculate EHR time per office visit was validated using 2014 data.¹² It may be less accurate for earlier years if workflows were drastically different. Fourth, our data warehouse does not store note text, which limits the metrics available for study. Future studies may be needed to examine progress note characteristics in more detail with more specific metrics. Fifth, this study analyzed only office visit audit log data that were recorded after patient check-in time, but EHRs are used in a variety of ways and for activities other than office visits. Further studies with a wider scope may be useful in understanding trends in overall EHR use. Sixth, this study did not take into account presence of scribes or trainees, which likely impacts all factors analyzed in this study.⁴³ Although trainees are commonplace at our institution and frequently do perform documentation during office visits, scribes were not widely used during the study period. Future studies of the effect of trainees and scribes on documentation behavior would be valuable. Finally, this study analyzed data from a single academic institution using 1 EHR. Although we believe OHSU to be a representative academic institution using a common EHR, our findings may not be applicable to providers from other institutions with different documentation practices and different EHRs.

In summary, our study at a single academic institution showed that over the past decade, there has been more EHR time per office visit, faster chart closure times, and longer progress notes. Taken together with other current research, these study findings raise concerns about provider documentation time and note length. Collaboration among clinicians, system developers, and policy makers will be required to address these challenges.

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Abbreviations and Acronyms:

EHR	electronic health record
IQR	interquartile range
MU	Meaningful Use
OHSU	Oregon Health & Science University

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Figure 1.

Graph showing changes in electronic health record (EHR) time per office visit over the course of 1 decade. Meaningful Use (MU) periods are labeled. A total of 13 312 data points were considered outliers and were excluded from the figure.

Figure 2. Graph showing changes in chart closure time over the course of a decade. Meaningful Use (MU) periods are labeled. A total of 53 433 data points were considered outliers and were excluded from the figure.

Figure 3.

Graph showing changes in progress note length over the course of a decade. Meaningful Use (MU) periods are labeled. A total of 11676 data points were considered outliers and were excluded from the figure.

Table 1.

Characteristics of Faculty Study Providers and Average Office Visits and Years of Service from 2006 through 2016

Characteristic	Faculty Providers (n = 70)
Gender, no. (%)	
Female	28 (40)
Provider type, no. (%)	
MD	63 (90)
OD	7 (10)
Subspecialty, no. (%)	
Comprehensive	16 (23)
Cornea	7 (10)
Genetics	3 (4)
Glaucoma	6 (9)
Low vision	2 (3)
Neuro-ophthalmology	3 (4)
Oculoplastics	3 (4)
Oncology	1 (1)
Optometry	5 (7)
Pediatrics	9 (13)
Retina	8 (11)
Uveitis	3 (4)
Dual specialty	4 (6)
Office visits per year	
Average $\pm$ SD	1830.6 $\pm$ 1163.5
Years at OHSU	
Average $\pm$ SD	5.9 3.8

MD = Doctor of Medicine; OD = Doctor of Optometry; OHSU = Oregon Health & Science University; SD = standard deviation.

Table 2.
Differences in Time Spent Using Electronic Health Record per Office Visit in Minutes

Meaningful Use Period	Median Time per Office Visit (Interquartile Range)	Before Meaningful Use	Change in Effect (%) [*]	Meaningful Use Stage 1	Meaningful Use Stage 2
Before MU (January 1, 2006–November 2, 2010)	4.6 (4)	NA			
MU stage 1 adoption (November 2, 2010–August 7, 2011)	5.1 (4.9)	8.9±0.3	NA		
MU stage 1 attestation (August 7, 2011–December 31, 2013)	7.5 (8.1)	39.8±0.2	30.9±0.3	NA	
MU stage 2 attestation (January 1, 2014–December 31, 2016)	6.9 (5.3)	31.9±0.2	23.0±0.3	−7.9±0.2	NA

MU = Meaningful Use; NA = not applicable.

Differences and *P* values were calculated using the Tukey test and Holm-Bonferroni method.

^{*} *P* < 0.001 for all comparisons.