Financial performance of primary care physician practices prior to electronic health record implementation

Neil S. Fleming, PhD, CQE, Edmund R. Becker, PhD, Steven Culler, PhD, Dunlei Cheng, PhD, Russell McCorkle, MBA, and David J. Ballard, MD, PhD

While electronic health records (EHRs) are being widely implemented across the nation, few empirical data are currently available regarding their potential impact on financial performance and resource use. HealthTexas Provider Network is implementing a networkwide EHR, providing a unique opportunity to describe and evaluate fiscal effects. We conducted a retrospective, longitudinal observational study of financial performance related to inputs and income- and productivity-related outputs for the 33 primary care practices (July 2002–April 2006). Models for each outcome were constructed to test for a linear trend over time, adjusted for practice characteristics. F tests based on these models were used to determine the effect of each adjustor and to determine existence of a trend in each outcome. The observed staff per physician full-time equivalent (FTE) (3.6) was similar to staffing ratios reported for other primary care–only practices, while observation of 4692 work relative value units per physician FTE annually was higher than reported nationally. Significant monthly trends were identified for three of the outcome measures. During the pre-EHR baseline period, staffing ratios were equivalent to and physician productivity greater than reports available for these measures nationally or in other settings. Identification of time trends in three measures will allow these to be accounted for in the model used to evaluate the financial performance impact of EHR implementation.

Widespread implementation of electronic health records (EHRs) has been identified as an important step in improving the quality of health care in the United States (1). One of the frequently cited barriers to adoption of EHRs, particularly among small ambulatory care practices, is the high cost of implementation (2–4). Compounding this problem is the uncertainty regarding the savings and/or increases in revenue a practice can expect to realize through use of the EHR—i.e., lack of information regarding the business case for EHR implementation. A business case for a health care improvement intervention exists if the entity that invests in the intervention realizes a financial return on its investment in a reasonable time, using a reasonable rate of discounting. A business case is normally judged on relatively short-term return on investment (5). Based on existing reports in the literature, the business case for quality initiatives in which the investing organization is a health care provider is typically unfavorable under the current reimbursement schemes, even when the innovation is effective for patient care (5).

In addition to the lack of information available regarding the business case for implementing an EHR, estimates of implementation costs and later benefits in the literature vary too widely to get a good sense of what an ambulatory care practice can expect to spend and/or later recoup. Reports and estimates of startup costs range from approximately $13,000 to $44,000 per physician (depending on factors such as size of practice and comprehensiveness of the EHR system) (2, 6–9). Renner reported a case study of projected cost savings with EHR implementation in a 40-physician primary care group, showing a net loss of ~$11,000 per physician in Year 1, but projecting a 41% internal rate of return over the 4-year period and a net value of the investment of $7000 per physician at the Year 1 US dollar value (10). A cost-benefit study using a hypothetical patient panel, of which 17% were reimbursed under capitated care, estimated productivity loss in the first year at $11,200 per provider, but the net benefit for the first 5 years—derived from reduced drug expenditure, decreased use of radiology, better capture of charges, and decreased billing errors—at $86,400 per provider (9).

In examining financial performance, it is essential to define and measure uniform quantifiable outputs across the practice setting. One such set of outputs for physician services is the relative value unit (RVU) in the Medicare physician fee schedule. In 1992, Medicare established a standardized physician payment schedule based on the resource-based relative value scale (RBRVS) (11), replacing payments based on usual, customary, and reasonable charges. Under the RBRVS system, payment rates are based on relative weights, called RVUs, which account for the relative costliness of the inputs used to provide physician services. These inputs include physician work, physician practice

From the Institute for Health Care Research and Improvement (Fleming, Cheng, Ballard) and HealthTexas Provider Network (McCorkle), Baylor Health Care System, Dallas, Texas; and Rollins School of Public Health, Emory University, Atlanta, GA (Becker, Culler).

