AHRQ Grant Final Progress Report

Title of Project: Rural Hospital Collaborative for Excellence Using IT

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1. STRUCTURED ABSTRACT

a. **Purpose:** To implement information technology for the purpose of measuring process improvement in quality of care and patient safety among rural and small community hospitals in Texas.

b. Scope: Rural and small community hospitals typically have few resources and little experience with quality improvement and current literature suggests poorer quality of care than larger facilities. The current project intends to decrease this gap through the implementation of information technology (IT) tools for data collection and to provide formalized quality improvement education.

c. **Methods:** The project was carried out in two distinct phases: I) Implementation of advanced IT to allow rural and small community hospitals to submit administrative data for analysis specific to quality of care and patient safety measures; and II) a hospital-randomized controlled trial (RCT) to evaluate the effectiveness of a rapid cycle clinical care process educational program.

d. **Results:** Sixty-six hospitals successfully received IT and 47 of these enrolled in the RCT: 23 in the intervention arm and 24 in the control group. Study findings suggest that IT alone did not increase patient safety or improve inpatient quality of care. Likewise, the incremental effect of the education program, with limited data to date, has not significantly improved CMS quality of care performance.

a. Keywords: Quality of care and patient safety, Health Information Technology, Rural and community hospitals, Randomized Controlled Trial

2. PURPOSE

a. To implement information technology for the purpose of measuring process improvement in quality of care and patient safety among rural and small community hospitals in Texas and make the data available (via web portal).

b. To evaluate the impact of the implemented IT tools through a comparison between baseline and follow-up data. Measures used were the Agency for Healthcare Research and Quality (AHRQ) patient safety and quality measures as well as the Centers for Medicare and Medicaid (CMS) measures. The grant also provided the opportunity to benchmark against like facilities.

c. To conduct a randomized trial (RCT) to evaluate the effectiveness of rapid cycle process improvement in education to evaluate clinical care on selected CMS and AHRQ quality of care and patient safety measures. Participant hospitals were randomly assigned to the implemented technology only group or to a technology plus educational program group.

3. SCOPE

a. Background / Context: The practice of medicine today has increased in complexity as a result of the explosion in research and technology as well as the increased demand for services. This complexity is exacerbated by poorly designed care and delivery systems and aging or non-existent access to technology. These pressures are felt most acutely in rural and small community hospitals. One of the greatest challenges for the existing rural hospitals is the need to develop programs to monitor and improve quality of care and patient outcomes [1]. Questions about the ability of small community and rural hospitals to survive arise with the current focus on quality of care following the release of the U.S. Institute of Medicine (IOM) reports *To Err is Human* [2] and *Crossing the Quality Chasm* [3]. As consumers and U.S. regulatory agencies call for hospitals to report their performance on quality indicators [4, 5], and pay for performance programs gain popularity among public and private health care payers [6], hospitals' viability is coming to depend not only on their ability to provide good quality care but also on their ability to monitor and report their performance efficiently.

Rural communities account for approximately one-fifth of the US population and differ greatly from urban and suburban communities in terms of health care needs, availability, and quality. Many studies have detected that urban hospitals had better outcomes [7-9] than their rural counterparts. In 2004, the IOM published its third report in the series on quality of care – *Quality Through Collaboration: The Future of Rural Health* – focusing on the current state of rural health care and the need for quality improvement in this setting, and including several recommendations in support of rural community quality and patient safety monitoring systems [10]. Implementing such systems raises the issue of the inadequate use of information technology – which the IOM has identified as having the potential to considerably improve many aspects of health care quality [3] – in U.S. rural hospitals [11, 12]. Of particular interest is the use of information technology for quality of care benchmarking and case review. Benchmarking – whereby a provider's performance on quality indicators is compared to similar providers' performance – has been shown to enhance the effectiveness of provider profiling by making the performance data easier to evaluate [13, 14] and to stimulate quality improvement [13, 15]. Other quality improvements long known to other industries are now being applied by health care organizations in an effort to bridge the gap between medical knowledge and current health care standards [18, 19]. Specifically, continuous quality improvement (CQI) has become a popular strategy for health care quality improvement [20]. The principles of CQI include the use of the "Plan-Do-Study-Act" cycle developed for industrial engineering. Although CQI is still a new process in health care, its potential to produce improved clinical outcomes [21-23], reduced health disparities [24], and improved efficiency of health care [16] has already been demonstrated. Education on how to conduct CQI has been identified as a necessary step for the process' success [25, 26]. The Baylor Health Care System has developed such an educational program – "Accelerating Best Care at Baylor" (ABC Baylor), which was launched in 2004.

