

Using HIT to Improve Ambulatory Chronic Disease Care

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Abstract

Purpose: To evaluate new functionality added to the University of Missouri Health Care (UMHC) EMR to improve chronic disease performance indicators and patient-provider communication.

Scope: Diabetes performance reports were phased in at 10 UMHc primary care practices. In 3 practices, a patient portal for secure communications was implemented. A trial of home monitoring of blood glucose and blood pressure occurred in 108 patients.

Methods: Multiple studies included: a usability study of a diabetes dashboard; quasi-experimental study of two kinds of performance reports distributed in a factorial design for one year; qualitative analysis of differences between clinics with different patterns of performance; surveys of interest and experience with the patient web portal; testing accuracy and response to patients electronically reporting medication inconsistencies; and a randomized trial of 3-months of home monitoring of blood glucose and blood pressure with electronic reporting.

Results: The diabetes dashboard was efficient and improved accuracy. A composite measure improved in practices able to access performance information in the electronic record. Practices improving in the second year showed strong leadership, sharing of information, and exhibited adaptive reserve. Initial use of the patient portal was relatively limited; however, physicians felt better about its impact after use. In-home medication reconciliation is potentially limited by incomplete information from patients and failure to update records by providers. Home monitoring did not improve outcomes, but qualitative findings pointed to important implementation principles.

Key Words: electronic medical records, quality improvement, home monitoring, patient web portals, chronic conditions, medication reconciliation

Purpose

AHRQ IQHIT grants supported projects designed to test strategies for clinician use of health IT in ambulatory settings to improve outcomes through more effective clinical decision support, medication management, or care delivery. The initiative encouraged consideration of the role of workflow and effective use of clinical alerts and reminders, with an emphasis on prevention and chronic illness management. Medication management was a particular focus, as medication therapy is a significant source of medical errors, cost, and missed opportunities for health care coordination, and health IT can be a potent intervention to address these issues.

Our project sought to leverage collaborative efforts between the University of Missouri (MU) Department of Family and Community Medicine and its electronic medical record (EMR) vendor, the Cerner Corporation, to create new tools and functionalities to improve chronic disease care. We proposed to evaluate several aspects of these efforts within three primary aims:

Aim 1. To evaluate the change in patient care processes and outcomes following introduction of HIT-generated clinician quality performance reports with comparison across practices and different peer comparisons.

Aim 2. To evaluate the effectiveness and changes associated with an interactive web-based patient interface software system (IQ Health), including in-home medication reconciliation.

Aim 3. To evaluate the use of in-home “smart” diagnostic devices (e.g., blood pressure, glucometers) connecting patients with their patient care teams.

Scope

Background

Chronic disease accounts for over 75% of total health expenditures, but management of chronic illnesses is often fragmented and ineffective.¹⁻³ Additionally, this fragmented care poses hazards to patients, such as conflicting medications prescribed by multiple providers.⁴

Improving chronic disease care may be facilitated by incorporating Wagner's multifaceted chronic care model⁵⁻⁷ that includes care coordination, active follow-up, support for self-management, clinician decision support, and information systems to provide data on an entire panel of patients.⁸ Health information technology (HIT) provides a crucial infrastructure for accomplishing these processes, and hence has significant potential to improve chronic illness care; nonetheless, reviews prior to our project implementation had demonstrated mixed results.⁹⁻¹¹ In particular, simply implementing an electronic medical record absent specific strategies to manage patients with chronic diseases is likely to be insufficient.^{9,12} In fact the recent positive report from Cleveland on the positive effect of ambulatory EMRs on Diabetes Mellitus outcomes occurred in the setting of all practices participating in a major quality improvement effort.¹³ We proposed to take advantage of phased implementation in diverse practices of planned HIT implementation to evaluate how different implementation approaches affected patient care processes and outcomes and patient and provider perceptions.

Chronic illness care often involves multiple specialties; however, multiple providers substantially increase the risk for medication errors.⁴ An NCCAM and AARP funded study noted the extensive use of complementary and alternative medications (CAM), which many patients never discuss with their physicians.¹⁴ Without systems to facilitate physician awareness of all medications being used, including non-prescription medications and CAM products, significant drug interactions or drug-disease interactions may occur. One of the planned HIT innovations

that we proposed to assess was a structured web-based format for patients to indicate whether the medications they were taking agreed with the medical record.

Home-based technologies enable health care professionals to monitor patients' physiological (e.g., blood pressure) and psychological (e.g., depression and mood) variables more routinely than is possible through face-to-face office visits. Furthermore ambulatory blood pressure monitoring is more predictive of clinical outcomes than office blood pressures, and its use leads to improved blood pressure control.¹⁵⁻¹⁷ Data is not as clear for home glucose monitoring; however, data is suggestive of benefit at least for diabetics receiving insulin and possibly also for type 2 diabetics treated without insulin.¹⁸⁻²² The primary role of the technology is not to change the care provided. Rather, these technologies change the communication channel between the provider and patient in order to minimize barriers to care and improve delivery of service. Increased surveillance, support, and enhanced communication afforded by home telehealth have significant potential to improve patient's attention to and adherence with disease treatment, and to facilitate patient-provider communication. Thus, home telehealth may hold the most promise for individuals dealing with multiple chronic illnesses. However, questions remain unanswered about the use of these technologies,²³⁻²⁷ including: what types of patients benefit the most from these technologies (i.e., ranging from the well outpatient to the complex elderly individual with multiple conditions); what characteristics of the technologies do patients find most useful and desirable; can serial data provided by these technologies be useful in establishing diagnosis; and how can these data be best integrated into the workflow of the physician? We proposed to test whether home blood glucose and blood pressure monitoring with "smart devices" that uploaded data to a web site would improve timeliness of management and patient outcomes.

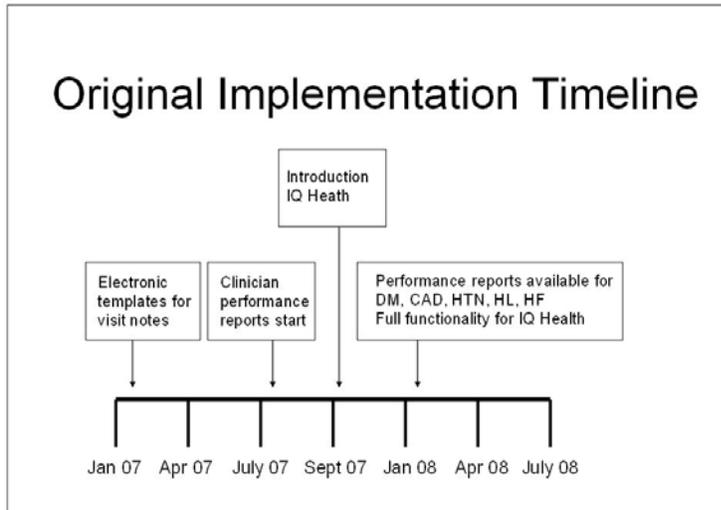
Context, Setting, and Participants

The study took place in the primary care practices of the Department of Family and Community Medicine (FCM) and the Division of General Internal Medicine (GIM) of the Department of Internal Medicine at the University of Missouri Health System (UMHC). Among these practices there was considerable variability in the approach to chronic disease care. Four of the eight FCM practices had added nurse case managers to collaborate with the physicians in improving care of those with chronic illnesses. The two GIM practices, which did not use nurse case managers, had placed a major emphasis on educating around standards in chronic disease care. Both FCM and GIM practices used an electronic record, although the extent of use varied, particularly in some FCM practices, which were just beginning to extensively use electronic problem lists and medication lists.

