

Grant Final Report

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EHR Use and Care Coordination

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Abstract

Purpose: While Electronic Health Records (EHR) systems have been promoted as a policy priority for improving the quality of our healthcare system, there is limited evidence to inform policy-makers on how the organizational context may impact potential benefits from EHR use. I examined the impact of a certified-EHR and primary care team member's working relationships on measures of care coordination and clinical care for patients with diabetes.

Scope: This study provides evidence on the role of EHR use on care quality, and how the organizational context modifies these effects.

Methods: Using self-administered surveys of primary care team members and patient level claims data, I examined the interaction between team cohesion and EHR on care coordination and clinical care for patients with diabetes. I used multivariate regression to adjust for secular time trends and patient-level fixed effects.

Results: Use of an outpatient and an integrated outpatient-inpatient EHR was associated with improvements in care coordination across clinicians and delivery sites respectively. Use of the outpatient-EHR was associated with improvements in glycemic and lipid control for patients with diabetes. I found a statistically significant interaction effect between team cohesion and EHR use on clinical outcomes for patients with diabetes and care coordination. Clinicians working in teams with higher cohesion were able to achieve greater improvements from use of the EHR in these outcomes. The organizational context, in particular primary care team members' working relationships, is critical to maximize potential gains from EHR use.

Key Words: electronic health records; primary care; teamwork; care coordination

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Final Report

Purpose

The purpose of this study was to examine the association between EHR use and care coordination and clinical care quality for patients with diabetes, and how team working relationships modify these effects. I used existing primary care clinician team member survey responses, as well as the health system's comprehensive automated data collected over four years (2005-2009) while a large integrated delivery system in Northern California engaged in the staggered implementation of a commercially-available, certified-EHR system. These analyses were divided into three aims addressing the following main questions:

Aim 1: Use of Electronic Health Records and Care Coordination

I examined the association between EHR use and care coordination. Specific questions included the following:

- Is use of a commercially available outpatient EHR, and an integrated outpatient-inpatient EHR associated with improvements in clinician reported measures of:
 - Coordination of care across clinicians (e.g., from a specialist to the primary care team)?
 - Coordination of care across delivery sites (e.g., from hospital to outpatient care)?

Aim 2: Impact of Electronic Health Records and Teamwork on Care Coordination

I examined the association between EHR use and reported measures of coordination for care transferred across delivery sites (e.g., from hospital to outpatient care) among teams with higher and lower reports of team cohesion, while adjusting for patient, physician, team, and medical center characteristics.

- Does team cohesion modify the effect of use of an integrated outpatient-inpatient EHR on coordination of care across delivery sites?

Aim 3: The Impact of Electronic Health Records and Teamwork on Quality of Diabetes Care

I examined the association between outpatient EHR use and clinical care quality for patients with diabetes receiving care from teams with higher and lower reports of team cohesion. This paper addressed the following research questions:

- Does team cohesion modify the effect of use of an outpatient EHR on physiologic measures of disease control for patients with diabetes including:
 - Glycosylated hemoglobin (HbA1c) values?
 - Low-density lipoprotein (LDL-C) values?

Scope

Increasing Prevalence of Patients with Complex Care Needs and Coordination Challenges

The number of Americans living with at least one chronic condition is large and growing. These numbers are expected to rise sharply as the population continues to age. Any efforts to tackle the efficiency and quality of the American healthcare system will have to pay special attention to this growing population. Patients with multiple chronic conditions typically see multiple providers and take numerous prescription drugs [1, 2]. Clinical management for these patients requires coordination between multiple physicians (e.g., primary care and specialists), sites of care (e.g., inpatient and outpatient), and treatments (e.g., drug regimens) across the health care system. In the current environment, where patient care is increasingly fragmented, effective care coordination is essential to ensure quality care [3, 4].

