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The Impact of Electronic Health Records and Teamwork on Diabetes Care Quality

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Abstract

Objective—Evidence of the impact Electronic Health Records (EHR) on clinical outcomes remains mixed. The impact EHRs likely depends on the organizational context in which they are used. We focus on one aspect of the organizational context: cohesion of primary care teams. We examined whether team cohesion among primary care team members changed the association of EHR use and changes in clinical outcomes for patients with diabetes.

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Study Design—We combined provider-reported primary care team cohesion with lab values for patients with diabetes collected during the staggered EHR implementation (2005–2009). We used multivariate regression models with patient-level fixed effects to assess whether team cohesion levels changed the association between outpatient EHR use and clinical outcomes for patients with diabetes.

Subjects—80,611 patients with diabetes mellitus.

Measures—Changes in hemoglobin A1c (HbA1c) and low-density lipoprotein cholesterol (LDL-C)

Results—For HbA1c, EHR use was associated with an average decrease of 0.11% for patients with higher cohesion primary care teams compared with a decrease of 0.08% for patients with lower cohesion teams (difference 0.02% in HbA1c, 95%CI: 0.01–0.03). For LDL-C, EHR use was associated with a decrease of 2.15 mg/dL for patients with higher cohesion primary teams compared with a decrease of 1.42 mg/dL for patients with lower cohesion teams (difference 0.73 mg/dL, 95%CI: 0.41–1.11 mg/dL).

Conclusions—Patients cared for by higher cohesion primary care teams experienced modest but statistically significantly greater EHR-related health outcome improvements, compared with patients cared for by providers practicing in lower cohesion teams.

Introduction

Adoption of electronic health records (EHRs) has been promoted as a policy goal to improve the quality and efficiency of the American healthcare system. Starting in 2011, qualified healthcare providers in the United States of America began receiving federal incentive payments for meaningful use of certified EHRs.[1–3] While the meaningful use criteria were developed to target improvements in the overall quality of healthcare,[4] they do not address organizational environment in which EHRs are used. The healthcare system consists of a myriad of organizational settings that affect how various technological innovations are implemented and used.[5] Recent calls for the adoption of patient centered medical homes and the increasing demand for primary care is propelling the adoption of multidisciplinary, team-base care.[6–8] Therefore, it is important to understand how the team environment in particular impacts the adoption and effectiveness of new technology. Team cohesion is a measure of constructive work relationships among primary care team members.[9–12] How well teams work together may be an important factor in helping practices maximize the potential benefits of EHRs.[13]

Previous studies of the effects of health information technology (IT) on diabetes clinical outcomes have been mixed, with some showing improvements in LDL-C and HbA1c values,[14] whereas others reported mixed or even negative results.[15–20] Differences in the work environment, such as team cohesion, may help explain these conflicting findings. Work relationships are crucial for providing safe and reliable patient care and establishing the collective capacity for change, such as adopting new technologies, which demand considerable changes to the clinical workflow.[21–28] Team cohesion may promote more informal learning, where members are more comfortable experimenting with the EHR and sharing best-practices with each other. Consequently, cohesion among team members likely

influences how successful teams are at successfully adopting EHRs and achieving desired improvements in patient care.

In prior work, we reported that use of a commercially available federally certified outpatient EHR within a large integrated delivery system resulted in modest improvements in patient physiologic outcomes, measured by lipid and glycemic levels, and in fewer unfavorable clinical events such as hospitalizations.[2930] In this study, we explore the heterogeneity of these physiologic effects by examining how primary care team cohesion changes this EHR-associated improvement in clinical outcomes for patients with diabetes. We hypothesized that patients cared for by primary care teams with higher team cohesion would achieve greater improvements from EHR use compared to patients cared for by teams with lower team cohesion.

Methods

Study Setting

This study was conducted at Kaiser Permanente Northern California (KPNC), a large, prepaid Integrated Delivery System (IDS) providing comprehensive medical care for over three million members. The system receives bundled prospective payment for all medical care. Primary care clinicians worked in 110 primary care teams, across 18 Medical Centers. Primary care teams were created in 1990's in an effort to redesign primary care using multidisciplinary teams. The size and composition of teams varied, but generally included physicians, nurse practitioners, registered nurses, health educators, pharmacists, behavioral medicine specialists, physical therapists, etc. Teams ranged in size from 5 to 37 members per team (Table 1).