In 2005, FCM Department leaders began to collaborate with the Cerner Corporation to develop an enhanced ambulatory HIT system to support chronic disease care. Of multiple proposed components, several were anticipated within the time frame of the proposed evaluation or in the case of the condition summary screens occurred earlier than expected:

- Condition summary screens: specially designed dashboards, accessible from a tab within the electronic record, which included key information needed for managing that condition, such as blood pressure readings in diabetes mellitus (DM), as well as indicators of whether quality metrics were being achieved for that particular patient;
- Easily accessible condition algorithms outlining standard care management;
- Electronic templates for creating visit notes, that would facilitate data acquisition for performance reports; and
- Performance reports on chronic condition quality indicators (e.g., having a glycohemoglobin during the past year in patients with DM) for the patients assigned to individual providers as well as the entire practice, including a list of patients with out of range values.

Figure 1. Original implementation timeline for HIT innovations to be evaluated in this application.



Additionally, tied to this effort, the Health System planned introduction of a web-based patient interface, IQ Health, to enhance connectivity and secure communication between patients and clinicians. It was anticipated to enable patients to access information in their electronic health record, to upload clinical data and verify medications. It was anticipated that “smart” devices that could directly upload readings, such as blood pressure and blood glucose, would interface with IQ Health to upload data directly into the electronic health record. For those without Internet access, the

“smart” devices would be able to upload data over an ordinary phone line.

Figure 1 summarizes the implementation timeline for the HIT innovations that we proposed to evaluate at the time of the application. Starting with performance reports for diabetes mellitus (DM), reports were planned for several chronic conditions, including also coronary artery disease (CAD), hypertension (HTN), hyperlipidemia (HL), and heart failure (HF). IQHealth was scheduled for introduction in September 2007.

Study participants included patients who participated in surveys or whose data was used in defining performance indicators, clinicians, and other key informants. Further details are provided with discussion of individual studies.

Methods

As there were multiple components of the project, we will address methods (and results) by aim.

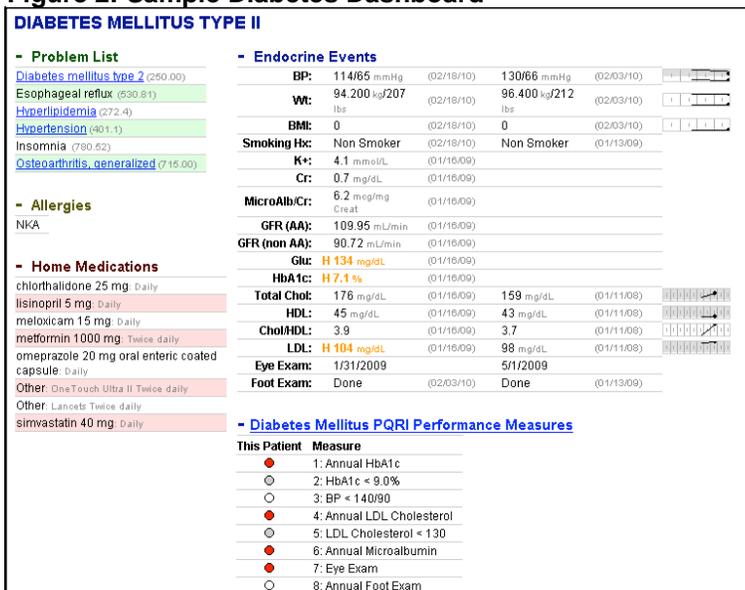
Aim 1: To evaluate the change in patient care processes and outcomes following

introduction of HIT-generated clinician quality performance reports with comparison across practices and different peer comparisons.

Condition Summary Screens (Dashboards)

There were two separable components of studies conducted in pursuit of Aim 1: condition summary screens and performance reports. A condition summary screen for DM, a diabetes dashboard, was implemented ahead of schedule in April 2008. If a patient had diabetes mellitus on their problem list, 8 quality indicators were evaluated

Figure 2: Sample Diabetes Dashboard



and presented graphically as well as numerical data. Figure 2 shows a sample **diabetes dashboard**. For example this patient's last blood pressure was 114/65, which met the quality indicator standard. However, he had not had a hemoglobin A1c within one year, so the indicator beside that measure is red.

We conducted a usability study just prior to implementation of the **diabetes dashboard** with 10 primary care physicians of varying experience being asked first to find key pieces of information needed for an ambulatory diabetes visit and then with a second but similar case being asked to find the same information but with use of the **diabetes dashboard**. We used Morae software and think aloud methods to assess mouse clicks, time to complete the task, and cognitive processes that physicians went through to complete the task. Further details are contained in our publication.²⁸

To further assess whether dashboard implementation affected physician perception of the EMR, we surveyed physicians both immediately pre-implementation and 19 months post-implementation. Questionnaires addressed physician perceptions of the EMR, how the EMR affected their care of patients with diabetes, documentation of visits, and workflow. The post-implementation survey was similar to the pre-implementation survey for comparative purposes but also contained several new questions informed by themes developed from analysis of qualitative semi-structured interviews with 10 providers. Additionally, we questioned providers post-implementation about how they were using the dashboard. Both surveys included questions with 5-point Likert scale responses from Strongly Agree to Strongly Disagree. There were also questions with responses grouped categorically into time increments. The sample included both General Internal Medicine (GIM) and Family and Community Medicine (FCM) physicians from 10 ambulatory primary care practices in the University of Missouri Health System, including 8 suburban practices and 2 rural practices. Both surveys included faculty and resident physicians and were conducted online.

Survey response categories were grouped and analyzed as dichotomous variables using a chi-square test of binomial proportions. For the 5-point Likert questions, the proportion of physicians who agreed was analyzed, comprising the Strongly Agree and Agree responses. Questions involving time increments were grouped as well, for example, for a question about time required to document a visit, we analyzed those providers responding with categories greater than 10 minutes.