While patients with complex care needs face a higher clinical risk, evidence suggests that they are often receiving sub-optimal care [5-15]. Recent studies show that patients with multiple chronic conditions are more likely to experience an adverse drug event, and that the presence of one chronic condition decreased the likelihood that another condition would be treated [16, 17]. In addition, evidence indicates that clinicians rarely have access to complete medical information when patient care is transferred across providers and that patient safety may be jeopardized during transitions in care [7, 13, 18-23]. Lack of timely information often results in inadequate patient monitoring, redundant care, medical errors, and greater use of services [24-28]. Any practical realization of a model for coordinated care must rely heavily on timely availability of comprehensive clinical information, likely provided through an integrated EHR system [28, 29]. Without adequate coordination, patients may receive sub-optimal care with significant implications for their overall health and well-being.

Calls for Action: Health Information Technology and Care Coordination

The IOM report on improving the delivery of health care in the United States, “Crossing the Quality Chasm: A New Health System for the 21st Century,” specifically targeted both coordination of care (across patient-conditions, types of medical services, and sites of care over time) and effective use of information technologies as top health system redesign imperatives [3]. The Patient Protection and Affordable Care Act of 2010 (PPACA) included several provisions specifically targeting care coordination through the use of Patient Centered Medical Homes

(PCMH) and Accountable Care Organizations (ACO). Also, the 2009 stimulus bill allocated billions of dollars to promote the adoption and meaningful use of certified EHR systems [30-33]. The HHS defined meaningful use to specifically target five health care goals, including care coordination and care quality [34]. While Health IT has been consistently promoted as a policy priority for improving the quality and efficiency of the American healthcare system, there is still limited research evidence to inform policy-makers about the effects of Health IT on care coordination. Better evidence of the benefits of EHR on all aspects of health care delivery, including care coordination, may help promote its adoption.

Teamwork

Primary care in the United States is increasingly provided through the use of teams. In 2001, a seminal report from IOM called for a redesign of the American healthcare delivery system centered around primary care teams [3]. Many new and existing care models, such as ACOs, PCMH, and the chronic care model, continue to emphasize the vital role of teams in the provision of primary care. Multidisciplinary teams have been found to be especially important for managing the care of chronically ill patients [35-37]. Previous studies found that team care was associated with greater work satisfaction, perceived effectiveness, better clinical outcome measures, and patient satisfaction when compared with traditional non-team care [35, 38, 39]. The measure of team cohesion used in the existing KPNC clinician surveys derives from a measure developed in earlier research examining organizational attributes of primary care practices [40]. This instrument was specifically designed to measure relationships among team members that encourage communication and collaboration. High scores in this measure represent teams where members work together through open discussion to address and solve problems. This study focuses on team climate instead of organizational culture because of the assumption that climate is more applicable to the primary care team level.

KPNC and EHR: A Natural Experiment

This study was conducted in Kaiser Permanente Northern California (KPNC), a large, prepaid integrated delivery system (IDS) providing comprehensive medical care for over three million members, including outpatient, inpatient, emergency department, pharmacy, and laboratory services. In February 2005, the IDS began a five-year staggered implementation of a commercially available, integrated EHR system certified by the Certification Commission for Health Information Technology (CCHIT) [33]. The EHR is an EpicCare®-based system that provides multiple new clinical functions including an electronic medical record (EMR), computer-based provider order entry (CPOE), decision support, and secure messaging across clinicians and patients.

The system was rolled out in two phases. Phase 1 (2005-2008) included the deployment of the system across its outpatient clinics, and phase 2 (2007-2010) across its hospitals. The EHR system was rolled out in the outpatient clinics, by medical center, and staggered by primary care team within each medical center. Once implemented, the EHR system completely replaced the paper-based medical record system.

Conclusion

In summary, EHR has great potential for improving care coordination, especially for patients with complex healthcare needs. This patient population is growing rapidly and the complexity of their care underscores the importance of timely, integrated clinical information to facilitate delivery of high quality coordinated care and improved outcomes. This study leverages existing data, including survey responses that capture detailed measures of clinician reported care coordination, teamwork, and cohesion at multiple points in time, as well as the substantial data resources from the study setting to explore the relationship between EHR use and teamwork on care coordination and quality. Lastly, the staggered nature of the EHR implementation allows for adjustment of secular changes.