Corresponding author: Neil S. Fleming, PhD, CQE, Vice President, Health Care Research, Baylor Health Care System, 8080 North Central Expressway, Suite 500, Dallas, Texas 75206 (e-mail: neilfl@BaylorHealth.edu).

expenses, and professional liability insurance expenses and are summed to calculate a total RVU for each physician service. The RVUs for physician work reflect the relative levels of time, effort, skill, and stress associated with providing each service. Initially, the physician work values were based on the Harvard resource-based relative value scale (11). Currently, the values are updated periodically through the Relative Value Scale Update Committee at the American Medical Association (12) and maintained and monitored by the Centers for Medicare and Medicaid Services (13). Because the relative values in the RBRVS are calibrated on a common scale within the same year, summaries of physician activities based on relative values that represent similar episodes of patient care and physician activities can be compared. We have decided to use a single year's RVU scale (2005) for all years to make cross-year comparisons on a standardized basis by eliminating the impact of changes in the nominal RVU values for specific CPT-4 codes. If the definitions of episodes of care and physician activities are consistently applied, such comparisons regarding resource utilization are valid across physicians, clinical departments, and organizations over time.

We will use the RVUs in the Medicare physician fee schedule to describe physician performance before, during, and after the implementation of a commercially available EHR in 33 primary care practices within a large fee-for-service ambulatory care physician network (14). Over the 3 years following implementation, we will evaluate the impact of the EHR on both quality of care and financial performance for the 33 primary care practices within HTPN. This provides the opportunity to substantially add to the available information regarding the costs and benefits small physician practices (<10 physicians) operating in similar environments can expect with EHR implementation.

In order to conduct a meaningful evaluation of the EHR's impact, baseline preimplementation financial performance must be established. This study presents baseline financial performance data for the 33 practices.

METHODS

Setting

HealthTexas Provider Network (HTPN) is the ambulatory care physician network component of the Baylor Health Care System, an integrated not-for-profit health care delivery system, and has >100 primary care, specialty care, and senior health centers throughout the Dallas–Fort Worth metroplex. HTPN accepts no risk-based contracts, which are prohibited under group policy. While all HTPN practices will receive the EHR (composed of GE Centricity Physician Office–EMR 2005, Clinical Content Consultants, and Kryptiq Secure Messaging), the differences in activities between specialties led to the decision to examine the effect of the EHR only in the 33 primary care practices with no previous EHR exposure.

Outcome measures

We examined seven outcomes related to resource use and financial performance, divided into "inputs" (practice expense per work RVU, staff per physician full-time equivalent [FTE]), "income-related outputs" (payment received per work RVU and net income per work RVU), and "productivity-related outputs" (work RVU per physician FTE, work RVU per visit, and visits per physician FTE). Practice expenses included nonphysician/physician assistant staff compensation, overtime, and overhead.

Data collection

For each physician, we collected data on age, specialty, and years with HTPN from the Baylor Contract Information System. Practice characteristics, including size (number of physicians), specialty (percentage family medicine), and monthly number of work hours, were collected from the Lawson payroll system.

Data related to individual patient visits and revenue were obtained from the HTPN MisysPM and Vision billing systems, collected at the end of each monthly accounts receivable system close and available from July 2002. Billing data provide detailed component information. Charges are captured at the procedure code level and linked to the RVU values, obtained from Ingenix (15). Data related to practice expenses and staffing levels/payrolls were obtained from the Lawson general ledger and payroll systems. Data were accessed through a standard query language server database and transferred into SAS data files for analysis.

Analysis

Financial and staffing data from July 2002 to April 2006 were used to establish pre-EHR implementation financial performance and productivity. Models for each outcome were constructed to test for a linear trend over time, adjusting by number of physicians in the practice, average age of the physicians, and physician specialty (percentage of family medicine). Regression coefficient estimates and their F tests based on these models were used to determine the effect of each adjustor and to determine existence of linear or nonlinear (quadratic) trends in each outcome.

Plan to evaluate the impact of the ambulatory EHR on financial performance: Once EHR deployment is complete and at least 12 months of postimplementation data are available for all practices, the impact of the EHR will be evaluated using an interrupted time series design with switching replications, "in which time series of identical length are assembled for two or more . . . similar groups," taking advantage of the staggered implementation of the EHR throughout the network. Such a design facilitates both comparisons over time in the same practice (pre- and postimplementation) and comparisons between practices that have and have not received the EHR at a particular point in the study period. Since the intervention occurs at different times for the groups, the threat of historical events affecting internal validity and causal interpretation is reduced, in contrast to conclusions based on a single group pre- and posttest design (16). Additionally, since all practices receive the intervention and are included in the evaluation, the threat to internal validity from selection bias is essentially negligible.