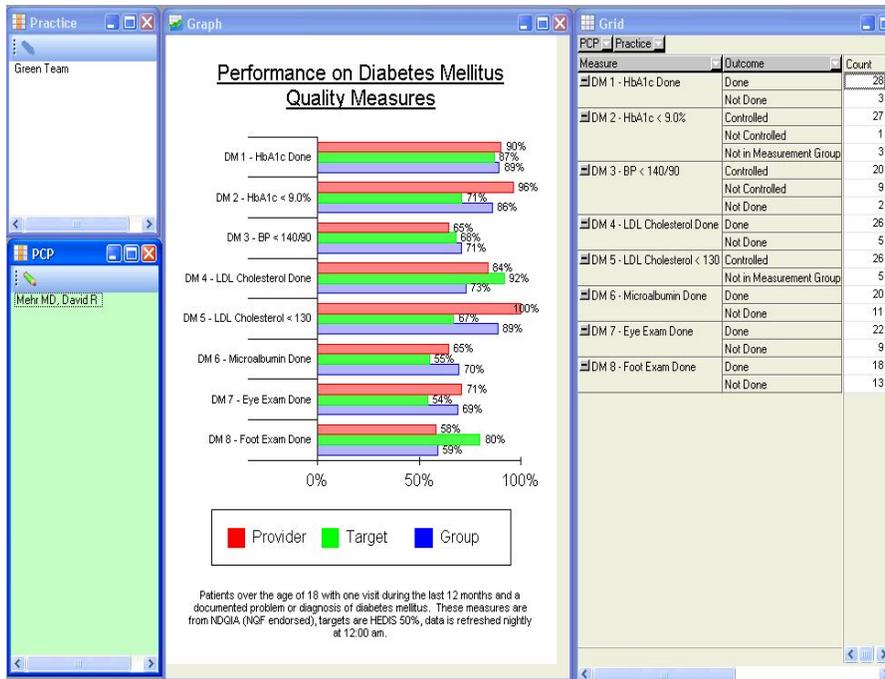
As the summary screens were made available to all physicians in the University of Missouri Health System (UMHS), we were not able to assess their impact in comparison to a control group. However, we did obtain data from about 10,000 patients with at least two visits at any of the primary care clinics between April 2006 and April 2008 who had any of several chronic diseases on their problem list. This allowed a crude comparison of whether eight DM performance measures (see below) had improved from before the **diabetes dashboard** implementation until the beginning of performance reports as described immediately below. Hemoglobin A1c values, blood pressures, LDL cholesterol values, and microalbumin values could be directly obtained as discrete data elements from the electronic record with queries written by IT staff. Information on eye examinations and foot examinations were obtained on a sample of patients' electronic records that were individually examined by project staff.

Performance Reports

Performance reports (reports of 8 quality indicators) for care of patients with DM became available in the production environment at UMHC in late February 2009, substantially later than originally expected.

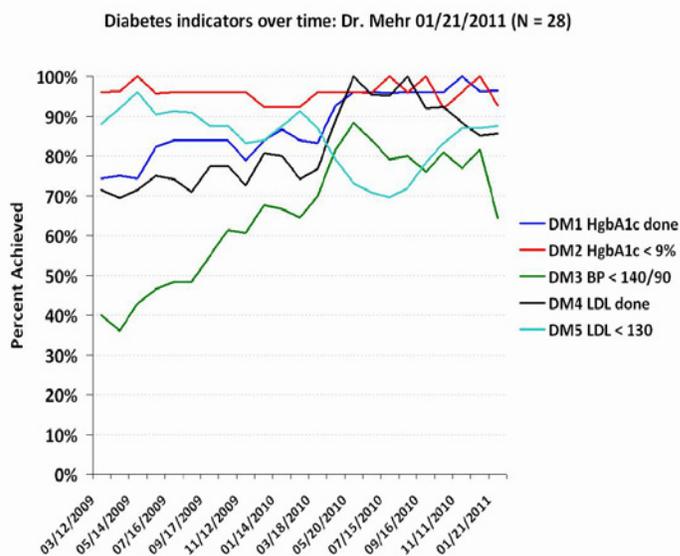
Moreover, performance reports never were fully functional for conditions other than diabetes. Nonetheless, we were able to conduct a substantial evaluation of the effect of these performance indicators with a quasi-experimental non-equivalent control group design. Incorporating qualitative methods, we also attempted to understand in more detail differences in practice outcomes in relation to contextual factors, such as local barriers and facilitators towards achieving better performance measure scores.

Figure 3: Pull Report



Over the first year of their availability, information on the 8 DM quality indicators were presented to the physicians of the 10 primary care practices in two different ways with two clinics not receiving any performance indicator information except at the individual patient level as available on the diabetes dashboard. One way of receiving information was the ability to go into the electronic record to view reports of performance data (Figure 3) as well as information

Figure 4: Part of a Push Report



on which patients assigned to a physician or a practice were and were not meeting the criteria for each indicator. We termed these “pull” reports. The other way reports could be received was by an e-mail report showing the individual physician’s performance as well as the performance of each practice. Figure 4 shows one of two graphics that comprised the individual physician’s report. We termed these “push” reports. Pull and push reports were assigned to practices in a factorial design with two practices receiving no reports, two practices receiving pull reports only, four practices receiving push reports only, and two practices receiving both push and pull reports.

We downloaded results from all practices on a weekly basis and statistically analyzed results over the first year with a multilevel model nesting physicians within practices and controlling for experience of physicians and whether there was a nurse case manager in the practice. We considered the 8 individual indicators plus composite measures of the first 6 and first 8 indicators. Composite measures required that all 6 or all 8, respectively, of the measures were achieved to be counted as positive. The 8-measure composite had the disadvantage of requiring physician entry in the record that eye examinations or foot examinations had occurred. In contrast, all of the data for the 6-measure composite constituted discrete items in laboratory or vital sign data that could be determined without the need for physicians or others to enter data. The experience variable was less than thirty or more than 30 patients assigned to the physician as primary care physician and was almost 100% equivalent to whether the physician was a resident or attending physician. That is, almost no residents had 30 patients with DM and almost no attendings had less than that number of diabetic patients.

Qualitative data was collected in two waves: June to November 2009 (30 interviews) and May to August 2010 (52 interviews). A few key-informant interviews were collected somewhat later to better understand particular patterns not adequately explained in prior interviews. Interviews were recorded and transcribed and analyzed with the assistance of Nvivo 8 and Nvivo 9 software. After reading several transcripts, initial coding schemes were suggested and subsequently modified in an iterative process. Themes emerged from discussions of codes from selected clinics with validation through application to other clinics. Additional data were also collected on the clinics, such as whether residents practiced there, when the clinic started operations, and when the electronic record became moderately operational (defined as when problem lists and medication lists began to be populated regularly). Qualitative results were considered together with patterns of change in performance measures. In particular, we focused on changes after the first year when all clinics gained access to both “push” and “pull” data.

Aim 2: To evaluate the effectiveness and changes associated with an interactive web-based patient interface software system (IQ Health), including in-home medication reconciliation.

