

The AHRQ Health IT Value Grant Initiative: A Programmatic Review of the Peer-Reviewed Literature

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Introduction

In late 2003, the Agency for Healthcare Research and Quality (AHRQ) published four requests for applications (RFAs) (HS-04-010, HS-04-011, HS-04-012, HS-05-013) that comprised the AHRQ-sponsored Transforming Healthcare Quality through Information Technology (THQIT) initiative. This report addresses the initial peer-reviewed published findings of the Demonstrating the Value of Health Information Technology RFA (HS-04-012), known as the THQIT Value RFA.¹ The primary purpose of this RFA was to fund projects that would increase the knowledge and understanding of the value of health information technology (health IT) to improve patient safety and quality of care. At the time of the publication of these RFAs, AHRQ's long-term Health IT Portfolio outcome goals included:

- Supporting the successful deployment of hospital health IT systems that reduce medical errors and improve patient safety.
- Increasing the identification and reporting of medical errors and adverse events.
- Decreasing the number of actual errors and adverse events.
- Increasing the number of hospitals utilizing electronic health records (EHRs) and computerized provider order entry (CPOE) with clinical decision support (CDS) systems.
- Increasing the number of nonhospital providers utilizing EHRs and CPOE with CDS.¹

Despite several decades of use of health IT and associated promise for improvements in quality and safety in health care, adoption of health IT has been slow.²⁻³ Determining the value of its use required demonstration of successful implementation and operation. The THQIT Value RFA was a sentinel effort by AHRQ and one of the first attempts by the Federal Government to sponsor health IT implementation and use projects in rural hospitals and community health care settings that evaluate the real value of health IT across a variety of these settings with a diverse group of key stakeholders.

The timing of the release of the THQIT Value RFA and the others comprising the Transforming Healthcare Quality through Information Technology program was particularly opportune because of the growing interest in and funding for health IT on the part of both the Federal Government and the private sector. For the purpose of that solicitation, value was defined as “clinical, organizational, financial, or other benefits derived from the adoption, utilization, and diffusion of HIT less the costs of achieving these benefits” (page 2).¹ However, the projects did not need to show a return-on-investment but rather to demonstrate that improvements in care delivery and other processes and outcomes could be made with the anticipated realization of cost savings.

In September 2004, 24 THQIT Value grants were awarded. These grants had funding for 3 years, with potential for no-cost extensions. Four of the grants concluded in fall 2007 after 3 years; 16 grants exercised their option for a fourth no-cost extension year and concluded in fall 2008; and in fall 2009, the 4 remaining grants, which had experienced challenges early on, concluded.

These grants involved a variety of health IT applications, disparate health care settings, and diverse groups of key stakeholders. In addition, a number involved research focusing on rural and small community hospitals or community health care settings, priority settings for AHRQ. The THQIT RFA included specific requirements and goals for these grants. The investigators were "expected to produce evidence, tools, models, and other information or resources that can be utilized by public and private entities to improve the safety, quality, effectiveness and efficiency of health care" (page 12).¹ Further, they were expected to pursue dissemination strategies including, but not limited to, presentations at annual meetings and/or publishing in peer-reviewed journals.

This report presents an initial programmatic review of the peer-reviewed publications of the THQIT Value grantees. While the projects are not homogeneous in the traditional sense, they offer a broad view of the outcomes of the solicitation and present the results of health IT evaluation, not just from the large academic medical centers that have been leaders in the field but from a variety of small and large organizations in urban and rural areas. This review provides a snapshot of the value of health IT as it is being implemented, discussing the opportunities for and impediments to the realization of Transforming Healthcare Quality through Information Technology.

The THQIT Value grantees produced a number of scholarly works derived from their research. These included abstracts of presentations at scientific meetings, slide sets from presentations, posters presented at scientific meetings with their concomitant abstracts, publications in the lay press, and peer-reviewed publications in scientific literature. Only the 47 peer-reviewed publications meeting the criteria described below are reviewed in this report. Other scholarly works such as the presentations and posters, reviewed through their artifacts (slide sets and abstracts), reiterated the findings of their published research. These additional works are categorized in Appendix A.

Nine THQIT Value grants did not have eligible peer-reviewed reports for consideration at the time this report was prepared. Of those, three contributed to the knowledge base through presentations at national meetings. Some THQIT projects have only recently ended and peer-reviewed publications are forthcoming, while others disseminated findings through non-peer-reviewed literature. More information about all of the THQIT Value grants can be found at the AHRQ-Funded Projects section of the National Resource Center for Health Information Technology (NRC) Web site (www.healthIT.ahrq.gov).