Methods

I examined the association between EHR use and care coordination measures, and how team working relationships modify the effect of EHR use on reported measures of care coordination and clinical outcomes for patients with diabetes. I used existing primary care clinician survey responses, collected as part of the AHRQ sponsored R01 IMPACT study, as well as the health system's automated data collected over four years (2005-2009) while a large IDS in Northern California engaged in the staggered implementation of a new, certified EHR system.

I analyzed quasi-experimental changes in exposure to EHR across a staggered implementation in inpatient and outpatient settings during 2005-2009, using a pre-post analytic design with concurrent controls (Figure 1). This study used primary care team member surveys collected in 2005, 2006, and 2008 and the longitudinal experience of patients within an IDS. Care coordination and team cohesion were captured using self-administered clinician survey responses, including measures collected before and after the EHR was launched. Quality and clinical outcome measures for patients with diabetes were derived from the system's automated databases and included physiologic disease control (measured by laboratory tests) for patients with diabetes.

To examine the impact of EHR use on care coordination, I evaluated clinician reported measures of care coordination collected over three years while the IDS was implementing a certified outpatient-inpatient EHR system. To evaluate the association between EHR and teamwork on clinical care for patients with diabetes, I will examine guideline-consistent lab results (e.g., HbA1c and LDL levels) using the IDS's automated clinical data. These measures represent areas for which the IDS has clinical guidelines and consistent capture of patient data, and where significant room for improvement exists. These are considered standard physiologic measures of disease control for patients with diabetes.

Study Setting: Kaiser Permanente Northern California

This study was conducted in Kaiser Permanente Northern California (KPNC), a large, prepaid Integrated Delivery System (IDS) providing comprehensive medical care for over three million members, including outpatient, inpatient, emergency department, pharmacy, and

laboratory services. The IDS provides care for over two million adult members and has over 1,000 adult primary care clinicians in the Internal Medicine and Family Medicine departments, grouped in 110 primary care teams across 18 medical centers.

Population

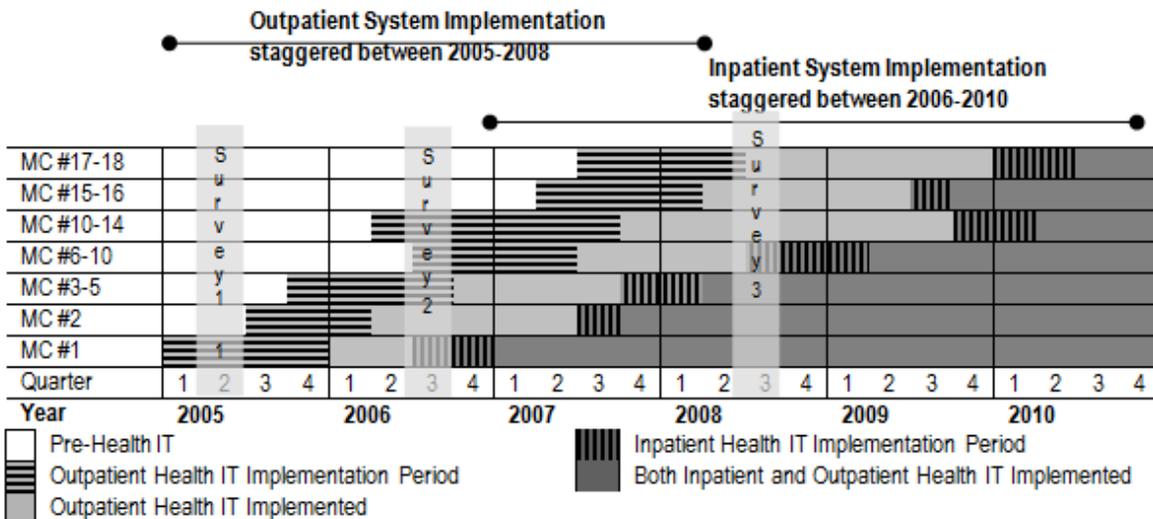
Survey data on teamwork and coordination used in this study was collected from all adult primary care team members working at KPNC, including physicians, nurse practitioners, and physician's assistants. Primary care team member survey responses were linked with patient panels using the health system's automated databases. Since patients with complex health care needs are likely to benefit most from improvements in care coordination, this study focused on patients with diabetes. The study population included IDS members who were in the healthplan diabetes clinical registry as of the last quarter of 2003. I then used IDS administrative data to link patients with a single primary care team and excluded members who had changes in their primary care team linkage during the study period (1/2005-12/2009). In addition, members left the study cohort when they first dis-enrolled from the IDS (average 4.9% per year) or died (2.6% per year).

