

Electronic Health Record Components and the Quality of Care

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Background: Electronic health records (EHRs) have been promoted as an important tool to improve quality of care. We examined the association between EHR components, a complete EHR, and the quality of care.

Methods: Using data from the 2005 National Ambulatory Medical Care Survey and the National Hospital Ambulatory Medical Care Survey, we conducted a cross-sectional analysis of all visits with an established primary care provider and examined the association between presence of EHR components and: (1) blood pressure control; and (2) receipt of appropriate therapy for chronic conditions. We examined similar associations for complete EHRs which we defined as one that includes physician and nursing notes, electronic reminder system, computerized prescription order entry, test results, and computerized test order entry. We constructed multivariate models to examine the association between EHR components and each outcome controlling for patient sociodemographic, health, physician practice, and geographic factors.

Results: We found no association between electronic physician notes and blood pressure control or receipt of appropriate therapies, with the exception of inhaled steroids among asthmatics (adjusted odds ratio 2.86; 95% confidence interval, 1.12–7.32). We found no association between electronic reminder systems and blood pressure control or receipt of appropriate therapies, with the exception of angiotensin converting enzyme inhibitors or angiotensin receptor blockers in patients with diabetes with hypertension (odds ratio 2.58; 95% confidence interval, 1.22–5.42). We found no association between

electronic physician notes and any measure of quality. We found no relationship between having a complete EHR and any of the quality measures investigated.

Conclusions: We found no consistent association between blood pressure control, management of chronic conditions, and specific EHR components. Future research focusing on how an EHR is implemented and used and how care is integrated through an EHR will improve our understanding of the impact of EHRs on the quality of care.

Key Words: quality of health care, personal health record, hypertension, ambulatory care

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The adoption of electronic health records (EHRs) has been promoted as an important tool to improve the quality of health care by industry, physicians, policy makers, and the federal government.^{1–5} EHRs are postulated to lead to improved quality of care by reducing adverse events related to medications, decreasing testing and duplication of health care services and improving the management of chronic conditions among other things.^{5–9}

A recent national study using the National Ambulatory Medical Care Survey (NAMCS)¹⁰ failed to find any relationship between use of an EHR and receipt of appropriate therapy for a chronic condition, or receipt of appropriate screening tests. However, this study was limited by the lack of details on EHR components available in physician offices, prohibiting the discernment between offices that had electronic physician notes and electronic reminder systems and offices that only had test results in an electronic format. Different components may affect different aspects of care and physicians with a complete electronic health record may be able to provide better care.

The release of the 2005 NAMCS and National Hospital Ambulatory Care Survey (NHAMCS) provides an opportunity to investigate the relationship between EHR components and the quality of care. The 2 surveys have expanded their data collection on the characteristics of EHRs used in physician's offices and contain information on whether the EHR includes any of the 6 following components: (1) physician notes; (2) nursing notes; (3) test results; (4) electronic reminder system; (5) computerized prescription order entry (CPOE); and (6) computerized test order entry. The purpose

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of this study is to examine the effect of EHR components on the medical management of select chronic conditions.

Methods

Study Design

We conducted a cross-sectional analysis using combined data from the 2005 NAMCS and NHAMCS.^{11,12} NAMCS collects data on visits to nonfederally employed office-based physicians engaged in direct patient care. NHAMCS collects data on provision of ambulatory care services in nonfederal hospital outpatient departments. For both surveys, trained interviewers visit physician offices or hospitals to review and provide physicians with instructions on how to complete the forms.^{11,12} In 2005, both surveys collected similar data on the characteristics of EHRs physicians used in their offices.

Sample

During 2004 to 2005, data were collected on 25,564 visits in NAMCS and 29,975 visits in the NHAMCS. Both surveys are based on a multistage national probability sample. We limited our analytic sample to all patient visits to the primary care provider with patients 18 years of age or older. We excluded patients new to their primary care provider leaving 11,889 visits for analysis.