Methods

To identify the articles for this review, two separate Medline searches were conducted on the grants' Principal Investigator(s), looking for citations of any publications for which they had author attribution. All articles published or referenced through 2008 were included. The

bibliographic results of these searches were then compared with the publications listed in the grantee annual summary reports for concurrence. Full-text articles were obtained for all potential bibliographic citations. Several of the principal investigators with longstanding research in related content areas had numerous articles on the topics of their grants. To limit the scope of the review, only those articles that specifically cited their THQIT Value grant were included. In several instances, the MEDLINE® searches identified articles that were not initially listed by AHRQ's NRC Web site or mentioned in final annual reports for the grants. Subsequently, the NRC Web site was updated. It was also discovered that some of the articles listed in the grantee-generated project-specific summaries were relevant to the THQIT Value grant yet actually reflected work supported by other grants. These publications were excluded from this programmatic review.

Analysis of the original set of potential peer-reviewed articles yielded 47 for inclusion in this review. Further analysis determined that nine articles focused on relevant contextual issues related to health IT implementation and measuring improvement in quality of health care. These can be informative for future health IT implementation and evaluation although health IT was not included in the research or commentary. The article topics ranged from identification of factors contributing to medical errors to an analysis of the financial environment for rural hospitals. All nine of these articles provided a foundation for the implementation and evaluation of health IT.

The 38 articles that specifically addressed the intent of the RFA were evaluated to determine the relationship of the research to four major areas of value:

- Clinical, including medical errors, effectiveness, and CDS systems.
- Organizational, including access to health care and coordination of care.
- Financial, including costs and productivity.
- Other, including patient satisfaction, transparency, readiness for health IT adoption, and so on, and the five long-term goals of the THQIT initiative listed in the Introduction.

All of the articles, including those not specifically addressing health IT, were further examined to determine whether AHRQ's priority populations (low-income persons, minorities, women, children, elderly persons, and persons with special health needs such as chronically ill and disabled persons) were addressed by the research. In addition, the articles were classified based on the health care settings in which the research took place or the focus of the research. The settings of interest included emergency departments (EDs), inpatient hospitals, ambulatory care facilities, long-term care facilities, and other areas such as pharmacies and educational settings.

Categorical Findings

Table 1 contains the breakdown of the categories in which the articles addressed the outcome goals and focus priorities of the THQIT Value Grants. The categories were loosely grouped into clinical, organizational, financial, and other goals and priorities. The 47 articles were reviewed and categorized based on these groupings. All of the articles addressed at least one of the goals and priorities. Nine addressed two goals and priorities and one addressed three.

The majority of the research centered on clinical applications, including health IT's impact on medical errors, effectiveness, and CDS. Twenty-four of the 47 articles examined the effects of health IT on clinical care. Fourteen articles grouped in the organizational category looked at how health IT could improve both access and coordination of care, and nine articles looked at the financial aspects of health IT. Twelve articles, grouped under the "other" category, dealt with patient satisfaction, environmental scans to assess readiness for adoption of health IT, adoption of health IT as a critical component of health care quality, and quality and patient safety considerations.

The priority populations were not segmented in most of the articles since most health IT applications, when implemented, serve all patient populations. However, a few of the grants did focus on specific populations. Three articles addressed issues involving children, two involving women, three involving the elderly, and five involving chronically ill persons.

Health care settings were classified as hospital ED, inpatient facilities, ambulatory care, long-term care, and other areas such as pharmacy or education. Six articles looked at multiple health care settings, primarily the ED and inpatient facilities or inpatient facilities and ambulatory care. Two articles focused solely on the ED, 19 on inpatient facilities, 8 on ambulatory care, 7 on long-term care, and 5 on other settings, primarily pharmacy based.

AHRQ is also interested in rural adoption and use of health IT, so within each of the health care settings, the articles were analyzed as to whether their research focused on rural and/or urban populations. Four articles dealt with both urban and rural populations; over half of the articles focused on urban populations.

Table 1. Outcome goals and focus priorities for value grants

Articles and Related Grants			Specific Goals and Focus Priorities of the THQIT VALUE RFA (HS-04-012)			
Article Reference Number and Primary Author	Principal Investigator	AHRQ Grant Number	Clinical Medical Errors Effectiveness CDSS	Organizational Access Coordination	Financial Costs Productivity	Other Patient Satisfaction Transparency Environment
4 Nance	Graumlich, J	HS015084		X		
5 Keenan	Keenan, G.	HS015054		X		
6 Schnipper	Middleton, B	HS015169	X			
7 Lobach	Lobach, D.	HS015057	X			
8 Lobach	Lobach, D.	HS015057	X			
9 Linder	Middleton, B	HS015169	X			
10 Chi	Ward, M.	HS015009		X		X
11 El-Kareh	Gandhi T	HS015226	X		X	
12 Linder	Middleton, B	HS015169	X			
13 Judge	Gurwitz, J	HS015430	X			
14 Graumlich	Graumlich, F	HS015084		X		
15 Tang	Thomas, E	HS015234		X		
16 Jaana	Ward, M	HS015009				X
17 Ward	Ward, M	HS015009				X
18 Li	Ward, M	HS015009				X
19 Bahensky	Ward, M	HS015009			X	
20 Fischer	Weissman, J	HS015175				X
21 Schadow	Schadow, G	HS015377	X			
22 Schadow	Schadow, G	HS015377	X			
23 Mantena	Schadow, G	HS015377	X			
24 Burton	Schadow, G	HS015377				X
25 Field	Gurwitz, J	HS015430	X		X	
26 Subbramanian	Gurwitz, J	HS015430			X	

