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Electronic Medical Records and Diabetes Quality of Care: Results From a Sample of Family Medicine Practices

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ABSTRACT

PURPOSE Care of patients with diabetes requires management of complex clinical information, which may be improved by the use of an electronic medical record (EMR); however, the actual relationship between EMR usage and diabetes care quality in primary care settings is not well understood. We assessed the relationship between EMR usage and diabetes care quality in a sample of family medicine practices.

METHODS We conducted cross-sectional analyses of baseline data from 50 practices participating in a practice improvement study. Between April 2003 and December 2004 chart auditors reviewed a random sample of medical records from patients with diabetes in each practice for adherence to guidelines for diabetes processes of care, treatment, and achievement of intermediate outcomes. Practice leaders provided medical record system information. We conducted multivariate analyses of the relationship between EMR usage and diabetes care adjusting for potential practice- and patient-level confounders and practice-level clustering.

RESULTS Diabetes care quality in all practices showed room for improvement; however, after adjustment, patient care in the 37 practices not using an EMR was more likely to meet guidelines for process (odds ratio [OR], 2.25; 95% confidence interval [CI], 1.42-3.57) treatment (OR, 1.67; 95% CI, 1.07-2.60), and intermediate outcomes (OR, 2.68; 95% CI, 1.49-4.82) than in the 13 practices using an EMR .

CONCLUSIONS The use of an EMR in primary care practices is insufficient for insuring high-quality diabetes care. Efforts to expand EMR use should focus not only on improving technology but also on developing methods for implementing and integrating this technology into practice reality.

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INTRODUCTION

Use of an electronic medical record (EMR) in ambulatory care settings has been widely recommended as a method for reducing errors, improving the quality of health care, and reducing costs.[1-10] One area where EMRs are expected to improve quality is in the management of care for patients with chronic illnesses, such as diabetes. For example, by facilitating the management of complex clinical information, EMRs have been shown to improve the coordination of tasks among members of the health care team,[8] to lead to lower rates of missing clinical information,[11] and to support evidence-based clinical decision making.[12-15] Several recent systematic reviews of EMRs and clinical decision support systems have shown that systems developed in-house over many years lead health care institutions to improve adherence to clinical guidelines.[16-18] There is little evidence, however, on whether commercially developed multifunctional health information technology systems, such as EMRs, improve patient care in the primary care settings, where most chronic illness care is delivered.[18,19]

Much of the current evidence addressing EMR effectiveness in primary care settings is derived from a few intervention studies and from case study reports. Some studies have documented improved diabetes-related patient outcomes after EMR adoption,[20,21] whereas others have shown improvements in the processes of diabetes care but not in patient outcomes.[22-24] In a previous case study we found that, with everyday use of an EMR in a primary care practice, clinical decision support functions may be disabled, resulting in EMR uses which differ substantially from those in institutions reporting efficacy of this technology.[25]Another comparative case study found that EMR implementation can have a temporarily negative impact on the quality of diabetes care and care outcomes. In this case, the EMR practice failed to exceed outcomes of a similar non-EMR practice 4 years after implementation.[26] To date, no studies have examined the effect of EMR use across a large number of primary care settings. Such studies are needed to assess the impact of widespread EMR implementation on quality of care in primary care settings.

We examined the relationship between EMR usage and diabetes care quality across a variety of primary care settings by analyzing baseline data collected in 50 family medicine practices participating in an organizational change intervention.

METHODS

Setting

We analyzed data from family medicine practices in New Jersey and Pennsylvania participating in the Using Learning Teams for Reflective Adaptation (ULTRA) study. This study was designed to improve adherence to multiple chronic disease guidelines through a quality improvement process of organizational reflection and adaptation. The intervention in the study is described in detail elsewhere.[27] A convenience sample of 60 family medicine practices was recruited for the ULTRA study. Practices represented a range of ownership and practice arrangements, including private community-based practices, university-owned practices, health-system-owned practices, solo practitioners, and single-specialty and multispecialty group practices. Five practices withdrew from the study, and 1 practice did not provide information about their medical record system, leaving 54 practices for analysis. Four of the remaining practices had implemented an EMR within the past year. Because the earliest stages of implementation can be disruptive to practice systems,[25,26] we took a conservative approach and excluded the recent-adopter practices from the analyses. Notably, these 4 practices had diabetes care quality similar to those practices without an EMR, and including recent-adopter practices in either the EMR or non-EMR groups did not substantively change our results.

Data Collection

Physician-owners or office managers at participating practices completed a practice information form that asked about various organizational characteristics, including practice type, ownership structure, number of clinicians and other staff, number of years in business, estimates of insurance payer mix, whether they used an EMR, the presence of a registry of patients with diabetes, the regular use of clinician reminder systems, and whether they had adopted a new medical records system within the past 12 months.