Dependent Variables

Blood pressure control (systolic and diastolic) was categorized dichotomously as controlled or uncontrolled, with control defined as systolic blood pressure ≤ 140 , diastolic blood pressure ≤ 90 .¹³ All other dependent variables were dichotomous indicators for the use of a therapy. Receipt of aspirin for ischemic heart disease or cerebrovascular disease, a beta blocker for ischemic heart disease, an angiotensin converting enzyme inhibitor or angiotensin receptor blocker (ACE/ARB) for diabetic patients with hypertension, and an inhaled steroid for asthma were considered appropriate therapy.^{14–17}

Independent Variables

We created indicators for each EHR component (physician notes, nursing notes, availability of test results, electronic reminders, computerized prescription order entry, and computerized test order entry). We did not limit the sample to only the physician offices that had electronic health records, but also included visits to offices that had no EHRs (ie, were using paper records). For example, when the independent variable, physician notes, was categorized as absent, it included both physician offices that had an electronic health record but did not have physician notes and physician offices that did not have any form of an electronic health record. We defined a complete EHR as one that includes physician and nursing notes, electronic reminder system, computerized prescription order entry, test results, and computerized test order entry. Patient sociodemographic characteristics included age, sex, race, ethnicity, and insurance status. Patient comorbidities included hypertension, asthma, cancer, cerebrovascular disease, congestive heart failure, chronic obstructive pulmonary disease, hyperlipidemia, ischemic heart disease, obesity,

and osteoporosis. We included data on patient's smoking status, number of visits in the past year, physician specialty, practice type (group or solo), and practice location including census region, and whether or not it was in a Metropolitan Statistical Area (MSA) in the analyses.

Statistical Analysis

We performed separate logistic regressions to estimate the effect of EHR on blood pressure control and the odds of receiving appropriate therapy for select chronic conditions. We first examined the relationship between each electronic health record component and the outcomes of interest using χ^2 statistics. We then constructed multivariate logistic regression models examining the effect of EHR components on the outcome of interest controlling for age, gender, comorbid conditions, smoking status, practice type, region of country, and whether the visits were in an MSA. Visits with missing blood pressure data ($<4.2\%$) in the sample were excluded from the analysis. All analyses took into account the complex survey design and weighted sampling probabilities and were performed using Stata statistical software, version 9.2 (Stata Corporation, College Station, TX).

Results

EHR Components

Electronic physician notes (21.6%) were the most common and electronic reminders (12%) were the least common component of an EHR reported in visits to primary care providers (Table 1). A complete EHR that we

TABLE 1. EHR Components Available in Visits to Primary Care Provider Offices*

	No. Visits	Estimate US Visits (Millions) [†]	%
Individual components			
Physician notes	2565	75	21.6
Nursing notes	2222	63	18.1
Test results	3281	68	19.6
Electronic reminder system	1895	42	12.1
Prescription order entry	2445	56	16.2
Test order entry	2405	48	13.8
Combinations of components			
Physician and nurse notes	2173	62	18.0
Physician notes and electronic reminders	1696	39	11.3
Physician notes and test results	2341	62	17.7
Physician notes and CPOE	2029	52	14.9
Physician notes and electronic reminders and test results	1568	31	8.9
Physician notes and electronic reminders and CPOE	1468	34	9.8
Physician notes and electronic reminders and test results and CPOE	1404	28	8.1
All 6 components	1209	24	7.0

*Survey weighted percentages, age >18 .

[†]The US population represented by the sample of visits for which data was collected.

TABLE 2. Patient and Practice Characteristics Associated With the Use of a Complete Electronic Health Record*