Survey Collection

In 2005, 2006, and 2008 we mailed a self-administered questionnaire to all adult primary care team members working at KPNC (IMPACT survey). Each clinician received a letter introducing the study, a copy of the survey, and a pre-paid return envelope. Respondents who completed the survey received a small gift card. Non-respondents were sent reminder letters and additional copies of the surveys; up to four follow-up mailings were sent during each year of survey collection. The Institutional Review Boards of the Kaiser Foundation Research Institute and UC Berkeley approved the study protocol and materials.

Overall, 565 primary care clinicians responded in 2005 (48% response rate), 678 in 2006 (62% response rate), and 626 in 2008 (61% response rate). Figure 1 shows a collapsed version of the staggered integrated EHR implementation schedule and survey collection. The full implementation was staggered by medical center, and by clinic within medical center (with approximately a 3-week lag between clinics within given medical centers). The survey was collected in three waves: first, in 2005, during the early stages of the EHR implementation, when few clinicians had access to the new EHR system; then in 2006, roughly midway through the outpatient EHR implementation process; and finally in 2008, after all outpatient clinics had finished implementing the outpatient component and roughly half of the hospitals had completed the implementation of the inpatient EHR.

Figure 1. Quasi-experimental study: staggered implementation of integrated health IT across medical centers



Note: The actual implementation schedule has different specific staggered start and stop dates for all 18 medical centers. We collapsed this detailed schedule into the figure above.

Survey Instrument

Care Coordination. On the survey, we asked primary care clinicians about four specific aspects of care coordination when patient care is transferred across clinicians (e.g. from a specialist to the primary care team) and across delivery sites (e.g., from the hospital to the outpatient team). We asked clinicians how often each of the following occurs: (1) “all relevant medical information is available”; (2) “the information transfer is timely, i.e. available when it is needed”; (3) “all clinicians agree on the treatment goals and plans”; and (4) “all clinicians agree on roles and responsibilities of each party.” The response categories were: never, rarely, sometimes, usually, and always.

Team Cohesion. The survey also included 16 previously validated questions on team climate.¹² This scale addressed the following five dimensions: (1) conflict resolution (e.g., “When there is conflict in this team, the people involved usually talk it out and resolve the problem successfully”); (2) working relationships (e.g., “The team members operate as a real team”); (3) leadership and decision-making approaches (e.g., “All team members participate in important decisions about the clinical operation.”); (4) stress (e.g., “Working in the team is stressful”); and (5) quality improvement efforts (e.g., “Team members are involved in developing plans or improving quality”). Each item was scored on a one to five scale (“strongly disagree”...“strongly agree”). Response were averaged over the four team cohesion items for each respondent and aggregated across members from the same primary care team. The overall measure demonstrated high internal consistency reliability with a Cronbach Alpha coefficient of reliability of 0.83. To create a binary indicator of low team cohesion, we then categorized team cohesion scores into quartiles and created an indicator for teams in the lowest quartile.