For each practice chart auditors retrospectively assessed 20 patient charts randomly selected from a list of all adult patients coded (for insurance purposes) as having been treated for diabetes (ICD-9 diagnosis code 250.x) within the last year. In the 3 non-EMR practices with fewer than 20 patients coded for diabetes, auditors assessed the charts of all diabetes patients. Chart auditors reviewed any paper records available in all practices; in practices with an EMR, they also reviewed the electronic records. Auditors assessed these records in 2003 and 2004, looking at the previous 12-month period to determine diabetes care quality. All chart auditors were formally trained as licensed practical nurses or medical assistants and had experience working in patient care settings. A project physician trained the chart auditors in standard chart review techniques. Using a chart abstraction form developed by clinician researchers on the ULTRA project, auditors abstracted approximately 300 items from each chart.

This study was reviewed and approved by the Institutional Review Board at the University of Medicine and Dentistry of New Jersey-Robert Wood Johnson Medical School. Because this study was a retrospective review of patient records, and no identifiers were recorded, informed consent from individual patients was waived by the Institutional Review Board.

Measurement

We assessed diabetes care quality by measuring adherence to guidelines for processes of care, treatment, and achievement of intermediate outcomes for patients with diabetes. A team of family physicians and health services researchers selected the guidelines from the clinical practice guidelines of the American Diabetes Association.[28] Processes of care guidelines were based on their relationship to intermediate outcomes associated with cardiovascular disease risk. To avoid an overly conservative adjustment of significance levels as a result of multiple testing, we created dichotomous

composite scores for adherence in each of the 3 areas (Table 1). For process of care, the care of individual patients was scored 1 if 3 or more of the 5 criteria were met and 0 if fewer than 3 criteria were met. Patients whose care met all of the treatment guidelines were given a score of 1, with all others scoring 0. For the intermediate outcomes variable, we used 2 acceptable limits: (1) patients were given a score of 1 for partial achievement of intermediate outcomes targets if 2 of 3 laboratory values were at or below the target value; and (2) patients were given a score of 1 for complete achievement of outcomes targets if all 3 laboratory values were at or below the target value. We examine these 2 outcomes adherence criteria in separate analyses.

Table 1. Components of Guideline Adherence Scores

Processes of Care Any 3 of 5	Treatment All Required	Outcomes Evaluated Both as 2 of 3 and as All Required*
HgA_{1c} assessed within last 6 months	HgA_{1c} ≤8% or >8% and on hypoglycemic agent	HgA_{1c} <7%
Urine microalbumin assessed within last 12 months		
Smoking status assessed within last 6 months		
LDL assessed within last 12 months	LDL ≤100 mg/dL or >100 mg/dL and on lipid-lowering agent	LDL ≤100 mg/dL
Blood pressure recorded at each of 3 previous visits	Blood pressure ≤130/85 mm Hg (systolic and diastolic) or >130/85 mm Hg (systolic or diastolic) and on antihypertensive medication	Blood pressure ≤130/85 mm Hg (systolic and diastolic)

HgA_{1c} = glycosylated hemoglobin, percentage of total hemoglobin; LDL = low-density lipoprotein cholesterol.

* For outcome measures the most recent recorded value was used.

Statistical Analysis

To explore differences between the EMR and non-EMR practices, we used Fisher exact tests for categorical variables (eg, ownership, practice type), and analysis of variance for continuous variables (eg, number of clinicians). When exploring differences between patient level variables, we used hierarchical linear models to account for clustering of patients within practices. With binary variables such as sex, a logit link was used, whereas with continuous variables such as age, a standard identity link was used.

Because our dependent variables were all binary, we used hierarchical logistic regression to examine the log-odds of adherence as a function of EMR use while controlling for practice- and patient-level confounders (eg, practice ownership, staff/clinician ratios, patient age and sex). We used generalized estimating equations, applying the GENMOD procedure within SAS, for estimation.[29] The odds ratios associated with each covariate were estimated, and standard errors were adjusted for correlation between patients with diabetes within a practice using a working correlation matrix with an exchangeable structure.[30-32]

RESULTS

Of the 50 practices, 13 (26%) had used an EMR for 1 year or more. Whereas larger practices were disproportionately represented among EMR-using practices, this pattern was not statistically significant. Although one commonly mentioned benefit of an EMR is the disease registry, only 9 (18%) practices (3 EMR and 6 non-EMR) reported that they used a registry to track the care of patients with diabetes, and this difference was not statistically significant. Furthermore, there were no significant differences between the 2 groups of practices in their use of various electronic or paper reminder systems, such as flow sheets, reminders to clinicians, patient recall systems, or internal chart auditing designed to improve practice adherence to clinical guidelines. Patients in practices that did not use an EMR were somewhat older than those in the practices that reported using an EMR (Table 2). EMR and non-EMR practices did not differ significantly on any of the other patient-level or organizational-level variables. Across both groups, older patients were somewhat more likely to receive the selected treatments and to meet the targets, and male patients were more likely than female patients to meet all 3 treatment targets.