	Visits	Estimated US Visits (Millions) [†]	Complete HER %	Incomplete EHR/Paper Records %	P
Age (yrs)					0.90
<50	5363	132	38.4	37.9	
50 or older	6526	216	61.5	62.1	
Gender					0.012
Female	7670	208	66.1	59.3	
Male	4219	140	33.9	40.7	
Race					0.97
White	9078	294	84.9	84.1	
Black	1893	36	9.7	10.1	
Other	918	18	5.9	5.3	
Ethnicity					0.50
Hispanic	1490	29	6.8	8.7	
Non Hispanic	10399	319	93.2	91.3	
Insurance					0.30
Private	4564	178	53.4	50.9	
Medicare	2816	96	27.1	27.6	
Medicaid	2801	39	6.6	11.5	
Other	1708	35	12.7	9.8	
Visits with the following conditions					
Hypertension	4433	139	35.8	40.2	0.51
Diabetes	1920	54	15.6	15.6	0.98
Hyperlipidemia	2706	94	28.9	26.9	0.75
Obesity	1312	39	11.7	11.2	0.90
Ischemic heart disease	605	21	5.6	6.2	0.80
Cerebrovascular disease	241	9	3.0	2.5	0.67
Congestive heart failure	343	10	2.4	3.0	0.72
Asthma	849	22	5.4	6.5	0.45
Osteoporosis	469	18	4.6	5.2	0.75
Chronic renal failure	184	7	2.2	2.0	0.82
Current smoker	1862	45	13.0	10.6	0.41
Practice type					0.36
Group practice	9293	190	65.9	53.7	
Solo practice	2596	158	34.1	46.3	
Location					0.02
Northeast	3366	64	4.1	19.4	
Midwest	3330	105	17.7	31.2	
South	3113	119	39.3	33.6	
West	2080	60	38.7	15.6	
Metropolitan Statistical Area (MSA)	9535	288	91.5	81.8	0.18
Non MSA	2354	61	8.5	18.2	
Survey [‡]					0.36
NAMCS	5733	325	90.1	93.4	
NHAMCS-OPD	6156	23	9.9	6.5	

*Complete EHR includes electronic physician notes, nursing notes, electronic reminder system, test results, computerized prescription and computerized test order entry. Percentages may not add up because of rounding.

[†]The US population represented by the sample of visits for which data was collected.

[‡]NAMCS surveys ambulatory clinic visits in free-standing clinics. NHAMCS surveys hospital outpatient clinics.

defined as an EHR with all 6 components was present in 7.0% of the visits. Use of a complete EHR was not associated with patient age, sex, race, ethnicity, insurance

status, comorbidities, physician specialty, or practice type (group vs. solo) (Table 2). A complete EHR was more common in the south ($P < 0.05$).

TABLE 3. Percent of Visits With Controlled Blood Pressure as a Function of the Presence of EHR Components and Adjusted* Odds Between Use of Electronic Health Records and Blood Pressure Control

Physician Offices	Controlled Hypertension Target Blood Pressure <140/90 mmHg	
	Age >18 Visits 4433 [†]	Age >65 Visits 1893
With complete EHR	59%	63%
Without complete EHR	55%	56%
Adjusted odds ratio	1.12 (0.67–1.88)	1.19 (0.79–1.80)
With physician notes	61%	63%
Without physician notes	54%	55%
Adjusted odds ratio	1.35 (0.99–1.85)	1.35 (0.90–2.00)
With nurses notes	59%	60%
Without nurse notes	55%	56%
Adjusted odds ratio	1.15 (0.82–1.60)	1.12 (0.73–1.71)
With electronic reminder system	62%	67%
Without electronic reminder system	55%	55%
Adjusted odds ratio	1.27 (0.84–1.92)	1.54 (1.03–2.29) [‡]
With above 3 components	62%	66%
Without above 3 components	55%	56%
Adjusted odds ratio	1.24 (0.78–1.97)	1.39 (0.89–2.15)

*Adjusted for age, gender, insurance race, ethnicity, smoking status, presence of arthritis, asthma, hypertension, chronic renal failure, cancer, cerebrovascular disease, congestive heart failure, chronic obstructive pulmonary disease, hyperlipidemia, diabetes, ischemic heart disease, obesity, osteoporosis, physician specialty, number of visits in the past year, group or solo practice, region of country, and MSA or non-MSA setting.

[†]No. visits represent number of patients with select chronic condition seen by their primary care provider, over age 18 (new patients excluded).

[‡] $P < 0.004$, no other statistically significant relationships.