Automated Data

The Kaiser Permanente administrative databases will be used to assess clinicians' use of the integrated EHR system and to obtain specific clinician characteristics, including age, gender, job title, and race/ethnicity. It will also be used to link clinicians to patients in their care. The primary outcome measures of clinical care quality are patient lab results for HbA1c and LDL-C.

Analysis Approach

The analytic approach allows for separation of EHR and care coordination effects from concurrent background secular changes, while accommodating the staggered introduction of the EHR system across clinics within the medical centers. I used repeated measure outcome data obtained from clinician surveys collected in 2005, 2006, and 2008 and patient outcomes captured over the same period using the automated databases. The models include terms to represent the concurrent secular trend using dummy variables to represent each year covered in the study. By modeling secular trends in this way, I can estimate the EHR effects over and above the effect of the background time changes. My approaches account for clustering in the repeated outcome data at multiple levels in the care hierarchy: medical center (which contain each hospital), team, clinician, and patient.

Aim 1: Use of Electronic Health Records and Care Coordination. To analyze the effect of using an integrated EHR system on the three measures of coordination of care, I used a generalized estimating equation (GEE) model to adjust for repeated clinician observations. A GEE approach provided an overall view of the averaged population association between EHR and measures of care coordination controlling for a number of variables. I included the following clinician characteristics as covariates: age, gender, race/ethnicity, job title, and weekly hours worked. I also included a year indicator variable to control for time trends that may have affected the dependent variables but were unrelated to the implementation of EHR. In addition, I included indicator variables for each medical center to control for medical center specific fixed effects.

Aim 2: Impact of Electronic Health Records and Teamwork on Care Coordination. To analyze the interaction effect of using an integrated EHR system and team cohesion on our three measures of care coordination, I used a generalized linear latent and mixed models (GLLMM) logistic regression with random intercepts for clinician and hospital[41]. Models included interaction between the indicator for team cohesion and integrated EHR status. I included the following clinician characteristics as covariates: age, gender, race/ethnicity, and job title. I also included a year indicator variable to control for time trends that may have affected the dependent variables but were unrelated to the implementation of EHR. To calculate the estimated EHR effect for clinicians working in cohesive vs. non-cohesive teams, we multiplied the interaction coefficient by the non-cohesion team and EHR coefficients. We used results from our logistic regression models to compute the marginal adjusted percent of respondents who reported each outcome by fitting each model as if all respondents worked in teams with: (1) no EHR and a non-cohesive team, (2) no EHR and a cohesive team, (3) EHR and a non-cohesive team, and (4) EHR and a cohesive team. Team cohesion was created to be a team level variable, including responses of three or more clinicians per team; whereas coordination was designed as an individual clinician level variable.

Aim 3: The Impact of Electronic Health Records and Teamwork on Quality of Diabetes Care. To examine the interaction between team cohesion and EHR use on follow-up HbA1c and LDL-C values, we used linear regression models with fixed-effects at the patient level, adjusting for calendar quarter and year. All models included an interaction variable of the EHR status and their primary care team's indicator for low team cohesion. To calculate the estimated EHR effect for patients cared for by clinicians working in teams with low cohesion, we multiplied the EHR effect estimate by the estimate for the interaction effect of EHR and the low team cohesion indicator. As a sensitivity analysis, we ran all models using random-effects at the patient level while controlling for patient characteristics (including gender, age, race, chronic disease indicators) and attained comparable results to the fixed effects models.

All analyses were implemented using Stata 10 (StataCorp LP, College Station, TX).