Table 1. Outcome goals and focus priorities for value grants (continued)

27 Graumlich	Graumlich, F	HS015084				X
28 Bahensky	Ward, M	HS015009		X	X	X
29 Keenan	Keenan, G	HS015054		X		
30 Rochon	Gurwitz, J	HS015430	X			
31 Levine SR	McConnochie, K	HS015165	X	X		
32 McConnochie	McConnochie, K	HS015165	X	X		
33 Graumlich	Graumlich, J	HS015084		X		
34 Love	Cebul, R	HS015123	X			
35 Eden	Guise, J-M	HS015430	X			
36 Wolfstadt	Gurwitz, J	HS015430	X			
37 Porter	Porter, S.	HS014947	X			
38 Linder	Middleton, B	HS015169	X		X	
39 Fischer	Weissman, J.	HS015175			X	
40 Gurwitz	Gurwitz, J.	HS015430	X			
41 Field	Gurwitz, J	HS015430	X			
42 Wakefield	Ward, M	HS015009		X		X
43 Ward	Ward, M	HS015009		X		X
44 Li	Ward, M	HS015009		X		X
45 Li	Ward, M	HS015009		X		X
46 Roberts	Ward, M	HS015009	X			
47 James	Ward, M	HS015009	X			
48 Friedman	Friedman, A	HS015234	X			
49 Thomson	Gurwitz, J	HS015430			X	
50 Clabaugh	Ward, M	HS015009			X	
TOTALS			24	14	9	12

Table 2 shows a cumulative analysis of the settings of the research, including urban and rural designations.

Table 2. Distribution of health care settings for THQIT Value Grantees

Setting	Urban-Rural Designation			
	Urban	Rural	Not specified	Total
Emergency department	5	1	2	8
Inpatient facilities	11	8	8	27
Ambulatory care facilities	8	0	2	10
Long-term care facilities	7	0	0	7
Other, including pharmacy and academia	1	0	4	5
Total	32	9	16	57

Content Findings

The characterization of these articles in terms of the outcome goals and focus priorities of the funding opportunity announcement were quite informative for determining the extent to which the articles addressed the issues. However, a more logical grouping, one more consistent with health IT nomenclature and framework, was used to organize the findings. For this programmatic review, the content of the THQIT Value grant articles was divided into four logical categories of article focus (description, system evaluation, outcomes research, and contextual issues) and further subdivided into focus on health IT or focus on quality/patient safety, predicated in part on MESH (Medical Subject Headings) descriptors.

The description group contained seven articles that described health IT systems or applications addressing specific problems. Of these articles, two looked at continuity of care through discharge and handoffs, three dealt with decision support as it related to disease or health management, and two described non-disease-related applications of decision support.

Twenty-one articles addressed the evaluation of health IT systems or applications. This group of articles offers the results of research that can be used to inform future implementation projects and looks at issues ranging from provider use of EHRs to e-prescribing to costs and benefits of system implementation. Specifically, five articles dealt with provider issues, four articles with issues affecting hospitals and health care systems, five with medication and e-prescribing issues, two with cost issues, and one with the patient perspective. In addition, there were four commentaries.

Articles in the outcomes research group responded specifically to the concept of the RFA, the value of health IT. Instead of evaluating the process of implementation or even adoption and use, all were concerned with either quality of care or patient safety. These 10 articles were further subdivided into two categories, quality of care (4 articles) and patient safety and e-prescribing (6 articles).

The nine remaining articles fall under the broad category of contextual issues for health IT and are further subdivided into quality and patient safety factors (four articles), quality factors impacting specific conditions (two articles), and measurement factors (three articles). Although these articles did not specifically mention health IT, they offered principles that could later be applied to the adoption and evaluation of EHRs, CDS, and other forms of health IT. Following is a summary review of the articles of the THQIT Value grantees and their relationship to the basic tenets of the RFA for Demonstrating the Value of Health Information Technology:

Descriptions of Health IT Systems or Applications To Address Specific Problems

The THQIT Value projects are best characterized as independent research projects. This group of articles represents case studies of health IT systems designed and implemented to respond to a number of issues that arise in health care. Among the issues included are challenges related to patient-centered coordination, continuity of care, and decision support for both disease management and administrative activities.

