Grant Final Report

Grant ID: 1R01HS015009

Health Information Technology Value in Rural Hospitals

Inclusive Dates: 09/01/04 – 08/31/08

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Abstract

Purpose: The primary objective of this grant was to increase our knowledge and understanding of the patient safety issues and value of health information technology (HIT) in rural hospitals.

Scope: The project focused primarily on Iowa's 89 rural hospitals.

Methods: We created advisory groups of rural hospital staff, interviewed rural hospital key informants, conducted surveys on patient safety issues and HIT capacity, analyzed Iowa and national hospital discharge data to identify patient safety performance issues, and reviewed and compiled the literature on HIT.

Results: A number of rurally-relevant patient safety issues were identified along with several key factors related to poor performance. Analyses characterized the use of HIT in rural hospital, barriers to such use, and approaches to enhancing HIT, especially in Critical Access Hospitals (CAH). We formed the Iowa CAH HIT Interest Group and created decision-making toolkits to provide HIT solutions that were appropriate for CAHs and assist CAHs in making HIT investment decisions. During the timeframe of the grant, 17 peer-reviewed papers were published, 27 presentations were made, and toolkits were constructed and evaluated.

Key Words: health information technology (HIT), rural hospitals, Critical Access Hospitals (CAH), patient safety

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Final Report

Purpose

The overall goal of this grant was to increase our knowledge and understanding of the value of health information technology (HIT) in rural hospitals, ultimately to help rural hospitals make more informed HIT investment decisions that enhance patient safety and healthcare quality. To accomplish this goal, the project had four primary objectives. First, the project documented the patient safety and healthcare quality challenges unique to rural hospitals. Second, the project explored the current HIT capacity in rural hospitals, the potential use of HIT by rural hospitals to address their patient safety and healthcare quality issues, and the barriers faced by rural hospitals in adopting HIT. Third, the project identified costs of commonly implemented HIT systems in rural hospitals, measured value derived from HIT in rural hospitals, and identified which HIT solutions for enhancing patient safety and healthcare quality have the greatest applicability in rural hospitals. Fourth, the project created decision-making HIT toolkits to provide Critical Access Hospitals (CAH) with information they need to make more informed HIT investment decisions. The toolkits were developed with input and evaluation by the Iowa CAH HIT Interest Group.

To accomplish these four objectives, the project had the following specific aims:

Specific Aim 1. Characterize patient safety and healthcare quality issues in rural hospitals

Specific Aim 2. Characterize the HIT capacity and barriers of rural hospitals

Specific Aim 3. Identify which HIT capacities are most strongly related to patient safety and healthcare quality issues in rural hospitals

Specific Aim 4. Identify the cost of HIT in rural hospitals

Specific Aim 5. Develop toolkits to help rural hospitals make informed HIT investments

Scope

Enormous progress has been made in HIT applications. Today, hospital-based IT includes enterprise-wide clinical information sharing and point-of-care decision support in such applications as electronic medical records (EMR) and computerized physician order entry (CPOE). However, very few rural hospitals have these HIT capacities because of expense, limited in-house HIT expertise, and the fact that many HIT applications are designed with larger hospitals in mind. Currently, there are significant gaps in our knowledge of the value of HIT, especially in rural areas. Rural hospitals greatly need assistance and tools to aid in their HIT decision-making.

In addition to substantive differences between urban and rural hospitals in HIT capacity, there are also potential differences in the patient safety and healthcare quality issues they face. There has been little systematic study of whether the key quality and patient safety issues facing rural hospitals are the same as their urban counterparts. Neither the relative complexity nor specific types of patient care quality and safety issues faced by rural hospitals has been addressed.

There is a wide range of potential quality and patient safety HIT applications in which hospitals might invest including: EMR, personal health records, e-mail communication, clinical alerts and reminders, CPOE, computerized decision support systems (CDSS), hand-held computers, electronic information resources technology, electronic monitoring systems, as well as telehealth consultative and diagnostic services. While many of these are routinely being considered for large hospitals, rural hospitals frequently lack the financial, technological, and human resources to make such investments. Unanswered is the extent to which quality and patient safety in rural hospitals might be improved by investment in these HIT options. There has been little systematic study of whether existing HIT capacities, or investment in the commonly endorsed HIT solutions, readily lend themselves to quality enhancement in rural hospitals. For a rural hospital with limited resources there needs to be a better understanding of the fit between actual quality and safety problems and the HIT solutions being invested in.

This grant was designed to answer many of these questions. To do so, an in-depth study of Iowa's rural hospitals was conducted. Iowa had 116 community hospitals (and split one hospital into two) during the project. Of these, 20 hospitals are classified by Medicare as urban hospitals (located in a Metropolitan Statistical Area or MSA), 7 are classified as rural referral centers ("rural" hospitals that have operating characteristics similar to a typical urban hospital), and 89 are classified as rural (not located in an MSA). Of these 89 rural hospitals, 80 are classified as Critical Access Hospitals (CAH). Iowa's rural hospitals were the focus of much of this project.

Methods

The project made use of multiple methods for data collection and analyses. These included: 1) literature reviews; 2) primary data collection using surveys, key-informant interviews, and workgroup discussions; 3) secondary data analysis of hospital discharge datasets and HIT databases; and 4) economic analysis. The methods using these approaches as they were applied in each Specific Aim are described below.