EHR Components and Blood Pressure Control

We identified 4433 visits by patient with hypertension (Table 3). There were no univariate associations between EHR components and blood pressure control. In multivariate models, we found no relationship between blood pressure control (140/90) and presence of electronic physician notes [odds ratio (OR), 1.55; 95% confidence interval (CI), 0.99–1.85], nursing notes (OR, 1.15; 95% CI, 0.82–1.60), or an electronic reminder system (OR, 1.27; 95% CI, 0.84–1.92). To examine if there may be an EHR effect among older patients who may be affected by quality improvement efforts focused on the Medicare population, we limited the sample of hypertensive patients to those older than age 65 ($n = 1893$). We found a 54% (OR, 1.54; 95% CI, 1.03–2.29) increased odds of blood pressure control associated with the presence of an electronic reminder system and no relationship between physician notes, nursing notes, or a complete EHR and blood pressure control.

Quality of Care for Select Chronic Conditions

We identified 605 patients with ischemic heart disease, 787 patients with cerebrovascular disease and/or ischemic heart disease, 1288 patients with diabetes and hypertension, and 849 patients with asthma (Table 4). With the exception of patients with diabetes, less than a third of patients received

appropriate therapy across all conditions considered. In multivariate analyses, there were generally small and nonsignificant differences in receipt of appropriate therapy as a function of physician notes with the exception of receiving an inhaled corticosteroid in asthmatics (OR, 2.86; 95% CI, 1.12–7.32). Similarly, use of electronic reminder was not associated with receipt of appropriate therapy with the exception of receipt of ACE/ARBs for treatment of patients with diabetes and hypertension (OR, 2.58; 95% CI, 1.22–5.42). There were generally small and nonsignificant differences in receipt of appropriate therapy as a function of CPOE in univariate and multivariate analyses.

Discussion

Using a national survey of nonfederal ambulatory clinics and hospital outpatient clinics, we found minor and inconsistent relationships between EHR components and the quality of care for chronic conditions. We found no relationship between physician notes, nurse notes, electronic reminders, and blood pressure control across the entire sample; however, in a subgroup analysis among older hypertensive patients (>65) we found that use of electronic reminders is associated with blood pressure control in elderly patients with hypertension. We also found that an electronic reminder system led to increased use of ACE/ARBs in patients with diabetes with hypertension. However, these relationships were inconsistent across all outcomes evaluated.

The benefits of an EHR seem self-evident and their widespread adoption has been deemed critical to improve the efficiency and quality of care.^{5,18–21} The impact of CPOE on decreasing medication errors has been the most thoroughly examined component of EHRs.^{8,9,22–26} In our study, we found no relationship between CPOE and the quality of prescribing for chronic conditions in ambulatory settings.⁹ However, research that has documented improved prescribing through the use of EHRs has usually used guideline reminders and e-mail prompts as interventions that helped physicians identify patients who would benefit from a specified therapy.^{9,25–28} It is unclear if CPOE in our sample of visits was deployed with any of these other important features. Although 12% of visits in NAMCS and NHAMCS involved an EHR with an electronic reminder system, we found minor and inconsistent relationships between presence of electronic reminders and quality of care. However, whether an electronic reminder was used or not in practice for the conditions investigated was unknown.

How EHRs are used is a critical determinant over the ultimate effect of EHR on clinical practice.^{29,30} It is doubtful that presence of an EHR alone can improve the quality of care. To be effective, EHRs must be deployed with decision support for specific conditions and in addition the EHR must have the capability to recognize if a specific measure for a patient has been implemented.^{5,9,18,31–34} In addition, the number of physicians who have access to the same EHR may effect its utility in improving care. In the United States, patients access care through multiple different systems of providers. The average Medicare beneficiary is cared for by 2 primary care providers, 5 specialists in 4 different practice sites,³⁵ and it may be more difficult to improve care efficiency

TABLE 4. Percent of Visits With Receipt of Recommended Care as a Function of the Presence of EHR Components and Adjusted* Odds Between Use of Electronic Health Records and Receipt of Recommended Care