Discharges/Handoffs

Continuity of care is critical in hospitals as health care providers change shifts and during the transition from hospital-based providers to ambulatory care when a patient is discharged from a hospital. Two articles describe software systems designed to mitigate problems caused by the movement of patients between providers.^{4,5} Both articles emphasize that the communication of complete and accurate information is essential to protect against the types of errors that could result in patient harm.

The first article focuses on the discharge summaries that follow patients released from a hospital. Standardized forms result in more accurate diagnoses and medication dispensing and administration while reducing provider time for inputting the information. As a result, primary care providers are able to understand the full extent of both the diagnosis and hospital-based treatment of their patients.

The second article deals with inpatient handoffs between nursing shifts. This project confirmed the first article's findings that a uniform approach using standardized terminology to disseminate information is critical to care improvement. By putting the handoffs in context using the conceptual model of collective mind and heedful interrelating, the grantee's customized system was associated with greater reliability in information control, leading to better patient outcomes.

Decision Support—Disease/Health Management

Three articles describe systems that used decision support for the management of chronic disease.⁶⁻⁸ Patient safety and quality of care are frequently at risk when management of complex illnesses requires coordination among a number of providers. All the articles note that success of

the implementation depends on a number of principles, including an understanding of workflow, enough time for data entry and use, and participation by the end users in the design and development of the system.

While decision support within a single health care system is critical, two of the articles⁶⁻⁷ note that population health management has become possible through a recently developed HL7 Decision Support Standard. These articles describe a system designed to use this standard with information gleaned from regional health information organizations (RHIOs), which are critical in chronic disease management when patients may be referred to providers outside of a single health system.

Decision Support—Miscellaneous

The two final articles in the health IT category discuss usability testing of decision support for acute problems and building a decision support referral system.⁹⁻¹⁰

The first reports on an evaluation model, using standardized patients who simulate a set of symptoms or problems, which is designed to demonstrate the use of decision support tools in a patient environment. The outcomes of this research demonstrate not only the efficacy of the evaluation model but also how such an approach can provide an interactive means to foster development of a health IT system.

The second article describes the development of another decision support tool in context of the management of the referral process given specific patient specific information, such as the travel distance, to assist in the choice of specialists.

Summary

All of the articles in the health IT category, although diverse in system content, note that timely and accurate information is key to successful implementation and that the user or recipient of the information must be a significant part of the design to ensure optimum outcomes.

Evaluation of Health IT Systems or Applications

The articles in the evaluation category are broadly grouped into issues that are discovered during the implementation and use of a system. Iterative evaluation, evaluation focused on process, is essential to successful implementation of health IT. The following group of articles offers insights for future health IT adoption.

Provider Issues

One of the most critical aspects of effective use of health IT is understanding the needs and workflows of health care providers. The principal means to evaluate not only the current acceptance of health IT but also its continued use is to seek provider input on the functionality of

the system and the benefits and inhibitors to continued use. Five articles specifically seek to identify and understand the issues impacting health IT use.¹¹⁻¹⁵

One article discusses attitudes of primary care physicians. While primary care physicians found that, over time, EHRs improved the quality of care, particularly in the followup of test results, they also felt that use of EHRs, especially during patient visits, significantly inhibits patient-provider interactions.¹¹ Another article expands on this and finds that use of EHRs with the patient present inhibits eye contact (and therefore communication), resulting in a perception of being rude.¹² Both articles report that EHR use has added time to an overburdened schedule.

In long-term care facilities, CPOE with CDS in the form of alerts has the ability to reduce medication errors. However, routine use of the system is needed for it to be effective. Although one study notes a reduction in errors, it identifies the increase in time required to do the order entry as the major negative factor in successful use of the health IT. This leads the authors to note that effective use requires a systems-level approach to implementation.¹³

One of the benefits of health IT mentioned in several of the articles is cross-provider communication. This is particularly true when providers are from different health care environments. Communication between a specialist and a primary care provider is tenuous at best. However, one article reports that computerized discharge summaries were well received by primary care providers because of timeliness and completeness/adequacy of the discharge plan. Validating the suggestion of the article by Judge, the success was predicated on the involvement of the primary care providers during the design phase of the system.¹⁴

The final article in this set looks at workflow in the intensive care unit to determine whether remote monitoring is feasible. An environment that requires distributed work, a usable clinical information system, and provider collaboration are all major factors affecting quality and efficiency. A systems approach takes into account the contextual relationship of components within a given system and with other systems with which they interface. This approach to the implementation of health IT can result in successful use of remote monitoring.¹⁵

When reviewing articles dealing with provider issues, a few major principles become readily apparent. Health IT can facilitate provider communication and improve quality of care. However, implementation requires a systems approach and providers must be involved early in the process to define usability and address workflow issues, particularly as they impact time requirements.