Specific Aim 1: Characterize Patient Safety and Healthcare Quality Issues in Rural Hospitals

A major phase of this project was focused on identifying and prioritizing the quality of care and patient safety issues facing rural hospitals. A number of approaches were used to gather input on the patient safety issues that were most rurally relevant. First, we worked with several existing groups, including the Iowa CAH Data Workgroup, to identify patient safety issues in CAHs. We attended their meetings and surveyed participants using existing measures. Second, quality directors at rural hospitals were interviewed to identify patient safety issues at their facilities. Third, we worked with the Iowa Healthcare Collaborative to survey all Iowa hospitals

on their priority and progress on the NQF 30 Safe Practices. We conducted the survey in 2004 and repeated it in 2007. Fourth, the SID for Iowa and the AHRQ Patient Safety Indicator (IQI) and Inpatient Quality Indicator (IQI) software were used to examine measures where Iowa hospitals under-performed compared to national norms. We also worked with the Iowa Healthcare Collaborative to analyze PSIs and IQIs for all Iowa hospitals and publicly report their performance. And fifth, the AHRQ H-CUP Nationwide Inpatient Sample (NIS) and the AHRQ PSIs were analyzed to examine patient safety and quality performance in hospitals in a national sample and identify factors related to PSI performance.

Specific Aim 2: Characterize the HIT Capacity and Barriers of Rural Hospitals

A second major phase of this project was focused on characterizing the state of HIT implementation in rural hospital and factors related to barriers and challenges that Iowa rural hospitals faced. A number of methods helped us to understand where Iowa rural hospitals were in terms of HIT implementation and why. First, an extensive review of the literature was conducted. Second, we created the Iowa CAH HIT Interest Group - a group of IT leaders from Critical Access Hospitals who advised us throughout the project. Third, a survey of HIT in Iowa hospitals that we had conducted in 2002 was analyzed. Fourth, we designed and conducted an updated HIT survey of Iowa hospitals in 2005. Fifth, based on the results of the new survey, follow-up interviews were conducted with rural hospitals that indicated that they had EMR operational or being installed. Sixth, we conducted case studies of EMR implementation in two Iowa CAHs that were listed as "Most Wired" hospitals in *H&HN Most Wired* magazine. And seventh, the HIMSS Analytics survey conducted on a large national sample was analyzed to examine factors related to EMR implementation.

Specific Aim 3: Identify Which HIT Capacities Are Most Strongly Related to Patient Safety and Healthcare Quality Issues in Rural Hospitals

The purpose of the third Specific Aim was to identify which HIT capacities and practices are most strongly related to patient safety and enhanced healthcare quality in rural hospitals. To carry out this Specific Aim, a review of the literature was conducted to see if there were reports of efforts that would be useful for rural hospitals. We interviewed HIT directors at urban hospitals to see if their approaches might be helpful to rural hospitals. Analyses were conducted to examine whether HIT implementation status was related to performance on patient safety and quality metrics. And project team efforts were focused on generating matrixes of possible relationships.

Specific Aim 4: Identify the Cost of HIT in Rural Hospitals

One of the barriers to investment in HIT capacity in rural hospitals is a lack of information about the likely costs and benefits of investment. To attempt to address this gap, we used findings from the previous Specific Aims, gathered new cost information from participating hospitals, and verified cost estimates with members of our workgroups. To carry out this

Specific Aim, an extensive literature search was completed to try to identify existing cost estimates for acquiring and maintaining HIT in hospitals. A list was compiled of all available vendors for HIT applications that were popular in rural hospitals. We met with staff of ICE Technologies, the consulting firm in Iowa that is used by many Iowa rural hospitals as they consider expanding their HIT applications. We conducted interviews with rural hospitals in Iowa that indicated that they had EMR systems. The project team assembled the estimates and produced tables of average estimated costs plus information on the range of estimates for each candidate HIT capacity or function. The project team assembled initial estimates of cost for EMR and CPOE in terms of the short-term costs (implementation phase) and longer-term costs (maintenance phase). These estimates were shared with the Iowa CAH HIT Interest Group.

Specific Aim 5: Develop Toolkits to Help Rural Hospitals Make Informed HIT Decisions

The final Specific Aim of the project was to use the information from the previous Specific Aims to develop toolkits that would help rural hospitals to make informed decisions pertaining to HIT investments. To complete this Specific Aim, a review was conducted of the print and electronic literature on potential HIT solutions for safety/quality problems and on HIT toolkit development. In addition, we examined experiences at Iowa rural hospitals that were further along in terms of HIT implementation to see what had worked for them and what benefits they were realizing. A web-based toolkit with multiple components was developed. We showcased the toolkit at meetings of the Iowa CAH HIT Interest Group and solicited the groups' feedback on the usefulness of the content and usability of each component of the web-based format. A cost calculator toolkit was also created to assist hospitals in calculating the costs of implementing an EMR system in their facility.

Results

The grant activities involved an array of approaches to meet the Specific Aims. Described here are the principal findings from the major project activities.

Specific Aim 1: Characterize Patient Safety and Healthcare Quality Issues in Rural Hospitals

A major aim of this project was focused on identifying and prioritizing the actual quality of care and patient safety issues facing rural hospitals. Described below are findings from various methodological approaches to better understand these issues.

