Grant Final Report

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Impact of Health Information Technology on Clinical Care for Patients with Chronic Medical Conditions

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Abstract

Purpose: We evaluate the effects of ambulatory health information technology (HIT) on quality, safety, and resource use in a large, integrated health delivery system (IDS).

Scope: Within the study site, there is an ongoing natural experiment, involving staggered HIT implementation across 110 primary care teams starting. We focus on a cohort of IDS members with at least one of five chronic diseases (Asthma, Coronary Artery Disease, Heart Failure, Diabetes Mellitus, and Hypertension).

Methods: In this quasi-experimental study, we use automated data and surveys of administrative leaders and clinicians to explore the impact of adopting a commercially available ambulatory HIT system. Our main predictor is use of HIT at the primary care team level.

Results: Basic use of HIT has been high, but systematic use of the HIT its information is variable. Clinicians report that care coordination measures (timeliness and completeness of relevant clinical information and agreements on treatment goals and plans) increase substantially with HIT use. While HIT implementation and initial use did not appear to be related to either quality processes or outcomes, subsequent analyses suggest an increasing association with longer follow-up periods and more detailed measures HIT use. HIT continues to hold much promise for improving clinical care, particularly with respect to the coordination of care, though the benefits might take some time to accrue, and use of more detailed measures and analytic approaches could improve the documentation of the benefits.

Key Words: health information technology, health care quality, safety, resource use, chronic disease care, care coordination

Final Report

Purpose

This study evaluates the impact of Health Information Technology (HIT) on clinical care for patients with chronic diseases in a large, prepaid integrated delivery system (IDS), Kaiser Permanente-Northern California (KPNC). This natural experiment involves the staggered introduction of a commercially available ambulatory HIT system with an electronic medical record (EMR), computer-based provider order entry (CPOE), and embedded computer-based decision support systems (CDSS) across over primary care teams serving over three million patients. The new HIT has the potential to improve information availability and decision-support at the point of care, to enable greater performance feedback and system integration, and to reduce redundant or downstream care. Whether and how these benefits might occur in community-based, ambulatory settings are currently unknown; conversely, whether and why there might be unintended adverse consequences also are unknown.