Hospital and Health Care System Issues

Four articles address the issues faced by hospitals in adopting health IT, with two articles looking specifically at issues faced in the rural health care environment. The first article, in assessing the technological sophistication of hospitals, looks at four global areas: structural capacity, including the number of employees and beds; financial capacity, including available resources and private-pay mix; leadership capacity, focusing on the IT department; and knowledge-sharing capacity, including technical knowledge resources and health care system membership.¹⁶

While financial resources have been cited as one of the major impediments to health IT adoption in rural areas, the authors of the first article find that IT leadership and knowledge resources are consistently identified as more critical factors than limitations on financial resources. In three corresponding articles, the basic tenets of adoption hold true in comparing rural and urban hospitals, investigating multihospital systems, and looking at the role of IT in critical-access hospitals.¹⁷⁻¹⁹ The critical success factors identified include finding a means to mitigate limited financial and health IT resources by a commitment to adoption, a willingness to take a systems approach to planning and implementation, and a culture that embraces health IT as a means to quality improvement.

Medication/E-Prescribing Issues

E-prescribing has been offered as one means to reduce medication errors. In looking at the uptake in e-prescribing supported by large insurers among clinicians, the authors find that while there has been a steady increase in use, adoption is not complete among all providers, with younger physicians and pediatricians having the greatest likelihood of use.²⁰

One of the factors critical to the success of any health IT system is the usefulness of the information presented. Standards are essential to ensuring that the information is accurate and corresponds to the medical problem. Two articles look at the HL7/FDA Structured Product Labeling standard and conclude that it offers a viable approach to medication linkage to EHRs and that it improves the detection of drug intolerance, thus enabling a new decision support model.²¹⁻²²

Decision support in other e-prescribing applications was explored in two additional articles, looking specifically at **S**ystematized **N**omenclature of **M**edicine -- **C**linical **T**erms (SNOMED) problem lists of the Veterans Health Administration and Kaiser Permanente. The ability to map clinical concepts to medications is critical to understanding and facilitating enhanced EHR applications; this research demonstrates that extant terminologies can be used within an EHR framework to provide decision support for drug indications.²³⁻²⁴

This set of articles further underscores the importance of standards and interoperability in health IT. However they also suggest a roadmap for future research in e-prescribing that ranges from the identification of factors that influence adoption of currently available CPOE and e-prescribing systems to the need for integration of disparate systems using both messaging standards and accepted ontologies.

Cost Issues

Cost has been cited as one of the most important hindrances to adoption of health IT. While many of the THQIT Value grant articles mention cost, two look specifically at the costs associated with developing and implementing a health IT system and the benefits accrued. Many cost models tend to focus only on the actual cost of hardware and software; some factor in the health IT personnel costs. However, these articles look additionally at the provider time required to develop decision support within a commercially available CPOE system, concluding that even

extant systems require a huge commitment and willingness to invest clinical time and effort into making the system viable.²⁵⁻²⁶

In looking at the benefit side, the authors make the point that not all key stakeholders share in the benefits equally, but the overarching outcome should be better patient safety and a reduction in medication errors. As noted in other articles, factors that ensure successful adoption include a systems approach to implementation through active involvement of the entire health care team and an understanding of workflow issues and mitigation of those that cause significant problems, such as requiring the use of multiple systems. The article also addresses the need for incentives from third-party payers and others and the recognition that frequently the benefits are accrued long after the expenditures have been made.

Patient Issues

While most of the THQIT Value grants involved the implementation of health IT and research in order to determine the impact of the intervention on the health care enterprise, one article looks at the direct impact on the patient. Structured interviews were used to determine patients' perceptions of their readiness for discharge in terms of understanding their medications. Continuity of care is essential to positive long-term outcomes. While it is necessary to deliver accurate and timely discharge summaries to primary care providers, it is equally important to ensure that patients have enough information to be compliant with their medication regimen.²⁷

The results of the patient telephone interviews indicate that patients feel well informed about the medication therapies and reflect a high level of preparedness for discharge from their inpatient stay. This one article underscores the need for patient-centeredness when developing and implementing health IT, something frequently forgotten in the quest to improve quality and patient safety through the actions of the providers and the health care system.

Commentaries

Four of the THQIT Value grants stimulated the authorship of commentaries addressing critical issues in the health IT debate.²⁸⁻³¹ One takes a broad look at the adoption of EHRs, particularly in rural areas, as a component of the national health IT agenda. While the authors reiterate common themes of technical issues—such as the need for reliability, usability, standardization, integration, and security—they raise two issues potentially problematic for all these issues: national policy that impacts local implementations, such as the role of the Certification Commission for Healthcare Information Technology (CCHIT), and the burgeoning privacy rules and legislation.²⁸

Another article focuses exclusively on terminology standards and how ontologies can impact nursing practice, while a third commentary takes a hard look at prescribing practices in long-term care, where adverse events are frequently caused by the multiple medications, age, and health status of patients in these facilities.²⁹⁻³⁰ The last commentary focuses on the use of telemedicine in an acute medical event—specifically, stroke. It demonstrates that rural patients can benefit from telephone assistance provided by a designated stroke center with improved

survival and long-term outcomes. While the potential for telehealth has existed for almost a half century, it is only now achieving its place as a viable form of health IT.³¹

While the commentaries each support particular positions in regard to health IT, they offer success factors that need to be considered when implementing any system. Local financial, organizational, and technological issues must be addressed. Health IT cannot be implemented in a vacuum. Privacy and security, as well as certification of health IT systems, need to be critical parts of overall planning. Standardization of terminologies and technology applications are key to ensuring quality of care. Nontraditional technologies must be considered to ensure that all have equal access to health care regardless of location.