Input of Rural Hospital Quality Workgroup to Identify Patient Safety Issues in CAHs. The Iowa Hospital Association and the Iowa Department of Public Health – Iowa Medicare Rural Hospital Flexibility Program (FLEX) created a workgroup of representatives from CAHs to focus on identifying "rurally relevant" patient safety and quality issues. They are referred to as the Iowa CAH Data Workgroup and one of their primary goals was to identify patient safety

indicators that CAHs were willing and able to measure so that they could benchmark within the group of 80 Iowa CAHs. We met with this group a number of times and they provided input to this Specific Aim. We asked participants in the Iowa CAH Data Workgroup to rate the 52 patient safety issues identified by a panel of national experts as having high priority for application in rural hospitals (Coburn et al., 2004). Surprisingly, the representatives from the Iowa CAHs rated many of the items as having relatively low priority in their CAH. Thus, their ratings did not agree with those of the national experts. The "rurally relevant" patient safety and quality issues that the Iowa CAH Data Workgroup identified as having the highest priority for Iowa CAHs were: medication errors, falls, appropriate assessment and treatment of chest pain presenting in the emergency department, and births for those hospitals that have obstetric services. They established a web-based reporting tool for all CAHs to report on these five topics on a quarterly basis for benchmarking within Iowa's CAHs. The Iowa CAHs have been participating in this voluntary reporting and benchmarking effort since 2005.

Interviews of Rural Hospital Quality Directors to Identify Patient Safety Issues. Tanya Uden-Holman led the effort to conduct interviews with the directors of quality at 9 rural hospitals. We queried them on what type of internal quality-related studies they had conducted in their hospitals during the previous two years. Several patterns emerged. First, a number of their quality initiatives were closely related to JCAHO safety measures, even among hospitals that were not JCAHO accredited. Second, other initiatives were closely related to the efforts being advanced by the Iowa Healthcare Collaborative – namely NQF 30 Safe Practices and the Institute for Healthcare Improvement 100,000 Lives Campaign. And third, a small group of initiatives were related to LEAN interventions that they had identified for hospital-specific areas for improvement. A remarkable pattern was the degree to which the hospitals agreed on the issues they were addressing. The common vector appeared to be the Iowa Healthcare Collaborative, which has done extensive education over the past several years to get all hospitals in Iowa onboard with a shared strategy for promoting patient safety.

Survey of NQF 30 Safe Practices in Iowa Hospitals. We were fortunate that the Iowa Healthcare Collaborative has as its primary mission the furthering of healthcare safety, quality, and value in Iowa. In 2004 the Iowa Healthcare Collaborative spearheaded administration of a survey on the NQF 30 Safe Practices. They asked all 116 Iowa hospitals to rate the 30 Safe Practices in terms of priority and progress and 100 Iowa hospitals responded (86%). At the beginning of the grant we were given the opportunity to analyze this data.

In comparing Iowa's urban and rural hospitals, there were relatively few differences. Two of the 30 items (Q4 and Q12) showed higher *priority* ratings in urban than rural hospitals, and five of the 30 items (Q4, Q14, Q16, Q21, and Q29) showed higher *progress* ratings in urban than rural hospitals. The Safe Practices that showed differences on *priority* ratings were two of the three Leapfrog Group recommendations – CPOE and intensivist staffed ICUs. Many rural hospitals responded that intensivist staffed ICUs were not applicable in their hospital and that CPOE was a very low priority. The items that had higher *progress* ratings in urban hospitals were related to intensivist staffing, preventing wrong-site procedures, evaluating patients for risk of pressure ulcers, evaluating patients for risk of surgical site infection, and identifying high alert drugs[1].

In partnership with the Iowa Healthcare Collaborative, Lance Roberts led the effort to re-administer the survey in 2007 and 104 Iowa hospitals responded (88%). Many rural hospitals

reported that several of the NQF 30 items were not applicable in their hospital (Q24, Q7, Q19, Q20, Q12, and Q26) usually because they did not perform the related procedure. Of the items that were considered applicable, analysis indicated that Iowa rural hospitals lagged behind urban hospitals on Q4 (disclosure of serious outcomes), Q14 (medication reconciliation), and Q17 (identify high alert medication). These findings were presented at the 2008 AHRQ Annual Meeting[2].

Analysis and Reporting of AHRQ Safety and Quality Indicators in Iowa SID. We worked with the Iowa Healthcare Collaborative to analyze the Iowa SID using the software available from AHRQ to identify safety and quality indicators. We assisted the Iowa Healthcare Collaborative to produce the data for the 2005, 2006, 2007, and 2008 *Iowa Report* which provides hospital-specific performance data on a set of AHRQ PSIs and CMS Hospital Compare process measures. We examined all of the AHRQ PSIs and IQIs and benchmarked Iowa rates with AHRQ data nationally in each of the past 5 years to identify items that may represent an "issue" in Iowa rural hospitals. The only indicators where Iowa showed substantially worse rates than the national benchmark involved maternal trauma during vaginal deliveries. Lance Roberts led an in-depth analysis of this and determined that a number of factors were involved including maternal risk factors (e.g., higher prevalence of teenage mothers), baby risk factors (e.g., higher prevalence of large babies), and procedure risk factors (e.g., lower rate of cesarean deliveries). This compounding of risk factors occurred more often in rural hospitals and appeared to be related to emergency deliveries in rural hospitals that were not staffed to handle unplanned cesarean deliveries[3].

Another in-depth analysis that we conducted was of Iowa patients hospitalized with acute myocardial infarction (AMI) to see how patient characteristics, patient management, and in-hospital mortality compared in urban and rural hospitals. Paul James and Pengxiang Li led the effort and found that the raw in-hospital mortality rate in Iowa rural hospitals (14%) was twice the rate of Iowa urban hospitals (6.4%). However, AMI patients admitted to rural hospitals were a decade older and sicker than those admitted to urban hospitals and AMI patients in rural hospitals that were then transferred to urban hospitals were younger and healthier than those who remained. This pattern pointed to considerable differences in patient characteristics and suggested that patient choice played a very large role in where patients were hospitalized. When we used an instrumental variable approach to control for unobserved variables, the difference in in-hospital mortality rates disappeared[4].

