

AHRQ Health Information Technology Ambulatory Safety and Quality

Findings and Lessons
From the Improving Quality
Through Clinician Use
of Health IT
Grant Initiative



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HEALTH IT



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Preface

The Improving Quality Through Clinician Use of Health IT initiative is part of the Agency for Healthcare Research and Quality's (AHRQ's) Ambulatory Safety and Quality (ASQ) program. The purpose of the AHRQ ASQ program is to improve the safety and quality of ambulatory health care in the United States. The program's components, with the exception of the risk assessment grant initiative (FOA HS-07-003), emphasize the role of health information technology (IT). The ASQ program included the following grant initiatives:

- Enabling Quality Measurement Through Health IT (FOA HS-07-002), which focused on strategies for the development of health IT to assist clinicians, practices, and systems to measure the quality and safety of care in ambulatory care settings.
- Ambulatory Care Patient Safety Proactive Risk Assessment (FOA HS-07-003), which supported research in risk assessment and modeling to identify preventable patient injuries and harms, and to inform the development and deployment of intervention strategies to reduce threats to patient safety in ambulatory care settings and during transitions of care.
- Improving Quality Through Clinician Use of Health IT (FOA HS-07-006), which supported research related to the development, implementation and use of health IT to assist clinicians, practices, and systems in improving the quality and safety of care delivery in ambulatory care settings.
- Enabling Patient-Centered Care Through Health IT (FOA HS-07-007), which was designed to investigate approaches to improve the patient experience of care through the use of health IT in ambulatory care settings.
- Improving Management of Individuals with Complex Healthcare Needs Through Health IT (FOA HS-08-002), which was aimed at clinician and patient and family use of health IT in ambulatory settings to improve outcomes through more effective decision support or care delivery for patients with complex health care needs.

This is one in a series of five reports highlighting findings and lessons from the health IT-focused ASQ grant initiatives. These reports summarize the projects in each initiative and identify practical insights regarding the use of health IT to improve safety and quality in ambulatory settings.

Acknowledgments

This report was developed through a collaborative process that would not have been possible without the contributions of many individuals. The project director would especially like to thank the following key participants who contributed to and guided the work:

- The Improving Quality Through Clinician Use of Health IT (IQHIT) grantees whose work in advancing the use of health IT for quality and safety improvement inspired and informed this report.
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Executive Summary

This report highlights key findings and lessons from the experiences of 24 projects awarded in 2007 under the Agency for Healthcare Research and Quality (AHRQ) Improving Quality Through Clinician Use of Health IT (IQHIT) initiative (Funding Opportunity Announcement [FOA] HS-07-006, <http://grants.nih.gov/grants/guide/rfa-files/RFA-HS-07-006.html>). This initiative was designed to investigate approaches for using health information technology (IT) to support clinicians in making patient care decisions and coordinating care with a focus on effectively incorporating evidence-based information at the point of care. It is part of AHRQ's Ambulatory Safety and Quality (ASQ) program, which was designed to improve the safety and quality of ambulatory health care in the United States.

This report summarizes the extent to which the projects addressed the areas of interest of the IQHIT initiative and identifies practical insights regarding the use of health IT to improve clinical decisionmaking and care coordination in the ambulatory setting. It presents illustrative project findings in an effort to inform research discussion and provide guidance to other entities implementing health IT systems that help clinicians improve the quality of patient care. As the researchers continue to disseminate findings from these projects, additional lessons may become evident.

The body of the report is organized around the four main areas of interest in the FOA, plus a section on understanding the impact of health IT on outcomes in ambulatory care. Each area of interest is described below:

- Providing patient-specific information, clinical knowledge, and decision support, addressed in 15 projects, includes the provision of clinical recommendations and guidelines and clinical information about specific patients from registries and other sources to help clinicians and patients make decisions that improve outcomes.

- Supporting clinical workflow, addressed in seven projects, refers to the study of how the implementation of health IT systems can support effective and efficient clinical workflows, taking into account organizational factors in ambulatory settings.
- Coordinating care, addressed in three projects, is defined as “the deliberate organization of patient care activities between two or more participants (including the patient) involved in a patient’s care to facilitate the appropriate delivery of health care services” (AHRQ, 2007).
- Understanding the impact of health IT on outcomes in ambulatory care settings, addressed in two projects, includes research to better understand how clinician use of health IT can impact outcomes.

The IQHIT initiative also specified several funding preference areas including two priority areas: one for projects focused on medication management and a second for project sites serving vulnerable populations. There was also a funding preference for projects being conducted at or by practice-based research networks (PBRNs). A total of 24 projects were awarded under the initiative. The projects were carried out in a variety of ambulatory care settings, including primary care and specialty care offices and clinics. They addressed a range of relevant care topics, including several priority areas for health care quality improvement identified by the Institute of Medicine (IOM, 2003).

The names of the principal investigators, their institutions, and the project titles are shown in the Appendix, along with links to additional information about the projects on the AHRQ National Resource Center for Health IT Web site (<http://healthit.ahrq.gov/portfolio>).

The findings and lessons from the IQHIT initiative can inform researchers and front-line implementers who use health IT to help clinicians achieve better health care outcomes. The projects demonstrated significant progress toward addressing AHRQ's goal of advancing understanding of how clinicians can use health IT to improve the quality of patient care. They developed and tested a range of approaches for enhancing clinical decision support, providing clinical information at the point of care, and improving care coordination, while also studying how to integrate health IT systems into clinical workflows. Several projects showed a positive impact on process

outcomes related to the delivery of evidence-based care or the use of health IT. In addition, several projects showed a positive impact on intermediate outcomes such as chronic disease control, clinician perceptions of health IT usefulness, and clinician satisfaction. Other projects demonstrated improvements in health outcomes such as health status and adverse drug events. The continuing rapid pace of technological change and the continuing interest in use of health IT for improving health and health care delivery make the results of this body of research timely and relevant.

Introduction

This report highlights key findings and lessons from the experiences of 24 projects awarded in 2007 under the Agency for Healthcare Research and Quality (AHRQ) Improving Quality Through Clinician Use of Health IT (IQHIT) initiative (Funding Opportunity Announcement [FOA] HS-07-006, <http://grants.nih.gov/grants/guide/rfa-files/RFA-HS-07-006.html>). This initiative was designed to investigate approaches for using health information technology (IT) to support clinicians in making patient care decisions and coordinating care with a focus on effectively moving evidence-based information to the point of care. The IQHIT initiative is part of AHRQ's Ambulatory Safety and Quality (ASQ) program, which was designed to foster research on the use of health IT to improve the safety and quality of ambulatory health care in the United States.

This report summarizes the extent to which these projects addressed the areas of interest of the IQHIT initiative and identifies practical insights regarding use of health IT to improve health care quality in the ambulatory setting. The report presents illustrative findings in an effort to inform future research and provide guidance to other entities implementing health IT systems to help clinicians improve the quality of patient care. The report is organized around the four main IQHIT initiative areas of interest. Each section includes a brief background on the topic, followed by a description of how the projects addressed the topic, plus illustrative examples from the projects. In addition, the report includes a synopsis of key findings from the projects as measured by several types of outcomes, including process outcomes, intermediate outcomes, and health outcomes.

The names of the principal investigators, their institutions, the project titles, and the IQHIT areas of interest addressed in each project are included in the Appendix, along with links to additional information about the projects on the AHRQ National Resource Center for Health IT Web site (<http://healthit.ahrq.gov/portfolio>).