Value of Health IT

Ten articles address the overarching intent of the RFA, to demonstrate the value of health IT in terms of health care outcomes in diverse settings with multiple information systems. Four address quality of care and six address patient safety. Five address priority populations, including women, children, the elderly, and those with chronic disease. Six of the articles use different classes of technology as the basis for the interventions. One article is a systematic review, while the other nine use various accepted research methods ranging from randomized controlled trials to pre-post data analysis.

Quality of Care

Of the four articles addressing quality of care,³²⁻³⁵ all show positive or neutral outcomes directly or indirectly related to patient care. Because some questions have been raised about the safety of health IT, even finding neutral outcomes related to quality of care can be considered positive for the purposes of value, assuming that the health IT addresses a system issue with positive results.

The first article addresses telemedicine used to provide care for acute pediatric illness at schools and child care sites. Among children with similar conditions, those children for whom telemedicine service was available to parents had 22.2-percent fewer in-person ED visits than others. The results of this research have major implications for the use of telehealth to mitigate the escalating costs of health care, frequently centered in the misuse of EDs.³²

Lack of communication between specialists and referring providers has been shown to be associated with poor outcomes for patients upon release from the hospital. A randomized controlled trial of patients discharged from an academic medical center hospital was conducted, with the control group having primary care providers receiving usual care dissemination in the form of a handwritten discharge summary and the experimental group having providers who received a structured discharge summary produced by a computerized system. A review of 6-month followup data found that there was no statistical difference between the control group of patients and the experimental group in terms of patient readmission, ED visits, and postdischarge adverse events, although the actual rates of readmission and ED visits were slightly less among the experimental group.³³

The third article in this set looks at the use of an EHR to facilitate the design and deployment of a cluster-randomized trial to identify evidence in support of care and outcomes for diabetes, one of the most complex and insidious diseases. The results of this research can lead to improvement in care based on evidence of the efficacy of certain therapies while identifying the potential for adverse events. This research focuses on the ability of the health IT system to create appropriate data sets that will in turn lead to improved health care outcomes. It demonstrates that a major strength of health IT systems is the secondary use of patient data to improve health care outcomes.³⁴

Just as the quality of information communication among providers is critically important, having information on patients that is complete and accurate can mean the difference between good outcomes and poor ones. This is particularly true in labor and delivery, where past medical conditions, current infections, or history of pregnancy can mean the difference between a successful delivery with a healthy baby or major complications. In the final article in this group, the authors, using a pre-post intervention study, demonstrate that the data contained in the EHR are far more complete and accurate than the data contained in paper records.³⁵

These studies have not only shown that health IT can provide value to the health care system but can also result in the positive outcomes for the individual patient. Quality of care can be enhanced with the effective implementation and adoption of appropriate forms of health IT.

Patient Safety and E-Prescribing

The other group of THQIT Value-based health IT articles falls into the category of patient safety and e-prescribing. Five of the six articles look at the impact of decision support and its influence on adverse drug events.³⁶⁻⁴⁰ Another article addresses the impact of a patient/communication-centered health IT application on medication errors.⁴¹

The first article is included in this group because of its focus on the value of a specific type of health IT. It is a systematic review of research involving CPOE with CDS and its impact on the rates of adverse drug events. The authors identified 543 articles as potential candidates for the review, but only 10 met the criteria for inclusion. Of those, half of the articles report research showing statistical significance in the reduction of adverse drug events using CPOE with CDS. Four other articles demonstrate significant, but nonstatistical, reductions in such events. The authors of the systematic review find no research on this topic done in long-term care facilities and provide a rationale for the next two studies discussed.³⁶

For one article, the investigators used a cluster-randomized controlled trial to determine whether CPOE with decision support in the form of alerts has an impact on both adverse drug events and preventable events in long-term care facilities among patients on 29 residential care units. Finding no statistical difference between the control units and the intervention units, they hypothesize that the lack of statistical significance was due in part to the burden of the alerts, the limited scope of the alerts, and the lack of integration with clinical and laboratory information.³⁷

Another article by the same group of investigators looks at CDS for medication orders specifically for long-term care patients with renal insufficiency. In this randomized trial, alerts are the intervention. The authors find that the final drug orders in the intervention group were appropriate significantly more often than in the control group. Specifically, improved frequency of administration, lower rates of inappropriate medications, and more attention to the results of serum creatinine tests are found among the intervention group, demonstrating that specificity in contextual alerts can have an impact on patient safety.³⁸