Experience with IQHealth

IQHealth was scheduled for implementation in 2007 with additional functionality in 2008. Originally the plan had been to include all FCM and GIM clinics in the implementation; however, the implementation champion (Dr. Hodge) encountered multiple issues in converting the generic product to one suitable for the UMHC environment. Facing administrative, training, and technical issues, implementation was stalled. To facilitate the implementation and its evaluation, the study’s PI (Dr. Mehr) and study staff facilitated pulling together an implementation steering committee. With the assistance of this committee, IQ Health was eventually implemented on a pilot basis in three clinics (the two GIM clinics and one FCM clinic) in the fall of 2008. Study staff also helped to monitor issues patients encountered in logging in and using the system, which provided valuable additional information on issues involved in implementing a patient portal. The experience gained in helping to implement the portal led to a publication describing a conceptual framework of issues involved with planning and implementation as well as key questions to be addressed in such a venture.²⁹

The evaluation of the portal itself was primarily conducted by way of surveys of patients and providers. Anticipating the portal’s implementation, in February and March 2008 we conducted a paper-questionnaire survey of patients waiting to be seen in 5 UMHC primary care practices to gauge their use of the internet and their interest in secure communication with their physicians. Using a logistic regression model, we evaluated factors associated with use of e-mail or the internet.³⁰ We also conducted on-line surveys of patients who enrolled in IQHealth at

the pilot clinic sites from November 2008 to April 2009 and a follow-up survey after several months of enrollment to judge patient experience with IQHealth. Detailed methods from each of these surveys are contained in the publication describing internet use and a publication discussing patient interests in using and perceptions of use of IQHealth.^{30,31}

Using paper questionnaires, we also conducted three surveys of providers. The first, conducted in April 2008, asked unselected FCM residents, internal medicine residents and FCM and GIM attending physicians about their use of electronic communication with their patients and their expectations and perspectives on implementing a patient portal. The second, in October 2008, asked similar questions of attending physicians in the pilot clinics; residents were excluded because the FCM pilot clinic did not have residents and restricting to attending physicians was thought to create more comparable data. The final survey, in October 2009, assessed experience with and perspectives on patient portals after one year of use among physicians at the pilot clinics.

In-home Medication Reconciliation

As originally implemented, IQHealth included a “medication verification” function, which enabled patients to view their medication list from the electronic record; add other medications, over-the-counter (OTC) products, and complementary and alternative medications; and send an updated medication list to providers, including these additional medications and products. Our intent had been to conduct a study of the use of the medication verification feature to test its ability to provide an in-home medication reconciliation. However, while patients were able to send these items to providers in their electronic record inbox, the reports were in an unwieldy and difficult to use format. Moreover, in pilot testing, we determined that even with detailed instructions, the format of the EMR medication information provided and the verification process was not adequately usable to conduct the planned evaluation. Eventually for these same reasons, institutional leaders turned off the feature making any use of the feature for a study impossible.

We had always intended to validate in-home medication reconciliation with pharmacy visits to approximately 25 subjects in their homes to determine the accuracy of reports. We revised our plans to exclusively study the process of in-home medication reconciliation while a pharmacist was present. Among IQHealth enrollees who had agreed to be contacted for possible future studies and who indicated that they had a chronic illness on our enrollment questionnaire, we obtained consent for home visits by a clinical pharmacist (Dr. Caligiuri). He helped each patient view his or her medications in IQHealth and send an electronic message to the provider concerning discrepancies that the patient identified. Dr. Caligiuri then made his own assessment of medications that the patient was taking and prepared a report to the provider that was sent one week after the home visit unless there was an urgent issue. Research staff obtained medications from just before the visit and two weeks after the visit. We compared what the patients identified to the gold-standard assessments of the pharmacist. We also evaluated what changes providers made to the EMR medication list following communication from each patient and the subsequent communication from Dr. Caligiuri. The goal of this revised substudy was to assess potential issues in the process of patients communicating electronic information about medications to their providers and how the providers acted on this information. In this small sample of chronically ill individuals, we also sought to identify potentially serious medication issues that had not been recognized according to what was recorded in the electronic record.

Aim 3: To evaluate the use of in-home “smart” diagnostic devices (e.g., blood pressure, glucometers) connecting patients with their patient care teams.

The purpose of this aim was to evaluate the effectiveness in adult patients with diabetes of short-term use of remote data transmission of blood glucose (BG) and blood pressure (BP) to the clinic. The primary outcomes were hemoglobin A1c of less than 7% and blood pressure less than 130 over 80 at the end of three months of the program. We also collected data on issues surrounding implementation of the remote monitoring program in primary care.

Potential patient subjects at selected clinics were identified by reports generated from the EMR every two weeks with established diabetes and hypertension who were out of control on either blood glucose (A1c greater than 8%) or blood pressure (systolic blood pressure greater than 130). We then created letters addressed to potential subjects for primary care physicians to sign if they agreed with participation. Patients who did not send in a card asking not to be contacted were called by research staff to ask if they would consider participating and to determine eligibility.

Patients randomized to the intervention group measured their blood pressure daily and tested their blood glucose as currently advised by their provider. Using a telephone or personal computer, the patient then uploaded their data to a secure web portal for a 3 month period. Patients assigned to the control group tested their blood pressure and blood glucose on the same schedule as the intervention group, recorded their readings in a paper and pencil diary, and were instructed to bring these diaries to their clinic visits. All treatment changes for intervention and control group patients were individualized according to patient need. Due to the nature of the intervention, neither the patients nor the physicians were blinded to the patients' (random) group assignments.

For the blood glucose and blood pressure outcomes, linear mixed models were fit to the data with both fixed and random effects along with some fixed effect interaction terms and key covariates (sex, baseline measurement of outcome, age at enrollment, and a questionnaire score which measured their confidence in managing their condition. Main fixed effects included time in the study (days since enrolled) and group (intervention or control), and the key group-by-time interaction. Random effects included a subject-specific random intercept to account for the heterogeneity among patients with respect to baseline outcomes. A random effect due to the primary care provider was also included to account for the hierarchical nature of patients being treated by the same primary physician and the dependency among patients that could induce. The models were fit to the data using SAS 9.22 and primarily involved PROC MIXED.

Physicians who had patients enrolled as an intervention participant, clinic nurses who participated in the data review and management, and patients were interviewed following completion of the program to collect data on perceptions of the program.

Results

Aim 1 Principal Findings

Condition Summary Screen (Diabetes Dashboard)

The usability study (published in the *Annals of Family Medicine*) suggested that using a patient-specific diabetes dashboard improved both the efficiency and quality of diabetes care.²⁸ Among the 10 clinicians tested, the mean time to find all data elements using the conventional approach was 5.5 minutes vs. 1.3 minutes using the diabetes dashboard ($p < 0.001$). Physicians using the conventional method found 94% of the data requested, vs. 100% with the dashboard ($p < 0.01$). The mean number of mouse clicks for the conventional searching was 60 vs. 3 with the diabetes dashboard ($p < 0.001$). A common theme from physician comments was

that in everyday practice, if physicians spent too much time searching for a piece of data, they would either go on without it or order a test again.

The pre-implementation survey (March 2008) had a response rate of 64% with 11 GIM and 33 FCM physician respondents. The post-implementation survey (November 2009) had a 75% response rate with 25 GIM and 57 FCM physician respondents. Key results are shown in Table 1.

Table 1: Results of Physician Pre- & Post-Implementation Surveys about DM Summary Screen

	Pre (%)	Post (%)
EMR makes it easy to follow current DM care best practices	12	36*
It is easy to collect data needed for a DM visit	37	68*
I am frustrated by the time to document visits in the EMR	80	56*
I can document a return visit in the EMR for an adult with DM in 10 minutes or less (excludes dictation)	54	79**
I know where to find the information I need	87	87
I have a systematic approach to reviewing quality data for diabetes	46	62
I am comfortable using the EMR	84	90
I am less efficient because of the EMR	46	21
Accomplishing tasks in the EMR is intuitive	10	12
*Pre-post difference significant at $p < 0.01$		
**Pre-post difference significant at $p < 0.05$		

Additionally, one unexpected consequence of the implementation of the diabetes summary dashboard was that post implementation, 55% of physicians reported giving patients a printed copy of their summary dashboard for at least some visits. In summary, the implementation of the diabetes dashboard was associated with increased physician perceptions of efficiency and quality. It also, unexpectedly, resulted in increased information flow to the patients themselves.