The Improving Quality Through Clinician Use of Health IT Grant Initiative

Each IQHIT study focused on improving quality through clinician use of health IT. The IQHIT initiative solicited grant applications to investigate novel methods or evaluate existing strategies to incorporate evidence-based information at the point of care, including the use of clinical alerts and reminders, and the electronic exchange of key information between clinicians to support care coordination. AHRQ was interested in advancing knowledge regarding the impact of health IT on outcomes in ambulatory settings and across high-risk transitions in care, in the use of health IT to support novel approaches to providing high-quality care, and in the development of strategies for health IT adoption in ambulatory settings. The projects were designed to demonstrate how quality improvement approaches using health IT improve health outcomes, patient safety, and both clinician- and patient-reported experiences, as well as ways to implement health IT without negatively affecting clinical workflows. Researchers were encouraged to focus on the following areas of interest:

- Providing patient-specific information, clinical knowledge, and decision support. This includes the provision of clinical recommendations and guidelines and clinical information about specific patients from registries and other sources to help clinicians and patients make decisions that improve outcomes.
- Supporting clinical workflow. This refers to the study of how the implementation of health IT systems can support effective and efficient clinical workflows, taking into account organizational factors in ambulatory settings.
- Coordinating care. This is defined as “the deliberate organization of patient care activities between two or more participants (including the patient) involved in a patient’s care to facilitate the appropriate delivery of health care services” (AHRQ, 2007).

- Understanding the impact of health IT on outcomes in ambulatory care settings. This includes research to better understand how clinician use of health IT can impact outcomes.

The IQHIT initiative also specified several funding preference areas including two priority areas: one for projects focused on medication management and a second for project sites serving vulnerable populations. There was also a funding preference for projects being conducted at or by practice-based research networks (PBRNs). A total of 24 projects were awarded under the initiative. The projects were carried out in a variety of ambulatory care settings, including primary care and specialty care offices and clinics. They addressed a range of relevant care topics, including several priority areas for health care quality improvement identified by the Institute of Medicine (IOM, 2003).

Many projects addressed more than one area of interest. As shown in Figure 1, the most commonly addressed area was providing information and decision support, addressed in 15 projects. Seven of the projects studied clinical workflow, while three focused on care coordination and two worked to develop understanding of the impact of health IT on outcomes.

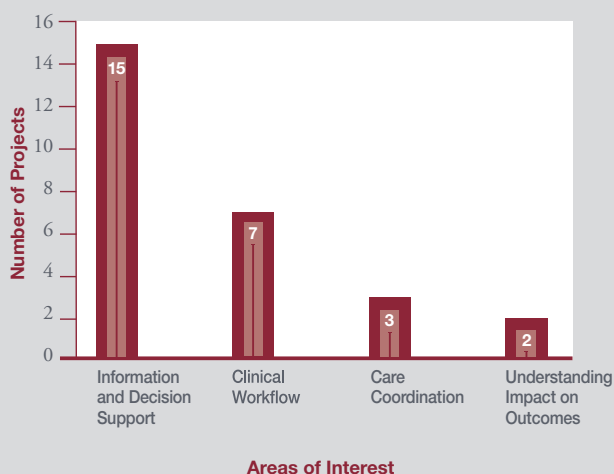
As shown in Figure 2, 18 projects were funded under the medication management preference area, eight under the vulnerable populations preference area, and six under the PBRN preference area. In addition, three other projects addressed areas related to medication management and another three focused on vulnerable populations.

Twenty-one of the 24 projects took place in primary care settings including pediatric practices. The other three projects took place in specialty care settings such as mental health clinics or dentist offices. Organizationally, the study settings included physician offices, urgent care centers, academic medical centers, and Community Health Centers, including Federally Qualified Health Centers.

As shown in Figure 3, the projects also addressed a range of priority areas for health care quality improvement identified by the Institute of Medicine (IOM, 2003). Each project addressed at least one Institute of Medicine (IOM) priority area.

**FIG.
1**

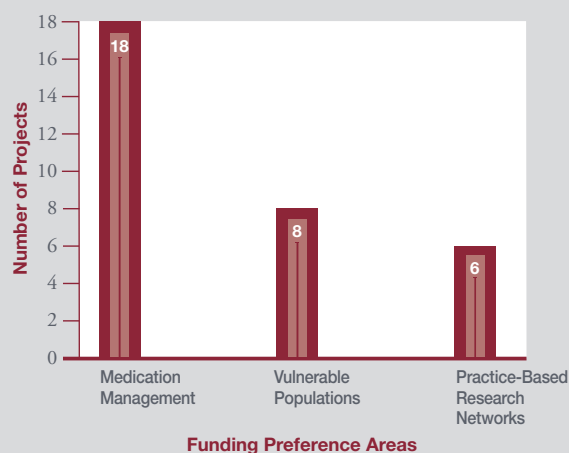
**Grant Initiative Areas
of Interest Addressed
Across Projects***



*Some projects addressed multiple IQHIT areas of interest.

**FIG.
2**

**Funding Preference Areas
Addressed Across
Projects***

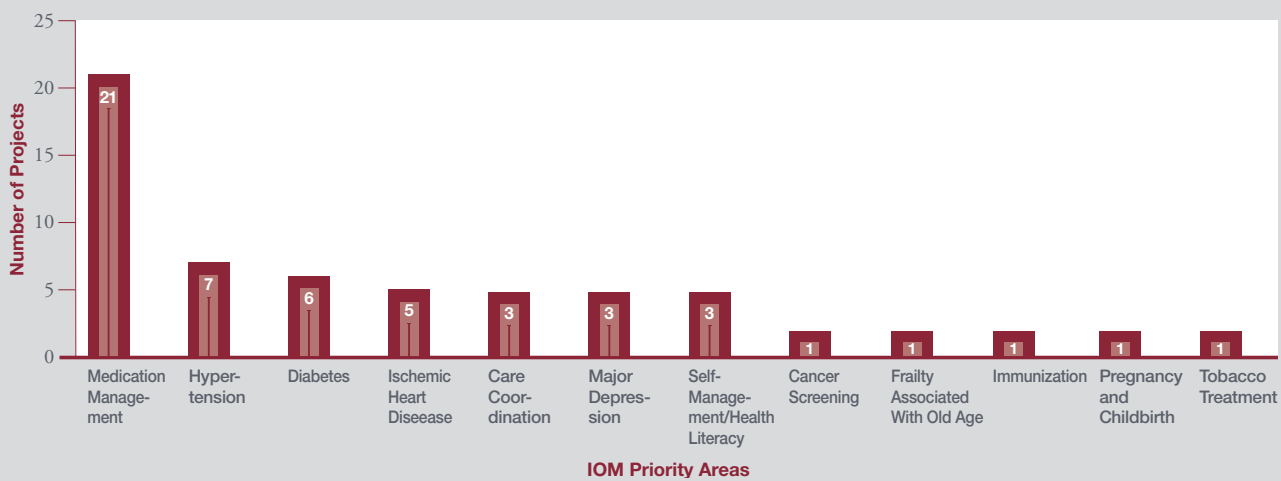


*Some projects addressed multiple funding preference areas.

FIG.

3

IOM Priority Areas Addressed Across Projects*



*Some projects addressed multiple priority areas.