The 50 practices had between 7 and 21 charts of diabetic patients per practice audited, for a total of 927 patients. Across all 50 practices the care of 49.9% of patients met our criterion for processes of care, 46.2% met the criterion for treatment, and 40.3% met the criterion for achievement of 2 of the 3 intermediate outcomes targets; 8.7% met our criterion of simultaneous achievement of all 3 outcomes. Table 3 displays the mean practice-level rates of guideline adherence for EMR and non-EMR practices. In all cases, the mean rates for non-EMR practices were higher. Hierarchical logistic regression analyses showed that, after controlling for potential practice- and patient-level confounders and for the clustering of patients within practices, patients with diabetes in practices that did not have an EMR were significantly more likely to have received care that met the guidelines for processes of care, treatment, and intermediate outcomes (Table 4). For intermediate outcomes, the odds of patients in non-

Table 2. Patient (N = 927) and Practice (N = 50) Characteristics

Characteristic	EMR Practices	Non-EMR Practices	Test Statistic	*P* Value*
No. of patients	257	670		
Mean age, y (SD)	57.3 (15.1)	60.7 (14.4)	9.86†	.002
Sex, %			2.04†	.15
Women	53.9	48.7		
Men	46.1	51.3		
No. of practices	13	37		
No. of clinicians, mean (SD)	4.5 (3.2)	4.7 (3.2)	0.02‡	.89
No. of staff, mean (SD)	10.2 (8.7)	14.9 (10.9)	1.92‡	.17
Staff/clinician ratio (SD)	2.3 (1.6)	3.2 (1.6)	3.35‡	.07
Practice type, % (n)			–	.66§
Solo practice	7.7 (1)	18.9 (7)		
Group practice	92.3 (12)	81.1 (30)		
Practice ownership, % (n)			–	.32§
Physician	53.8 (7)	70.3 (26)		
Health system/other	46.2 (6)	29.7 (11)		

EMR = electronic medical record.

* Bonferroni adjusted significance level $P \leq .007$.

† Hierarchical model, Wald test statistic.

‡ Analysis of variance, degrees of freedom = 1, 48.

§ Fisher exact test.

Table 3. Practice Percentages of Patients Whose Care Meets Quality Standards

Variable	EMR Practices (n = 13) Mean (SD)	Non-EMR Practices (n = 37) Mean (SD)
Processes of care (3 of 5 guidelines met)	35.0 (19.5)	53.8 (22.1)
Treatment (all guidelines met)	35.3 (16.9)	48.6 (15.7)
Outcome targets (2 of 3 guidelines met)	29.0 (11.7)	43.7 (15.4)
Outcome targets (all guidelines met)	3.9 (3.8)	10.7 (9.0)

EMR = emergency medical record.

EMR using practices meeting all 3 targets was 2.68 times the odds of patients in EMR-using practices.

DISCUSSION

Diabetes care in the family medicine practices assessed here, regardless of whether they reported using an EMR, showed marked room for improvement, especially with regard to achievement of target values for intermediate outcomes. Contrary to the assumptions underlying suggestions from professional organizations, other researchers, and federal policy makers, we found that EMR usage was associated with poorer adherence to the diabetes quality of care measures examined here. Because we have data for the presence or absence of an EMR only, rather than on specific features of each EMR, our explanation for the quality differences between the 2 groups is somewhat speculative. Because commercially developed EMR systems vary by manufacturer in the features and levels of technological support available to users, our findings are likely to represent an accurate picture of the systemwide health effects of EMR implementation on quality of diabetes care in primary care practices.[33] Thus the study findings from our sample may be more representative of the overall effects of EMR implementation than the findings of previous studies evaluating the impact of particular EMR systems or features.

The main limitations of this study derive from the cross-sectional nature of the observations and that data were collected as a baseline for a practice improvement trial rather than to evaluate EMR effects on diabetes care quality. Specifically, our sample may not be representative; in fact, we found that in comparison with national data, a relatively high proportion of the practices participating in this study reported using an EMR.[34-37] Our findings are similar to the National Ambulatory Medical Care Survey data in that we found proportionately fewer solo practitioners reporting EMR use.[36] Moreover, our overall findings of quality of diabetes care are similar to those from a recent study of a nationally representative sample of patients, which documented a low proportion of recommended care provided to patients with chronic illnesses, such as diabetes.[38]

