



Analysis of the Financial Return of Electronic Health Records



Although there are a number of benefits of electronic health records (EHR), ophthalmologists are concerned about the costs and potential loss of productivity associated with their use.^{1,2} The purpose of this study is to report a detailed postimplementation financial analysis of 1 practice's experience with EHR implementation.

Data that impacted the incremental cash flows relevant to the implementation of EHR (Medflow) at the authors' practice, Asheville Eye Associates, was collected for 2006, the last year the practice used paper records, and between 2007 and 2011, the first 5 years after implementation of EHR, in a prospective fashion. Asheville Eye Associates is a private multisubspecialty ophthalmic practice that had 10.8 full-time equivalent (FTE) providers (11 ophthalmologists and 2 optometrists) practicing in 3 locations at the beginning of the study. All providers had been in practice for ≥ 3 years in the community and had full clinic schedules based on each provider's template at the initiation of the study. The provider population remained stable with the exception of 1 optometrist who left the practice in 2009 and was replaced by another optometrist and 1 part-time medical ophthalmologist who retired from practice at the end of 2010.

The incremental cash flows for the first 5 years of implementation are shown in Table 1. Details related to each category of cash flow are provided in Table 2 (available at www.aaojournal.org).

Provider productivity changes specific to the initiation and implementation of EHR as a result of changes in physicians' schedule templates were recorded by physician for each year relative to 2006. The schedule for the initial 7 providers who underwent EHR implementation was reduced in the first month. After the first month of implementation, all schedules were returned to the baseline. The remaining 6 providers had no reduction in their schedules. Schedule reduction in the first month resulted in an average decrease in productivity of 0.41 patients per day for the first year of implementation. In years 2-4, there were no changes in the physicians' schedules. In year 5, there was a net annual increase in productivity for the entire group of 1.23 patients per day as familiarity with the EHR grew and a greater proportion of patients were returning patients, which reduced the amount of new data entry. Actual productivity changes (number of patients seen per day) closely mirrored changes in providers' schedule templates. Provider productivity is a sensitive factor in the return on investment of EHR, because small changes can result in significant changes in annual revenue. Other factors which impacted revenues are shown in Table 1. Incentive payments related to the Medicare and Medicaid EHR incentive programs were relatively small because the study period, for the most part, predated this program.

The greatest positive cash flows among expenses related to the net reduction in staffing as a direct result of changes in processes related to EHR. These changes were progressive and cumulative during the course of the study period and resulted from reductions in staffing in the areas of medical records, transcription, billing, check-out, and appointment scheduling (Table 3, available at www.aaojournal.org). Increases in incremental expenses were

related primarily to addition of information technology staff, EHR maintenance costs, scanning of paper medical records, and increased printing costs in the initial phase of implementation.

The incremental net cash flows for each year relative to the base year of 2006 are shown in Table 1. The return on investment multiple measured 3.71. The payback period was 2 years and 10 months. When 5-year cash flows were discounted by the inflation rate, the net present value was \$1 198 414 or \$112 211 per FTE provider and was \$1 024 275 or \$95 906 per FTE provider with a 5% discount rate, the cost of capital (mean FTE providers over study period = 10.68). The internal rate of return on the investment was 41%.

This study reports the actual financial results of EHR implementation. Postimplementation audits are not performed commonly after a capital acquisition, although a number of benefits may accrue. First, the organization that performs such a study will improve its forecasting skills for future projects, and second, operations on the project under consideration often improve as the organization attempts to realize the gains anticipated from the project and looks for reasons for negative variances and seeks to remedy those variances. These studies are not performed more frequently because those who recommended the project may have moved on to other departments or organizations, the analyses are time consuming, and the results of the capital acquisition are often difficult to isolate from those of the organization as a whole. Nonetheless, the benefits to medical practices contemplating significant capital acquisitions in an era of increasingly constrained resources may be significant, and it has been suggested that organizations that do so tend to be more successful.³

This report demonstrates that an EHR can produce financial and operational benefits in a large, single-specialty, multioffice ophthalmic practice over a 5-year period. Although the generalizability of the results may be limited, because each implementation will have a different impact depending on the specifics of each practice, this report provides a methodology all practices can use in thinking about the return on this significant capital investment.^{4,5} Furthermore, we emphasize that the introduction of EHR was not by itself responsible for the positive financial returns but rather because it was seen as an opportunity to examine workflow efficiency continuously over the 5-year period. A key factor in the outcome included physician and staff engagement, training, and workflow changes, which resulted in significant net staff reductions. Physician productivity is a sensitive factor in the analysis of financial returns and should be maintained in the early phases of implementation. Improved efficiencies and productivity, which occurred during the latter part of the implementation period, contributed to the positive return. It will be important that vendor software upgrades facilitate and future regulatory requirements related to EHR minimize impacts on productivity to avoid negatively impacting the return on investment for practitioners.