Providing Patient-Specific Information, Clinical Knowledge, and Decision Support

Background

With the rapid growth in the publication of medical research and the development of evidence-based clinical practice guidelines, clinicians face a challenge in maintaining current knowledge of prevention and treatment recommendations on a wide range of topics relevant to care delivery in the ambulatory setting. Through the IQHIT initiative, AHRQ was interested in improving understanding of how health IT can bring together relevant information about evidence-based practices with important information about each patient's history, values, and preferences to guide and support clinical decisionmaking.

One approach that may be used to provide evidence-based information to clinicians at the point of care is the development of electronic clinical decision support (CDS) systems. CDS refers to the provision of clinical knowledge and patient-specific information to help clinicians and patients make decisions that enhance patient care (Osheroff et al., 2005). In most cases, CDS systems match patient-specific information (e.g., current medication regimen, a recent laboratory result) to an evidence-based clinical knowledge set (e.g., known drug interactions, clinical contraindications), and then generate customized assessments or recommendations that can be communicated to clinicians in a variety of ways (e.g., via alerts, reminders, or order sets). CDS has the potential to improve quality and reduce costs by increasing adherence to evidence-based practices (Berner, 2009).

Highlights From the Projects

Fifteen projects focused on providing information and decision support to increase the delivery of evidence-based care by addressing the barriers to the effective use of CDS systems and other types of health IT. Several developed and tested interventions that offered multiple forms of support such as providing clinical information at the time and place of the delivery of care, guideline-based alerts or recommendations, order sets, documentation templates, reminders, and retrospective feedback, including comparisons of performance to benchmark(s) and

lists of patients in need of services. Other projects created and assessed CDS systems that emphasized one or a few of these forms of support or focused on specific clinical processes. What follows are illustrative examples of both approaches.

Interventions That Offered Multiple Forms of Support Including CDS

Four projects were based on interventions that offered multiple forms of information, support, and feedback:

David Baker, M.D., M.P.H. (R18 HS 017163) tested the impact on outcomes of a CDS system to improve quality measurement and provide accurate point of care reminders and valid, actionable feedback to clinicians about their performance on selected quality measures. The first phase of the study included reminders about needed services, along with tools for documenting exceptions, such as refusals, inability to afford medications, contraindications, or adverse reactions to the recommended intervention. It also offered linked order sets that make it easy for physicians to order needed services at the point of care. For each physician the system also provided retrospective feedback in the form of quarterly performance reports and monthly lists of patients not prescribed essential medications. The second phase included a list of each patient's unmet quality measures to be reviewed by the physician prior to entering the examination room and decision support for patients who refused a recommended service by providing information about its benefits and an outreach call to urge reconsideration.

Christopher Forrest, M.D., Ph.D. (R18 HS 017042) developed and tested the impact on outcomes of an EHR-based CDS system combined with retrospective performance feedback on the quality of otitis media care. The system included a visual display of prior episodes and treatments, a structured data collection form, guideline-based recommendations, facilitated order entry, and individualized patient instructions. The system also provided information based on patient risk factors to help guide care. During the final 10 months

of the project, physicians received six retrospective performance reports. Two study team members hand-delivered the reports, answered clinician questions, and obtained their input on the value of the reports and the CDS system. Reports highlighted individual clinician performance compared to that of the entire practice, a network of practices, and the top-performing providers.

Based on findings from semistructured interviews with providers, **Helene Kopal, M.P.A., M.P.H.** (R18 HS 017167) evaluated the impact of implementing a CDS system to support providers in caring for patients with hypertension. The system included the following: alerts about elevated blood pressure; a template that shows the information that should be collected from the patient related to hypertension and facilitates documentation; medication adherence forms to prompt support staff to ask patients about taking their medications and to document their responses; a hypertension order set that allows ordering of tests and treatments through a single screen; and clinical reminders to screen for tobacco use and/or update indicated laboratory tests. The researchers also sent to providers retrospective feedback via quarterly reports that show individual physician performance on various hypertension-related metrics, such as the percentage of hypertensive patients with visits in the previous quarter who have their blood pressure under control.

David Mehr, M.D., M.S. (R18 HS 017035) created and evaluated the impact on outcomes of condition-specific dashboards, accessible from a section within a commercial electronic health record (EHR) system, that provided key information for managing the condition, along with data on whether quality metrics have been achieved for the individual patient. The dashboard also included easily accessible decision trees outlining standard care management for the condition and electronic templates for creating visit notes. The system also offered performance reports that gave practice-wide and physician-specific data, along with a list of individual patients with out-of-range values. Two report delivery approaches were evaluated: one that required the doctor to go into the electronic record to see the information and list of patients and one that was delivered automatically to each physician via email.

CDS to Support Specific Clinical Processes

Eleven projects developed and/or evaluated point of care support for specific clinical activities.

James Friction, D.D.S., M.S. (R18 HS 017270) offered decision support to dentists and their patients in order to improve the quality of dental care for patients with selected chronic conditions that may affect dental health and/or dental care. Dental offices received an alert within the electronic dental record whenever a patient with a chronic health condition that might affect the course of his/her dental care scheduled a dental appointment. When the dentist opened the electronic dental record, the alert displayed the patient's relevant chronic health conditions and included links to customized, condition-specific, evidence-based guidelines that specifically addressed the implications for the dental encounter. In addition, patients received a secure email within their personal health record (PHR) or a mailed letter, if not registered for the PHR, ahead of the visit that noted the possible presence of the relevant medical condition(s) and urged the patient to discuss the condition(s) with the dentist at the upcoming appointment and to remind the dentist to review the alert.

On June 21, 2011, AHRQ hosted a national Web conference on using health IT to improve chronic disease management featuring Dr. Friction and Ms. Kopal. Information about this national Web conference can be found at:

<http://healthit.ahrq.gov/chronicdiseasemgmttel-econference>

William Gardner, Ph.D. (R18 HS 017258) tested an interactive voice response (IVR) system that contacted families of children 6 to 17 years old a week after being prescribed an antidepressant to gather relevant clinical information about the medication. The system called the families 7 times over 3 months, with the goal of monitoring medication adherence, side effects, and patient symptoms. The system automatically notified triage staff on the

research team if any of the responses suggested a need for followup. After receiving the notification, clinic staff accessed a Web-based decision support application to review the information from the IVR call and access a module of suggested followup questions for each patient-reported concern. These modules guided the followup interview, which focused on gathering additional details about specific symptoms. After collecting the needed information, the triage person assessed the level of risk and developed a plan to address detected risks.



This story highlights the clinical decision support algorithm Dr. Kevin Johnson and his research team developed to improve pediatric medication dosing. For more information about this project (Grant No. R18 HS 17216), an overview is available: [PDF](#) (600 KB).



Kevin Johnson, M.D., M.S. (R18 HS 017216) developed and integrated a pediatric dose rounding algorithm into an e-prescribing system to address the complexity of calculating the correct medication dose for children and infants. The research team used a Delphi approach to generate expert consensus about each rounding recommendation based on balancing the goals of therapy with the potential for side effects on a medication-by-medication basis. The CDS algorithm also took into account the medication form along with patient age and weight. This algorithm eliminated the need for manual rounding to the nearest measurable and easily administered amount, which can lead to possible over or underdosing. Physicians remained largely unaware of the change, as it fit into existing work processes and did not require them to take additional steps.