Scope

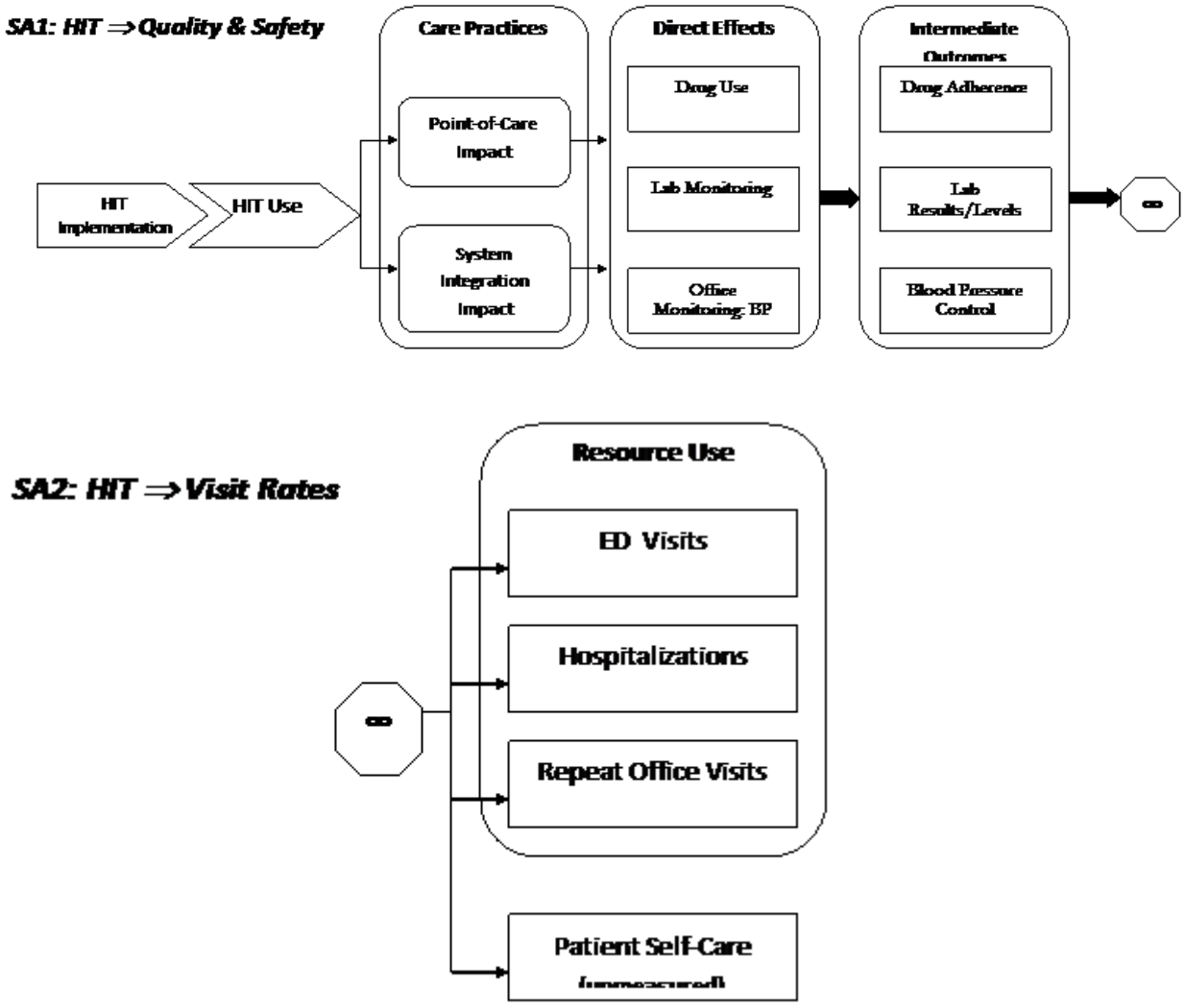
HIT has great potential for transforming clinical care, especially for patients with chronic diseases. The technology represents both a basic structural change and also an innovation that could enable other care delivery changes, including moving care delivery closer to the ideals in chronic disease care models. The existing research suggests that HIT may be particularly effective in improving drug and laboratory monitoring care practices; other studies suggest potential adverse effects or unclear benefits in different settings or on patient outcomes. Significant work remains in evaluating HIT outside of academic medical centers and hospitals, such as in community-based ambulatory systems with non-home grown HIT systems, and evaluating effects in large populations with adequate samples sizes to detect changes in outcomes other than process measures. In fact, there has never been a large-scale evaluation of HIT effects on patient quality and safety outcomes or on visit rates in a community-based delivery system. The HIT introduction within the KP IDS creates an ideal natural experiment for understanding the quantitative effects of HIT on clinical care.

Using a quasi-experimental design with concurrent controls, we evaluate HIT associated changes in quality, safety, and resource use in chronic disease care patients between 2004 and 2008. We focus on the 780,000 patients with chronic diseases (asthma, congestive heart failure [CHF], coronary artery disease [CAD], diabetes mellitus [DM], and hypertension [HTN]), because these patients tend to require regular and complex ambulatory care, thus may be sensitive to HIT effects. We use measures of quality, safety, and resource use that are quantifiable both before and after the HIT intervention.

Methods

This study evaluates the impact of health information technology on clinical care using the longitudinal experience of KPNC chronic disease patients (2004-2007) with quasi-experimental changes in exposure to Health Information Technology (HIT), and using a pre-post analytic design with concurrent controls. We focus on measures of quality, safety, and resource use in patients receiving care for any of five chronic diseases (Asthma, CAD, CHF, DM, and HTN) from 100+ primary care teams. The primary questions are whether introduction of HIT improves the quality and safety of care, and how HIT affects resource use, as measured by visit rates (Figure 1).

Figure 1. Conceptual model and specific aims



To evaluate quality and safety, we assess the association between HIT and guideline-consistent drug use and laboratory monitoring, drug adherence, and lab results. These measures

represent areas for which the Integrated Delivery System (IDS) has clinical guidelines and consistent data records, yet significant room for improvement exists. These measures also may be affected indirectly by HIT, such as through the use of performance feedback or greater care coordination between providers.

To evaluate resource use, we assess the association between HIT and office visits, ED visits, and hospitalizations. Previous work suggests that HIT could reduce the need for office visits because of better information availability; other studies suggest that improved ambulatory care could reduce the need for more acute care in the ED or hospital, e.g. the preventable hospitalizations in AHRQ's PQI. Alternatively, HIT could increase visit rates because of decreases in visit productivity or provision of more care (reduction in "underuse"). The IDS's existing automated databases provide the outcome data for these studies.