We also used the Iowa SID to examine patient safety indicators in CAHs. Iowa has 89 rural hospitals and 80 of these are now CAHs. Pengxiang Li led the analyses to examine the changes in PSIs over time in the rural hospitals that converted. Six AHRQ PSIs that had adequate data in these hospitals were examined. We used GEE logit and random-effects tobit models to assess the effect of CAH conversion on hospital patient safety. The models were adjusted for patient case-mix and market variables. CAH conversion in Iowa rural hospitals was associated with better performance of risk-adjusted rates of iatrogenic pneumothorax, selected infections due to medical care, accidental puncture or laceration, and a composite score of four PSIs, but had no significant impact on the observed rates of death in low-mortality DRGs, foreign body left during procedure, risk-adjusted rate of decubitus ulcer, or a composite score of six PSIs. Thus, CAH conversion was associated with enhanced performance of a set of PSIs that are relevant in small hospitals. We speculate that the increased performance may be a result of the enhanced finances after CAH conversion[5].

Analysis of AHRQ PSIs in the NIS. We also used the AHRQ H-CUP NIS and the AHRQ PSIs to examine patient safety and quality performance in hospitals in a national sample. We published two papers on factors related to PSI performance[6,7].

Smruti Vartak led the effort to assess PSIs in urban and rural hospitals nationally and to examine the relation of hospital and patient factors to patient safety outcomes. The study sample was restricted to hospitals with less than 100 beds. Out of 293 hospitals in the NIS, 186 were rural hospitals and 107 were urban hospitals. Nine AHRQ PSIs that had adequate data in small hospitals were examined. The results showed that most of the observed rates for the 9 PSIs were higher for urban hospitals than for rural hospitals. In multivariable analyses, after adjusting for important patient and hospital characteristics, these differences disappeared except for decubitus ulcer. Urban hospitals had significantly higher odds for decubitus ulcer than rural hospitals. These analyses highlight the importance of understanding the many factors that differ between urban and rural hospitals when developing patient safety interventions at these hospitals[8].

Specific Aim 2: Characterize the HIT Capacity and Barriers of Rural Hospitals

A second major phase of this project was focused on characterizing the state of HIT implementation in rural hospital and factors related to barriers and challenges that Iowa rural hospitals face. A number of methods helped us to understand where Iowa rural hospitals were in terms of HIT implementation and why.

Create Iowa CAH HIT Interest Group. We originally proposed to collaborate with the Iowa chapter of the Healthcare Information Management Systems Society (HIMSS) to identify a group of members from rural hospitals who were involved in HIT purchases and implementation. However, HIMSS membership in Iowa, as elsewhere, includes very few representatives from rural hospitals. Thus, we partnered with the Iowa Medicare Rural Hospital Flexibility Program (FLEX) in the Iowa Department of Public Health to create an HIT workgroup from CAHs. We kicked off this effort at the FLEX annual meeting in May 2005 and recruited members at the quarterly CAH User's Group meeting in July. We partnered with the FLEX program to create the Iowa CAH HIT Interest Group, which became our key advisory group throughout the rest of the grant. We co-sponsored a series of meetings of the group with the following topics:

- October 2005 meeting - with 28 attending, we discussed the purpose of the group and gathered input from the attendees on their level of interest and experience with HIT and degree of implementation at their CAH.

- December 2005 meeting - with 16 attending, the members drafted a mission statement and goals and we discussed plans for our web-based toolkit.

- February 2006 meeting - with17 attending, we demonstrated the format for our proposed web-based toolkit to be hosted on *Sharepoint* through the University of Iowa license. We shared results of our 2005 HIT survey. Because of confidentiality issues for our HIT survey data, we cannot release identified data. Members would like access to an inventory of applications at each CAH and discussed approaches to creating their own. Members also developed plans to make a panel presentation on their approaches to

staffing HIT at their hospitals. Four members participated in a panel presentation at the April meeting of the Iowa CAH Peer User Group Meeting and it was very well received.

- April 2006 meeting - with 23 attending, we demonstrated the initial content of our web-based toolkit on *Sharepoint* and collected input on a survey of member's evaluation of desired content. Based on their feedback, we plan to add folders for policies and procedures. A member presented approaches for selecting an HIT vendor, especially strategies for handling vendor bids for HIT systems. IFMC presented on current efforts in Iowa for a health information exchange initiative. Members gave updates on their HIT activities.

- September 2006 meeting – with 18 attending, we presented the Garets and Davis model (HIMSS Analytics) of EMR stages and got reactions from the members. Two members presented a long list of freeware and inexpensive software that they had found useful in their CAHs. A member made a presentation on his CAH's use of internal and external employee and physician portals tied into their EMR. Members gave updates on their HIT activities.

- January 2007 meeting - with 18 attending, we presented more detailed information from our 2005 HIT survey and information on the HIMSS Analytics database and their request that the CAHs submit their data. IFMC gave an overview of the Health Information Security and Privacy Collaboration (HIPSC) grant and other IFMC HIT initiatives. Members shared information about how they handle infrastructure and security at their CAH.

- October 2007 meeting - with 15 attending, we gave an update on additions to the web-based toolkit on *Sharepoint*. The IT Security Coordinator at an urban hospital in Iowa presented approaches to securing IT information on a limited budget. IFMC provided an update on the Health Information Security and Privacy Collaboration (HIPSC) grant. Visiting presenters gave an overview of new Microsoft software solution products. This presentation was not well received by the members so presentations by sales staff of vendors will only be scheduled if they are previously vetted by the group. Members gave updates on HIT activities at their CAHs during a roundtable discussion.