These data were presented at the North American Primary Care Research Group Annual Meeting in Seattle in November 2010.

Concerning impact of the condition summary (diabetes dashboard) on diabetes quality measures, results overall showed

stability in the 8 months prior to introduction of the summary screen in April 2008. There were few exceptions among clinics with an adequate amount of data. Following introduction of the summary screens, on some measures, such as blood pressure control ($<140/90$), there was no appreciable change from April 2008 to April 2009, which was shortly after we began

routinely measuring quality indicators in late February 2009. However on other measures, including a composite measure of meeting 6 of 8 indicators (excluding eye and foot exam, which required physician entry), there was improvement in most clinics from April 2008 to April 2009. These findings suggest that the summary screens may have had some impact; however, multiple alternative explanations are possible since there was no control group.

Effect	Num DF	Den DF	F Value	Pr > F
push	1	6.023	0.56	0.4812
time	1	5718	58.47	<.0001
time*push	1	5718	1.86	0.1721
pull	1	6.577	0.48	0.5115
time*pull	1	5718	6.77	0.0093
experience	1	5718	0.02	0.8811
time*experience	1	5718	0.02	0.8827
nurse	1	6.366	1.97	0.2072
time*nurse	1	5718	0.37	0.5415

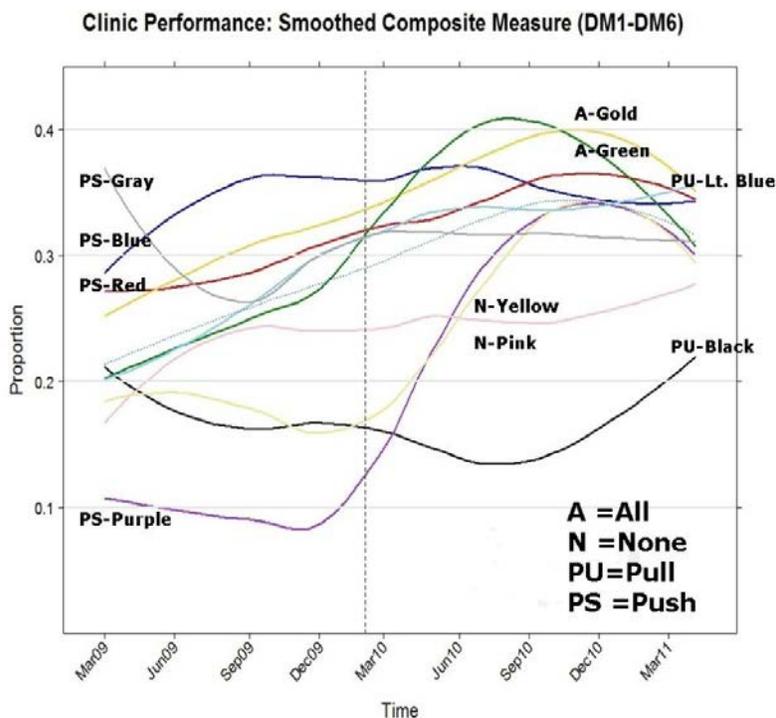
Performance Indicators

At the midpoint of the two year evaluation of the performance indicators, there were 106 resident and attending physicians listed as primary care physicians for 3259 patients with diabetes. Currently (November 2011), 162 individuals, including 140 physicians, have access to

the on-line performance reports available through the EMR, which we have termed “pull reports.” This is almost certainly close to the number who previously had access. Eighty-three individuals, including 57 physicians, have accessed the reports one or more times. Thus, although not a perfect estimate because of potential turnover in those with access, about 50% of those who potentially had access to performance reports took advantage of viewing them through the EMR. The usage was highly varied across both providers and clinics with several clinics exhibiting almost no use of these reports, while nurse case managers or clinical leaders in several practices have viewed them several times per month and continue to use them. The e-mail reports (“push reports”) were sent out until spring 2011 but have not been continued since.

During the first year that performance reports were available, push and pull reports were distributed among clinics in a factorial design. In multilevel mixed models, which treated physicians as the unit of analysis and incorporated clinician experience and the presence or absence of a nurse case manager, six of the eight performance indicators improved over time (significant time main effects), but none of the treatment by time interaction terms were significant. This indicates that overall care was improving on most of the indicators; however, neither push nor pull reports showed a significant association with this change over time. The two exceptional measures that did not show improvement were the outcome indicators of Hemoglobin A1c < 9% and LDL cholesterol < 130. Both of these indicators were conditional on the test being done; those without a result in the prior year at the time of calculation of the indicator were excluded from both the numerator and the denominator. With that caveat, the values of both of these indicators were generally very good, better than 80% of patients satisfied the measure in each case in almost all clinics.

Figure 5: Loess-smoothed plots of data from 10 clinics



Findings were different, however, for a composite measure that required meeting all of the first six indicators. As physicians with less than 4 patients with diabetes on their problem list were excluded, 61 physicians are included in this analysis. There was no evidence of a significant time by push effect, but the time by pull interaction term was highly significant ($p=.0093$). Table 2 shows the analysis of effects. “Num DF” and “Denom DF” refer to numerator and denominator degrees of freedom, respectively. As before the time main effect was also highly significant. Together, these terms indicate that overall physicians were showing improved performance over time in the composite measure, but physicians in clinics with

access to pull reports (on-line access) were improving more over time than physicians in clinics without access to pull reports. We intend to present this data in a manuscript.

An alternative approach to viewing the data is to present results for the clinics, which includes all patients assigned to physicians in a clinic regardless of the number of patients that physician has. Figure 5 shows Loess-smoothed longitudinal plots of data from all ten clinics over the two years since the initiation of the performance reports until spring of 2011. The dashed vertical line in the middle of the figure indicates the approximate point at which both push and pull reports became available to all clinics. Consistent with the data presented above, over the course of the first year, most clinics were showing improvement and the weighted average overall (the fine dotted line) was improving steadily. The plots also indicate some limitations of the data. The two clinics that show initial steep declines (gray and black lines) had data issues. Both clinics had relatively few patients with a primary physician at that clinic and diabetes on their problem lists initially. Initial declines were associated with adding diabetes to the problem list on more patients, and initial numbers were likely artificially high.

From the perspective of our mixed methods analysis, we were particularly interested in the performance of 4 clinics: the pink and yellow clinics, which had had access to neither push nor pull reports in the first year, showed dramatically different trajectories in the second year (relative stagnation and marked improvement respectively); the purple clinic, which had had access only to push reports, showed marked improvement; and the black clinic, which had access to push reports initially, showed continued stagnation through much of the second year. We also note that starting just before or in the early months of 2011 many of the clinics began to show a decline in the composite measure. Unfortunately, we did not become aware of this decline until after we had completed our qualitative interviews, so we have no direct information to shed light on this finding.