The conceptual model in Figure 1 displays the basic steps between implementation (introduction of the new technology into ambulatory care sites) and our main outcomes of interest. Specifically, after implementation, clinicians need to use the technology and embedded clinical information at the point of care; separately, clinician and health system leaders need to use the aggregate clinical information at the system level. The HIT use in turn could affect specific clinical decisions around diagnosis or treatment, such as the need for or frequency of monitoring of lipid levels or the decision to prescribe or intensify drug treatment. To the extent that these processes occur, the HIT use may result in changes in either physiologic outcomes, e.g., lipid levels, or in patient behavior, e.g., drug therapy adherence. To the extent that there are changes in intermediate patient outcomes, the HIT use may result in changes in our primary outcomes of interest.

In exploratory analyses, we investigate the mechanisms underlying the HIT effects at the medical center, team, and patient levels. For example, we explore time-related HIT effects, e.g. a learning curve. Working with IDS collaborators at the Care Management Institute, we also use data from an annual survey of clinical and administrative leaders, chronic care disease managers, disease specialists, and primary care team members. The surveys focus on potential explanatory variables for the HIT effects and important organizational characteristics associated with chronic disease care, e.g. use of performance feedback, level of HIT decision support, or coordination of care between providers. In addition to the explanatory structural variables, we pay particular attention to potential confounders, since the HIT will not be assigned at random. We use this information to construct time-changing variables for analysis.

The four-year study period encompasses the year before and three years during HIT implementation; under the staggered implementation plan, the last primary care team implemented the integrated electronic health record in mid 2008. The HIT start dates vary by medical center, and by team within medical centers (approximately a 3-week lag between starts within medical centers).

Overview of Analytic Approach

We evaluate the effect of HIT on changes in quality, safety, and resource use measures using a repeated measures (monthly) model with time-changing covariates. We capture electronic data from 2004–2008 on drug use and adherence, laboratory tests and results, office visits, ED visits, and hospitalizations for patients with any of five chronic diseases (asthma, CAD, CHF, DM, and HTN). (Table 9) We examine the experience of all patients with known chronic diseases in the health system. The covariates include patient, insurance, and organizational data, such as patient

socio-demographic characteristics, comorbidity status, cost-sharing levels, and use of feedback reports and incentives. We are paying particular attention to the HIT introduction date for each team, and the start dates of each type of embedded decision support within HIT. The analyses vary by the outcome type as appropriate. We obtain all of the outcomes from the existing automated databases and the annual survey of the chronic disease delivery structure, i.e. by not depending on the HIT data, we have consistent capture of our measures before and after the HIT introduction.

Analytic Issues

Given the size of the dataset, we have encountered computational issues when examining models with multiple levels of random effects. We are continuing to explore analytic solutions to these computational issues. We are also still examining analytic strategies to best disentangle time effects from HIT effects over the staggered implementation schedule of the HIT system.

Results

Implementation

- The study health delivery system successfully completed implementation of its ambulatory electronic health record (EHR, aka KP HealthConnect) between 2005 and 2008.

- Prior to this implementation, the health system introduced web-based health information technology tools in 2004 to assist with documentation (eChart), ordering (eRefill), and consultations (eConsult). These tools permitted clinicians to perform the basic clinical functions with minimal decision support, and importantly did not replace the paper medical record.

- Implementation of the inpatient version of the electronic health record is continuing with more than half of the hospitals online at the end of 2008.

Summary of Analyses

- To date, we have conducted a number of preliminary examinations. For example, we spent much time examining various measures of HIT use. Based on these analyses, we believe that HIT presence alone, i.e., adoption or introduction date, is not a sensitive or useful predictor. We are examining measures of any HIT use, use of tools for specific clinical functions, and self-reports of use of information.

- Using automated data (2004-2006) from outpatient visits to assess the association between the implementation of a new health information technology system (HIT) and

clinical data quality, including the timeliness of data and the thoroughness of documentation for patient diagnoses in an integrated health system. We found that the implementation of a new HIT system is associated with a dramatic increase in the timeliness of diagnostic information from that system (Figure 1), but not in the number of diagnoses charted during patient visits.