An individual with diabetes will often receive care from multiple members of the care team. For example, a primary care physician or nurse practitioner provides routine care ("checkups") and acute care; a health educator teaches diabetes self-care; a dietitian assists with dietary and nutritional needs; a pharmacist provides information regarding medications; and a behavioral medicine specialist can help address stress, depression, and other mental health issues.

Team cohesion measure

In 2005, before the staggered implementation of an EHR, we mailed a letter introducing the study, a survey, and a pre-paid return envelope to all primary care team members working in the IDS. Respondents who completed the survey received a five dollar gift card. Non-respondents were re-sent up to three follow-up surveys.

The team cohesion measure was designed to describe the quality of working relationships and communication between primary care team members and was developed using published validated instruments.[9–12] While other instruments capture similar aspects of the team environment, such as team participation, team dynamics, and relational coordination, we chose to use this specific one because it was the only validated instrument available at the time of the study created specifically for use among primary care teams.[9] We asked primary care team members whether they agreed or disagreed with the following four items:

1. When there is conflict on this team, the people involved usually talk it out and resolve the problem successfully.
2. Our team members have constructive work relationships.
3. There is often tension among people on this team (reverse scored).
4. The team members operate as a real team.

Response options included a five-point Likert-like agreement scale (1–5) and were averaged over the four team cohesion items for each respondent and then averaged across members from the same team. The overall measure demonstrated high internal consistency with a Cronbach Alpha coefficient of reliability of 0.83. For ease of interpretability, we categorized team cohesion scores into quartiles and created a binary indicator variable classifying each team as having lower or higher cohesion, with the lowest quartile of scores representing lower cohesion teams. We chose to categorize lower cohesion teams as those in lowest quartile of cohesion because the median cohesion score in the study setting was higher than those previously reported; our 25th percentile scores were similar to the median score previously published.[31]

Patient Population

The study population included all patients who were in the health plan's diabetes clinical registry at the start of 2004. The registry used the following four health plan data sources to identify patients: pharmacy data, lab values, and inpatient and outpatient diagnosis. Patients with one inpatient principle diabetes diagnosis, two outpatient diabetes diagnosis within five years, two or more abnormal lab results within two years (HbA1c>6.5%, fasting glucose >162 mg/dl, random glucose >200 mg/dl), or one diabetes medication prescription were entered into the registry. We used delivery-system administrative data to link patients with their primary care provider and team based on patients' assigned primary care provider at the beginning of the study (2005). Members left the study cohort when they first dis-enrolled from the IDS, died, or changed their primary care team.

Outcome measures- HbA1c or LDL-C Value

Using the health plan's automated lab data, we collected all HbA1c and LDL-C values for the patients in our study cohort during the study period, between January 1, 2005 and December 31, 2009. We chose these specific measures of disease control (HbA1c and LDL-C) since they are reliably captured, have been previously shown to improve with EHR implementation, and are associated with risk for adverse clinical events.[3032]

Health Information Technology

Between 2005 and 2008, KPNC implemented an outpatient EHR in a staggered schedule across medical centers and teams. Although the implementation schedule was not randomly ordered, we confirmed that it was not associated with baseline level of diabetes care quality and did not coincide with other organizational changes.[29] This implementation schedule created a quasi-experimental setting to examine the effects of team cohesion and EHR use with concurrent-controls to adjust for secular trends in diabetes care practices unrelated to

the EHR.[29] The outpatient EHR replaced the paper-based medical record and a patchwork of non-integrated health information technology tools that were previously available.

The EHR is a commercially available EpicCare®-based system that has been certified as a complete EHR, thereby qualifying its users for federal incentive payments. The system provides clinicians with complete outpatient information at the point of care, as well as lab and drug order entry and management, clinical decision support, and secure messaging with patients and across providers. Once implemented, the system was used by both clinical and support staff.

To determine the EHR status for each patient lab value, we linked patients in the study population to the medical facility where they sought care and defined each patient's lab value according to whether the EHR was in use at their facility at the time of the test. We defined a facility as using the EHR once it was used for at least 80% of outpatient visits in a given calendar month. For each patient, we separately classified the first lab value after EHR implementation as having been done during the transition to the EHR, since it likely captured effects of treatment decisions based on the previous test value obtained pre-EHR.[32] We defined each patient's second and subsequent values after EHR implementation as being post-EHR follow-up values. This allowed for the patient to be fully exposed to the EHR and its potential effect on treatment and follow-up care.