Kate Lapane, Ph.D. (R18 HS 017150) developed algorithms for use in electronic prescribing (e-prescribing) systems to identify potential medication management issues for geriatric patients using medication history data from community pharmacies. The researchers focused on 15 drugs with safety or limited efficacy concerns for older adults. They developed alerts for a commercial e-prescribing system that were easy to view, relevant, concise, and consistent with other elements of the onscreen display. They then studied how clinicians used this information during patient encounters and the extent to which physicians overrode the alerts.

David Lobach, M.D., Ph.D., M.S. (R18 HS 017072) developed a CDS system that took information from multiple sites and used 40 rules within a network-wide knowledge base to identify instances of likely medication non-adherence for six chronic conditions (persistent asthma, diabetes, hypertension, congestive heart failure, ischemic heart disease, and stroke), taking into account medical indications and contra-indications. The system generated two types of medication adherence reports. The first alerted primary care providers to potential non-adherence a day in advance of a scheduled appointment, with the goal that non-adherence issues would be discussed during the patient visit. The second report alerted care managers about patients who did not appear to be adhering to their medication regimens and have not seen their primary care provider on a weekly basis, allowing the care manager to followup with the patients.

Jonathan Nebeker, M.D., M.S. (R18 HS 017186) used qualitative methods and simulation studies to collect and later evaluate information about providers' mental models regarding medication management, including behaviors and goals related to searching for information, generating hypotheses, and ordering. This information guided efforts to refine the user interface and logic behind the Integrated Medication Manager, an information management and decision support tool designed to support clinicians in medication management for chronic conditions.

Eleanor Schwarz, M.D., M.S. (R18 HS 017093) developed a CDS system to prevent medication-related birth defects based on findings from focus groups with physicians and patients. The system featured use of tablet computers immediately before an office visit to collect data from women of child-bearing age about their reproductive plans. The responses appeared on a paper report given to the primary care physician prior to seeing the patient. Because the tablet did not interface with the EHR, an office staff member had to enter the patient's answers manually into the EHR. In addition, physicians received one of two types of alerts whenever they attempted to order a drug that could potentially interfere with a fetus' development. One alert noted that "concern has been raised about the use of this medication during pregnancy." The second alert incorporated patients' responses to produce a more tailored warning with an accompanying link to a structured order set. The alerts were designed to require the physician's acknowledgment. While alerts were triggered for both new prescriptions and renewals, they appeared only for the first potentially dangerous medication ordered during each encounter so as to avoid alert fatigue.

Thomas Sequist, M.D., M.P.H. (R18 HS 017075) evaluated the impact on appropriate followup care of providing electronic alerts to primary care doctors seeing patients with a chief complaint of chest pain (identified by a trained medical assistant within the practices). For those identified, the system automatically calculated the Framingham Risk Score, extracting relevant information from the EHR, including age, sex, total and high-density lipoprotein (HDL) cholesterol, smoking status, systolic blood pressure, presence of antihypertensive therapy, and presence of diabetes. The substance of the alert varied based on the risk score. For those designated as low risk (a Framingham score of less than 10 percent), the alert recommended against a cardiac stress test if the physician attempted to order one (due to its low diagnostic yield). For patients with high risk (a score above 10 percent), the alert recommended an electrocardiogram and administration of aspirin and facilitated one-click ordering of each. The alerts appeared in both passive and active forms within each patient's electronic chart. The active alert displayed when clinicians accessed the

ordering module and required acknowledgement from physicians to proceed. The passive alert could be seen at any point during an encounter through the electronic visit summary screen.

Steven Simon, M.D., M.P.H. (R18 HS 017201) identified barriers to and facilitators of laboratory monitoring and timely followup on abnormal results, and then designed, implemented, and evaluated point of care alerts that address these barriers in a widely used, commercially available EHR system. The intervention included both real-time medication alerts, occurring at the time of e-prescribing during a visit, as well as alerts that can be viewed when the clinician opens the record at the beginning of each encounter where a patient is receiving one of the designated medications, but does not have the recommended laboratory tests ordered or results in the record.

On January 28, 2014, AHRQ hosted a national Web conference on using clinical decision support to improve medication management featuring the work of Drs. Fiks, Simon, and Trivedi's IQHIT grants. Information about this national Web conference can be found at:

<http://healthit.ahrq.gov/cdsmedmgmtteleconference>

Madhukar Trivedi, M.D. (R18 HS 017189) provided and tested the use of decision support integrated in an EHR to assist with assessment and treatment of depression (particularly medication management) at community mental health clinics. The system featured a user-friendly, interactive application. A rules engine translated guidelines-based clinical algorithms into specific rules based on information entered by the clinician. The system generated recommendations and also featured measurement tools to monitor symptoms, side effects, treatment adherence, and functional status; reminders about needed followup and preventive care; alerts about potential medication errors and adverse drug events (ADEs); and electronic documentation, record-keeping, and information-retrieval functions.

James Veline, M.B.A. (R18 HS 017149) evaluated the implementation of an e-prescribing system that allowed the physician to access the patient's medication history, select the appropriate medication and dosage using medication decision support, review any alerts and consider the potential adverse reactions,

and finalize the prescription including selecting the medication and preferred pharmacy. Providers could then monitor whether the prescription had been processed by the pharmacy and whether the patient obtained the medication as an indication of adherence to the medication regimen.

Medication Management

Health IT has the potential to improve medication management phases such as prescribing and ordering, order communication, dispensing, administration and monitoring as well as education and reconciliation through use of both clinician and patient-focused applications (McKibbon et al., 2011). Eighteen projects were funded under the medication management funding preference area. Three other projects also addressed areas related to medication management. All 21 researchers studied the use of health IT to improve aspects of medication management in their projects as described below:

- Evaluating the design and operation of e-prescribing systems, testing the impact of medication safety alerts and facilitating the transmission of medication orders to the pharmacy. (Investigators: **Dr. Carrow**, **Dr. Lapane**, and **Mr. Veline**)
- Evaluating improvements in the design of clinician interfaces for e-prescribing and medication management components of EHRs, using qualitative methods and simulation studies. (Investigators: **Drs. Fischer**, **Gorman**, and **Nebeker**)
- Supporting medication reconciliation through communication and sharing of information in ambulatory settings or during transitions from the hospital setting to ambulatory care. (Investigators: **Drs. Fox**, **Gurwitz**, **Kaushal**, **Ornstein**, **Pohl**, and **Singh**)
- Improving patient adherence to medication regimens by reporting instances of potential non-adherence to clinicians and facilitating interventions with those patients. (Investigators: **Drs. Baker**, **Gardner**, and **Lobach**)
- Enhancing the capabilities of EHRs to support appropriate prescribing, dosing, or monitoring of medications. (Investigators: **Drs. Forrest**, **Johnson**, **Schwarz**, **Sequist**, **Simon**, and **Trivedi**)

Supporting Clinical Workflow

Background

The implementation of health IT systems can have a major impact on clinical workflow, the sequence of physical and mental tasks performed by various people within and between work environments (Carayon, 2010). For health IT to be effective, it needs to be integrated into the multiple levels of workflow that exist in ambulatory health care settings in ways that support the cognitive work of clinicians, and are designed to fit the specific organizational context and patient population of a practice. Health IT systems may not achieve their full potential due to a lack of integration into clinical processes in a way that supports the workflow during a patient visit, within a clinic, and across organizations (e.g., between a clinic and community pharmacy) (Karsh, 2009). In contrast, health IT implementations that do take into account workflow may achieve gains in quality, safety, or efficiency as measured by guideline adherence, access to and sharing of clinical information, clinician and staff workload, and coordination among members of the care team.