We will assess the impact of the EHR using the following model:

$$Y_{it} = \beta_0 + \beta_E * E + \beta_T * T + \beta_H * H + \varepsilon_{it}$$

where Y_{it} is the financial measure for practice i at time t (in months since the beginning of the study) and H is a vector of practice-level effects: practice size (number of physicians), specialty, and average physician age. β_H represents the vector of regression coefficients reflecting the effect of each of the practice-level effects. When evidence of a strong autocorrelation is present, a first difference of ($Y_{it} - Y_{i,t-1}$) is modeled, where $Y_{i,t-1}$ is the lagged value of the dependent measure 1 month before t in order to achieve stationarity in the model error. A time trend component is also included with T = 1 to 46 representing the month since the beginning of the study, and β_T is the regression coefficient representing the monthly trend. The E variable indicates whether EHR implementation has occurred. In the final evaluation of the impact of the EHR, this variable will be set to zero for all preimplementation months and set to 1 for all postimplementation months to model if a "step" function has occurred. Testing H_0: $\beta_E = 0$ will allow us to determine how the EHR affects these financial measures over time. Further transformation of the E variable related to the number of months since implementation will allow estimation of potential linear effects (e.g., the EHR has an improving impact over time) or nonlinear effects (e.g., the EHR has a short-term negative impact followed by a longer-term positive impact that could be modeled by inclusion of a quadratic term). A transformation may also be used to achieve normality.

A nonindependent error structure for ε_{it} representing the error for practice I at time t may be assumed to account for repeated measures on each practice over time. Several different error structures were used depending on the best fit, including compound symmetry, first-order autoregressive (AR[1]), unstructured, and first-order autoregressive and moving average (ARMA[1,1]) (17, 18). If the first autoregressive parameter exceeded 0.9, then a first difference was used to model the dependent variable. Table A in the online appendix describes error structures and estimates of the related parameters (see http://www.baylorhealth.edu/proceedings/22_2/22_2_fleming_appendix.pdf).

We will perform secondary analyses to assess the strength of our assumptions and the robustness of our models. We will use measures of EHR implementation to examine the effect of the EHR in just those practices with high levels of implementation. To assess the differential effect of the EHR on types of providers and practices, we will replicate primary analyses, including provider and practice characteristics as cross-level effects. We will evaluate models using methods for generalized linear models to assess their performance, including goodness-of-fit statistics such as R-square and residual plots, to ensure that we have properly modeled linear and nonlinear secular as well as EHR effects. We will use standardized residuals to identify potential outliers and leverage statistics to investigate influential observations and report outliers and influential points if they exist.

Sample size and statistical power for evaluation of the impact of the ambulatory EHR on financial performance: We assumed 3 years of preimplementation data and at least 1 year of postimplementation data. Mixed models with appropriate error structures were assumed based on 46 months of actual billing data. For most target variables, AR(1) or ARMA(1,1) structures were chosen because of easier convergence and smaller Akaike information criterion and Bayesian information criterion values (Table A in the online appendix). We found $\sigma^2 I$ the best error structure for work RVU per visit. Table A also shows the values of ρ or γ in the structure of AR(1) or ARMA(1,1) for each outcome measure, as well as D(1) indicating if a first difference was modeled when the AR(1) coefficient exceeded 0.9 for the original level of the dependent variable.

We fitted each financial performance or resource use outcome with a mixed model that included certain residual error structures to obtain σ^2(residual error). Estimates of minimum detectable differences were based on the half-width of the 95% Wald confidence interval. The Wald test statistic, as a ratio of effect size and error variance, calculates a w statistic. Scaled error variance, after considering the unit effect and pre- and posttiming difference, was used to construct Wald test statistic intervals. The estimated Wald interval accounts for practice-to-practice variation as well as repeated measures on each practice over time.

Table 1. HealthTexas Provider Network primary care practice profiles by physician specialty composition (July 2002–April 2006)

	Practice physician composition		
Variable	Family practice	Internal medicine	Mixed practices
Physician profiles			
Mean physician FTEs	3.0	8.1	5.8
Mean physician age	42.4	40.9	43.0
Mean years at HealthTexas	3.3	3.9	5.1
Mean staff FTEs	3.5	3.1	3.8
Number of practices	16	5	12
Practice workload profiles			
Monthly visits per practice	1367	3154	2240
Monthly visits per FTE physician	437	415	473
Work RVUs per visit	0.89	0.99	0.91
Total RVUs per visit	2.05	2.25	2.04
Monthly work RVUs per physician FTE	384	406	395
Mean monthly work RVUs per practice	1195	3386	2123
Mean monthly practice expense RVUs per practice	1516	4509	2691
Mean monthly total RVUs per practice	2776	8102	4936
Financial profiles			
Payment per work RVU	$110.97	$103.85	$105.55
Net income per work RVU	$36.03	$38.00	$32.24

FTE indicates full-time equivalent; RVU, relative value unit.