- February 2008 meeting – with 13 attending (because of bad weather, Marcia Ward and Jim Bahensky missed this one meeting). A member gave an overview of HL7 basics and beyond. A member presented on the effectiveness of heterogeneous computer environments (e.g., Mac, Windows, Linux). Two members presented on successes and challenges of interface engines. Members gave updates during a roundtable discussion.

- October 2008 meeting – with 17 attending, we presented our analysis of staffing issues and business approaches for supporting HIT in CAHs. IFMC gave an update on the Health Information Security and Privacy Collaboration (HIPSC) grant and the specific intervention topics that they are working on. Belinda Udeh gave an overview of the cost calculator toolkit. We collected data from 8 of the CAHs in attendance on their estimates for each of the variables in the model. We estimated low, high, and median levels from

their estimates to populate the spreadsheet on-line. Belinda explained the functioning of the cost calculator and showed that the median estimates yielded an acquisition cost of $1.5 million. Members found that value to be a reasonable match to their experiences. They suggested additional cost elements which Belinda subsequently incorporated into the toolkit. Members expressed positive feedback and requested copies of the revised toolkit for use with their executive boards. Members gave updates on HIT activities at their CAHs during a roundtable discussion.

Literature Review and Validation of Barriers to HIT Capacity in Rural Hospitals. We conducted literature reviews of HIT throughout the project. Initial literature reviews indicated that the barriers to HIT most important in rural hospitals include: 1) the high costs associated with infrastructure and software; 2) immature technology; 3) problems with reimbursement; and 4) a focus on technology issues at the expense of health and business issues. We presented information from the literature reviews to the Iowa CAH HIT Interest Group and got their input on barriers and issues in rural hospital HIT capacity. The group members generally agreed with the barriers identified in the literature. In addition, many CAHs had made IT investments in past years and felt "burned" by lack of ongoing vendor support. Many are waiting for the interoperability barriers to be solved at a national level before they make additional investments.

Analysis of HIMSS Analytics Survey of EMR. We were able to gain access to the HIMSS Analytics™ Database survey conducted on a large national sample. Pengxiang Li and Jim Bahensky led our effort and focused analysis on factors related to EMR implementation. In particular, we examined the impact of different types of multihospital system affiliation on EMR adoption. A cross-sectional design was used with a sample of 4,017 hospitals. Multivariable regression analysis was used to examine the impact of multihospital system affiliation on EMR level of adoption. For small hospitals, the mean EMR adoption level varied significantly between independent hospitals and hospitals owned by a system. After adjusting for the number of operating rooms, the number of emergency room visits, and the number of hospital total FTE staff, small hospitals owned by multihospital systems were associated with 0.25 higher mean EMR adoption level than independent hospitals; no significant relationship was observed for hospitals that were leased / managed by a system. There was no significant effect of multihospital system membership on EMR level of adoption for medium and large hospitals. Small hospitals owned by multihospital systems had a significantly higher EMR level compared to independent hospitals. Smaller hospitals in ownership arrangements with larger healthcare systems have an advantage over small independent hospitals in HIT capacity possibly due to the greater availability of capital, access to shared HIT capacity, and other resources including technical expertise[9].

Review Previous HIT Survey. Prior to the grant, Mirou Jaana led our efforts to conduct a survey of Iowa hospitals to examine their HIT capacity, especially in terms of clinical services. We analyzed the results from this 2002 survey to identify which HIT capabilities are prevalent in urban and rural hospitals. We published a paper comparing the findings in Iowa with Canadian hospitals (Jaana et al., 2005), a paper on rural-urban differences in Iowa hospitals (Ward et al., 2006), and a paper on organizational factors related to HIT capacity (Jaana et al., 2006). Most relevant to the current grant, we found that Iowa urban hospitals had twice the level of HIT

capacity as Iowa rural hospitals. These papers are listed below. Analysis of this previous survey helped us when we designed a new HIT survey for the current grant[10-12].

Design and Conduct New HIT Survey. Jim Bahensky led the effort to develop a new HIT survey. We interviewed a number of IT practitioners around the state and got their input. We generated a list of HIT capacities that were not included in our previous survey, and the project team completed a draft of a new survey instrument. After considerable input, we designed the new survey to largely consist of an "inventory" of business and clinical systems. Limiting the new survey to such an inventory permitted us to be more exhaustive in the types of technologies involved while keeping the length of the survey manageable. The newly devised survey instrument was shared with IT directors at a number of hospitals to get their feedback and suggestions, and was reviewed by other key organizations to get their endorsement (i.e., Iowa Hospital Association, Iowa chapter of HIMSS, Iowa Healthcare Collaborative, Iowa Foundation for Medical Care, and the FLEX program). The newly devised survey instrument was administered during Fall 2005 to all 116 Iowa hospitals and we achieved a favorable response rate of 76%. Initial analysis again showed considerable differences between Iowa's urban and rural hospitals. Iowa's rural hospitals have not progressed much further in attaining HIT capacity since we surveyed them three years previously.

Follow-up Interviews on EMRs. Because the survey was designed to serve as an inventory, we conducted follow-up interviews to gather more in-depth information. We focused interviews on the 20 CAHs and Rural PPS hospitals that responded that they had EMRs operational or being installed. These interviews were conducted during spring 2006. Analysis indicated diverse responses for factors involved in the decision to buy EMR systems, which system to buy, and the benefits perceived from implementing EMR. CAHs are purchasing EMRs from certain vendors that market to smaller hospitals. These EMR systems do not include sophisticated CPOE and CDSS, components that have been most closely linked to enhanced patient safety.