Results

Aim 1: Use of Electronic Health Records and Care Coordination

For care transferred across clinicians, clinicians with access to only outpatient EHR were significantly more likely to report access to timely and complete information (OR=2.09, 95% CI: 1.41-3.09) and clinician agreement on treatment goals and plans (OR=1.67, 95% CI: 1.10-2.53) compared with clinicians without EHR. Clinicians with access to both outpatient and inpatient EHR were significantly more likely to report high coordination for all three measures of coordination: access to timely and complete information (OR=2.69, 95% CI: 1.39-5.20), clinician agreement on treatment goals and plans (OR=2.36, 95% CI: 1.21-4.60), clinician agreement on roles and responsibilities (OR=1.96, 95% CI: 1.04-3.69) compared with clinicians without EHR.

For care transferred across delivery sites, clinicians with access to only outpatient EHR did not report significantly higher coordination than clinicians without EHR for any of the three coordination measures. However, clinicians with both outpatient and inpatient EHR, were significantly more likely to report high coordination than clinicians without EHR for two out of three measures: access to timely and complete information (OR=1.97, 95% CI: 1.02-3.84); clinician agreement on treatment goals and plans (OR=2.02, 95% CI: 1.09-3.74).

Aim 2: Impact of Electronic Health Records and Teamwork on Care Coordination

For cohesive teams, reported access to complete and timely clinical information was substantially greater with EHR use (53.5% with EHR vs. 37.6% non-EHR) compared with non-cohesive teams (31.7% with EHR vs. 32.6% non-EHR). Likewise, for cohesive teams, reported clinician agreement on treatment goals and plans was higher with access to an integrated EHR (64.3% with EHR vs. 50.6% non-EHR) compared with non-cohesive teams (44.0% with EHR vs. 45.9% non-EHR). Clinician agreement on roles and responsibilities for cohesive teams was higher with access to an integrated EHR (63.9% with vs. 55.2% non-EHR) compared with clinicians working in non-cohesive teams (48.7% with vs. 46.7% non-EHR).

Aim 3: The Impact of Electronic Health Records and Teamwork on Quality of Diabetes Care

Overall, 80,611 patients with diabetes mellitus were included in these analyses. From our multivariate analysis, we found statistically significant interactions between team cohesion and EHR use on improvements in patient HbA1c and LDL-C levels ($p < 0.01$). Specifically, patients cared for by clinicians working in primary care teams with high cohesion had substantially better patient outcomes with the EHR compared with patients care for by teams with low cohesion. Patients cared for by clinicians working in primary care teams with higher cohesion experienced a 0.11 percentage point (95% CI: 0.09-0.12%) decrease in HbA1c and a 2.15 mg/dL (95% CI: 1.86-2.43 mg/dL) reduction in LDL-C with use of the EHR compared to a 0.08 percentage point (95% CI: 0.07-0.10%) decrease in HbA1c and 1.42 mg/dL (95% CI: 1.03-1.80 mg/dL) reduction in LDL-C with the EHR for patients cared for by clinicians working in primary care teams with lower cohesion.

Limitations

It is important to note that this study has several limitations. Data for this study was collected from primary care providers and patients within a single IDS. In other, more fragmented settings, the effect of the EHR use and team cohesion on care coordination and patient's clinical outcomes may differ. Additionally, our measure of care coordination and team cohesion are based on self-reported data, not an audit of actual information available; however, such measures are unavailable.

The primary care clinician surveys had limited response rates, which could limit the generalizability of the results. Still, clinician populations are notoriously difficult to recruit, and our response rates are comparable to those of other published survey studies with similar populations. In addition, we were able to collect a wide range of relevant data, and adjust for several potential categories of confounders including demographic, clinical, and organizational variables. Although confounders are always a great concern in any non-experimental analyses of clinical data, this concern is partially attenuated given the longitudinal nature of this study. In the analyses of patients' clinical outcomes, I used fixed effects for patients, which limits the analyses to only within patient changes. Also, since the study was limited to patients that did not have any changes in the primary care linkage, this method of analyses allowed me to control for all patient, physician, and medical center time stable characteristics. The staggered nature of the EHR implementation allowed me to have a study design that included data of concurrent control groups, thus permitting separation of the background effects from the EHR effect.

