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Electronic health record impact on pediatric ophthalmologists' productivity and efficiency at an academic center

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Abstract

Purpose—To measure the effect of electronic health record (EHR) implementation on productivity and efficiency in the pediatric ophthalmology division at an academic medical center.

Methods—Four established providers were selected from the pediatric ophthalmology division at the Oregon Health & Science University Casey Eye Institute. Clinical volume was compared before and after EHR implementation for each provider. Time elapsed from chart open to completion (OTC time) and the proportion of charts completed during business hours were monitored for 3 years following implementation.

Results—Overall there was an 11% decrease in clinical volume following EHR implementation, which was not statistically significant ($P = 0.18$). The mean OTC time ranged from 5.5 to 28.3 hours among providers in this study, and trends over time were variable among the four providers. Forty-four percent of all charts were closed outside normal business hours (30% on weekdays, 14% on weekends).

Conclusions—EHR implementation was associated with a negative impact on productivity and efficiency in our pediatric ophthalmology division.

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This study was conducted at Oregon Health & Science University, Portland, Oregon

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Electronic health records (EHRs) are becoming an integral part of modern medical care in response to advancements in technology.¹ Federal initiatives^{2,3} aggressively promote EHR adoption by physicians and hospitals to address health care challenges, including the need for better sharing of patient data, changes in the medicolegal environment, and unacceptable rates of medical errors due to misinterpretation of handwriting in paper records.⁴⁻⁶ The increased capability for storage and transfer of data using EHRs creates new opportunities in public health and quality assurance that have the potential to improve quality, decrease unnecessary testing, and reduce the cost of care.⁷⁻¹⁰

Despite these potential benefits, ophthalmologists have been slow to adopt EHR systems. Among all ambulatory physicians in the United States, less than 50% have adopted even a rudimentary EHR system.¹¹⁻¹³ Adoption in ophthalmology may be even more limited, growing from 12% in 2008 to 34% in 2012.^{14,15} There are several impediments to more widespread adoption of EHR, including concerns that EHR implementation may negatively affect clinical productivity and efficiency, that the steep learning curve associated with EHR use is impractical, and that electronic systems may *increase* medical errors.^{2,9,10,16-21}

Among ophthalmologists, there are additional concerns that commercially available institution-wide EHR systems are often designed for use in general medical fields and may not be well suited for ophthalmology. Indeed, several unique documentation elements in ophthalmology may be difficult to adapt to EHRs, including various combinations of drawings, text, numbers, and diagnostic imaging.^{22,23} In addition, ophthalmologists have a unique and complex clinical workflow, have relatively high patient volumes, and must often transition seamlessly between medical and surgical documentation environments.²²

As a small subspecialty, pediatric ophthalmology may face even more potential barriers to effective EHR implementation compared to ophthalmology as a whole. For example, documentation of ocular motility and alignment are crucial portions of the examination in pediatric ophthalmology, which include intricacies that may be difficult to accommodate in commercially available EHRs designed in collaboration with general ophthalmologists.

It has been our impression that pediatric ophthalmologists have expressed frustration with EHRs due to decreased clinical volume, poor efficiency, and increased documentation time. We have previously shown in the department of ophthalmology at Oregon Health & Science University that EHR implementation was associated with decreased clinical volume, prolonged documentation time, and a large proportion of documentation completed after hours.²⁴ The present study provides a detailed subgroup analysis of that previous work, which focuses on productivity, efficiency, and work hours in pediatric ophthalmology, with the rationale this niche subspecialty that may be particularly affected by EHR implementation.

Methods

This study was reviewed by the Institutional Review Board at Oregon Health & Science University and conformed to the requirements of the US Health Insurance Portability and

Accountability Act of 1996. It was granted an exemption because there was no collection of data in a manner that patients could be identified.

Study Institution and Electronic Health Record System

In 2006 an institution-wide EHR system (EpicCare; Epic Systems, Madison, WI) was implemented across all subspecialties within Casey Eye Institute at Oregon Health & Science University (OHSU), an academic medical center. All practice management, clinical documentation, order entry, medication prescription, and billing tasks have been performed using components of the EHR since that time. Prior to implementation, all providers used traditional paper-based records.