Analysis of transcripts suggested several important themes that helped explain differences in trajectory among clinics and led to a tentative explanatory model for response to the availability of performance indicator data. We are completing our analysis of qualitative data with the plan to prepare a major manuscript. In the two clinics that showed major improvements associated with gaining access to pull reports, there were some striking similarities. In both clinics data were shared at joint meetings with physicians and clinic staff, and there was shared embarrassment at existing level of performance. The physician practice head at the purple clinic stated:

...it all kind of came back to they were kind of embarrassed that they were so low.

Engaged leadership led the practices in developing specific improvement plans and in continuing to monitor and share results. Leadership also saw the importance of creating a shared vision within all of the staff at the clinic. The physician practice head at the yellow practice, stated:

So I mean every one to two months, we're doing some sort of presentation that tries to involve the entire staff...in the vision of the office and the way we're looking at that, and ask them for their feedback.

In contrast, at the pink practice, there was not a shared culture of common purpose. While there were some improvement activities, diabetes was not a focus. Moreover there were no shared discussions about performance indicators or shared expectations about how staff could collaborate to improve care. Quotations from two different physicians illustrate these points:

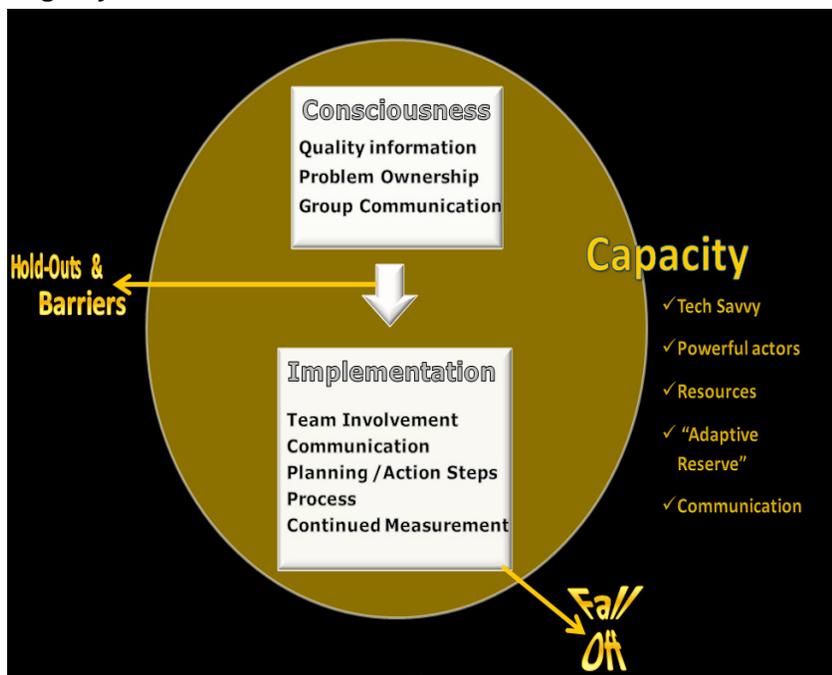
I don't know that we've reviewed those reports specifically as a clinic ever, as far as meetings and things like that.

So there's not been a clear communication on what specifically she is doing or not doing, and I'm just going with the flow.

The second physician was a founder of the practice who was not happy with many recent changes. He was disengaged from practice improvement:

It's not my problem. I mean that's sort of where I really don't complain that much about electronic medical records because there's nothing that's going to happen! You kick a dog enough, it quits barking.

Figure 6: Preliminary Model for Performance Improvement with Registry Information



Based on our review of qualitative and quantitative data, we have developed a tentative explanatory model of factors associated with improved performance in response to access to registry information with performance data (Figure 6). Quality information becomes usable when there is problem ownership and group communication. We call this step consciousness. The translation of consciousness to implementation is mediated by the practice's capacity to integrate major projects or change. Leadership is crucial in all of these steps. We also found that communication played a key role in all of these

steps: communication about the problem to create ownership at the consciousness stage; effective communication as a tool for effective functioning within the clinic (a capacity issue); and communication as a tool in creating an effective process to implement an improvement strategy. We also recognized that hold-outs and barriers could inhibit an improvement process and that there was potential for fall off after a period of time as seen in Figure 5. The second physician quoted from the pink clinic above would be an example of a hold-out. This physician did view his “push” reports and was concerned about his performance on quality indicators; however, he was disengaged from creating processes to accomplish this. Within our setting, having individuals who were skillful with computers and using the electronic record (“tech savvy”) within a clinic also appeared to be an important facilitator. Finally, many of our capacity components nicely fit into Nutting and colleagues’ concept of “adaptive reserve” from their evaluation of the national demonstration project.³²

Aim 2 Principal Findings

Internet Use by Primary Care Patients (“Waiting Room Survey”)³⁰

Study staff approached 713 patients waiting to be seen in 5 primary care practices and 638 (89.6%) completed questionnaires; 499 (78%) were Internet users (reported use of either e-mail or the internet; 97% used both) and 139 (22%) were non-users. Lack of computer access and not knowing how to use e-mail or the Internet were the most common barriers to Internet use. Consistent with prior studies, older individuals, those with less education and income, with poorer self-reported health, and those with chronic illness were less likely to use the internet (all $p < 0.001$). In a logistic regression model that incorporated these variables, age, household income, and education were independently associated with internet use while having a chronic illness was no longer associated with Internet use (adjusted odds ratio [95% confidence interval]

0.899 [0.521 – 1.55]). Non-Hispanic Blacks also had less internet use than other groups, although this association was also not statistically significant when controlling for other variables. However, even among the groups least likely to use the internet, the proportion using the internet was at worst slightly below 50% (the lowest group was 45% for those reporting household income less than \$20,000). Seventy percent of those reporting a chronic illness were internet users. These results indicate that a large proportion of primary care patients, including those with chronic illness, have internet access and might be able to use on-line health resources. However, some groups have substantially less use, which requires attention in any plans for use of the internet to support health interventions.

Issues in Implementing Secure Electronic Patient-Provider Web Portals²⁹

Based on our experience with the implementation of IQHealth, we developed a framework for issues that needed to be addressed in a planned implementation of a patient-provider web portal communications system. The framework includes the following issues, which are sequential in terms of when they become important in the implementation process: 1) strategic fit and priority (e.g., how does the portal fit within the institution's strategic plan and where will it be deployed?); 2) selection process and implementation team (e.g., who will be the executive owner and supervise the roll out?); 3) integration in patient care communications and workflow (e.g., will messages go directly to providers or be filtered by staff?); 4) Aligning organizational policies with HIPAA (e.g., will only secure portal communications be allowed after portal implementation and how will access to EMR information be handled with split families or caregivers of elderly patients?); 5) system implementation and training (e.g., what is the system testing and implementation time line and who will need training?); 6) marketing and enrollment (e.g., which patients will be targeted for enrollment with what marketing materials and what will the enrollment process be?; and 7) ongoing system use and performance monitoring (e.g., who will be responsible for monitoring system performance and what plans are in place for use during system failures?). Addressing the issues raised by this framework and the more extensive list of questions in our publication can assist systems in avoiding pitfalls as they implement secure web portals as part of meaningful use requirements.