Implications

EHR has great potential for improving care coordination, especially for patients with complex healthcare needs. This patient population is growing rapidly and the complexity of their care underscores the importance of timely integrated clinical information to facilitate delivery of high quality coordinated care. The staggered EHR implementation within the KP IDS created an ideal natural experiment for understanding the effects of integrated EHR on care coordination, and the combined effect of team cohesion and EHR use on coordination and quality outcomes.

This study is the first to demonstrate that the association of EHR use on care coordination and quality vary by team working relationships.

I first examined how use of an outpatient EHR and an integrated inpatient-outpatient EHR was associated with coordination of care across clinicians and across delivery sites. I found that while the introduction of an outpatient EHR was associated with substantial improvements in coordination of care across clinicians; it was not associated with improvements in coordination across delivery sites. Reassuringly, I found that the implementation of the integrated outpatient-inpatient EHR system was associated with significant improvements in coordination of care across delivery sites and across clinicians. EHR systems that are integrated across delivery sites represent an important tool for facilitating the coordination of patient care across clinicians and delivery sites; however, use of stand-alone EHR systems may not result in improvements in care coordination.

Subsequently, I examined how the effects of use of the integrated outpatient-inpatient EHR on coordination of care across delivery sites vary by primary care team member working relationships and cohesiveness. I found that while use of the integrated EHR was associated with significant improvements in all reported measures of coordination for clinicians working in teams with higher cohesion, I did not find any benefits of EHR use on coordination for clinicians working in primary care teams with lower cohesion scores.

Lastly, I analyzed how the effect of use of an outpatient EHR on clinical outcomes for patients with diabetes vary by primary care team member's working relationships. I found that while EHR use resulted in improved physiologic measures of disease control for all patients with diabetes, team functioning is an important moderator of this effect. Patients cared for by primary care teams with lower team cohesion experienced significantly smaller improvements in their HbA1c and LDL-C levels as a result of the EHR. Conversely, teams with higher team cohesion more successfully leveraged the EHR to achieve greater improvements in care quality for their patients.

This study leveraged survey data obtained in previous studies and multiple linkable datasets. The 2009 stimulus bill allocated billions of dollars to promote the adoption and meaningful use of EHR. In fact, the definition of meaningful use was specifically designed to target both care coordination and care quality. Still, there is limited research on the effect of EHR on care coordination and how the team environment can modify the impact of the EHR on care outcomes. This study provides important evidence on the role of EHR use on care coordination and quality improvement that are broadly applicable across the nation. In the current clinical environment, where care provided to patients is increasingly fragmented, and also increasingly complex, effective care coordination is essential. Health Information Technology, and specifically EHR, offer new opportunities for improving overall quality of care, preventing medical errors, and reducing health care costs. Still, EHR systems are not silver bullets and their impact will be limited if any deficiencies of the work environment and team relationships are not mutually addressed.

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List of Publications and Products

Publications

Graetz I, Reed M, Shortell SM, Rundall T, Hsu J. "Linking the Pieces Together: The Impact of Electronic Health Records and Team Cohesion on Coordination of Care Across Delivery Sites." *Health Services Research*. Under Review (Submitted 12/28/12).

Graetz I, Huang J, Brand R, Rundall T, Shortell S, Hsu J, and Reed M. "The Impact of Electronic Health Records and Teamwork on Quality of Diabetes Care." In preparation.

Graetz I, Reed M, Rundall T, Shortell S, and Hsu J. "Use of Electronic Health Records and Care Coordination ." In preparation.

Presentations

Graetz I, Reed M, Rundall T, Shortell S, and Hsu J. "EHR Use and Diabetes Care: Does Primary Care Team cohesion Moderate Improvements in Care Quality?" presented at AMIA Annual Symposium. Chicago, IL, November 2012.

Graetz I, Reed M, Rundall T, Shortell S, and Hsu J. "Linking the pieces together: Predictors of care coordination" poster presented at APHA Annual Meeting. San Francisco, CA, October 2012.