Physician Offices	ASA for IHD/CVD Visits = 787 [†]	Beta Blocker for IHD Visits = 605	Ace Inhibitors/ARBs for Diabetics With Hypertension Visits = 1228 [†]	Inhaled Steroids for Asthma Visits = 849
With complete EHR	12%	33%	53%	10%
Without complete EHR	30%	39%	46%	11%
Adjusted OR	0.25 (0.05–1.27)	0.69 (0.29–1.27)	1.60 (0.64–3.97)	0.58 (0.09–3.38)
With physician notes	33%	39%	55%	19%
Without physician notes	27%	39%	45%	9%
Adjusted OR	1.19 (0.58–2.44)	0.84 (0.46–1.55)	1.54 (0.86–2.83)	2.86 (1.12–7.32) [‡]
With electronic reminders	25%	39%	63%	18%
Without electronic reminders	29%	39%	44%	10%
Adjusted OR	0.92 (0.27–3.07)	0.79 (0.33–1.87)	2.58 (1.22–5.42) [§]	1.93 (0.62–6.02)
With CPOE	29%	47%	54%	21%
Without CPOE	28%	37%	45%	10%
Adjusted OR	0.83 (0.34–2.03)	1.24 (0.57–2.69)	1.35 (0.75–2.42)	2.16 (0.88–5.31)
With above 3 components	19%	39%	60%	21%
Without above 3 components	29%	39%	45%	10%
Adjusted OR	0.53 (0.13–2.18)	0.81 (0.33–1.99)	2.14 (0.99–4.58)	2.08 (0.60–7.16)

*Adjusted for age, gender, insurance race, ethnicity, smoking status presence of arthritis, asthma, hypertension, chronic renal failure, cancer, cerebrovascular disease, congestive heart failure, chronic obstructive pulmonary disease, hyperlipidemia diabetes, ischemic heart disease, obesity osteoporosis, physician specialty, number of visits in the past year, group or solo practice, region of country, and MSA or non-MSA setting.

[†]No. visits represent number of patients with select chronic condition seen by their primary care provider, over age 18 (new patients excluded).

[‡] $P = 0.028$, no other statistically significant relationships.

[§] $P < 0.012$.

and quality when the information and functionality of the EHR is not shared by multiple providers. It is more difficult to accrue all the theoretical benefits of an EHR to our health care system without a universally shared EHR.⁹ The absence of a strong primary care system where patients generally are seen in the same practice makes pay-for-performance as a vehicle to garner improved care in tandem with an EHR and appropriate decision support systems more challenging in the United States.³⁵

Limitations

This analysis has several limitations that deserve comment. Although we found some evidence that electronic reminders may improve quality, we subjected each outcome to multiple comparisons and positive findings by chance cannot be dismissed. If we consider a lower threshold for significance ($P < 0.01$), there seems to be some effect of electronic reminders on blood pressure control in the elderly and on receipt of appropriate therapy among patients with diabetes. Also, NAMCS and NHAMCS are cross-sectional surveys. It is possible that the quality of care did improve in practices that implemented an EHR. A longitudinal data source where the effect of the implementation of an EHR can be assessed may be more useful to tease out the impact of EHR on the quality of care. In addition, there was no data on the length of time EHRs had been used in any practice. We also do not have any information on whether specific com-

ponents of the EHR were used at all or how they were used. We do not know, for example, if office practices used their electronic reminder system to improve blood pressure control or improve the quality of prescribing for asthma, diabetes, ischemic heart disease, or cerebrovascular disease. Questions on how these components were used were not included in the survey and electronic reminders may be deployed to improve billing and not necessarily health care. Finally, we examined combinations of different components and their effect on the outcomes of interest. The null findings presented in this analysis could be a result of inadequate power. Future research using a larger sample size may yield a different result.

In conclusion, although multiple studies^{8,25,26} have demonstrated that EHRs can improve quality, we did not find a consistent relationship between presence of specific components of an EHR and blood pressure control and appropriate use of medications for chronic conditions. Future research focusing on how an EHR is implemented and used and how care is integrated through an EHR will improve our understanding of the impact of EHRs on the quality of care.

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