Data Analysis

We examined follow-up HbA1c and LDL-C values using linear regression models with fixed-effects at the patient level,[33] adjusting for calendar quarter and year, with an interaction term between outpatient EHR use and low team cohesion. To calculate the estimated EHR association for patients cared for by clinicians working in teams with lower cohesion, we added the coefficient for the EHR association and the interaction term for EHR and the lower team cohesion indicator. The interaction term represents the difference in the EHR association with clinical outcomes for patients cared for by teams with higher versus lower cohesion scores. In addition, we also used logistic regression models with fixed-effects at the patient level adjusting for the same covariates to examine the interaction effect of team cohesion and EHR use on follow-up binary measures of good clinical HbA1c and LDL-C control (e.g., HbA1c≤7% and LCL-C≤100 mg/dL).

As a sensitivity analysis, we also ran all models using random-effects at the patient level while controlling for patient characteristics (including gender, age, race, chronic diseases) and obtained comparable results to the fixed effects models. We also conducted sensitivity analyses using continuous cohesion scores, other thresholds, and separate quartile indicators of team cohesion yielded comparable findings. We chose to present findings using the binary lower cohesion indicator for ease of interpretation of interaction term results. All analyses were implemented using Stata 10 (StataCorp LP, College Station, TX).

The Kaiser Foundation Research Institute Institutional Review Board reviewed and approved the study protocol.

Results

Table 1 provides a description of the primary care teams (N=104, 95% of teams) included in the study, we excluded six teams that had fewer than three respondents. The mean team cohesion score was 3.71 (a score of five represents the highest possible level of cohesion), with a range from 2.84 to 4.42 (SD=0.29).

Table 2 describes the individual characteristics of respondent and non-respondent primary care team members (N=780, 49% individual response rate). Respondents and non-respondents were were comparable in age and race ($p>0.05$), but team members who were male and physicians were less likely to have completed our survey ($p<0.05$).

Our study included 80,611 patients in the health plan's clinical diabetes registry at the end of 2003. Table 3 shows patient characteristics at baseline. During the study period (2005–2009), these patients had a total of 598,924 HbA1c and 549,619 LDL-C tests; 60.1% of HbA1c and 58.4% of LDL-C tests were done after the implementation of the certified, outpatient EHR. On average, patients had four HbA1c and four LDL-C tests prior to the EHR, and three of each test after the EHR implementation. At baseline (last test in 2003), patients treated by teams with higher and lower team cohesion had similar mean HbA1c values (7.2% and 7.1% respectively, $p=0.11$); but modestly different LDL-C values (96.8 mg/dL for lower cohesion vs. 97.5 mg/dL for higher cohesion teams, $p=0.01$).

Table 4 shows the adjusted association between EHR use and patient HbA1c and LDL values for primary care teams with lower and higher team cohesion. For patients cared for by clinicians working in primary care teams with higher cohesion, use of an EHR was associated with significantly greater improvements in HbA1c levels (0.11 percentage point decrease in HbA1c) compared with patients whose provider worked in a lower cohesion team (0.08 percentage point decrease); the difference in the EHR associated reduction in HbA1c for patients cared for by teams with higher versus lower team cohesion was 0.02 percentage points (95%CI: 0.00–0.03%, $p<0.01$). Similarly, for patients whose provider worked in a team with higher cohesion, use of the EHR was associated with a greater decrease in LDL (2.15 mg/dL decrease) than for patients whose provider worked in a lower cohesion team (1.42 mg/dL decrease); the difference in the EHR associated reduction in LDL for patients cared for by teams with higher versus lower team cohesion was 0.73 mg/dL (95%CI: 0.41–1.11 mg/dL, $p<0.001$). Similarly, in the logistic models we found that the association of EHR use and good physiologic control among patients with diabetes (HbA1c≤7% and LDL-C≤100 mg/dL) was significantly higher for patients treated by primary care teams with high cohesion compared with those treated by teams with low cohesion ($p<0.01$, appendix table A1).

Discussion

We found that the association between primary care teams' use of an outpatient EHR and improvements in glycemic and lipid control in their patients with diabetes varied significantly by provider-reported team cohesion. For patients cared for by more cohesive primary care teams, using an EHR was associated with statistically significantly greater

reductions in their glycemic and lipid levels than for patients cared for by less cohesive teams. These findings highlight the importance of attributes of the organizational environment, such as team cohesion, in the successful adoption of new technologies and practices.