There may be additional unaccounted-for selection biases that could explain the better performance of non-EMR practices. For example, we did not collect detailed information regarding possible variations in use of EMRs, the number of years each practice had been using an EMR, or the particular diabetes care-related EMR features used in each practice. Furthermore, medical records typically do not include information on patient-level demographic variables (such as insurance status, socioeconomic position, and literacy), which may affect the outcomes measured here. In addition, since several of the practices provided only a few patient charts for audit, they may have had unusually few patients with diabetes or

Table 4. Practice and Patient Characteristics Associated With Diabetes Care Quality

Characteristics	Adjusted Odds Ratio	*P* Value	95% CI
Processes of care			
No EMR/EMR	2.25	<.001	1.42-3.57
Solo practice/other	0.38	.02	0.17-0.87
Physician owned/other	1.03	.90	0.65-1.62
Staff/clinician ratio	1.03	.66	0.91-1.17
Patient sex, male/female	1.21	.22	0.89-1.62
Patient age in 10-year increments	1.02	.68	0.92-1.13
Treatment			
No EMR/EMR	1.67	.02	1.07-2.60
Solo practice/other	0.63	.04	0.41-0.98
Physician owned/other	1.03	.89	0.70-1.50
Staff/clinician ratio	1.01	.86	0.89-1.16
Patient sex, male/female	1.06	.74	0.77-1.45
Patient age in 10-year increments	1.27	<.001	1.14-1.41
Outcomes 2 of 3			
No EMR/EMR	1.67	<.001	1.25-2.24
Solo practice/other	0.61	.11	0.33-1.12
Physician owned/other	1.44	.02	1.05-1.96
Staff/clinician ratio	1.08	.08	0.96-1.18
Patient sex, male/female	1.36	.02	1.07-1.72
Patient age in 10-year increments	1.11	.03	1.01-1.22
Outcome all			
No EMR/EMR	2.68	.001	1.49-4.82
Solo practice/other	0.93	.85	0.45-1.94
Physician owned/other	1.43	.30	0.73-2.78
Staff/clinician ratio	0.96	.50	0.86-1.08
Patient sex, male/female	1.40	.17	0.87-2.25
Patient age in 10-year increments	1.19	.04	1.01-1.42

CI = confidence interval; EMR = electronic medical record.

Note: These odds ratios are obtained from a single regression model for each outcome such that the odds ratios are adjusted for all other covariates in the table.

particular difficulties providing lists of patients, which would potentially bias our results. Even so, excluding these practices from our analyses did not lead to substantially different results.

Finally, this study faces the same limitations of any study that relies on chart audit in that the thoroughness of chart documentation may vary considerably among clinicians, across practice sites, or even between paper and electronic records. Despite these limitations, the guidelines examined here include items likely to be included in most medical records (ie, physical examinations, laboratory testing orders, and laboratory testing results), and a recent study found that in terms of intermediate outcomes, such as those assessed here, electronic and paper charts do not differ in the information that they include.[39]

Primary care practices are under increasing pressure to computerize their patient records and, as the recent United Kingdom experience has shown, documentation requirements of pay-for-performance programs are likely to increase this pressure.[40] Furthermore, the Medicare Management Performance Demonstration of the Centers for Medicare and Medicaid Services, set to begin payments to participating practices in summer 2007, includes a bonus for reporting data using a certified EMR.[41] Although pay-for-performance systems also include incentives for increased quality of care and have been successful in the United Kingdom,[42] practice leaders may react to these reporting pressures by implementing EMR systems without paying sufficient attention to the effects on the overall system of care delivery within their practices.[25] As has been found with computerized physician order entry and other technologically based safety procedures, implementation of health information technologies without sufficient attention to workflow redesign can create new quality problems and adversely affect patient health.[43-46] Our findings suggest that these sorts of unintended consequences may already be affecting the quality of diabetes care in our sample of US family medicine practices.

The findings presented here suggest that national policy makers and primary care practice owners should pay renewed attention to maintaining and improving quality in primary care settings during and after EMR implementation. EMR vendors should be encouraged to address existing recommendations to develop products that provide more than a means to enhance billing for clinician services. They should include, or make more easily usable, features that can support improved health care quality (such as developing a chronic illness registry capable of identifying patients for whom treatment intensification would be warranted or offering real-time clinical guidelines support).[47,48] More research on best uses of EMR technology and a high level of support for EMR implementation will be required if the federal goal of an electronic health record for every American by 2014 is to be met while preserving and enhancing the quality of care delivered. Policy makers should demand that evidence-based quality benchmarks be met as part of this support to ensure that EMR technology is used to enhance the quality of care. Finally, practice leaders

should encourage a culture of improvement and quality within their practices and work to develop methods to improve diabetes care before implementation of an EMR. Simply having an EMR does not guarantee higher quality care.

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Key words: Medical record system/computerized; diabetes mellitus; quality of health care; primary health care; electronic medical records

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