b. **Setting / Participants:** The project team recruited and signed agreements with 66 rural and small community hospitals across the state of Texas for IT implementation and data extraction. The effectiveness of IT was assessed in this cohort of 66 hospitals. However, only 47 (74%) of the 66 hospitals enrolled in Phase I met the inclusion criteria for the RCT, allowing 23 and 24 to be randomized to the intervention and control arms, respectively. These 47 hospitals represent 25% of all Texas hospitals meeting the Phase I inclusion criteria, and are geographically diverse, providing strong external validity for this study's results within the context of rural Texas [27].

4. METHODS

a. **Study Design:** The study consists of two distinct phases. In Phase I we implemented (between September 2004 and July 2005) IT that allowed participating rural and small community Texas hospitals to analyze their quality of care and patient safety measures, and benchmark against like facilities. Phase II started in March 2006 and comprises a hospital-RCT to evaluate the effectiveness of a rapid cycle educational program on tools and techniques for implementing and evaluating quality improvement initiatives. Outcomes included changes in performance on patient safety indicators, and AHRQ inpatient quality indicators from one year prior to implementation and the two years post-implementation. We evaluated the additional benefit of the educational program by comparing the quality of care measures between groups of hospitals randomized to receive the IT only or IT plus the educational program.

b. **Data Sources / Collection:** Data on the CMS inpatient quality of care Core Measures considered for this study were collected from Texas Medical Foundation via the state's QualityNet Exchange system. Performance on the selected AHRQ patient safety indicators were derived from administrative data provided by study hospitals. The administrative data were also used to derive the AHRQ inpatient quality indicators of interest. Retrospective data (starting 1 year prior to implementation) on quality indicators have been collected for hospitals enrolled in the RCT for the baseline assessment. Follow-up data have already been collected for 1 year following completion of the educational program. Data collection will continue up to two years from the completion of the educational program.

Data management: Dallas Fort Worth Hospital Council (DFWHC), working in conjunction with the Rural and Community Health Institute (RCHI), served as the data coordinating center (DCC) for this trial. The DCC developed the study database of Texas hospitals to identify potential study participants, obtained encounter-level administrative and clinical data from all participating hospitals, and managed all data related to study outcomes. Data management included warehousing, quality control, reporting, and producing the data extracts necessary for statistical analysis. The DCC did oversee the process whereby core

measures components were obtained from CMS (via Texas Medical Foundation) and distributed to study participants for quality improvement initiatives, and maintained a web portal that provided access to participating hospitals' inpatient quality and patient safety measures on an aggregate level. The Institute for Health Care Research and Improvement, Baylor Health Care System, executed the randomization scheme for the study and the statistical analysis.

c. Interventions:

i. Web-based Benchmarking and Case Review Tool: The IT implemented in the participating hospitals facilitated better organization, storage, and analysis of data. In particular, hospitals were able to better record and track quality of care and patient safety indicators. It was expected the benchmarking tool would improve quality of care and patient safety, especially in those hospitals that lacked good IT resources. The main component of the benchmarking tool supplied to participating hospitals is Cognos PowerPlay [29], an online analytic processing (OLAP) or multidimensional analysis tool (also known as a business intelligence application). With Cognos PowerPlay, a quality analyst can perform multidimensional analysis, create reports, and share them to make better decisions regarding patient safety and quality initiatives within a healthcare organization. In addition, hospital leadership can utilize the data within the warehouse to examine demographic and market trends to better meet the needs of their communities. The experience of DFWHC personnel with this tool and hospital staff is that professionally educated individuals within the healthcare delivery systems with diverse clinical, business or technical skill levels can explore large volumes of summarized data with sub-second response times with minimal training and support.