Since the Institute of Medicine called for the redesign of our healthcare system centered around the use of multidisciplinary teams more than a decade ago, their use continues to grow.[34] New care models, such as patient centered medical homes and accountable care organizations emphasize the importance of multidisciplinary teams to ensure high quality, coordinated care.[6–8] Expansions in insurance coverage through the Affordable Care Act will increase demand for primary care services, which combined with our nation's shortage of primary care physicians, may result in a greater reliance on the use of teams. Our findings are particularly timely given the ongoing federal incentive payments for "meaningful use" of EHRs and concurrent efforts to promote team based primary care with patient centered medical homes.

One way in which team cohesion may enhance the EHR-associated improvements in care could be through promoting informal learning. Members in more cohesive primary care teams may be more open to sharing best-practices and minimizing unintended consequences than less cohesion teams.[35] For example, use of an EHR may increase the amount of information included in the patient's record, creating new processing challenges. It is possible the members working in less cohesive teams had fewer agreed-upon approaches to document and retrieve critical patient health information.[13]

Evidence suggests that team member relationships are important for managing the care of chronically ill patients and successfully adopting new practices and technologies.[2123–2636] Our previous study found that cohesion among primary care teams significantly changed the association between EHR use and a number of clinician-reported coordination outcomes.[37] Nonetheless, while team cohesion enhanced the EHR adoption process and its short-term effect on clinical outcomes, it is possible that in the longer-term all clinicians will achieve comparable improvements in care. Future studies should examine whether differences in the EHR associated changes in care by team cohesion persist over time.

Although the magnitude of the changes in LDL-C and HbA1c in this study are modest, our analyses were designed to measure the incremental within patient changes associated with outpatient EHR use and team cohesion, excluding any secular trends.[29] Whereas a small reduction in LDL and HbA1c control may have little effect on an individual, small changes in a large population accompanied by parallel unmeasured improvements across other care pathways, could have clinically relevant favorable effects on downstream events. In addition, the results from the logistic regression models showed that patients cared for by more cohesive primary care teams were more likely to achieve guideline recommended glycemic and lipid targets with EHR use compared with patients cares for by less cohesive teams. In a previous paper, we showed that outpatient EHR use was associated with decreases in the rate of emergency department visits and hospitalizations for patients with diabetes.[38]

There are limitations to the generalizability of our findings. This study was conducted in a single delivery system and EHR system. In other settings, the team structure may differ with some physicians practicing without teams. Still, use of multidisciplinary teams in primary care continues to grow across the country. Prior to the EHR, the IDS did use a limited set of health information technology applications and used disease management programs to target patient intermediate outcomes, so there may have been somewhat limited room for improvement in the study outcomes. In contrast, the benefit of the EHR on new quality targets or in settings that do not have access to these tools at baseline could be potentially greater in magnitude. In addition, our measure of team cohesion measure was based on survey responses, which are subject to response bias. We compared characteristics of respondents and non-respondents and found that they were comparable in age and race, but not in gender or job title (see Table 2). Also, we were not able to include patients who changed or left their primary care team during the study period. It is possible that team members or cohesion levels changed during this time. Patients are the central figures in their care and the focus of their care team, yet in this study we only collected surveys from healthcare providers and not patients. Future studies should examine the patient perception of their healthcare team's cohesiveness. While we used a quasi-experimental study design with concurrent controls, this is still an observational study and therefore we cannot rule out unmeasured confounding. It is possible that an unobserved factor, such as leadership or resources, drove both team cohesion and outcomes, or that the differences in EHR-associated improvements in these outcomes will converge over time.

Conclusion

The implementation of an EHR system is inherently complex and not always successful.[39] There is also great variation in how health care providers are organized and surprisingly little known about how the organization of clinicians might influence the effect of EHR use on clinical care.[5] We found that patients cared for by primary care teams with higher team cohesion experienced greater EHR-related improvements in HbA1c and LDL-C levels than patients cared for lower cohesion teams. The organizational context, in particular team cohesion, may play an important role in fully realizing potential gains in care quality from EHR use. Understanding the conditions necessary to maximize any potential benefits of EHR use is a critical policy area in need of more evidence. Future studies should explore which factors promote greater team cohesion such as the development of shared goals and knowledge[40], the use of team development coaches, and the roles played by organizational culture and leadership. Identifying opportunities to improve team relationships in the work environment may enhance the effect of EHRs on quality.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Take-Away Points

Diabetes patients cared for by higher cohesion primary care teams experienced modest but statistically significantly greater EHR-related health outcome improvements, compared with patients cared for by providers practicing in lower cohesion teams.