RESULTS

Table 1 reports selected physician, workload, and financial practice profiles for the 33 HTPN primary care practices by the primary care practice composition. Overall, there were 183 physicians in the 33 practices with a mean size of 4.8 physician FTEs and a median of 4 physicians. Practices ranged in size from 1 physician to 35 physicians.

As shown in Table 1, 48.5% of the practices (16/33) were made up exclusively of family practitioners, while 15.2% (5/33) of the practices were exclusively internists. The other eight practices comprised combinations of specialties, including family medicine, internal medicine, pediatrics, gastroenterology, and obstetrics/gynecology. For these mixed practices, only data related to the physicians specializing in family medicine or internal medicine were used in this study. Practices comprised solely of physicians specializing in family medicine were smaller, averaging just 3.0 physician FTEs, while internal medicine practices were larger, with an average of 8.1 physician FTEs, and mixed specialty practices (including those practices that were a mix of family medicine and internal medicine physicians only, as well as practices that included non–primary care physicians) averaged 5.8 primary care physician FTEs. The average physician age was similar for all practice types (early 40s). Physicians in internal medicine or mixed specialty practices had generally been with HTPN longer than physicians in family medicine settings. Support staffing patterns also varied slightly across practice types, with family medicine practices averaging 3.5 staff per physician FTE, internal medicine practices averaging 3.1 staff per physician FTE, and mixed specialty practices averaging 3.8 staff per physician FTE for all specialties. Together, the 33 practices averaged 3.6 staff FTEs.

Table 1 shows that practice workload patterns varied dramatically by practice type. Family medicine practices averaged 437 visits per physician FTE; internal medicine practices, 415 visits; and mixed specialty practices, 473 visits, a 14% difference compared with internal medicine practices. Differences were also observed across practice types for monthly work RVUs, practice expense RVUs, and total RVUs. Family medicine and mixed specialty practices averaged work RVUs per primary care physician FTE of 384 and 395, respectively. In contrast, internal medicine physicians averaged 406 work RVUs per physician FTE, an approximate 6% difference compared with family medicine physicians. Together, the 33 practices averaged 391 work RVUs per physician FTE monthly.

Table 2. Monthly trends in resource use and financial performance measures during the period July 2002 to April 2006 for 33 HealthTexas Provider Network primary care practices

Type of measure	Outcome measure	Estimated monthly change	95% confidence interval	*P* value	R-square
Input	Practice expense ($) per work RVU	–0.013	–0.031, 0.0050	0.158	0.860
	Staff per physician FTE	–0.00013	–0.0016, 0.0014	0.864	0.910
Income-related output	Payment received ($) per work RVU	–0.060	–0.1357, 0.0150	0.117	0.747
	Net income ($) per work RVU	0.008	–0.0076, 0.024	0.314	0.904
Productivity-related output	Work RVU per physician FTE	1.57	1.129, 2.012	<0.001	0.677
	Work RVU per visit	0.0012	0.0045, 0.0020	0.002	0.632
	Visits per physician FTE	1.05	0.50, 1.60	<0.001	0.783

FTE indicates full-time equivalent; RVU, relative value unit.

Table 3. Annual resource use and financial performance measures for 33 HealthTexas Provider Network primary care practices (2003–2005)

Type of measure	Outcome measure	2003 Mean (SE)	2004 Mean (SE)	2005 Mean (SE)
Input	Practice expense ($) per work RVU	72.27 (1.32)	69.55 (1.31)	69.28 (1.31)
	Staff per physician FTE	3.59 (0.12)	3.57 (0.12)	3.53 (0.12)
Income-related output	Payment received ($) per work RVU	108.51 (1.47)	108.95 (1.45)	108.13 (1.45)
	Net income ($) per work RVU	33.73 (1.34)	36.73 (1.33)	36.48 (1.33)
Productivity-related output	Work RVU per physician FTE	384.17 (11.28)	382.97 (11.17)	400.72 (11.14)
	Work RVU per visit	0.88 (0.017)	0.92 (0.017)	0.93 (0.017)
	Visits per physician FTE	454.53 (16.68)	431.37 (16.51)	445.71 (16.47)

FTE indicates full-time equivalent; RVU, relative value unit; SE, standard error.