Communication is key to both patient safety and health care quality. While provider-to-provider communication is a frequent positive result of health IT implementations, patient-to-provider communication can also be markedly improved. However, in this quasi-experimental study, a patient-centered technology requiring parents to enter their child's symptoms and medication history and resulting in a printout with recommendations to the clinicians did not result in fewer medication errors in the ED. The authors note that the system, while patient-centered, is not integrated with other information technology, and such integration could have had a greater impact on the outcome.³⁹

In a pilot study, another group of investigators looks at antibiotic prescribing practices for acute respiratory infections by clinicians using a computerized form for decision support. Although it was a pilot study, of patients with an antibiotic-appropriate diagnosis, 100 percent were treated appropriately. Clinicians also prescribed antibiotics to a small number of patients with antibiotic-inappropriate diagnoses. The investigators also looked at the time required to use the form, a rate-limiting step to adoption. Most of the clinicians felt the form takes less time or is time neutral when compared to usual practice, demonstrating that the automated form can improve workflow and reduce inappropriate prescribing.⁴⁰

The last article in this group looks at the impact of electronic prescribing on use and cost. The health IT intervention was an e-prescribing system tied to formulary decision support. The study used pre-post data analysis of insurance company records. The findings indicated a cost-savings potential as a result of the health IT implemented, since there was a decrease in prescriptions written for the more expensive medications and an increase in prescriptions written for the less expensive medications. If the use of e-prescribing systems with formulary decision support consistently shows this result, it has significant potential implications for lowering health care costs, not just for third-party and government payers but also for patients, who frequently are responsible for the cost differences.⁴¹

This group of articles has mixed results but demonstrates that appropriate use of health IT can impact patient safety and reduce medical errors, even lowering costs in a variety of settings and across urban and rural areas. More research needs to be done, and more systems need to be developed and integrated to improve workflow. But there is a growing body of evidence that health IT can achieve some of the aims of quality and safety, not just in large academic health centers but across the Nation and across populations.

Contextual Issues for Health IT

The successful implementation of any health IT system is important, but only a first step. The ultimate goal should be defined by the impact on the quality of care and patient safety within the health care environment. The THQIT Value grantees understood this. While implementation process issues were frequently evaluated, changes in quality of care and patient safety outcomes were considered paramount. Several of the publications focused on the general issues of quality and patient safety as a foundation to establish the rationale for the use of health IT.

Quality and Patient Safety

Authors of one publication develop a 10-Rights Framework for patient care with the need for information permeating all of the rights to insure health care quality and patient safety.⁴² In three statewide studies, the same authors study hospitals to determine the adoption of safe practices, as well as factors affecting the decision of rural hospitals to convert to Critical Access Hospital status and the resultant effect on patient safety.⁴³⁻⁴⁵ While adoption of safe practices is considered to be of high importance, targeted progress toward adoption of information strategies was low, particularly in rural areas, and serves as a proxy for determining readiness for health IT adoption in nonurban areas.

Quality Factors Impacting Specific Health Conditions

Two articles look at the capture and use of existing data to improve quality of care.⁴⁶⁻⁴⁷ The first reports the use of two publicly available tools, AHRQ's Patient Safety Indicators (PSIs) and Inpatient Quality Indicators (IQIs), combined with discharge data, to compare regional and local factors involved with maternal birth-related trauma. The second article describes a method to use existing data to look at risk factors for myocardial infarction mortality in rural and urban hospitals. These articles offer a new look at problems and potential solutions, including health IT adoption, for rural health care quality.

Measurement Factors

Three articles address a classification of medication errors, a quantification of time required by nurses to administer medication, and the cost of illness in the Nation.⁴⁸⁻⁵⁰

The first article provides a framework for identification of the locus of medical errors involving ambulatory, chronically ill patients, an AHRQ priority; the second article looks at nursing time in medication administration in long-term care facilities, another AHRQ priority. The data provided by both studies could be used to support health IT implementation to mitigate issues of medication error identification and time of medication administration potentially resulting in medical error.

The final article in this group is a systematic review of the cost-of-illness (COI) methodologies used to determine direct costs. While a number of articles were identified in this study, the varying approaches did not give a solid approach to understanding the costs to the

system. These findings suggest that being able to use the COI as a component of determining the value of health IT based on the evaluation of the cost of care before and after implementation of the technology is problematic.

Summary

This group of nine articles addressing contextual issues, while not specifically looking at health IT, offers insight into significant areas that could impact health IT adoption and its potential to influence quality of care, patient safety, and even health care costs.

Conclusion

AHRQ's Transforming Healthcare Quality through Information Technology initiative has resulted in planning, implementation, and evaluation of health IT projects across a variety of settings meeting the needs of many types of health care providers and patient populations. To date, the THQIT Value grants have resulted in a number of research projects designed to inform future health IT development and adoption and to provide a basis for linking health IT with health care quality and patient safety.