- Previous studies of the effects EHR use on diabetes clinical outcomes have been mixed and none examined how the organizational environment may change the EHR impact on clinical care.
- Understanding the conditions necessary to maximize the potential benefits of EHR use is important.
- Our results suggest that team cohesion plays a critical role in fully realizing potential gains in care quality from EHR use.

Table 1

Primary care team characteristics

Total N=104	Mean	Std. Dev.	Min	Max
Team Size	15.4	5.1	5	37
Primary Care Providers (PCPs) per team	11.8	4.7	1	37
Team Response Rate	0.5	0.2	0.2	1.0
Respondents per team	7.5	3.0	3	16
Team cohesion score (possible range 1–5) by quartile:				
1st (lowest)	3.4	0.4	2.8	3.5
2nd	3.6	0.1	3.5	3.7
3rd	3.8	0.1	3.7	3.9
4th (highest)	4.1	0.2	3.9	4.4

Note: Team cohesion scores were calculated by averaging responses over the four team cohesion survey items and aggregating them across members from the same primary care team, and then categorized into quartiles. The possible range for team cohesion scores could was 1 to 5, with 5 representing the highest potential level of cohesion.

Table 2

Baseline primary care team member characteristics

	Respondents (N=780)		Non-respondents (N=824)		
	%	N	%	N	p-value
Age group, yr					
25–39	35.0%	273	30.9%	255	0.109
40–55	48.3%	377	46.5%	383	
55–75	16.7%	130	19.3%	159	
Missing	0.0%	0	3.3%	27	
Male gender	40.5%	316	47.0%	387	0.003
Missing	0.0%	0	2.9%	24	
Race					
Non-white	46.3%	361	47.8%	394	0.206
White	53.7%	419	49.0%	404	
Missing	0.0%	0	3.2%	26	
Job Title					
PCP Physician (M.D./D.O.)	65.0%	507	72.9%	601	0.001
PCP Other (N.P/P.A.)	12.7%	99	6.4%	53	
Nurse (LVN/RN)	7.2%	56	6.3%	52	
Physical Therapist	5.8%	45	5.0%	41	
Behavioral Medicine Specialist	5.1%	40	4.7%	39	
Health Educator	2.3%	18	4.1%	34	
Pharmacist	1.9%	15	0.5%	4	

PCP=primary care provider

Table 3

Baseline characteristics of patients with diabetes

Total N = 80,611	**%**	**N**
Age group, yr		
1–29	1.0%	815
30–49	15.2%	12,280
50–64	39.0%	31,445
65–74	25.3%	20,398
75+	19.4%	15,673
Male gender	53.6%	43,229
Missing	0.0%	23
Race		
Asian	16.3%	13,157
Black	9.8%	7,863
Hispanic	13.6%	10,924
Other	4.0%	3,214
White	48.1%	38,771
Missing	8.3%	6,682
Low Neighborhood SES	26.3%	21,174
Missing	2.6%	2,118
Other chronic conditions		
Asthma	13.0%	10,459
CAD	20.0%	16,090
Hypertension	73.9%	59,564
Heart Failure	11.0%	8,850

SES=Socioeconomic status

Table 4

Adjusted association between EHR use and HbA1c and LDL-C values by primary care team cohesion level

	Average change in HbA1c (%)	95% CI	Average change in LDL-C (mg/dL)	95% CI
Higher team cohesion: EHR vs. No EHR	−0.11***	[−0.12, −0.09]	−2.15***	[−2.43, −1.86]
Lower team cohesion: EHR vs. No EHR[1]	−0.08***	[−0.10, −0.07]	−1.42***	[−1.80, −1.03]
Difference in EHR association for higher vs. lower team cohesion[2]	0.02**	[0.01,0.03]	0.73***	[0.41,1.11]

Note: We used linear regression with fixed effects at patient level, adjusted for calendar quarter, calendar year, and dummy variables to control for medical center fixed effects.

[1]EHR effect for teams with lower cohesion was calculated by adding the EHR effect estimate by the interaction of EHR and lower team cohesion.

[2]The interaction coefficient for EHR and lower cohesion represents the difference in the EHR association on clinical outcome for patients cared for by teams with higher versus lower team cohesion.

EHR = Electronic Health Record, CI = Confidence Interval, LDL-C = Low Density Lipoprotein-Cholesterol, HbA1c= Glycosylated Hemoglobin A Protein.

** $p < 0.01$,

*** $p < 0.001$