All providers at the study institution were required to undergo 15 hours of training before using the EHR system. This included 3 one-hour online modules and 3 four-hour classroom-training sessions. There was supplemental online training available for advanced system features. A university clinical information systems group provides ongoing feedback and training to all faculty providers. Individual default note templates were selected by each subspecialty within the department, including pediatric ophthalmology. The OHSU EHR implementation team suggested that all departments should adjust clinical volume to 50% of baseline during the first 2 weeks, increase to 75% for the following 2 weeks, increase to 90% for 2 weeks thereafter, and then return to baseline clinical volume. However, the actual decision about how to adjust clinical volume during the immediate EHR implementation period was left to individual divisions within the ophthalmology department.

The study period extended for 3 years after the date of EHR implementation (February 1, 2006, to January 31, 2009). Study subjects were faculty providers in the division of pediatric ophthalmology at OHSU. To avoid potential biases introduced by new providers with growing practices or retiring faculty with shrinking patient volume, only “established providers” were included. Established providers were defined as having been in their respective position for at least 5 months before and 5 months after the study period. The authors contacted all providers included in the study to identify any changes in their scheduled number of clinic days over the course of the study period to allow adjustment for this potential confounder.

Evaluation of Productivity

The impact of EHR implementation on productivity was assessed based on clinical volume. Baseline clinical volume for each established provider in the division of pediatric ophthalmology for the 3 months before EHR implementation was identified from the practice management system. To determine clinical volume after implementation, the EHR enterprise reporting system was queried to obtain comparative data from the first 3 years after implementation.

Evaluation of Efficiency

The effect of EHR implementation on efficiency was assessed based on the time elapsed from chart open to completion (OTC time) and after-hours charting. The EHR enterprise reporting system was queried to identify the OTC time for every patient encounter during

the study period. Chart open time was defined as the first moment of data input for the respective encounter, regardless of appointment time, because this was felt to reflect office workflow most accurately. This included data entry by any health care provider, including technicians, orthoptists, or physicians. Chart completion was defined as the time at which the attending pediatric ophthalmologist finalized all clinical and financial documentation as well as any correspondence to other physicians involved in the care of the patient. OTC time was then defined as the time from chart open to chart completion for each patient encounter. This measure does not represent the actual time spent documenting each encounter but rather the time elapsed from initiation to completion of documentation. No OTC time data was available from the paper-charting period for comparison.

To assess the impact of EHR on work hours, the time of day of chart completion was cross-referenced with normal business hours of the pediatric ophthalmology division, defined as 8 AM to 5 PM from Monday through Friday. Chart completion time was categorized as occurring during normal business hours, after-hours on weekdays, or on weekends.

Data Analysis

Data were analyzed at the individual and group levels. Monthly clinical volume per provider was adjusted for changes in scheduled clinic time by calibrating these changes relative to baseline. This parameter was then assessed using descriptive statistics. Mean clinical volume was compared between the baseline paper-charting period and the EHR charting period using unpaired, two-tailed *t* tests. Any months with uncharacteristically low clinical volume (ie, <1.5 times the interquartile range below the lower quartile) were excluded from the analysis under the assumption that they represented brief absences or missed clinic days. Trends during the EHR period were analyzed using simple linear regression for each individual provider. OTC time per encounter was analyzed descriptively and using frequency tables. Statistical software (Excel 2011; Microsoft, Redmond, WA; Stata/SE12, StataCorp, College Station, TX) was used for data management and analysis.

Results

Study Subjects

Four providers in the pediatric ophthalmology department met criteria for established providers; two male and two female. No other demographic characteristics or identifying information were collected, to protect provider confidentiality in consideration of the small number of providers.

Productivity: Clinical Volume

At baseline, provider 1 held 2.5 clinic days/week; provider 2, 1.5; provider 3, 1.5; and provider 4, 2.5. Table 1 and Figure 1 report the change in clinical volume following EHR implementation. In total, volume among these providers changed from (mean $\pm$ standard deviation patients/provider-month) 381.5 ± 29.1 in the paper-charting period to 338.7 ± 53.5 while using EHR, a decrease of 11%, which was not statistically significant ($P = 0.18$). At the individual level, volume during the paper-charting period varied widely, ranging from 21.2 ± 3.8 patients/month (provider 1) to 204 ± 38 patients/month (provider 4). Changes in

volume during the EHR period compared to baseline ranged from an 18% decrease (provider 2) to an 11% increase (provider 1), none of which were statistically significant (P values: 0.16–0.96). Retrospective power calculations demonstrated only 15% to 22% power to detect the observed differences among study providers.