Case Studies of EMR in CAHs. During the course of the grant, two Iowa CAHs were listed as "Most Wired" hospitals in *H&HN Most Wired* magazine. Jim Bahensky created a structured interview guide and worked with the IT directors of both hospitals to compare and contrast their approaches to implementing HIT[13].

Specific Aim 3: Identify Which HIT Capacities Are Most Strongly Related to Patient Safety and Healthcare Quality Issues in Rural Hospitals

The purpose of the third Specific Aim was to identify which HIT capacities and practices are most strongly related to patient safety and enhanced healthcare quality in rural hospitals.

Review Literature on Relationship between HIT and Patient Safety. During December 2005 and January 2006, Jim Bahensky led a project that was funded by the Iowa Medicaid Enterprise (IME). IME was interested in the evidence supporting the use of EMRs for patient safety and quality. Several themes were identified in the available literature. First, there is still relatively little published on the use of EMR to enhance patient safety and quality. Of the studies that have been published, systems that use EMR exclusively have shown little benefit. Systems

that incorporate CPOE or CDSS along with EMR showed more benefits, largely involving reduction in medication errors. However, even this evidence must be interpreted cautiously given that the CPOE and CDSS systems were often custom built and thus their findings may not generalize to currently available commercial systems. Moreover, the studies involved data entry and other processes that were often paid for by grants or other research funding. Thus, commercial systems that require input by hospital staff may not show the same benefits. Financial barriers and a large number of HIT vendors offering different solutions present significant risks to rural healthcare providers wanting to invest in HIT. Important technical, policy, organizational, and financial barriers still exist that prevent the implementation of HIT in rural settings. We published our summary of the literature along with a set of recommendations. In particular, we advised that to expedite the spread of HIT in rural America, federal and state governments along with private payers, who are important beneficiaries of HIT, must make difficult decisions as to who pays for the investment in this technology. They must also drive standards, simplify approaches for reductions in risk, and create a workable operational plan[14].

Get Input from Advisory Group. We recruited members of a Project Advisory Group from healthcare professionals at urban hospitals in Iowa. Our concept was that these members, although employed by urban hospitals, would likely be informative sources of creative ideas about how HIT can provide solutions for rural patient safety and quality issues. Early in the grant period, Jim Bahensky conducted interviews with a number of HIT directors of urban hospitals in Iowa and asked them about ideas for affordable HIT solutions for Iowa's rural hospitals that would enhance patient safety and quality. Unfortunately, these individuals were unable to generate ideas that would be appropriate for smaller hospitals.

Correlate Patient Safety and Quality Indicators with HIT Implementation. We also attempted to use the findings from the HIT survey and the patient safety and quality measures to identify relationships between the two topics. Lance Roberts, Pengxiang Li, and Smruti Vartak led efforts to use the summary scores from our 2002 and 2005 HIT surveys of Iowa hospitals and correlate them with numerous patient safety indicators in Iowa hospitals. For the first wave of analyses, we correlated our 2002 HIT survey of Iowa hospitals with the AHRQ IQIs and PSIs for 2002, 2003, 2004, and 2005 data, and the NQF 30 Safe Practices summary and individual scores from our 2004 survey. For the second wave of analyses, we correlated summary scores from our 2005 HIT survey of Iowa hospitals with AHRQ PSIs and CMS Hospital Compare process indicators for 2005, 2006, and 2007, and our 2007 NQF 30 Safe Practices survey. We used correlations and regression analyses to examine the relationships between HIT capacity and patient safety/quality. A few correlations reached statistical significance, but the general pattern did not exceed that expected by chance and the individual correlations that did reach statistical significance were not readily interpretable. Thus, this approach to identifying patient safety indicators that were positively related to HIT implementation was not fruitful.

Matrix on Use of HIT and Patient Safety Benefits in Iowa Rural Hospitals. Based on our review of the literature, interviews with personnel at rural hospitals, and discussion with our various advisory and work groups, the project team created matrices of HIT applications that could be applicable to addressing patient safety and healthcare quality issues in rural hospitals. The matrices largely focused on HIT applications such as CPOE that have been shown to reduce medication errors, barcoding to reduce errors involving wrong medications and blood supplies,

and imaging technologies to facilitate prompt diagnosis. These technologies are being acquired by some rural hospitals, but their considerable expense is limiting wide-spread use. Our development of these matrices led to a conceptual framework of patient safety issues that could be used by hospitals to prioritize quality initiatives[15].

One technology that we found was being used by both urban and rural hospitals involves medication cabinets that use electronic devises to secure access (e.g., Pyxis, Omnicell). Given the shortage of pharmacists in rural hospitals, these devices appear to be one of the most widespread and cost-effective HIT (if we can use that term loosely) solutions.

Interview CAHs with EMRs about Patient Safety Benefits. Our 2005 HIT survey indicated that 22 of the CAHs in Iowa had EMR systems operational or were installing them. Bren Lowe and Tracy Lewis conducted site visits at 16 of these CAHs and interviewed the CEO, HIT director, Director of Nursing, and Quality Director using structured interview guides. Our structured interview guide included questions about any patient safety or quality improvements they noticed since using the system. Qualitative analysis of the survey transcripts and manuscript development are ongoing. Troy Mills is assisting with identifying themes in the interviews. He noted that none of the hospitals reporting having completed any systematic evaluation of benefits. Hospital executives noted that the primary benefit appeared to be enhanced communication within the hospital.