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Table 1. Incremental Revenues and Expenses Implementation Years 1–5

Revenues Variances		Year 1	Year 2	Year 3	Year 4	Year 5
Productivity						
A	Change in provider productivity (patients per day)	−0.41	0.00	0.00	0.00	1.23
B	Average revenue/patient/year	\$155.83	\$154.84	\$164.58	\$189.50	\$195.46
C	Days worked per year	240	240	240	240	240
D	Total number of providers	10.80	10.80	10.80	10.80	10.20
E	Total physician productivity (A × B × C × D)	\$(165 604)	\$0	\$0	\$0	\$588 538
F	Incremental optical revenues	\$268 347	\$385 732	\$349 669	\$244 795	\$216 093
G	Total productivity (E + F)	\$102 743	\$385 732	\$349 669	\$244 795	\$804 631
Improved collections						
H	Charge capture	\$0	\$0	\$0	\$0	\$50 322
I	Billing efficiency	\$(148 000)	\$0	\$0	\$0	\$113 425
J	Total improved collections (H + I)	\$(148 000)	\$0	\$0	\$0	\$163 747
Meaningful use incentives						
K	Meaningful use payment per provider (Medicaid)	\$0	\$0	\$0	\$0	\$21 250
L	Number of providers achieving meaningful use	\$0	\$0	\$0	\$0	2
M	Total meaningful use incentives (K × L)	\$0	\$0	\$0	\$0	\$42 500
Staffing variances						
N	Total FTE staff reductions (from Table 3)	\$(108 003)	\$(142 945)	\$(310 193)	\$(540 820)	\$(594 279)
O	IT staff	\$69 600	\$69 600	\$69 600	\$69 600	\$69 600
P	Staff scanning expenses	\$5682	\$5801	\$6002	\$6797	\$6720
Q	Total staffing variance (N + O + P)	\$(32 721)	\$(67 544)	\$(234 591)	\$(464 423)	\$(517 959)
Supply cost						
R	Total clinical charts per year	\$(83 100)	\$(84 307)	\$(84 044)	\$(85 746)	\$(87 449)
S	Printing of records	\$13 208	\$5188	\$5243	\$4942	\$5148
T	Electronic claims	\$0	\$0	\$0	\$0	\$(25 170)
U	Patient statements	\$0	\$0	\$0	\$0	\$(92 648)
V	Total supply cost (R + S + T + U)	\$(69 892)	\$(79 119)	\$(78 801)	\$(80 804)	\$(200 119)
Maintenance expense						
W	Annual maintenance expense	\$2412	\$50 262	\$50 262	\$54 612	\$54 612
Variable optical expense						
X	Total variable optical expense	\$115 550	\$157 764	\$166 408	\$112 851	\$96 702
Depreciation/interest expense						
Y	Depreciation	\$141 013	\$198 557	\$82 980	\$45 289	\$22 700
Z	Interest expense (financing)	\$25 013	\$20 486	\$15 733	\$10 742	\$5502
AA	Total operating cash flow (G + J + M) - (Q + V + W + X + Y + Z)	\$(226 631)	\$105 326	\$347 679	\$566 529	\$1 549 441
AB	Net operating cash flow (AA - AG)	\$(128 613)	\$ 60 036	\$199 046	\$324 338	\$887 055
Financials						
AC	Initial cost of EHR/PMS hardware/software: \$500 250					
AD	Net salvage value (10% of initial hardware purchase) (\$225K × 0.10)	\$0	\$0	\$0	\$0	\$22 500
AE	Federal tax rate	35%	35%	35%	35%	35%
AF	State tax rate	8.25%	8.00%	7.75%	7.75%	7.75%
AG	Total taxes (AE + AF) × AA	\$98 018)	\$45 290	\$148 633	\$242 191	\$662 386
AH	Inflation Rate (CPI-U Avg-Avg)	2.8%	3.8%	-0.4%	1.6%	3.2%
AI	Net cash flow (AB + Y + AD)	\$12 400	\$258 593	\$282 026	\$369 627	\$932 255
AJ	Net cash flow (inflation adjusted)	\$12 062	\$242 341	\$265 362	\$342 310	\$836 588

EHR = electronic health record; FTE = full-time equivalent; PMS = practice management system.