- In a quasi-experimental study with concurrent controls (2004-2006), we evaluated the association between having the new HIT and changes in physiologic outcomes for patients with diabetes, before and after the introduction of the system. We examined changes in low-density lipoprotein cholesterol (LDL) and Hemoglobin A1c (A1c), using data from two facilities in one medical center that implemented the EHR at different time points in 2005. We included an indicator for three implementation phases: pre-EHR, post-EHR-I (within 6 months of implementation), and post-EHR-II (6-month after the implementation). We examined LDL and A1c levels among continuously enrolled patients, who were in the diabetes registry during the study period and had at least one test both before and after implementation. We used mixed models with team, physician, and patient level random effects, adjusting for facility, year and month of the measurement, and patient characteristics (age, gender, race/ethnicity and neighborhood SES). In unadjusted analyses, the mean LDL levels were 100.6, 98.8, and 97.9 mg/dL during the pre-HIT, post-HIT-I, and post-HIT-II periods, respectively; mean A1c levels were 7.5, 7.4, and 7.5%, respectively. In multivariate analysis, compared with the pre-HIT period, the mean changes in LDL were 0.74(-0.42, 1.90) in post-EHR-I, and 0.72 (-1.11, 2.56) in post-HIT-II; the mean changes in A1c were -0.05 (-0.09, 0.002) in post-EHR-I and 0.005 (-0.07, 0.08) in post-EHR-II. In contrast, compared with 2004, mean changes in LDL were -3.4 (-4.33, -2.51) in 2005 and -7.6 (-9.51,-5.62) in 2006; mean changes in A1c were 0.04 (-0.09, 0.02) in 2005 and -0.04 (-0.12, 0.04) in 2006. This preliminary analysis found no statistically significant association between HIT implementation and changes in physiologic outcomes for diabetics; however, there were substantial secular changes in LDL levels. Further research is needed to assess the long-term effects. NOTE: In later analyses using longer follow-up periods, there appear to be statistically significant associations between HIT use and our quality outcomes.

- Using clinician survey data collected in 2005, we examined the levels and patterns of clinician use of available Health Information Technology (HIT) tools during primary care visits and the factors associated with systematic HIT use. We found that all clinicians reported at least some HIT use, however, the level of use varied significantly by function. Only 21.3% reported systematic HIT use for all functions. In multivariate analyses, factors associated with systematic HIT use included perceived training adequacy, HIT incorporation into the clinical workflow, and hours worked/week.

- We also used clinician survey data collected in 2005 and 2006 to examine the impact of having an integrated HIT system on primary care clinician reports of the completeness and timeliness of all relevant clinical information, agreement on treatment goals and plans, and agreement on roles and responsibilities when multiple clinicians are involved with a patients' care. We found that the HIT introduction was associated with substantial

improvements in the timeliness and completeness of relevant clinical information and agreements on treatment goals and plans.

- We also used these survey data to describe the extent of implementation of the Chronic Care Model within this integrated delivery system (IDS), and examine specific chronic care practices. We found that its primary care teams had higher levels of Chronic Care Model implementation than have been found in previous studies of other provider groups. Still, teams varied substantially in their implementation of the Chronic Care Model components, and in their processes for delivering chronic care. No systematic differences were found in chronic care model implementation by team size or composition.

- Building on a partnership with colleagues in the Danish Health System (DHS), we have also begun to compare chronic conditions care and the impact of health information technology on clinical care between KPNC and DHS. Using both survey and electronic data we have made initial comparisons of care-coordination and hospitalization rates between the two health systems. We have observed differences between two health systems in the perceived levels of care coordination and in hospitalization and rehospitalization rates for ambulatory care sensitive conditions. Follow-up analyses will continue to examine how HIT implementation may contribute to differences across health systems.

- We are continuing to develop methods to examine effects of HIT across multiple chronic conditions, incorporating data throughout the HIT implementation period (2008). While Implementation of HIT is complete in 2008, we will not be able to obtain complete data for all of the study covariates and outcomes until early 2009. In addition, it would be ideal to be able to incorporate as much additional follow-up time post-implementation as possible for many of the sites in order to capture any pattern in HIT-related outcomes after implementation (e.g. learning curve).

There remains much opportunity to improve the quality of care for patients with chronic medical conditions, even in settings with very high average or relative quality. HIT continues to hold much promise for improving clinical care, particularly with respect to the coordination of care, though the benefits might take some time to accrue, and use of more detailed measures and analytic approaches could improve the documentation of the benefits. More work also is needed to develop the concepts and associated measures surrounding health information technology and associated clinical information use.

List of Publications and Products

See Appendix A for a detailed description of Presentations, and Appendix B for Manuscripts.

Appendixes

Appendix A: Presentations

Hsu J. Update on HIT Research, Including the Status of the IMPACT Study [presentation]

In: *HMO Research Network Annual Conference,* 2006 May; Cambridge, MA. No abstract, slides available upon request.