Preliminary testing (Durbin-Watson tests and time-lagged correlation plots) indicated a low likelihood of serial correlations and that the assumptions required for linear regression analysis were likely satisfied. Regression of the EHR period showed a significant positive trend in volume for provider 1 (increasing by 0.43 patients per month [$P < 0.001$]), a significant negative trend for provider 2 (decreasing by 0.91 patients per month [$P = 0.003$]), and nonsignificant negative trends for provider 3 (decreasing by 0.55 patients per month [$P = 0.30$]) and provider 4 (decreasing by 0.06 patients per month [$P = 0.91$]).

Efficiency: Time from Chart Open to Completion (OTC time)

Table 2 summarizes OTC time for each provider during the first 3 years following EHR implementation. The total number of EHR charts completed over the course of the 3-year study period ranged from 1,656 (provider 1) to 6,184 (provider 4). Data for all providers studied exhibited significant positive skew, so geometric means were calculated for central tendency and interquartile ranges (IQR) were calculated for spread. Provider 2 had the fastest documentation time, with a mean of 5.5 hours (IQR, 1.8–138.8), which was more than five times faster than that of the slowest provider. Half of all charts were completed within 5 hours for provider 2, while completing 50% of charts required 26 hours for provider 1, 48 hours for provider 3, and 62 hours for provider 4.

Figure 2 shows time of chart completion with respect to normal business hours. Across all providers, 56% of charts were completed during normal business hours, 30% after-hours on weekdays, and 14% during weekends.

Discussion

This study measured the impact of EHR implementation on clinical productivity and efficiency in pediatric ophthalmology by assessing clinical volume, time elapsed from chart open to completion (OTC time), and after-hours charting. Key findings are that (1) overall clinical volume decreased by 11% after EHR implementation compared to baseline, although this change was not statistically significant; (2) nearly half of all EHR chart completion occurred outside normal business hours; and (3) there were large variations among individual providers with respect to direction and magnitude of change in clinical volume and OTC time following implementation.

Across all four providers, clinical volume decreased by 11% when using EHR compared to paper records. The fact that this change was not statistically significant may be due to inadequate power. However, this observed change was certainly perceived by the providers in this study. The decrease in volume within the pediatric ophthalmology division was greater than that experienced by the ophthalmology department as a whole over the same time period²⁴ and was quite marked in comparison to a recent study in a glaucoma clinic that observed essentially no change in clinical volume.²⁵ Outside ophthalmology, a study of

a multispecialty practice, including various medical and surgical fields, showed significantly increased patient volume using EHR.²⁶ These results suggest that productivity within pediatric ophthalmology as a subspecialty may be disproportionately burdened by currently available EHR systems, although additional studies in other settings should be pursued to further explore this possibility.

Clinical volume has several limitations as a measure of physician productivity. Scheduled patient volume was intended to return to baseline following a 6-week post-implementation transition period. Scheduling was performed by administrative personnel. Although they reverted to using the baseline appointment time templates after the 6-week transition period, the provider clinical volumes did not generally return to baseline. Despite its limitations, clinical volume as a metric has been used previously in the literature as a proxy for physician productivity.^{24,26} The factors explaining these changes in volume, as well as examination of related metrics of clinical productivity, such as patient wait time, patient satisfaction, deviation from practice patterns, and efficiency of physician communication, warrant future research.^{25,27,28}

In this study, nearly half of all clinical documentation was completed after-hours and on weekends. No comparison data were available from the paper-charting period, but anecdotally most providers indicated that the increase was great. This is consistent with a previous intradepartmental study²⁴ in which a single pediatric ophthalmologist was followed and found to spend significantly more time charting after hours using EHR (mean, 5.1 minutes per patient encounter) compared to paper documentation (mean, 0.0 minutes per patient encounter). From one perspective, greater accessibility to the medical record is a significant advantage of EHR documentation over the physical restrictions of paper charts. On the other hand, this study supports our anecdotal observation that some pediatric ophthalmologists feel that EHR documentation is slower than paper documentation. This finding has also been demonstrated objectively in a study of ophthalmology residents.²⁸ Standardized specifications for EHR systems used in pediatric ophthalmology may help improve charting speed.

There was considerable variation in the impact of EHR implementation on clinical volume among the four providers studied (Table 1). Two providers demonstrated decreases of greater than 10% in clinical volume using EHR (providers 2 and 4), one showed an 8% increase (provider 3), and one essentially no change (provider 1). None of these changes were statistically significant. Such variation in response to EHRs is commonly reported in the literature, and some proposed explanations have included differences in physician characteristics, such as intention to use and perceptions about the value of the EHR system, age, medical specialty, and previous computer experience.^{29,30} The current study was not designed to identify reasons for variations among providers because of the small division size. This question warrants further investigation to identify potential opportunities for improving the utilization of EHR systems.