Highlights From the Projects

Seven projects addressed workflow-related issues. These projects purposefully aimed to develop and implement health IT systems that integrated into workflow in order to improve quality. Project teams did this by taking into account clinician concerns about the potential to disrupt their normal workflow at the point of care and organizational factors associated with successful adoption and implementation of health IT systems. Specifically, researchers assessed current clinical workflows and/or organizational readiness for new health IT systems. In some cases, project teams also worked with practice sites to improve workflows to better take advantage of the benefits of health IT.

Grant Carrow, Ph.D. (R18 HS 017157) evaluated the safety, security, quality, and effectiveness of electronic transmission of prescriptions for federally controlled substances such as narcotics, stimulants, and sedatives in the ambulatory setting. The research team found a number of provider workflow issues

affecting the ability to use the e-prescribing system including provider identity authentication problems, inadvertent changes in operating system settings, and password changes. The researchers worked with the e-prescribing vendors to make refinements to the systems to address these issues.

On September 5, 2012, AHRQ hosted a national Web conference on e-prescribing and overcoming associated barriers featuring Dr. Carrow. Information about this national Web conference can be found at:

<http://healthit.ahrq.gov/erimplementationteleconference>



This video highlights the evaluation of an e-prescribing system for controlled substances by Dr. Grant

Carrow and his research team. Please access this video: [WMV](#) (60MB).

For more information about this project (Grant No. R18 HS 017157), an overview is available: [PDF](#) (600 KB).



Dr. Baker spent significant effort designing a reminder system that took into account current clinical workflow. The design made it easy for clinicians to see and react to reminders within the existing workflow while utilizing their current EHR system. The system featured nonintrusive reminders highlighted in yellow on the side of the screen, along with standardized ways to capture patient reasons (e.g., refusals) or medical reasons not to provide a recommended therapy. To further enhance the system's compatibility with current workflows, these exceptions automatically suppressed future reminders.

Dr. Lapane designed, in collaboration with software vendors, geriatric medication alerts embedded within the e-prescribing software that allowed physicians to see and react to the alerts as part of their usual workflow. For example, physicians did not have to click on any extra buttons to view the alerts. To integrate the alerts seamlessly, the development process involved several iterations based on feedback from system users.

Steven Ornstein, M.D. (R18 HS 017037) designed safety measures which were implemented and later evaluated in practice sites to encourage and support process redesign and quality improvement. Support consisted of two half-day site visits that included academic detailing, interactive discussions, review of measures and performance, dissemination of quality improvement strategies, and clinical decision support training. Practices also met once a year to share best practices. With support from the study team, participating practices selected and implemented a variety of workflow and process improvements, including enhanced medication reconciliation using the EHR, formalized refill and EHR-based dosing protocols, standing orders in the EHR for laboratory monitoring, patient activation and outreach strategies, and comparative performance reports on a set of medication safety measures such as inappropriate therapy, inappropriate dosing, drug-drug interactions, drug-disease interactions, and ADEs.

Joanne Pohl, Ph.D., A.N.P.-B.C., F.A.A.N., F.A.A.N.P. (R18 HS 017191) developed and used a partnership model to assist safety net practices, including Nurse-Managed Health Centers and Federally Qualified Health Centers, in using their EHRs. The partnership focused on implementing the EHRs without having a negative effect on organizational processes and provider workflow and productivity. To that end, practices received technical assistance over a period of several years, tailored to each site's needs. Preimplementation support generally included a readiness assessment, technical infrastructure preparation, organizational culture assessment and change management planning, workflow redesign, guided data preloading, software tailoring, integrated and upgraded billing, data exchange tools, and

assistance in negotiating and working with external partners. During implementation, support included shared hosting of the EHR, training and retraining of providers, formative evaluation, regular performance feedback, and corrective actions. After implementation, support included a leadership teleconference, annual partnership symposium, a centralized analytical data warehouse, and research capacity-building and summative evaluations.

Gurdev Singh, Ph.D. (R18 HS 017020) employed a systems engineering approach to improving medication safety. The study team worked with a group of four primary care practices, helping them to implement a Web-based Team Resource Management System built on an existing platform. The team focused on workflow issues, supporting each practice in identifying and prioritizing hazards, and then designing and implementing tailored interventions to improve medication safety.

Dr. Trivedi employed a three-stage process to develop a CDS system to assist with assessment and treatment of depression at community mental health clinics. The process was explicitly intended to make sure the system fit user needs and integrated into existing workflows. Stages included an end-user needs assessment; modification of the CDS system based on this assessment; and building and integrating the system interface into the existing EHR. As part of this effort, the study team realized that clinicians did not have time to administer the patient assessment and, consequently, designed the program so that nonphysician staff could do so. The team provided an array of support with implementation, including an intensive training program for clinical staff on the principles of guideline-based care and the role that the CDS system can play in facilitating such care. Clinicians had real-time support during a trial period, with information on problems encountered during this period used to inform system modifications. Clinicians and staff could also participate in biweekly teleconferences that offered additional training and provided an opportunity to give feedback on the system.

Coordinating Care

Background

Care coordination is the deliberate organization of patient care activities between two or more participants (including the patient) involved in a patient's care to facilitate the appropriate delivery of health care services. Organizing care involves the marshalling of personnel and other resources needed to carry out all required patient care activities and is often managed by the exchange of information among participants responsible for different aspects of care (AHRQ, 2007).

There are many inefficiencies and costs associated with lack of care coordination, including duplicate testing and procedures, lack of medication reconciliation, unnecessary emergency department visits, and preventable hospital admissions and readmissions. The IOM estimates that pursuing efforts that improve care coordination could result in a nationwide average annual savings of \$240 billion (IOM, 2010).

One of the most important competencies for care coordination is using health IT (Antonelli et al., 2009). Health IT can ensure that multiple providers have access to the right information at the right time across settings of care. It can also facilitate the development and oversight of care plans, and improve tracking and monitoring of the delivery of care. Care coordination has been prioritized under the Medicare and Medicaid EHR Incentive Program (CMS, 2012), reflecting the importance of health IT in general—and health information exchange (HIE) in particular—on the ability of clinicians to coordinate care.

Highlights From the Projects

Three researchers studied the use of health IT to support care coordination. Two of them focused on ensuring that primary care physicians receive timely, appropriate information after one of their patients has been discharged from the hospital. Highlights from these projects follow:

Paul Gorman, M.D. (R18 HS 017102) created a system that connected e-prescribing applications from multiple places to make sure that all providers and patients had an up-to-date medication list. The system allowed independent devices and applications to interact with each other, so that medication changes got automatically updated on the many devices and applications used by providers across care settings, allowing for improved communication and coordination through the use of shared medication management tools. Any user could view the changes and update information without the need for repetitive data entry.

On August 27, 2010, AHRQ hosted a national Web conference on health IT and underserved populations featuring Dr. Gorman. Information about this national Web conference can be found at:

<http://healthit.ahrq.gov/underservedpatientstele-conference>

Rainu Kaushal, M.D., M.P.H. (R18 HS 017029) used an HIE intervention to notify primary care providers about a patient being discharged from the hospital via an electronic alert sent to the provider's EHR inbox. The communication alerted the provider to the fact that a patient had been hospitalized, listed his or her discharge medications, and noted the time and date of a followup appointment with the provider. The goal was to reduce the risk of medication errors for patients transitioning between health care settings by improving care coordination and medication management. The intervention was tested via a randomized trial with one group receiving notification prior to the scheduled followup visit and a second group not receiving the alert. Both groups had access to the complete inpatient discharge summary via direct linkage to the outpatient EHR.