Specific Aim 4: Identify the Cost of HIT in Rural Hospitals

One of the barriers to investment in HIT capacity in rural hospitals is a lack of information about the likely costs and benefits of investment. To attempt to address this gap, we used findings from the previous Specific Aims, gathered new cost information from several sources, and verified cost estimates with members of the Iowa CAH HIT Interest Group.

Gather Initial Cost Estimates. We conducted an extensive literature search to identify existing cost estimates for acquiring and maintaining HIT in hospitals. We compiled the available estimates, although they were limited. The greatest number of estimates were available for EMRs in ambulatory offices and for CPOE. We also created a list of all available vendors for popular HIT applications used by rural hospitals. In addition, we met with staff of ICE Technologies, the consulting firm in Iowa that is used by many Iowa rural hospitals as they consider expanding their HIT applications. The staff of ICE Technologies gave us ballpark cost estimates for installing integrated EMR-CPOE systems in small hospitals with various existing HIT systems.

Refine Initial Cost Estimates. The project team assembled initial estimates of costs for EMR and CPOE in terms of the short-term costs (implementation phase) and longer-term costs (maintenance phase). We shared these estimates with the Iowa CAH HIT Interest Group and got their input.

Compile Costs of Various IT Staffing Models. Our 2005 HIT survey asked hospitals about their level of IT staffing. We computed frequencies for the various options for staffing HIT in rural hospitals and discovered that many rural hospitals were operating without any IT staff. We explored alternative approaches with the Iowa CAH HIT Interest Group, including hiring

multiple staff, a single HIT staff, using consultants exclusively, outsourcing, and using application service providers (ASP) for remote HIT hosting. Members of the Iowa CAH HIT Interest Group assembled the average cost for each option, plus the pros and cons of each approach, and reviewed their findings at one of their meetings. They then created a panel of representatives of these various models and shared this information with all CAHs at a quarterly meeting of the Iowa CAH User Group.

Systematic Review of Cost Methods. Our efforts to identify cost estimates in the literature led to a systematic review of the literature on methods used in cost analyses. Gerd Clabaugh led the effort to conduct a systematic review to examine the methods used by researchers in developing cost-of-illness (COI) studies. This review categorized the approaches that the published literature uses in terms of perspective, scope, components of care analyzed in the literature, datasets, and valuation approaches used for direct cost. It drew conclusions regarding the adequacy of current COI research methods and made recommendations on improving them. A HealthSTAR literature search identified references to 650 articles. Review of abstracts resulted in the identification of 170 of these for a more detailed review. This process identified 52 articles that met all criteria of COI studies. We identified 218 components of care analyzed across the 52 articles. Private insurance or employer-claims datasets comprised the largest source of utilization and cost information among the studies. Our research indicated that COI studies employ varied approaches and many articles have methodological limitations. We provided recommendations for standards to guide researchers in their execution of these studies[16].

Analysis of CAH Finances. A second preparatory step in our economic analysis was a detailed look at the change in finances in rural hospitals after they converted to CAH status. Pengxiang Li examined the effects of CAH conversion on rural hospital operating revenues, operating expenses, and operating margins using an 8-year panel of 89 rural hospitals in Iowa. Ad hoc hospital revenue, cost and profit functions were estimated using panel data fixed-effects linear models. We found that rural hospital CAH conversion was associated with significant increases in hospital operating revenues, expenses and margins. Interestingly, since Iowa now has 80 CAHs, and their revenue stream has improved substantially, they are looking to make HIT investments in the foreseeable future[17].

Related to this effort, Pengxiang Li also noticed that the time to conversion to CAH status extended over a 7-year period for Iowa hospitals. He led the effort to examine factors related to which year Iowa rural hospitals chose to convert to CAH status. Surprisingly, finances were less of a factor than other considerations[18].

Specific Aim 5: Develop Toolkits to Help Rural Hospitals Make Informed HIT Decisions

Create Web-based Toolkit. During our meetings with the Iowa CAH HIT Interest Group, we gained member's input on features that they would find most helpful in a toolkit. To facilitate ready access to the toolkit, we agreed to make it web-based. We hosted the toolkit on *Sharepoint*, which was available through a license held at the University. We provided members of the Iowa CAH HIT Interest Group with sign-on privileges. Jim Bahensky served as administrator and posted material to the toolkit. During the course of the project, we reviewed each new component at meetings of the Iowa CAH HIT Interest Group to get their reactions and

feedback. We then made adjustments to the content accordingly. The toolkit includes multiple components, as described below.

- Evidence-based Literature and Technical Reports – On an ongoing basis, we reviewed the print and electronic literature on potential HIT solutions for safety/quality problems. We posted research findings that reported evidence on best practices for HIT in rural hospitals. Technical reports from the federal government, consulting firms, and research institutes that were widely cited were posted.

- Information on Existing Vendor Solutions – Since our 2005 HIT survey asked respondents to identify the specific vendors they used for each type of hospital function, we compiled this information and identified the vendors that were used most often by rural hospitals. We conducted a web search of information about these vendors and compiled this information. We posted information on this topic.

- Sample RFPs for Soliciting HIT Bids – Another topic that the Iowa CAH HIT Interest Group identified as a need was best practices on creating RFPs for soliciting bids from HIT vendors. One member who had recently been through a very successful bidding process shared detailed information on the steps involved. We included sample RFPs in the toolkit.

- Freeware and Low-cost Software – Members of the Iowa CAH HIT Interest Group identified and shared sources of freeware and low-cost software that they found useful. They shared their personal experiences and recommendations at a meeting and we posted lists of their recommendations on Sharepoint.