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Whole Exome Profiling of Ocular Surface Squamous Neoplasia



Ocular surface squamous neoplasia (OSSN) represents a spectrum of diseases ranging from mild dysplasia to invasive squamous cell carcinoma. Ocular surface squamous neoplasia can be successfully managed with surgical excision or medical therapy. Interferon- α -2b (IFN α -2b) treatment recently has been established as a standard treatment option for OSSN, eliminating the need for surgical excision. However, approximately 15% of tumors do not respond to IFN α -2b therapy.¹ It remains unclear which tumor-specific factors may affect treatment response or course after treatment. This information is important because it can help individualize therapy. For example, physicians may proceed directly to surgery or use a different agent in patients in whom IFN α -2b is unlikely to be effective.

Understanding the genetic variability of OSSN may provide important information on the initial response to a specific therapy and subsequent patient course. However, limited data are available on genetic mutations associated with OSSN. The aim of this study was to apply the powerful whole exome sequencing technology to identify mutations in OSSN tumors and correlate these variants with clinical features and treatment response.

Seven patients with OSSN undergoing excisional biopsy were prospectively recruited for this study. Approval was obtained from the University of Miami Institutional Review Board, and the methods adhered to the tenets of the Declaration of Helsinki and were Health Insurance Portability and Accountability Act compliant. All subjects were white, and 3 self-identified as Hispanic. Three patients had a history of OSSN; 4 were initially treated with IFN α -2b for the current

tumor and subsequently underwent excisional biopsy because of an incomplete or no response to therapy. On histopathologic examination, 1 case was graded as moderate dysplasia, 1 case was graded as severe dysplasia, and 5 cases were graded as carcinoma in situ (Table 1).

Whole exome sequencing of these 7 OSSN specimens was conducted in the Sequencing Core facility at the University of Miami. More than 1000 changes in various genes were presented in each individual sample. To identify mutations that potentially underlie OSSN, we applied an online genomic analysis program Genomes Management Application (<https://genomics.med.miami.edu>) to exclude less likely causative genes. First, by excluding synonymous variants or variants located within untranslated regions, we determined 1295 variants in 1003 genes. These variants have frequencies less than 0.5% in the population, and the Genomic Evolutionary Rate Profiling (a measurement of the conservation for each nucleotide in the genome) scores are >2.0 . Second, we chose the genes represented at least twice in the dataset and ended up with 192 variants in 76 genes. Third, there were 64 variants in 26 genes that were mutated with the frequency $>5\%$ in any types of cancers in the COSMIC database (<http://cancer.sanger.ac.uk/cosmic>). Fourth, after literature review, 32 variants in 10 genes were chosen for verification on the basis of their potential functions in cancer. Finally, only 20 variants in 6 genes were confirmed by capillary sequencing (Fig 1, available at www.aaojournal.org).

The most frequent mutations were identified in genes Titin (*TTN*, Online Mendelian Inheritance in Man [OMIM] 188840) and Neuron Navigator 2 (*NAV2*, OMIM 607026). Four OSSN samples (#1, #2, #6, and #7) carry 10 unique mutations in *TTN*, of which 1 is novel and the rest have reference single nucleotide polymorphism numbers but with very low frequencies ($<0.50\%$) in the population. Three unique mutations in *NAV2* were identified in 4 samples (#1, #2, #3, and #5). Mutations in the gene FAT atypical cadherin 2 (*FAT2*, OMIM 604269) were shared by 3 samples (#5, #6, and #7). Two unique mutations in the gene hepatocyte growth factor (*HGF*, OMIM 142409) were found in the 2 samples (#6 and #7). Two mutations in the gene dynein axonemal heavy chain 8 (*DNAH8*, OMIM 603337) were discovered in 2 samples (#1 and #5), and 1 mutation in the gene CREB Binding Protein (*CREBBP*, OMIM 600140) was shared by 2 samples (#3 and #4). Overall,

Table 1. Demographics and Clinical Features of Our Study Population

Sample No.	Age, yrs	Sex	Race/Ethnicity	Prior OSSN	Nonresponse to Interferon	Tumor Location	Tumor Characteristics	Tumor Area	AJCC Stage	Pathologic Grade	TTN Mutation
#1	45	M	W/H	Yes	Yes	Superior OD	Corneal opacity	2 mm ²	3	CIS	Yes
#2	73	F	W/NH	Yes	Yes	Nasal OS	Leukoplakia	9 mm ²	1	CIS	Yes
#3	76	M	W/H	No	Untested	Temporal OS	Gelatinous Leukoplakia	25 mm ²	2	CIN3	No
#4	64	M	W/NH	Yes	Untested	Nasal OD	Leukoplakia	9 mm ²	1	CIS	No
#5	51	M	W/H	No	Untested	Nasal OD	Papillomatous	48 mm ²	3	CIS	No
#6	59	M	W/NH	No	Yes	Nasal OD	Papillomatous	36 mm ²	3	CIS	Yes
#7	33	M	W/NH	No	Yes	Temporal OD	Leukoplakia	4 mm ²	1	CIN2	Yes

AJCC = American Joint Committee on Cancer; CIN = conjunctival intraepithelial; CIS = carcinoma in situ; F = female; H = Hispanic; M = male; NH = non-Hispanic; OD = right eye; OS = left eye; TTN = titin; W = white.