Table 2 shows estimated monthly changes, adjusted through multivariate techniques for the effects of practice size, specialty, and physician age, in all financial measures for the period July 2002 to April 2006. Statistically significant ($P < 0.05$) monthly positive trends were observed for work RVU per physician FTE (1.57; standard error [SE], 1.129–2.012), work RVU per visit (0.0012; SE, 0.0045–0.002], and visits per physician FTE (1.05; SE, 0.50–1.60). *Table 3* shows mean monthly values and their standard errors for each resource use and financial performance measure for the years 2003, 2004, and 2005, sometimes illustrating nonlinear trends in the data. Tests for nonlinear trends over the entire 46-month time period, however, showed statistical significance only for payment received per work RVU

Table 4. Estimation of practice-level effects for 33 HealthTexas Provider Network primary care practices (July 2002–April 2006)

Type of measure	Outcome measure	Coefficient (*P* value)		
		Practice size	Speciality	Average physician age
Input	Practice expense ($) per work RVU	–0.49 (0.371)	–0.0067 (0.326)	–0.046 (0.187)
	Staff per physician FTE	–0.0055 (0.270)	–0.00015 (0.815)	0.066 (0.041)
Income-related output	Payment received ($) per work RVU	–0.285 (0.344)	–0.0007 (0.988)	–0.091 (0.299)
	Net income ($) per work RVU	0.09 (0.082)	0.0027 (0.663)	–0.024 (0.441)
Productivity-related output	Work RVU per physician FTE	–24.19 (<0.001)	0.290 (0.506)	2.28 (0.025)
	Work RVU per visit	0.011 (0.003)	–0.00043 (0.380)	–0.0010 (0.490)
	Visits per physician FTE	–32.71 (0.001)	1.91 (0.139)	1.02 (0.067)

FTE indicates full-time equivalent; RVU, relative value unit.

Table 5. Minimum detectable effects for resource use and financial performance measures at $\alpha = 0.05$ and $1 - \beta = 80\%$ following electronic health record deployment in 33 HealthTexas Provider Network primary care practices

Type of measure	Outcome	Baseline assumption	σ^2 for Wald test	Effect size
Input	Practice expense ($) per work RVU	70.53	2.59	0.71
	Staff per physician FTE	3.56	0.019	0.060
Income-related output	Payment received ($) per work RVU	107.93	38.60	2.67
	Net income ($) per work RVU	34.94	2.11	0.61
Productivity-related output	Work RVU per physician FTE	390.71	118.7	14.8
	Work RVU per visit	0.91	0.0039	0.027
	Visits per physician FTE	446.7	1,823	18.9

FTE indicates full-time equivalent; RVU, relative value unit.

($P = 0.007$). Plots of the predicted values versus the observed values for quarterly statistics show the goodness of fit and demonstrate the ability of the models to reflect a linear time trend when present for the three measures in which significant trends were identified. The plot for the model predicting visits per physician FTE demonstrates the overall upward trend despite a period of a higher level of activity during 2003 *(Figure 1).* The goodness of fit for this model is quite good, as indicated by the R-square = 0.783, which shows that 78.3% of the variance in this measure is explained by the model. R-square statistics for models of the other outcome measures are presented in Table 3 and also illustrate high levels of goodness of fit. The models for the other two outcome measures with statistically significant secular effects, work RVU per physician FTE and work RVU per visit, yielded R-squares of 0.677 and 0.632, respectively, with plots of actual versus predicted values that track the linear time trend *(Figures 2 and 3).* Since many of the measures share common numerators or denominators, a correlation matrix is included in Table B in the online appendix (see http://www.baylorhealth.edu/proceedings/22_2/22_2_fleming_appendix.pdf).