Kim K. Clinical Management and Physiologic Outcomes for Patients with Diabetes, Patient, Clinical, and System Factors [abstract]

In: *AcademyHealth Annual Research Meeting,* 2006 Jun; Seattle, WA.

Research Objective. Despite substantial evidence demonstrating the benefits of intensive diabetes management, little is known about care in everyday practice. We examined the association between patient, clinical, and system factors with prescription drug use, laboratory measurements, and physiologic outcomes.

Study Design. Using automated databases in a large, prepaid integrated delivery system, we examined the proportion of diabetic patients receiving diabetes drugs (eight drug classes) and laboratory testing (HbA1c) in 2004.

We defined drug adherence as the proportion of days covered (PDC) for any diabetes drug > 0.8 for the 90 days before the first HbA1c test in 2004. We defined HbA1c < 8.0 as the physiologic outcome target. Patient factors included age, gender, neighborhood socio-economic status (SES), and race/ethnicity. Clinical factors included number of drug classes, renal function, and history of coronary artery diseases or heart failure. System factors included having a regular doctor, insurance type, and years in the health system. We used logistic regression models to examine the association between these factors and each outcome: having a HgA1c test, being adherent to drugs, and achieving the physiologic target.

Population Studied. All 177,622 patients were health system members, 18+ years old, and had an existing diagnosis of diabetes as of January 2004: 70.6% received ≥ 1 diabetes drug in 2004.

Principal Findings. Among diabetic patients receiving diabetes drugs in 2004, 87.6% had ≥ 1 HbA1c test during the year and 62.6% met criteria for drug adherence. Among those with a HbA1c test in 2004: 10.6% did not receive any drugs in the 90 days before their test, 21.8% received insulin and 77.7% received an oral hypo-glycemic drug. Additionally, 50.5% received drugs in one, 30.7% in two, and 8.3% in three or more classes of diabetes drugs. Among patients with laboratory tests, 32.2% had a HbA1c $\geq$ 8.0% on the first measurement of the year, i.e. they

exceeded target levels. In multivariate analyses, patients with non-white race/ethnicity (OR = 1.14, 95% CI: 1.10-1.79), low SES (OR = 1.06, 95% CI: 1.04-1.10), or without a regular doctor (OR = 3.85, 95% CI: 3.33-4.54) were more likely to have poor drug adherence in the 90 days prior to their first test.

Patients with non-white race/ethnicity (OR = 1.33, 95% CI: 1.29-1.37) or low SES (OR = 1.19, 95% CI: 1.15-1.22) also were more likely to have a HbA1c $\geq$ 8.0% on their first measurement in 2004.

Conclusion. Two out of five patients with diabetes are not receiving recommended glycemic monitoring or meeting minimum levels of drug adherence. One in three was above the target level for glycemic control. Patients without a regular physician, of non-white race/ethnicity, or low SES are at particular risk.

Implications for Policy, Delivery, or Practice. Evidence from large, randomized controlled trials has demonstrated the benefits of intensive diabetes management in improving glycemic control and reducing complications. Yet many patients in everyday practice remain poorly controlled and do not receive the recommended standards of care. This difficulty in translating evidence into actual practice has been attributed to factors ranging from the medical system down to the patient level. This study attempts to provide the first steps in identifying which of these factors are associated with minimum levels of diabetic care and with the appropriate intensification of therapy.

Graetz, I. Clinician Electronic Communication with Patients: Who's Talking? [abstract]

In: *HMO Research Network Annual Conference*, 2007 Mar; Portland OR.

Background. Despite the potential benefits associated with new forms of Health Information Technology (HIT), little is known about how often physicians and other providers use specific HIT tools. Previous studies suggest that use of electronic messaging with patients is limited. We examined current levels of provider use of electronic communication with patients and predictors of use.

Methods. In 2005, we surveyed all adult primary care team members (50% response rate, n=556 respondents) in Kaiser Permanente Northern California (KPNC). Subjects reported the percentage of patient encounters that involved electronic communication either through email or a web-based messaging system. We examined use among primary care providers (PCP) and other clinical staff separately. Using multivariate logistic regression, we examined the characteristics associated with any and with high levels (20+% of patient encounters) of use.