Jerry Gurwitz, M.D. (R18 HS 017203) developed a health IT system that automated key steps in the transition of care from the hospital to home by proactively notifying primary care providers following the discharge of an elderly patient from the hospital via the primary care practice's EHR. In addition to notifying them about the transition from hospital to home, the system provided information about new drugs added during the inpatient stay, warnings about drug-drug interactions, recommendations of dose changes and laboratory monitoring related to high-risk medications, and reminders to support staff to schedule a post-hospitalization office visit.

The system was designed to address the challenges of managing information and coordinating data sharing across multiple settings for older adults.

On August 18, 2011, AHRQ hosted a national Web conference on health IT and medication management for elderly patients featuring Dr. Lapane and Dr. Gurwitz. Information about this national Web conference can be found at:

<http://healthit.ahrq.gov/elderlymedmgmtteleconference>

Vulnerable Populations

The IQHIT initiative had a specific interest in project sites serving vulnerable populations.¹ These groups are at risk of not obtaining necessary medical services because of financial, social, geographical, or health-related barriers. Eight of the projects were funded under the vulnerable populations funding preference area. Three other projects also focused on vulnerable populations. All 11 project teams designed interventions to facilitate clinician use of health IT to improve the quality of care for a variety of vulnerable populations. Many of these projects included more than one vulnerable population in the study population. Vulnerable populations that the projects focused on include:

- Low-income patients without insurance or on Medicaid, many of whom are cared for by safety net providers. (Investigators: **Drs. Fischer, Fox, Gardner, Kaushal, Lobach, and Pohl**, and **Ms. Kopal**)
- Racial and ethnic minorities. (Investigators: **Drs. Fischer, Fox, Gardner, Kaushal, Lobach, and Trivedi**, and **Ms. Kopal**)
- Frail, elderly patients, including those served by safety net practices and/or living in assisted living or skilled nursing facilities. (Investigators: **Drs. Gurwitz and Singh**)
- Rural primary care practices. (Investigators: **Dr. Fox** and **Mr. Veline**)

¹ As noted in the funding opportunity announcement "ambulatory health care sites that serve vulnerable populations as those ambulatory health care entities that meet the IOM definition of safety net providers: those providers that organize and deliver a significant level of health care and other related services to the uninsured, Medicaid, and other vulnerable patients. Core safety net providers have an additional distinguishing characteristic in that they, either by legal mandate or explicitly adopted mission, maintain an "open door", offering access to services for patients regardless of their ability to pay (IOM 2002)." Vulnerable patients, as defined by the Institute of Medicine (2002), are those populations served by health care entities that fall outside the medical and economic mainstream, with little or no access to stable health care coverage. As stated in the funding opportunity announcement "these include the uninsured, low-income underinsured, Medicaid beneficiaries, patients with special health care needs, minority populations, immigrant populations and geographically or economically disadvantaged communities." AHRQ recognizes that many rural and inner-city communities are medically vulnerable as well.

Understanding the Impact on Outcomes

Background

Research has shown that the use of health IT can improve health care safety and quality in ambulatory settings. However, the use of health IT, such as EHRs or e-prescribing systems, does not ensure improvement in outcomes (Crosson et al. 2012, Lorenzi et al. 2009). Through the IQHIT initiative, AHRQ was interested in advancing understanding of the essential strategies for safe, successful, and productive health IT adoption in ambulatory settings, and the impact of health IT implementation on outcomes. This is of particular relevance since the majority of health care is delivered in ambulatory settings, and health IT implementation in these settings is expanding rapidly with the majority of physicians reporting that they have implemented an EHR (Jamoom et al. 2012).

Highlights From the Projects

Two of the projects aimed to improve understanding of the impact of health IT on outcomes as described below:

Michael Fischer, M.D., M.S. (R18 HS 017151) assessed physician attitudes about and behaviors with various features of e-prescribing systems, such as who is most likely to use such systems and why. Qualitative data were evaluated to identify viewpoints that shaped the use of e-prescribing systems. System designers may be able to use this information in the future to guide system development so that e-prescribing systems can be used more frequently and effectively.

On August 27, 2009, AHRQ hosted a national Web conference on e-prescribing and medication management featuring Dr. Carrow and Dr. Fischer. Information about this national Web conference can be found at:

<http://healthit.ahrq.gov/erxandmedmgmtteleconference>

Karen C. Fox, Ph.D. (R18 HS 017233) designed a study to determine whether utilization of health IT, specifically EHRs, in diabetes management would enhance the delivery of evidence based health care and improve health outcomes among low-income, mostly minority patients. The study compared results at two medical clinics that used EHRs with two clinics that did not use EHRs. The researchers extracted clinical data from medical records to assess the potential for EHRs to facilitate patient outcomes tracking, improve provider communication, reduce medical errors, and improve the quality of care.

Impact on Outcomes

This section summarizes the IQHIT project findings with respect to their impact on the quality of care as measured by several types of outcomes, including process outcomes,² intermediate outcomes,³ and health outcomes.⁴ Several projects showed a positive impact on process outcomes related to the delivery of evidence-based preventive and chronic care or the use of health IT by clinicians. In addition, several projects showed a positive impact on intermediate outcomes such as chronic disease control, clinician perceptions of health IT usefulness, and clinician satisfaction. Other projects demonstrated improvements in health outcomes such as adverse drug events and functional status. The findings from these projects are consistent with those identified in a recent systematic review of the effect of CDS systems, which found that both commercially and locally developed systems are effective at improving health care process measures related to prevention, ordering, and prescribing across diverse settings (Bright et al., 2012, Lobach et al., 2012).

Selected results from the IQHIT grantees are highlighted below.

Process Outcomes

The IQHIT projects showed that health IT interventions can have a positive impact on process outcomes, including but not limited to delivering appropriate evidence-based preventive and chronic care, including management of medication therapy; increasing clinician use of health IT for decision support and/or documentation purposes; and increasing effective communication among clinicians and between clinicians and patients. Illustrative examples appear beginning in the next column:

Delivering Evidence-Based Care

Dr. Baker found that the CDS system that combined point of care reminders about needed services with documentation tools, order sets, and retrospective feedback led to improvements in various process metrics related to chronic disease management. During the year after implementation, performance improved for 14 of 16 such measures, a much greater rate of improvement than during the year before implementation (when performance on only 8 of the 16 measures improved). In addition, the rate of improvement in the year after implementation significantly exceeded that in the year before for 9 measures, with only 2 showing a decline in the rate of improvement (and the rest showing roughly the same rate). Improvements were driven by more people receiving recommended services and more exceptions being documented. In phase 2, performance improved significantly for 8 of the 16 measures, all of which had also improved significantly during the first phase.

On April 28, 2011, AHRQ hosted a national Web conference on quality metrics and measurement featuring Dr. Baker. Information about this national Web conference can be found at:

<http://healthit.ahrq.gov/qualitymetricsandmeasurementteleconference>

² Process outcomes include actions taken by members of a clinical team or by patients in the course of care delivery or self-management.