Mean OTC time also varied widely among providers (Table 2), ranging from 5.5 hours (provider 2) to 28.3 hours (provider 4). Such changes may represent differences in charting practices rather than actual time documenting, because this OTC metric simply measures

time from chart open to completion. One possibility is that providers may have delayed completion of portions of documentation until after the patient visit (eg, completing documentation on administrative days, at night, or on weekends when other responsibilities were less pressing). These changes in practice may contribute to quality and accuracy of documentation.^{23,24,28} Additional studies, perhaps utilizing time-motion analysis, are needed to better characterize the impact of EHR implementation on actual documentation time.

This study has several additional limitations. First, there is a strong possibility of missing a relationship that is actually present due to the limited amount of baseline data available, causing the study to be underpowered. Second, to protect confidentiality, demographic characteristics of physicians, which are potential confounding factors, were not collected and could not be studied, including age, sex, years in practice, part-versus full-time work status, and specific subspecialties. We note that there were large differences in clinical volume among study providers (Table 1) that may have been partly explained by such factors. Third, the parameters for normal work hours were based on departmental standards and may have not reflected each provider's individual schedule. For example, documentation conducted during these times may have occurred during periods that were previously used for nonclinical activities, such as teaching, research, or administration, leading to under-reporting of after-hours charting. Therefore, the true proportion of charting completed outside normal clinical work hours may have been even greater than 44%.

The transition toward EHR documentation is occurring rapidly and has potential benefits for clinical care, research, and public health. However, we feel that the study findings of potentially decreased patient volume and increasing time requirements should raise concerns for pediatric ophthalmologists. One approach to this problem may be to develop summary recommendations for EHR design and use by pediatric ophthalmologists to guide providers, vendors, and government policy makers. Such initiatives have been undertaken by several medical societies, including the American Academy of Ophthalmology.^{22,31–33} Presenting specific recommendations for pediatric ophthalmology may provide more leverage to develop future systems that better meet the needs of the specialty.

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FIG 1.

Impact of electronic health record (EHR) implementation on clinical volume by four established providers in an academic pediatric ophthalmology division. Baseline clinical volume data from 3-month paper documentation period are compared to clinical volume data from 3 years after EHR implementation. Quarterly clinical volume is adjusted for changes from baseline in number of scheduled clinic days. Vertical dashed line indicates time of EHR implementation.

FIG 2.
Time of electronic health record (EHR) chart completion by four established providers in an academic pediatric ophthalmology division. Data are shown for 3 years after EHR implementation.

Table 1

Impact of electronic health record (EHR) implementation on clinical volume for four established providers in an academic pediatric ophthalmology division^a

Provider	Clinical volume (patients/month) ^b			P value ^d
	Paper (mean ± SD)	EHR (mean ± SD)	% Change ^c	
1	21.2 ± 3.8	23.8 ± 7.6	11% Increase	0.56
2	63.3 ± 20.6	51.9 ± 19.9	18% Decrease	0.35
3	93 ± 56.3	93.9 ± 29.3	1% Increase	0.96
4	204 ± 38	177 ± 30.7	13% Decrease	0.16
Total	381.5 ± 29.1	338.7 ± 53.5	11% Decrease	0.18

^aBaseline clinical volume data from 3-month paper documentation are compared to clinical volume data from 3 years after EHR implementation.

^bAdjusted for fluctuations in scheduled clinic time during the study period.

^c“Increase” or “Decrease” during EHR charting period relative to paper charting period

^dTwo-sample *t* test; 2-tailed *P* value.

Table 2

Time elapsed from chart open to completion using a newly implemented electronic health record (EHR) for four established providers in an academic pediatric ophthalmology division^a

Provider	Charts Completed	Time to chart completion		Proportion of charts completed				
		Mean ^b (hours)	IQR ^c (hours)	<4 hours	<24 hours	<72 hours	<1 week	<2 weeks
1	1,656	15.7	1.8–138.8	39%	49%	60%	82%	97%
2	1,741	5.5	2.2–24.5	43%	73%	95%	99%	100%
3	3,068	20.2	2.7–123.4	29%	41%	62%	84%	96%
4	6,184	28.3	2.8–157.8	27%	39%	53%	75%	88%
Total	12,649	19.3	2.4–125.4	32%	45%	62%	82%	93%

^aTime to chart completion is defined as time elapsed from opening the electronic record to completion of all clinical and financial documentation. Data are shown for a 3-year period following EHR implementation.

^bGeometric mean.

^cInterquartile range.