- Solutions for Security Issues – One of the issues that appeared to be most daunting for the lone IT staff at many rural hospitals was keeping up with security requirements. The constantly changing policies regarding security were outside of their usual area of technical expertise. We brought IFMC staff who were involved in a national security project to several meetings to report on ongoing efforts and requirements. Iowa CAH HIT Interest Group members shared approaches and recommendations and discussed approaches for secure back-up especially off-site. We posted federal security requirements on the toolkit.

- Best Practices for HIT in Rural Hospitals – We solicited input from the members of the Iowa CAH HIT Interest Group on any ideas or practices that had worked in their hospital. Topics discussed at meetings included approaches to interfacing multiple systems, staging of HIT module implementation, training issues and approaches for clinical staff, and best systems and vendors for either a comprehensive approach or a best-of-breed approach. We discussed these topics at meetings and posted relevant information on the toolkit.

Create Hospital Referral Toolkit. Another component to the toolkit involved an expert system model created by Chi-Lin Chi and Nick Street. This model used existing data on patient outcomes to create an algorithm that could be used to refer patients with AMI or needing

coronary artery bypass surgery to the nearest hospital with the best outcomes for the patient's specific characteristics[19].

Create Cost Calculator Toolkit. We created a cost calculator to assist hospitals in calculating the costs of implementing an EMR system in their facility. This tool was designed only to assess the cost outlays by the hospital in question. This tool was designed to be as comprehensive as possible, while permitting hospitals to adjust or omit variables to suit their needs.

A companion document was created to use as a reference to the cost calculator. It includes definitions for each cost components and sources for published data that were used to populate the baseline case in the cost calculator.

The cost calculator was created in Excel to make it readily usable by CAHs. It is separated into three worksheets; Data Variables, Calculations and Additional Calculations. The Data Variables worksheet is the only worksheet requiring input. The remaining worksheets populate based on the data input into the Data Variables worksheet.

The Data Variables worksheet is divided into categories: Base Variables, Cost Variables, and Other Variables. For each variable in the Data Variables worksheet, there are four cells in which data may be entered: Value Used in Calculations, Low Value, Baseline Value, and High Value. For many of the variables, there may be more than one value. By having a Low Value, Baseline Value, and High Value category, changes in a particular variable can be tested to see how they affect the costs. The Value Used in Calculations cell is the one populating the Calculations worksheet.

The Calculations worksheet automatically populates with the data entered into the Data Variables worksheet. The costs are calculated for the implementation period (initial costs) and then for each subsequent year for a total of 10 years. It is assumed that all costs occur at the beginning of each year and are broken down by cost sub-category. A total for each year is provided. In addition, the cost for each future year is converted into a present value. The final worksheet is Additional Calculations. This worksheet populates on data entered into the Data Variables and the results are seen in the Calculations worksheet.

Assess Perceptions of the Usefulness of the Toolkits. We involved the Iowa CAH HIT Interest Group in our efforts to build these toolkits. As a part of most meetings of the group, we showcased components of the web-based toolkit and solicited the groups' feedback on the usefulness of the content and usability. We made modifications to meet their needs and increase the usability of various components. We asked members of the Iowa CAH HIT Interest Group to populate the Cost Calculator and collected their estimates. We used their estimates to generate means and ranges (low, baseline, and high values) for each cost component. We demonstrated the use of the Cost Calculator on-line and got their reactions, input for additional cost components, and advice for increasing usability. We then made adjustments accordingly and distributed the final Cost Calculator toolkit to all members.

Conclusions, Significance, and Implications

A primary area of significance of this project revolves around "rurally relevant" patient safety and quality issues in rural hospitals. Important findings from the current project include:

- Many patient safety and quality priorities are the same for urban and rural hospitals, such as medication safety.

- There are specific patient safety and quality issues that are particularly relevant to rural hospitals, such as stabilizing patients with acute myocardial infarction and promptly transferring them to referral hospitals.

- There are specific patient safety and quality issues that are not "relevant" for many rural hospitals, such as intensivist staffing of ICUs.

- Rural hospitals and urban hospitals have comparable rates of PSIs. Differences observed in some previous studies were probably related to varying patient characteristics and not to differences in the quality of care.

- CAHs have increased revenue since converting and have improved on relevant PSIs.

Another primary area of significance of this project focuses on the degree of HIT capacity in rural hospitals and factors related to it. Significant findings from the current project include:

- Rural hospitals have basic HIT capacity especially in terms of business applications, but they lag in most clinical applications.

- Rural hospitals are cautious about making HIT investments, but CAHs are beginning to have sufficient revenue to consider HIT investments in the future.

- Nationally, CAHs that are owned by hospital systems are more likely to have EMRs implemented than independent CAHs, probably due to increased access to financial and technical support.

- There is little in the literature to guide rural hospitals in HIT best practices. We created a web-based toolkit of the available information and developed a cost calculator toolkit to help small hospitals, especially CAHs, to make more informed HIT investment decisions.

Findings relevant to HIT solutions for patient safety issues in rural hospitals include:

- Published systematic review of the literature indicated little generalizable evidence that HIT enhances patient safety. Obviously AHRQ recognized the need for additional research when they funded the current portfolio of HIT implementation and value grants.

- The cost of sophisticated HIT systems is still prohibitive for many small rural hospitals and the opportunity costs of such investment must be considered – weighing any benefits

from HIT investment against those that could have been realized if the money had been spent on other quality initiatives. Alternative financing approaches would help small rural hospitals invest in HIT.

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List of Publications and Products

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