In the peer-reviewed publications analyzed in this programmatic review, common themes emerged as success factors for implementation. Among these are the need for early involvement of all key stakeholders in setting goals for health IT implementation and the design process. Workflow needs to be considered, both before and during implementation, not just for a single provider group but for the entire health care team. Concomitantly, it is critical that all needed information be integrated and available on a single workstation to reduce time needed to access different systems. This can be facilitated by adoption of standards. Costs, both capital and long term, need to be weighed against benefits of the project, understanding that the benefits might not be immediately realized or accrued equally among those involved with the health IT system.

In looking at quality of care and patient safety, the need for effective communication is the one factor that seems to permeate virtually all of the articles. Communication can be facilitated by or inhibited by health IT systems, and it is critical to understand the advantages and disadvantages of adopting these systems from this perspective. Other changes that resulted from health IT adoption included access to more accurate and complete information, use of decision support utilities to ensure appropriate management, and a mitigation of the differences in care frequently caused by distance and other factors.

Because many of the THQIT Value grants address issues faced by both rural and priority populations, much of the research provides value for future implementations in identifying factors that may assist or inhibit success. Some of the targeted projects present unique aspects of looking at health IT as a means to address problems and offer ideas for future development.

The AHRQ Transforming Healthcare Quality through Information Technology initiative has taken one of the first steps toward evaluating approaches related to the successful adoption of health IT in diverse health care settings.

Limitations of this initial programmatic review of the THQIT Value grants have been noted, including that fact that only 15 of the 24 THQIT Value grantees has at least one eligible peer-reviewed publication. However, this group of THQIT Value grantees has contributed to the understanding of factors associated with successful implementation of health IT to improve health care quality and patient safety. The current activities of the disparate and numerous stakeholders involved in health IT implementation and meaningful use of health IT will be able to capitalize on these published research findings of the THQIT Value grantees.

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Appendix A. List of Value Grantees (in Alphabetical Order by Principal Investigator)

Grant	PI	TITLE
1 R01 HS 15274	CARAYON, PASCALE	CPOE Implementation in ICU's
1 R01 HS 15123	CEBUL, RANDALL D	Trial of Decision Support to Improve Diabetes Outcomes
1 R01 HS 15002	FERRIS, TIMOTHY G	Improving Pediatric Safety and Quality with Health Care
1 R01 HS 15038	FRIEDMAN, AMY L	Web Based Renal Transplant Patient Medication Education
1 R01 HS 15226	GANDHI, TEJAL K	Improving Safety and Quality with Outpatient Order Entry
1 R01 HS 14891	GAZELLE, G SCOTT	Value of Imaging-Related Information Technology
1 R01 HS 15459	GOLDBERG, LEE RICHARD	Home HF Care Comparing Patient-Driven Technology Models
1 R01 HS 15084	GRAUMLICH, JAMES F	Value of Technology to Transfer Discharge Information
1 R01 HS 15321	GUISE, JEANNE-MARIE M	Improving Safety and Quality with Integrated Technology
1 R01 HS 15430	GURWITZ, JERRY H	Health Information Technology in the Nursing Home
1 R01 HS 15280	HSU, JOHN	Impact of Health Information Technology on Clinical Care
1 R01 HS 15188	HUCK, JACQUELINE	A Rural HIT Cooperative to Promote Clinical Improvement
1 R01 HS 15054	KEENAN, GAIL M	HIT Support for Safe Nursing Care
1 R01 HS 15164	KOSS, RICHARD	Toward An Optimal Patient Safety Information System
1 R01 HS 15057	LOBACH, DAVID F	Showing Health Information Value in a Community Network
1 R01 HS 15165	MCCONNOCHIE, KENNETH M	Valuation of Primary Care-Integrated Telehealth

1 R01 HS 15169	MIDDLETON, BLACKFORD	Evaluating Smart Forms and Quality Dashboards in an EHR
1 R01 HS 15409	OVERHAGE, JOSEPH MARCUS	Value of Health Information Exchange in Ambulatory Care
1 R01 HS 14947	PORTER, STEPHEN C	ParentLink: Better and Safer Emergency Care for Children
1 R01 HS 15413	SAMORE, MATTHEW H	Rural Trial of Clinic Order Entry with Decision Support
1 R01 HS 15377	SCHADOW, GUNTHER	Value of New Drug Labeling Knowledge for e-Prescribing
1 R01 HS 15234	THOMAS, ERIC J	Measuring the Value of Remote Intensive Care Unit (ICU) Monitoring
1 R01 HS 15009	WARD, MARCIA M	Health Information Technology Value in Rural Hospitals
1 R01 HS 15175	WEISSMAN, JOEL S.	E-Prescribing Impact on Patient Safety, Use, and Cost