³ Intermediate outcomes are indicators that are impacted by processes and that may precede or lead to health outcomes.

⁴ Health outcomes are symptoms and conditions that patients can feel or experience.

Dr. Forrest found that practices using the CDS system for treatment of otitis media were significantly more likely to adhere to guidelines than practices in the control group. Both CDS on its own and CDS combined with performance feedback increased the prescribing of high-dose amoxicillin for children with otitis media (as compared to a control group).

Ms. Kopal found that significant improvements occurred in all process measures except for one (medication intensification) after implementing the CDS component of the EHR. Improvements occurred in use of metabolic exercise tests (79.1 to 92.2 percent), electrocardiograms (6.6 to 52.2 percent), lipid panels (69.1 to 78.7 percent), measurement of body mass index (71.6 to 84.5 percent), and scheduling a followup appointment when elevated blood pressure is observed (86.9 to 88.9 percent).

Dr. Ornstein found that the practice-level retrospective feedback provided to participating practices led to statistically significant improvements in performance on three measures: avoidance of potentially inappropriate therapy (e.g., concurrent use of lithium and thiazide, avoidance of NSAID or Cox 2 inhibitors in patients with hypertension), avoidance of drug-disease interactions, and appropriate monitoring (e.g., of platelets in patients on anticoagulants and of glucose in patients on antipsychotic medications). Trends toward improvement were evident in other measures as well. However, high baseline avoidance rates (approximately 100 percent), the small number of eligible patients, and greater variability in performance across practices, may have contributed to a lack of statistically significant change in other measures.

Dr. Pohl found that clinician use of the EHR led to improvements in several processes associated with better patient safety and care, including entering all prescriptions into the office-based electronic prescribing system, monitoring patients sent to imaging facilities, identifying at-risk patients in the office, and providing assistance to patients in obtaining educational materials.

Increasing Clinician Use of Health IT

Dr. Fischer found that physicians became more active users of the e-prescribing system over time. Two years after implementation, between 60 and 70 percent of prescriptions were delivered to pharmacies electronically, with no paper involved. Some physicians initially converted e-prescriptions to faxes before sending them to the pharmacy, although use of this approach decreased significantly over time. Physicians using e-prescribing systems that were integrated into an EHR were significantly more likely to write prescriptions electronically most or all of the time, as compared to those using standalone e-prescribing systems.

Dr. Forrest found wide variations in physician adoption of the CDS system. Overall use was low. This was due, in part, to doctors' perception that they already knew how to treat otitis media and, hence, did not need additional support. Overall, 7 percent of doctors never used the tool, 75 percent used it for less than half of visits, and only 18 percent used it in more than half of visits. The retrospective performance feedback improved performance on one quality metric and promoted the use of the tool.

In the study of the transition from a locally developed to a commercial e-prescribing system, **Dr. Kaushal** found that the vast majority (more than 90 percent) of physicians used the new system to complete between 75 and 100 percent of their prescriptions.

Dr. Pohl found that use of the EHR varied significantly across participating safety net practices. For example, the percent of visits that included a clinical note in the EHR ranged from 39 to 97 percent across clinicians. Use of the diabetes template for structured data entry and notetaking during office visits also varied, with less use during diabetes visits in centers with younger patients and lower rates of diabetes. Use of the cardiovascular template for hypertensive patients was consistently low. Users found the form was inconvenient to use and the researchers plan to develop an alternative template. System use tended to be higher in Nurse-Managed Health Centers than in Federally Qualified Health Centers.

Increasing Effective Clinician Communication

Dr. Friction found that alerts for both dentists and patients significantly increased the rate at which providers referred to care guidelines (by 440 percent versus baseline for the provider alerts and by 221 percent for the patient alerts), while the control group experienced no change in provider behavior. The alerts triggered a response by 79 percent of dental providers, although response rates lagged during the last 3 months of the study, perhaps due to alert fatigue or the feeling among providers that they already understood the guidelines and did not need to access them any longer. The alerts also increased the frequency of correcting errors in the medical history based on pre- and postimplementation comparisons.

Dr. Schwarz found that the alerts increased documentation of family planning services when a potential teratogen (a drug that could harm a fetus) was prescribed (57 percent versus 28 percent), but not when such a drug was not prescribed. Alerts had a similar effect in both academic and community-based practices. Despite the interventions, women were not consistently counseled about potentially teratogenic prescriptions. The investigators believe there is a need to refine the approach, particularly to alert providers repeatedly when multiple, potentially dangerous prescriptions are initiated, so as to prevent the substitution of one potentially problematic drug with another.

Intermediate Outcomes

Controlling Chronic Diseases

Several projects had a positive impact on intermediate outcomes, such as blood pressure, glycated hemoglobin (HbA1c), or cholesterol levels. Illustrative examples include the following:

Dr. Fox tested the impact of EHR systems on the care and outcomes of diabetes patients in the Mississippi Delta. The study compared performance on various metrics in four clinics using similar models of diabetes care—two with EHRs and two without (each group included one rural and one urban location). The evaluation found mixed results, with EHR use showing a positive impact on low-density lipoprotein levels and mixed findings with respect to HbA1c and blood pressure.

Ms. Kopal found that average diastolic and systolic blood pressure fell among hypertensive patients after the CDS system was implemented. The proportion of hypertensive patients with their blood pressure under control at their last visit rose from 50.9 percent before implementation of the CDS system to 60.8 percent afterwards. Significant improvements also occurred in the proportion of hypertensive patients with diabetes who had their blood pressure under control (from 33.3 percent before implementation to 46.9 percent afterward). Controlling for other factors significantly associated with blood pressure control, patients were 1.5 times more likely to have their blood pressure under control after the intervention than before.

Dr. Pohl found that diabetes and hypertension outcomes showed improvement over time in the Nurse-Managed Health Centers, while scores remained steady in the comparison group. The improvements in diabetes scores were positively correlated with use of the diabetes management form.

Mr. Veline found that stand-alone electronic prescribing did not have an impact on hypertension control. However, after implementation of an EHR, the proportion of hypertensive patients with their blood pressure under control increased to levels higher than at baseline or during the period where only stand-alone electronic prescribing was offered.

Clinician Perceptions of Health IT Usefulness and Clinician Satisfaction

Several projects evaluated clinician perceptions of health IT, including their views on its usefulness to patient care and its impact on their satisfaction and productivity.

Dr. Fischer assessed physician attitudes about and behaviors with various features of e-prescribing systems. Physicians felt e-prescribing had a positive impact on medication safety—68 percent reported it made medication reconciliation easier and 57 percent reported it reduced calls from pharmacies about prescribing errors. The vast majority (88 percent) were satisfied with the e-prescribing system, with physicians that had integrated systems significantly more likely to be satisfied than those with a separate e-prescribing system.

Clinicians who used the pediatric dosing system developed by **Dr. Johnson** described it as potentially useful to assist with dosage rounding, but expressed preference for more flexibility in the recommendations for nonstandard medication schedules. Physicians in subspecialties that more frequently prescribe compounded medications found it useful that the system included these medications.

On July 23, 2010, AHRQ hosted a national Web conference on health IT and safety featuring Dr. Johnson. Information about this national Web conference can be found at:

<http://healthit.ahrq.gov/safetyteleconference>

In the study by **Ms. Kopal**, participating providers generally found many of the system components to be useful (although perceptions varied by provider and across components), including the alerts, order sets, templates, clinical reminders, performance feedback, and training.