Results. There were 450 PCP respondents: 50% female; 43% with 10+ years KPNC tenure; and 58% working 40+ hours/week. There were 106 staff respondents: 71% female; 53% with 10+ years KPNC tenure; and 49% working 40+ hours/week. Overall, 39% of PCPs and 54% of staff reported never sending electronic messages to patients; 42% of PCPs and 32% of staff reported sending messages for up to 20% of encounters; and 19% of PCPs and 14% of staff reported sending messages for 21+% of encounters. Overall, 48% of PCPs and 45% of staff

respondents agreed or strongly agreed that their team incorporated HIT tools into their clinical workflow. In multivariate analyses, both high levels of HIT integration into the team's clinical workflow and reporting regular use of other types of HIT were associated with PCPs reporting any electronic patient communication (OR = 1.80 for workflow, 95% CI: 1.32-2.47; OR = 2.22 for other HIT use, 95% CI: 1.35-3.64). There were no statistically significant associations between use and PCP age or tenure in the health system. Among other clinical staff, working 40+ hours and team incorporation of HIT tools into clinical workflow were associated with reporting any electronic patient communication (OR = 3.12 for hours, 95% CI=1.41–6.90; OR = 3.34 for workflow, 95% CI:1.41-7.94).

Conclusions. While use of basic HIT communication tools remains limited, more than half of PCPs and over forty percent of staff report communicating with patients electronically. Efforts to encourage HIT integration into the clinical workflow require additional examination.

Huang, J. Electronic Health Record (EHR) and Quality of Care for Patients with Diabetes [abstract]

In: *HMO Research Network Annual Conference,* 2007Mar; Portland OR.

Background. Despite the promise of EHR, there have been few rigorous studies on their effects on ambulatory clinical care. Kaiser Permanente Northern California (KPNC) started implementing an EHR in the beginning of 2005, using a staggered schedule. This study assessed changes in physiologic outcomes for patients with diabetes, before and after the introduction of the EHR.

Methods. In a quasi-experimental study with concurrent controls (4/2004-6/2006), we evaluated the association between having an EHR and changes in low-density lipoprotein cholesterol (LDL) and Hemoglobin A1c (A1c), using data from two facilities in one medical center that implemented the EHR at different time points in 2005. We included an indicator for three implementation phases: pre-EHR, post-EHR-I (within 6 months of implementation), and post-EHR-II (6-month after the implementation). We examined LDL and A1c levels among continuously enrolled patients, who were in the diabetes registry during the study period and had at least one test both before and after implementation. We used mixed models with team, physician, and patient level random effects, adjusting for facility, year and month of the measurement, and patient characteristics (age, gender, race/ethnicity and neighborhood SES). Results: The mean age of the 9,019 study subjects was 61 years old; 49% are female; and 46% were of White race/ethnicity. In unadjusted analyses, the mean LDL levels were 100.6, 98.8, and 97.9 mg/dL during the pre-EHR, post-EHR-I, and post-EHR-II periods, respectively; mean A1c levels were 7.5, 7.4, and 7.5%, respectively. In multivariate analysis, compared with the pre-EHR period, the mean changes in LDL were 0.74(-0.42, 1.90) in post-EHR-I, and 0.72 (-1.11, 2.56) in post-EHR-II; the mean changes in A1c were -0.05 (-0.09, 0.002) in post-EHR-I and 0.005 (-0.07, 0.08) in post-EHR-II. In contrast, compared with 2004, mean changes in LDL were -3.4 (-4.33, -2.51) in 2005 and -7.6 (-9.51,-5.62) in 2006; mean changes in A1c were 0.04 (-0.09,0.02) in 2005 and -0.04 (-0.12, 0.04) in 2006 .

Conclusion. This preliminary analysis found no statistically significant association between EHR implementation and changes in physiologic outcomes for diabetics; however, there were substantial secular changes in LDL levels. Further research is needed to assess the long-term effects. NOTE: In later analyses using longer follow-up periods, there appear to be statistically significant associations between HIT use and our quality outcomes.

Hsu, J. Use of Health Information Technology and Clinical Care [presentation]

In: Academy Health Annual Research Meeting, 2007 Jun; Orlando FL. No abstract, slides available upon request.

Graetz, I. Systematic Use of Health Information Technology: Are We There Yet? [abstract]

In: *Academy Health Annual Research Meeting*, 2007 Jun; Orlando FL.

Objective. In a system that had adopted new Health Information Technology tools, we examined how often clinicians used these tools during patient visits.

Design. Mailed survey to all primary care clinicians working in a large, integrated delivery system (IDS) in 2005 (n=483, 50% response rate).

Measurements. Self-reported use of available Health IT tools to perform eight specific clinical functions, including visit notes, data review, e-prescribing, and communicating with other clinicians. We defined routine use of each function as use in over 80% of visits and defined systematic use as routine use of Health IT for all clinical functions.