Table 4 provides estimates of practice-level effects including practice size, specialty, and average physician age. Our results show that increasing practice size is associated with two productivity-related output measures (increase in work RVU per visit, $P = 0.003$, and decrease in work RVUs per physician FTE, $P < 0.001$). This suggests that larger practices achieve greater economies from the standpoint of managing increased intensity of services. Increasing average age of the physicians was associated with increased input (staff per physician FTE, $P = 0.04$) and increased productivity-related outputs (work RVU per physician FTE, $P = 0.03$, and visits per physician FTE, $P = 0.07$). This suggests a trend towards physicians requiring more support. It also suggests that physicians achieve greater productivity overall as they grow older by seeing more patients rather than increasing the intensity of services per visit. We made this conclusion based on the fact that the intensity of services did not vary by age of

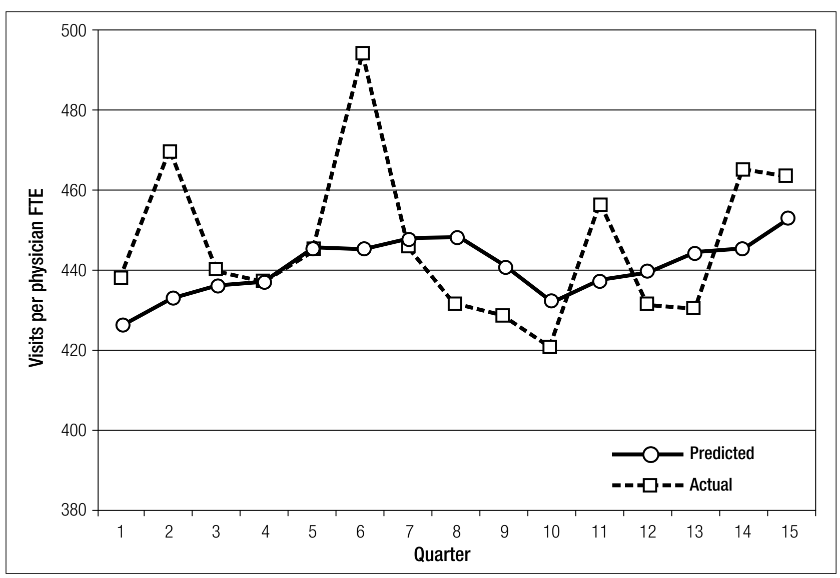

Figure 1. Actual and predicted changes in visits per physician full-time equivalent in HealthTexas Provider Network primary care practices (July 2002–April 2006, divided into 15 quarters).

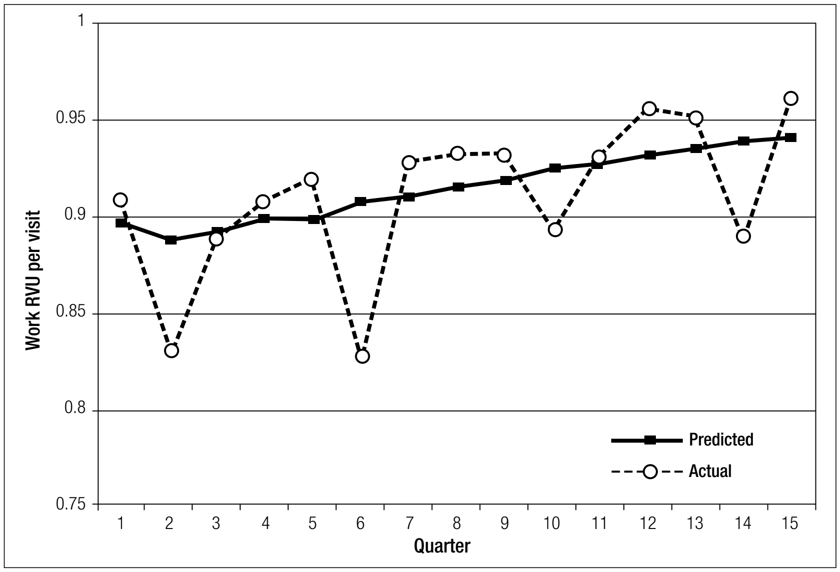

Figure 2. Actual and predicted changes in work relative value unit per visit in HealthTexas Provider Network primary care practices (July 2002–April 2006, divided into 15 quarters).