Reports

Table 2. Detailed Description of Incremental Revenues and Expenses

Revenues Variances		
Productivity		
A	Change in Provider Productivity (Patients per day)	Provider productivity changes specific to the initiation and implementation of the EHR as a result of changes in providers'
B	Average Revenue/Patient/Year	schedule templates were recorded by provider for each year relative to 2006. The schedule for the initial 7 providers who underwent EHR implementation was reduced in the first month. After the first month of implementation, all schedules were returned to the baseline. The remaining 6 providers had no reduction in their schedules. The reduction in productivity in the first month was due to a reduction in provider schedules secondary to EHR implementation and resulted in an average reduction in productivity of 0.41 patients per day for the first year of implementation. In years 2-4 there were no changes in the physicians' schedules. In year 5, efficiency gains allowed 3 FTE providers to increase their schedule template, while one decreased the template and the remainder had no change. These changes resulted in a net annual increase in productivity for the entire group of 1.23 patients per day (Row A). The net incremental increase in productivity was factored by the average revenue/patient (Row B), days worked in the clinic per year, and number of FTE providers (Row D) to arrive at the annual incremental change in revenues related to provider productivity (Row E)
C	Days worked per year	
D	Total Number of Providers	
E	Total Physician Productivity	(AxBxCxD)
F	Incremental Optical Revenues	Implementation of the EHR resulted in a process change whereby the optical prescriptions were forwarded electronically to the optical department where the patients picked up the prescription. This change in process resulted in an increase in the percentage of optical prescriptions written in the clinic that were filled in the practice's optical department in the main facility from 46% in 2006 to 60%-64% between the years of 2007-2011 and an associated increase in optical revenues
G	Total Productivity Improved Collections	(E + F)
H	Charge Capture	In May 2011, with the implementation of a new practice management system, a new process was implemented which involved posting charges in the exam room. At this time it was determined that \$50 322 in one diagnostic procedure (A Scan) had been missed in the base year using paper (as well as subsequent years), which was captured using the new process. The coding profile of the practice did not change as a result of EHR implementation. The EHR did not have a functional coding analyzer during the first 5 years of implementation.
I	Billing Efficiency	The average days in Accounts Receivable (AR) increased from a steady state of 40.0 days in 2006 prior to the implementation of the EHR/PMS to an average of 51.0 days in 2007 and did not return to baseline until 2008 with an average of 39.5 days. The decrease in efficiency of collections was attributed both to the changes related to a new PMS as well as the strained resources among the billing department staff, which was also assisted in managing the EHR implementation. This resulted in a loss in collections of \$148 000 in the first year of implementation which was not recovered. In May of the 5th year of implementation the process change of posting charges from the exam room resulted in a 3-day improvement in the collections of accounts receivable in the amount of \$113 425 over an 8-month period.
J	Total Improved Collections Meaningful Use Incentives	(H + I)
K	Meaningful Use Payment Per Provider (Medicaid)	Two providers, both pediatric ophthalmologists, received EHR "Meaningful Use" incentive payments in the first year of the Medicaid program in 2011. The remaining ophthalmologists began participation in 2012, beyond the time frame of this study.
L	Number of Providers Achieving Meaningful Use	
M	Total Meaningful Use Incentives	(KxL)
Expense Variances		
Staffing Variances		
N	Total FTE Staff Reductions (From Table 3)	Positive cash flows as a direct result of changes in processes related to EHR were due to reductions in staffing
O	Information Technology (IT) Staff	in the areas of medical records, transcription, billing, check-out and appointment scheduling. In 2011, a change in PMS created an interface between the PMS and the EHR allowing technicians to post charges and make follow-up appointments in the exam rooms. This allowed the elimination of 5 billing positions (posting and billing) and 3 check-out positions. This process change resulted in claims being submitted within 24 hours (98% clean) compared to greater than 72 hours (71% clean) prior to 2011. The improved clean claims ratio also resulted in a need for less billing staff. Negative cash flows were related to expenditures to scan entire paper records primarily using a separate server and software (PC Archiver) and to a limited extent into the EHR. Other additional staff expenses included the addition of 1.5 FTE information technologists and \$7500 for staff training allocated to the first year of operation. The IT specialists were employed to manage the system for the duration of the study period (row O). These individuals managed on-site hardware, communicated with the vendor regarding software, performed daily back up of the data, and managed the network.
P	Staff Scanning Expenses	
Q	Total Staffing Variance	(N + O + P)
Supply Cost		
R	Total Clinical Charts per Year	The supply cost of a new paper medical record was \$1.95. The annual cost savings was obtained by multiplying this figure by the number of new patient visits per year.