Results. All (100%) clinicians reported at least some use of Health IT: 66.1% reported routine use of Health IT for data-review; 39.3% for documentation; 83.7% for e-prescribing; and 66.7% for communicating with other clinicians. A substantial percentage (20.7%) reported never using Health IT for documenting visits. Overall 21.3% reported systematic use of Health IT for all clinical functions. In multivariate analyses, factors associated with systematic use included perceived training adequacy (OR = 2.70, 95% CI:1.61-4.54), team incorporation of Health IT into its clinical workflow (OR = 2.70, 95% CI:1.32-5.53), and individual hours worked/week (OR = 1.86, 95% CI:1.15-3.00).

Conclusions. Adoption is not synonymous with systematic use. All clinicians reported using Health IT to perform some clinical functions, but less than a quarter reported systematic use of Health IT for all functions. Additional attention to training and improving workflow could encourage more regular use of Health IT tools.

Hsu, J. HIT Return on Investment: Evaluating Progress in a Sea of Change [presentation]

In: *AHRQ Annual Conference*, 2007 Sep; Washington, DC. No abstract, slides available upon request.

Hsu, J. Improving Care for Diabetics with Hyperlipidemia: Drug Treatment Adherence, Intensification, and Outcomes [abstract]

In: *International Forum on Quality and Safety*, 2007 Oct; Paris, France.

Context. In a large, integrated delivery system (IDS), we examined the quality of care for diabetic patients receiving treatment for hyperlidemia. The IDS also is implementing several new forms of health information technology designed to improve clinical care. We examine the levels of drug treatment use, adherence, and intensification, and of actual patient outcomes. Problem: Despite improvements in standard, process-based quality measures, patient outcomes often do not change. Growing evidence suggest that many of these process measures are unrelated to outcomes, and that many patients have suboptimal outcomes. We examined changes in low density lipid (LDL) levels between 2004-2006 within a large IDS in the United States. We assessed the contribution of medication use, adherence, treatment regimen intensification, and health information technology (HIT) to these changes.

Analysis. Using automated pharmacy and laboratory data, we examined LDL levels over time, medication adherence as measured by proportion of days covered (PDC), and treatment intensification as measured by prescribed daily dose of statins (PDD). We also examined the impact of HIT use on medication adherence, treatment intensification, and LDL levels. We divided the study period into three periods: 1) pre-HIT; 2) basic HIT use; and 3) advanced HIT use. We focused on patients who had at least one LDL measurement in pre-HIT period and post-HIT period. We used mixed models with random effects at the physician and patient levels, and adjusted for patient age, gender, race/ethnicity, neighborhood socioeconomic status, and time. Changes: We examined at the population level changes in medication use and LDL levels. We also focused on the contribution of new forms of HIT on quality. The technology increased the availability of relevant clinical information at the point of care.

Effects. In 2004, 59% of diabetics were on any drug regimen for hyperlipidemia; the mean LDL-c level was 97mg/dL. Among subjects on any regimen, the mean proportion of days covered by any lipid drugs was 90.8%; among subjects on statins, the mean statin drug daily dose was 30 mg/day. Between 2004 and 2006, LDL-c levels improved substantially within the IDS (decrease of 6.2 mg/dL, 95% CI: 4.9-7.5). There also were modest increases in drug adherence (PDC increased 2.3%, 95% CI: 1.5-3.1%), and use of more intensive regimens (PDD increased 10.6 mg/day, 95% CI: 10.1-11.2mg/day) among subjects on statin regimens. The multivariate analyses indicate that the use of HIT was associated with drug regimen intensification and physiologic outcome improvements, but not with substantial changes in patient drug adherence.

Lessons. Within this system, the quality of antihyperlipidemia care is improving. Diabetic patients are receiving more intensive drug regimens and are experiencing substantially improvements in their LDL levels. The use of health information technology appears to be associated with some of these improvements.

Messages for Others. Health care systems can improve patient outcomes over time. Assessing drug adherence and prescribed drug regimens can be useful process measures. Measuring actual physiologic outcomes also help systems track quality. Finally, HIT can play a role in improving quality.

Bardach, N. Clinical Data Quality and Health Information Technology: Is More Technology Associated with Better Data? [abstract]

In: *Sixth Annual Bay Area Health Care Quality & Outcomes Conference*, 2008 May; San Francisco, CA.

Objective. To assess the effects on data quality associated with the implementation of two health information technology (HIT) systems.