Patient and Provider Perceptions about IQHealth

Patient expectations and perceptions concerning use of a web portal were assessed on two occasions, the "waiting room survey" described above and an enrollment survey for those enrolling in IQHealth. Perceptions of users of IQHealth were also assessed 3-6 months after enrollment. Among internet users from the waiting room survey (n=499), 25% reported having e-mailed their physicians, but only 6% at least monthly. In contrast, of the 163 enrollment survey respondents (55% response), 50% had e-mailed their physician within the last year, and 37% had done so 4 or more times. Compared to internet users on the waiting room survey, those who responded to the enrollment survey were older, had higher household incomes, more likely to have a college degree, and reported having at least one chronic illness ($p < 0.05$).³¹ More than 50% of enrollment survey respondents reported being very interested in emailing their doctors (73%), viewing lab and test results (75%), and requesting medication refills (52%). Follow-up survey respondents who reported using IQHealth had not used it much over three months. For example, only 25% reported sending 4 or more messages to providers. The most common response to questions asking about effects on care was neutral/no opinion (mostly 40-50%). As of May 2009, there were 831 patients signed up for IQHealth; at the end of November 2011, 4800 patients were registered for the successor product, Healthe.

Prior to IQHealth implementation, 39 internal medicine and family medicine residents and 43 generalist faculty physicians about attitudes responded to our questionnaire concerning the planned patient portal (77% response). Among faculty physicians at the 3 generalist clinics that participated in the pilot implementation, 11 (61%) responded to the pre-implementation

survey and 15 (68%) responded one year later to the post-implementation questionnaire. Residents received much less e-mail than faculty physicians; 2/3 of residents reported no email exchange with their patients in a typical month compared with only 9% of faculty ($p < 0.0001$). Residents were less likely to agree with allowing patients to view selected parts of their medical record on-line than faculty physicians (57% vs. 81%, respectively). While generally favoring implementation, both residents and faculty were concerned about potential increases in workload but felt quality of care would increase after implementation of a patient portal. Physicians who participated in the pilot implementation had expected workload to increase (64% agreed), but after implementation 87% of those responding were neutral or disagreed with workload having increased. However, after implementation only 33% believed quality of care had improved compared to 55% who had expected it to improve prior to implementation. A paper has been prepared on these findings and will be submitted shortly.

In-Home Medication Reconciliation

We had usable data on 20 home visits. Patients had a median age of 53 and were evenly distributed between male and female. The number of medications ranged from 5 to 24, and there were from 1-4 prescribers per patient. Eleven of the twenty patients were taking medications that were potentially “High Risk.” For 18 of the 20 participants, a total of 76 discrepancies between medications listed in patients’ EMRs and those found during the home visit were identified: 35 prescription medications (7 “High Risk”) and 41 OTC medications. The most common reason for a discrepancy among prescription medications was that a medication in the EMR was no longer being taken by the patient. Among OTC medications, the most common discrepancy was that the patient was taking the medication and it was not listed on the profile. There was no correlation between the number of medications a patient was taking and the number of discrepancies. Of the 76 discrepancies, 33 were updated in the EMR following the home visit and communication by the patient and pharmacist. The most common update was to medications that the patient was no longer taking. There was no correlation between the total number of medication discrepancies per patient and the total number of updates. Patient e-mails (usually via IQHealth) were documented in the EMR for 12 of the 18 patients with discrepancies; in only one of these emails did the patient accurately communicate all changes. Pharmacist communications were documented in the EMR for 15 of the 18 patients with discrepancies. The findings indicate that patients can identify important medication discrepancies but that this identification is not complete and that providers only partially adjust their records in response. Substantial room for errors of omission exist in this process.

Aim 3 Principal Findings

The sample included 108 patients who were randomized to intervention and control groups. The mean age of the sample was 60 years; 56% of patients were female; 87% were Caucasian and 11% were black; 63% were married; and 30% were divorced or single. At the end of three months, there were no statistically significant differences between the intervention and control participants on either A1c or systolic blood pressure (SBP). For example, for A1c, the covariate-adjusted difference in change at 90 days was -0.15 (negative favors intervention) with 95% confidence interval -0.649 to 0.348. The outer limit of the confidence interval would potentially admit a clinically significant change, but with the sample obtained and the implementation used, the remote monitoring program did not improve patients’ diabetes or blood pressure control.

We interviewed 11 physicians and 6 nurses, which included 2 RNs, 3 advanced practice nurses, and 1 LPN, to explore implementation facilitators and barriers. Nurses in the primary care practices were supportive of the intervention, and overall found it not to be too bothersome. However, the non-integration of the transmission system and website with the electronic health record and the Personal Health Record led to the nurses having to visit a website that was

outside of their usual workflow, and transcribe data from the website to the EMR for the physician to review. Lack of integration with a Personal Health Record meant that the nurses often communicated by telephone with the patient rather than using the functionality of the Personal Health Record. The nurses expressed that this form of communication likely took more time, but synchronous telephone communication did allow them to clarify issues around diet and to continue to maintain and build their therapeutic alliance with the patient. The nurses specifically identified that electronic data transmission did not eliminate the importance of a personal relationship with the patient.

Although physicians expressed some themes that were similar to nurses, two themes emerged from physicians that nurses did not express at all. Physicians were very concerned about the lack of a reimbursement strategy for this between-visit work in a fee-for-service climate. While concerned about the welfare of their patients, and allowing that this intervention might be helpful, they were concerned about spending time in un-reimbursed activities. Possibly related to this concern, almost every physician interviewed wanted to know about the evidence behind such an intervention and what type of improvement they could expect to see from it.

Workload Issues

Previous studies have not examined the burden of this activity on nurses embedded within the practice. In fact, most previous studies did not use nurses within the practice. To evaluate the sustainability of this type of intervention outside the research environment, we surveyed the six practice nurses on a weekly basis, asking them how much time they spent “yesterday” on various activities, including troubleshooting technical problems, reviewing patient data on the website, providing feedback to patients, communicating with providers, documenting data, documenting subsequent actions, and other tasks.

Nurses spent an average of 32 minutes per day in tasks related to this transmitted data. Their most time-consuming task was reviewing patient data on the website, an average of 9.8 minutes a day, followed by providing feedback to patients at 6.6 minutes a day. Communication tasks increased as the number of patients increased. On this weekly survey, we also asked nurses to rate their level of frustration with the various tasks on a scale of one to five, with one being the least frustrating. All tasks received an average score less than two, indicating that even time-consuming tasks were not viewed as very burdensome or frustrating.

Discussion and Conclusions

Our complex project investigated several changes in HIT that were implemented to improve chronic disease care. The diabetes dashboards were implemented ahead of schedule and were popular overnight as they saved clinicians effort. An unintended consequence of their implementation was to improve information flow to patients. Although the composite measure of meeting six diabetes performance measures (DM1-DM6) improved with use of the summary screen, we cannot be certain whether that was due to its impact or due to other factors leading to change in diabetes care at the involved clinics.

Similarly, with a small number of clinics and most practices continually improving over the first year of our study of different versions of performance reports, we cannot be certain that the reports had any impact. Nonetheless our quantitative and qualitative findings suggest that in practices primed to use the data, ability to access performance data can improve care. The specific form of performance data that appeared to have an impact was data that could be accessed by clinicians and practice staff and that provided the ability to drill down to looking at which patients were meeting criteria.