(Continued)

Table 2. (Continued.)

Expense Variances		
S	Printing of Records	In the early phases of implementation, all physicians would have a copy of the technician evaluation printed for review prior to entering the examination room. In time, the majority of physicians would either preview the record electronically prior to entering the room or view it electronically within the examination room and forego review of a paper report. The extra printing costs associated with this activity (paper and printer ink) are accounted for in this section.
T	Electronic Claims	With an update to a new PMS in year 5, the system allowed claims and payments to be submitted and received electronically which resulted in a savings in paper, printing, and scanning costs. (Row T). Similarly, the new PMS allowed for a process change whereby collection of co-pays and deductibles was performed at check-in resulting in a savings associated with the cost of paper statements (Row U). (R+S+T+U)
U	Patient Statements	
V	Total Supply Cost	
W	Maintenance Expense	
W	Annual Maintenance Expense	Annual maintenance expenses are reported including data lines and back-up tapes.
X	Variable Optical Expense	
X	Total Variable Optical Expense	Incremental supply costs were also accounted for to reflect the additional optical revenue (row F) generated from the increased capture rate.
Y	Depreciation/Interest Expense	
Y	Depreciation	Depreciation of the initial software and hardware expense was reported for each year (row Y). Payments for the conversion to a new PMS in 2011 did not begin until 2012. Therefore, no depreciation or interest payments are recorded as a result of this purchase.
Z	Interest Expense (Financing)	Interest expense on the bank loan was reported for each year.
AA	Total Operating Cash Flow	(G+J+M)-(Q+V+W+X+Y+Z)
AB	Net Operating Cash Flow	(AA-AG)
AC	Capital Expenditure/Salvage Value/Tax and Inflation Rates	
AC	Capital Expenditure	Initial cost of EHR/PMS Hardware/Software
AD	Net Salvage Value	10% of Initial hardware purchase (\$225 000)
AE	Federal Tax Rate	The marginal federal and North Carolina state income tax for the individual providers was utilized for this cash outflow in this for-profit limited liability company
AF	State Tax Rate	
AG	Total Taxes	(AE+AF) x AA
AH	Inflation Rate	CPI-U Avg-Avg
Total Net Cash Flows		
AI	Net Cash Flow	(AB+Y+AD)
AJ	Net Cash Flow	Inflation Adjusted

EHR = electronic health record; FTE = full-time equivalent; PMS = practice management system.

Table 3. Staff Savings

Savings in Positions	Year 1	Year 2	Year 3	Year 4	Year 5
Position					
Medical Records	3	1	1		
Transcription	1		1	1	0.5
Billing				3	2
Check In/Check Out				3	
Appointment Scheduling			3		
Total	4	1	5	7	2.5
Average Salary and Benefits					
Position					
Medical Records	\$82 047	\$27 442	\$27 442	\$0	\$0
Transcription	\$33 456	\$0	\$33 456	\$33 456	\$16 728
Billing	\$0	\$0	\$0	\$100 368	\$36 731
Check In/Check Out	\$0	\$0	\$0	\$96 803	\$0
Appointment Scheduling	\$0	\$0	\$106 350	\$0	\$0
Additional Training (Overtime)	\$(7500)	\$0	\$0	\$0	\$0
Total	4	1	5	7	2.5
Cumulative Average Salary and Benefits					
Position					
Medical Records	\$82 047	\$109 489	\$136 931	\$136 931	\$136 931
Transcription	\$33 456	\$33 456	\$66 912	\$100 368	\$117 096
Billing	\$0	\$0	\$0	\$100 368	\$137 099
Check In/Check Out	\$0	\$0	\$0	\$96 803	\$96 803
Appointment Scheduling	\$0	\$0	\$106 350	\$106 350	\$106 350
Additional Training (Overtime)	\$(7500)	\$(7500)	\$(7500)	\$(7500)	\$(7500)
Total	\$108 003	\$135 445	\$302 693	\$533 320	\$586 779