Design. An historical observation design (2004-2006) and automated data in an integrated delivery system for visits to ambulatory care clinics and emergency departments were used. Three types of HIT were used: Basic, Intermediated, and Advanced.
Measurements: For each month of the study period, we calculated the percentage of visits and the number of diagnoses chartered by HIT type, and the time to availability of electronically recorded diagnostic information.

Results. In January 2004, among the visits to ambulatory care clinics (ACC), 85% of them were recorded on paper, 11% by Basic, 5% by Intermediate, and none by Advanced, which was not available. At that time, 10% of visits to ACCs had diagnoses entered on the same day; 47% by the 4^{th} day after; and 90% by the 7^{th} day after. By December 2006, practitioners were using Advanced HIT for 67% of visits to ACCs and 95% of those visits had diagnoses available on the same day of the visit. Visits to the ED showed a similar pattern. In contrast, the mean numbers of diagnoses charted in ambulatory care clinics each month ranged 4.3-4.7 and in the ED ranged 1.6-1.7. In neither setting were there trends over time for the mean number of diagnoses.

Conclusion. The implementation of a new HIT system is associated with a dramatic increase in the timeliness of diagnostic information, but not in the number of diagnoses charted in patient visits.

Graetz, I. Care Coordination and Electronic Health Records: Connecting the Medical Home with the Rest of the Village [abstract]

In: *AcademyHealth Annual Research Meeting*, 2008 Jun; Washinton, D.C.

Objective. To examine the effect of EHR use on care coordination.

Study Setting. Survey data collected from primary care clinicians working in a large, prepaid integrated delivery system in 2005 and 2006 during a 3-year staggered implementation of an EHR system.

Study Design. We asked clinicians how often: all clinical information is available and timely; clinicians agree on the treatment goals; and agree on roles. Using multivariate logistic regression to adjust for clinician characteristics, we examined the association between EHR use and the three care coordination items.

Extraction Methods. Coordination items assessed using survey responses and EHR use based on automated data.

Principal Findings. More clinicians who used EHR for 6+ months reported access to timely and complete information, clinician agreement on treatment goals, and agreement on roles and responsibilities (67.0%, 72.4%, and 61.8% respectively), compared to clinicians without EHR (41.3%, 56.6%, and 48.7% respectively). After adjustments, clinicians who used the EHR for 6+ months were significantly more likely than those without EHR to report timely and complete information transfer and agreement on treatment goals.

Conclusions. Electronic Health Records represent an important tool for care coordination.

Appendix B: Manuscripts

We are working on the following four manuscripts that are under review or will be submitted for publication in the near future:

Systematic Use of Health Information Technology (currently under review at International Journal of Medical Informatics). Using clinician survey data collected in 2005, we examined the levels and patterns of clinician use of available Health Information Technology (HIT) tools during primary care visits and the factors associated with systematic HIT use. We found that all clinicians reported at least some HIT use, however, the level of use varied significantly by function. Only 21.3% reported systematic HIT use for all functions. In multivariate analyses, factors associated with systematic HIT use included perceived training adequacy, HIT incorporation into the clinical workflow, and hours worked/week.

Clinical Data Quality and Health Information Technology. We used a historical observational design (2004-2006) and automated data from outpatient visits to assess the association between the implementation of a new health information technology system (HIT) and clinical data quality, including the timeliness of data and the thoroughness of documentation for patient diagnoses in an integrated health system. We found that the implementation of a new HIT system is associated with a dramatic increase in the timeliness of diagnostic information from that system, but not in the number of diagnoses charted during patient visits.

Variation in Chronic Disease Care in Primary Care Teams of a Large Integrated Delivery System. We used clinician survey data collected in 2005 to describe the extent of implementation of the Chronic Care Model within this integrated delivery system (IDS), and examine specific chronic care practices. We found that its primary care teams had higher levels of Chronic Care Model implementation than have been found in previous studies of other provider groups. Still, teams varied substantially in their implementation of the Chronic Care Model components, and in their processes for delivering chronic care. No systematic differences were found in chronic care model implementation by team size or composition.

Care Coordination Across Clinicians and Health Information Technology. We used clinician survey data collected in 2005 and 2006 to examine the impact of having an integrated EHR system on primary care clinician reports of the completeness and timeliness of all relevant clinical information, agreement on treatment goals and plans, and agreement on roles and responsibilities when multiple clinicians are involved with a patients' care. We found that the EHR introduction was associated with substantial improvements in the timeliness and completeness of relevant clinical information and agreements on treatment goals and plans.