We had originally hypothesized that practices with a nurse case manager would be more successful using performance reports. While those practices started out with better performance than some other practices, over the course of a year, they did not provide additional advantage.

More important appeared to be issues of culture and leadership within practices. Moreover our findings supported the concept of “adaptive reserve,” developed by Nutting and colleagues, as a critical factor in practice change.³² While the literature on the impact of EMRs on diabetes care has been mixed,^{9-11,13} our data is consistent with our model suggesting that practice context (capability) is a critically important factor in improving care.

Our studies also found that many patients are prepared for enhanced electronic communication with providers and access to information in their medical records. Nonetheless, there are substantial challenges in successfully integrating patient portals into routine clinical care. However, in our small sample of physicians from three practices, physicians who had anticipated increased workload found that this was not the case. While patient use of the web portal was initially quite slow, a more developed product being implemented in more practices is achieving substantially increased adoption. From the perspective of using portals as a source of in-home medication reconciliation, our findings confirm problems in provider entered medication lists in EMRs; however, patients only partly identify these errors, and providers may not respond even when informed. These findings support the need for better processes to assure medication accuracy in the EMR that can compensate for provider omissions.

Finally, our effectiveness study of the use of remote monitoring did not demonstrate an impact on clinical outcomes but did lead to the identification of important themes that will inform practices who are considering a remote monitoring intervention for their patients with chronic illness. Such practices need to understand the capabilities and limitations of the technology. Additionally, they should seek independent references to evaluate the vendor’s performance on technical troubleshooting. In our case, this was quite good, but if it were not, we could foresee nurses spending time in this activity, which would not be desirable.

Practices should design and understand the workflow and consider protocols for the flow of information. Additionally, we found that the human side of the equation, patient-provider relationships, remained a crucial component of working with remote monitoring data. Buy-in by all participants appears important. Lastly, integration of the data transmission system with the EMR and electronic personal health record is key to the intervention’s sustainability in real practices.

Inclusion of AHRQ Priority Populations

This project was focused on improving adult chronic disease care, and electronic record data, such as the data on performance on diabetes quality measures, concerned thousands of chronically ill adults. Additionally, given the distribution of chronic illness in the population, many of these individuals likely were elderly, although we do not have statistics on these individuals by age. Two of the 10 clinics where these individuals received their primary care were in rural areas. Our survey data concerned a less selected population of patients; however, there was a substantial representation of priority populations among survey participants. For example, in our “waiting room survey,” 23% were 61 or older, 12% were non-Hispanic Blacks, 22% had family income below \$20,000, and 47% indicated that they had a chronic illness. Among those who responded to our IQHealth enrollment survey priority population representation was even higher; for example, 26% were over age 60 and 58% reported a chronic illness. Our study of remote electronic monitoring entirely concerned chronically ill patients with diabetes and hypertension, the mean age was 60, and 11% were Black. Our study did not include children as the subject of the study was care of chronic disease in ambulatory settings.

List of Publications and Products

Completed and in-press peer reviewed publications

Koopman RJ, Kochendorfer KM, Moore JL, et al. A diabetes dashboard and physician efficiency and accuracy in accessing data needed for high-quality diabetes care. *Ann Fam Med* 2011;9(5):398-405.

Wakefield DS, Mehr D, Keplinger L, et al. Issues and questions to consider in implementing secure electronic patient-provider web portal communications systems. *Int J Med Inform* 2010;79(7):469-77.

Kruse RL, Koopman RJ, Wakefield BJ, et al. Internet use by primary care patients: where is the digital divide? *Fam Med* In press 2011. (In Press)

Wakefield DS, Kruse RL, Wakefield BJ, et al. Consistency of patient preferences about a secure internet-based patient communications portal: contemplating, enrolling, and using. *Am J Med Qual* In press 2011. (In Press)

Presentations

Koopman R, Wakefield B, Johanning J, et al. Nurse burden associated with managing diabetes home monitoring data in primary care practice. *39th North American Primary Care Research Group Annual Meeting; 2011 Nov 12-16; Banff, Alberta. 2011. (Presentation)*

Mehr D, Wakefield D, Davis JW, et al. Improving outcomes on diabetes quality indicators: practice context matters. *39th North American Primary Care Research Group Annual Meeting; 2011 Nov 12-16; Banff, Alberta. 2011. (Presentation)*

Wakefield BJ, Wakefield DS. User perceptions of patient portals in an academic medical center. *Veteran's Administration (VA) Cyberseminar; 2011 Apr, 2011. (Presentation)*

Mehr DR, Kaushal R, Honour M, Lund B. *Practical Approaches to Using Electronic Health Records for Research: Challenges and Mitigation Strategies. March 15, 2011. (Webinar)*

Wakefield DS. Patient portals: interest in is not the same as signing up to use. *2011 American College of Healthcare Executives (ACHE) Congress; 2011 Mar 22; Chicago, IL. 2011. (Presentation)*

Wakefield DS. Implementing patient portals: not a plug and play proposition! *2011 Healthcare Information and Management Systems Society (HIMSS) Annual Meeting; 2011 Feb 24; Orlando, FL. 2011. (Presentation)*

Koopman RJ, Mehr DR, Kruse RL, et al. Diabetes dashboards (EMR-generated, patient-specific): making it easy for providers to do the right thing. *38th North American Primary Care Research Group Annual Meeting; 2010 Nov 14; Seattle, WA. 2010. (Presentation)*

Mehr DR, Kochendorfer KM. Improving chronic disease care with the use of automated real-time performance reports. *AAFP/STFM Conference on Practice Improvement; 2009 Nov 6; Kansas City, MO. 2009. (Presentation)*

Koopman RJ, Mehr DR, Kochendorfer KM, et al. Immediate and one-year evaluation of a single screen summarizing key data for diabetes care in an electronic medical record. *Agency for Health Research and Quality (AHRQ) Annual Conference; 2009 Sep; Bethesda, MD. 2009. (Poster Presentation)*

Wakefield D. Secure patient-provider communication system implementation: questions to consider. *Caring for the Frail Elderly Conference; 2009 Aug 22; Columbia, MO. 2009. (Presentation)*

Wakefield B, Koopman R, Keplinger L, et al. Effectiveness of remote monitoring in improving blood glucose and blood pressure management in primary care clinics. *American Telemedicine Association Annual Meeting; 2010 May; Tampa, FL. 2010. (Presentation)*

Mehr DR. E-Prescribing and medication management. *The Agency for Healthcare*

Research and Quality (AHRQ) National Resource Center for Health IT. March 31, 2009.
(Webinar)

Koopman RJ. A condition summary screen improves provider efficiency and accuracy in accessing data needed to provide high quality diabetes care. *North American Primary Care Research Group 2008 Conference*; Puerto Rico. 2008. (Presentation)

Kruse RL, Mehr DR, Wakefield DS, et al. Computer use among primary care patients. *36th North American Primary Care Research Group Annual Meeting; 2008 Nov*; Rio Grande, Puerto Rico. 2008. (Presentation)

Mehr D. Medical home impacts: AHRQ funded evaluation of MU-Cerner Medical Home Project. *Cerner Health Conference; 2008 Oct 7*; Kansas City, MO. 2008. (Presentation)

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