In the study by **Dr. Mehr**, clinicians found the diabetes dashboard to be efficient and believed it improved the quality of care. In a study of 10 clinicians, the dashboard was found to save time for providers, as it took only 1.3 minutes to find all data elements with the dashboard, compared to 5.5 minutes without it. Physicians using the conventional method required 60 mouse clicks to gather needed information, compared to just 3 clicks with the dashboard. In an unexpected finding, 55 percent of physicians reported giving patients a printed copy of the dashboard at some visits. Almost two thirds of physicians

(64 percent) thought that the patient portal would increase their workload, but after implementation the vast majority (87 percent) believed it did not actually do so. However, the proportion believing the patient portal would improve care decreased after implementation, from 55 percent to 33 percent.

Dr. Pohl found that clinician perceptions about the potential benefits of the EHR to the practice were slightly negative during implementation, but improved over time in the Nurse-Managed Health Centers (except for one center with known implementation issues and challenges). In general, providers with high expectations prior to implementation tended to experience a slight decline in positive perceptions over time, while those with significant initial fears about the EHR found that these concerns were alleviated (particularly with respect to the impact on patient-provider relationships).

Health Outcomes

Two projects evaluated the impact of health IT on health outcomes, such as health status and adverse drug events:

Dr. Fox found that patients at one site with an EHR experienced a significant, positive change in self-reported health status between baseline and followup.

Dr. Singh found that participating practices experienced a decreasing trend in ADEs (from 25.8 to 18.3 per 100 patients per year), while the rate remained the same in a control group of non-participating practices. While the difference was not statistically significant, the finding suggests that the program may be effective in improving medication safety.

Conclusion

The IQHIT projects demonstrated significant progress toward addressing AHRQ goals of advancing understanding of how clinicians can use health IT to improve the quality of health care. They developed and tested a range of approaches for enhancing CDS, providing clinical information at the point of care, and improving care coordination, while also studying how to integrate health IT systems into clinical workflows. Several projects showed a positive impact on process outcomes related to the delivery of evidence-based preventive and chronic care, or the use of health IT by clinicians. In addition, several projects showed a positive impact on intermediate outcomes such as chronic disease control, clinician perceptions of health IT usefulness, and clinician satisfaction. Other projects demonstrated improvements in health outcomes such as adverse drug events and functional status. Their findings and insights can provide the foundation for advances in several of the priority areas in the National Quality Strategy,

especially making care safer, coordinating care, and promoting the use of effective care (HHS, 2012), as the IQHIT researchers showed how clinician use of health IT can improve outcomes in all of these areas. The IQHIT projects continue to build the evidence base for clinician use of health IT as they are consistent with the findings of a recent systematic review of earlier research on the effects of clinician use of CDS systems (Bright et al., 2012, Lobach et al., 2012).

The findings and lessons from the IQHIT initiative can inform researchers and implementers interested in using health IT to help clinicians improve the quality of health care. The continued rapid pace of technological change and the continued interest in the use of health IT to improve health and health care delivery make the results of this body of research timely and relevant to ongoing efforts to expand the use of health IT to improve the quality of health care.

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Appendix: Improving Quality Through Clinician Use of Health IT Projects

	Principal Investigator (PI)*	Institution	Project Title**	IQHIT Initiative Areas of Interest Addressed
	Baker, David	Northwestern University	Using Precision Performance Measurement to Conduct Focused Quality Improvement	Decision Support Clinical Workflow
 	Carrow, Grant	Massachusetts State Department of Public Health	Enabling Electronic Prescribing and Enhanced Management of Medications	Clinical Workflow
	Fischer, Michael	Brigham and Women's Hospital	Impact of Office-Based E-Prescribing on Prescribing Processes and Outcomes	Understanding Impact on Outcomes
	Forrest, Christopher	Children's Hospital of Philadelphia	Improving Otitis Media Care with EHR-based Clinical Decision Support and Feedback	Decision Support
	Fox, Karen	Delta Health Alliance, Inc.	The BLUES Project: Improving Diabetes Outcomes in Mississippi with Health IT	Understanding Impact on Outcomes
	Friction, James	HealthPartners Research Foundation	eHealth Records to Improve Dental Care for Patients with Chronic Illness	Decision Support
	Gardner, William	Children's Research Institute	Pharmaceutical Safety Tracking (PhaST): Managing Medication for Patient Safety	Decision Support
	Gorman, Paul	Oregon Health & Science University	RxSafe: Shared Medication Management and Decision Support for Rural Clinicians	Care Coordination
	Gurwitz, Jerry	University of Massachusetts Medical School Worcester	Improving Posthospital Medication Management of Older Adults with HIT	Care Coordination
	Johnson, Kevin	Vanderbilt University	STEPStools: Developing Web Services for Safe Pediatric Dosing	Decision Support
	Kaushal, Rainu	Weill Medical College of Cornell University	Electronic Prescribing and Electronic Transmission of Discharge Medication Lists	Care Coordination
	Kopal, Helene	Primary Care Development Corporation	Evaluation of a Computerized Clinical Decision Support System and EHR-Linked Registry to Improve Management of Hypertension in Community-Based Medical Centers	Decision Support
	Lapane, Kate	Brown University	Optimizing Medication History Value in Clinical Encounters with Elderly Patients	Decision Support Clinical Workflow
	Lobach, David	Duke University	Improving Quality Through Decision Support of Evidence-Based Pharmacotherapy	Decision Support
	Mehr, David	University of Missouri-Columbia	Using HIT to Improve Ambulatory Chronic Disease Care	Decision Support

* To access video or written success stories, please select the icons next to the "Principal Investigator" column.

** To access descriptions of each project, please select the respective project title.

Appendix: Improving Quality Through Clinician Use of Health IT Projects

Principal Investigator (PI)*	Institution	Project Title**	IQHIT Initiative Areas of Interest Addressed
Nebeker, Jonathan	Western Institute for Biomedical Research	Veterans Administration Integrated Medication Manager	Decision Support
Ornstein, Steven	Medical University of South Carolina	Medication Safety in Primary Care Practice – Translating Research into Practice	Clinical Workflow
Pohl, Joanne	Michigan Public Health Institute	A Partnership for Clinician EHR Use and Quality of Care	Clinical Workflow
Schwarz, Eleanor	University of Pittsburgh at Pittsburgh	Harnessing Health IT to Prevent Medication-Induced Birth Defects	Decision Support
Sequist, Thomas	Brigham and Women's Hospital	Can Risk Score Alerts Improve Office Care for Chest Pain?	Decision Support
Simon, Steven	Harvard Pilgrim Health Care, Inc.	Improving Laboratory Monitoring in Community Practices: A Randomized Trial	Decision Support
Singh, Gurdev	State University of New York at Buffalo	A Systems Engineering Approach: Improving Medication Safety with Clinician Use of Health IT	Clinical Workflow
Trivedi, Madhukar	University of Texas Southwestern Medical Center at Dallas	Using Information Technology to Provide Measurement Based Care for Chronic Illness	Decision Support Clinical Workflow
Veline, James	Avera Health	Electronic Prescribing and Decision Support to Improve Rural Primary Care Quality	Decision Support

* To access video or written success stories, please select the icons next to the "Principal Investigator" column.

** To access descriptions of each project, please select the respective project title.