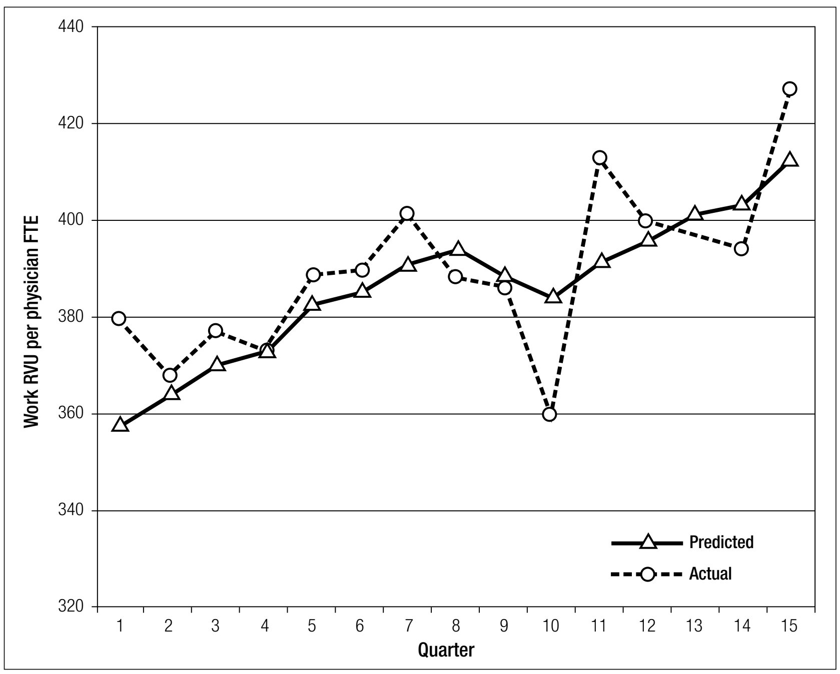

Figure 3. Actual and predicted changes in work relative value unit per physician full-time equivalent in HealthTexas Provider Network primary care practices (July 2002–April 2006, divided into 15 quarters).

physician, shown by the lack of statistical significance related to the age-related coefficient for work RVU per visit ($P = 0.49$).

Table 5 shows the detectable effects at power $1-\beta = 80\%$ and $\alpha = 0.05$ (two-sided) for all resource use and financial performance outcome measures after each of the 33 practices has had at least 12 months of exposure to the EHR.

DISCUSSION

We examined pre-EHR levels of input, income-related output, and productivity-related output financial measures for primary care practices in a large fee-for-service ambulatory care physician network. The mean of 3.56 staff members per physician FTE observed for the HTPN primary care practices for July 2002 to April 2006 is similar to the 3.48 found in a 2006 study by Lewandowski et al in a medical group practice that was transitioning its compensation model (19). The observed monthly mean of 391 work RVUs per physician FTE for HTPN physicians during this period annualizes to 4692 work RVUs per physician FTE, which is greater than the 3980 annual work RVUs found by Lewandowski et al and the 3737 annual RVUs per physician FTE cited nationally (19).

As shown in Table 2, the financial performance and resource use measures of interest for this evaluation were relatively stable over the baseline period. Monthly means decreased from 2003 to 2005 for input measures (practice expense per work RVU, staff per physician FTE). Increases were observed over this period in income-related and productivity-related output measures (net income per work RVU, work RVU per physician FTE, and work RVU per visit). The lack of change in payment received per work RVU over the 3-year time period most likely reflects the lack of change in the RVU "conversion factor" from all payers, especially in view of the relatively stable HTPN payer mix. The observed increase in work RVU per visit could be interpreted in two ways: 1) greater intensity of services required by the patients' conditions or 2) change in documentation practices, increasing the number of RVUs being billed. Insofar as HTPN has an active audit function that promotes accurate and consistent coding for services, it is likely that the increase in work RVUs is related to increased intensity of services.

Testing for trends in the pre-EHR implementation data was important, as we want to isolate the effect of the EHR on factors such as the mix of physicians and staff and the shift in the workloads of each of these groups in the evaluation. To date, few studies have been successful in tracking changes in terms of inputs and income- and productivity-related outputs over time and in analyzing how practices respond to changes or shifts in their patient workloads. We identified significant monthly trends for three productivity-related output measures (work RVU per physician FTE, work RVU per visit, and visits per physician FTE). Failure to identify and account for these secular trends in our data could have masked or exaggerated the impact of the EHR on some of our outcome measures by generating biased estimates of the intervention's impact through model misspecification. Being able to partition and compare different aspects of the structures, processes, and outcomes of the 33 HTPN primary care practices and isolate aspects of their organization that contribute to improved financial performance is essential to both evaluating the impact of the EHR and contributing to the national discussion on the best and most essential management and policy practices in the primary care setting.

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