Cognos PowerPlay draws information from relational databases within the Date Initiative warehouse to model and build PowerCubes ("Cubes"). The PowerCubes allow a user to bring back information from the server in seconds or minutes depending on the size of the query and number of dimensions involved in the query. They can be small or large, containing more than a billion rows of data and 2 million categories. With such rich and fast-response data sources, a hospital staff can analyze multiple aspects of a healthcare delivery system—to see how a measure changes over time, by patient population or level of risk; or compare how a hospital compares to peers or self designated peer groups. The data are presented in such a way that hospitals can compare their performance with the other hospitals and can identify the best performing hospitals in each clinical area. A second component of the web-based benchmarking tool is an electronic blackboard through which the participating hospitals can ask questions and share information. In this way, poor-performing hospitals can benefit from the advice and experience of hospitals

that have achieved better standards of care on various quality and patient safety indicators.

To ensure the data used for this study are consistent across hospitals, participating hospitals received Data Quality Analyst©, a personal computer-based application developed by DFWHC, and are supported in their use of Data Quality Analyst© by Texas A&M Health Science Center Rural and Community Health Institute (RCHI). The application manages the hospitals' exports and edits for content and formatting errors so that hospitals can correct data before it goes into the data warehouse.

Representatives from all participating hospitals completed a one-day training course on the use of Data Quality Analyst© and the Cognos PowerPlay tool, followed by "webinars" providing further training and education about these tools, as well as the interpretation and use of quality and patient safety indicators.

ii. Educational Program and Course Participants: The educational program provided to hospitals in the intervention arm of the RCT is a practical course focusing on health care quality improvement based on the Intermountain Health Care Mini-Advanced Training Program in Health Care Delivery Improvement [28]. It brings representatives from participating facilities together to learn the theory and techniques of rapid cycle quality improvement, outcomes management, and staff development. The course is designed to facilitate the development of skills and competencies needed to actively lead, participate in, and direct quality improvement efforts. It includes discussions of core principles of clinical quality improvement (designing data systems, methods for rapid improvement, data management); tools necessary to improve patient outcomes, quality of care and cost effectiveness; clinical guidelines and protocols; leadership skills necessary in building a foundation for continuous quality improvement; and customer service skills. For each hospital randomized to the educational intervention, the following people in leadership positions known to be influential in improving quality and safety were targeted for participation: 1) a physician leader; 2) a nursing leader; 3) an administrative leader (hospital president, chief executive officer, or chief financial officer); and 4) the patient safety officer.

The course consisted of 3 sessions and 2 annual conclaves. The first 2 sessions occurred a month apart, lasted 2 days, and involved didactic teaching of continuous quality improvement skills and techniques. Each participant then devised and completed a quality improvement project in the three months following the didactic sessions, and are receiving monthly support and coaching via scheduled teleconferences. Participants presented their projects in the third session, when they were evaluated by Baylor Health Care System quality improvement experts to gauge

participants' progress in applying the course methods to improving care.

Following completion of the class, participants were invited to attend workshops in which class alumni gave presentations regarding successful improvement initiatives. The conclaves were of one day in duration with the first gathering held a year after the third course session and the second conclave to be held the following year. As reported, in addition to the face-to-face education provided through the educational sessions and follow-up workshops, participants receive monthly coaching from quality improvement experts at Baylor Health Care System via teleconference and periodic email communication [27].

d. Measures/Analysis:

Phase I Analysis: The effectiveness of IT implementation was assessed through a pre-post analysis of 6 claims-based measures created by AHRQ (Table 1). Three of these measures come from the AHRQ Inpatient Quality Indicator (IQI) measure set: in-hospital CHF mortality; in-hospital stroke mortality; and in-hospital pneumonia mortality. The remaining three are part of the AHRQ Patient Safety Indicator (PSI) set. For each hospital, pre-implementation period was defined as the quarter of IT implementation plus the previous three quarters. The start of the 12-month post-implementation period was defined to allow for a 3-month gap beyond the quarter of implementation.

For each measure, a generalized linear mixed model with log link and Poisson error distribution was fit to assess change over time. These models took the following form:

$$Y = ed \bullet \exp(\mu + Ad + Bd + R + G + T + G \bullet T + h + h \bullet T).$$

In this model, the number of deaths/events (Y) is expressed as a function of number of 2004 acute care admissions per the AHA survey (Ad), number of acute care beds per the 2004 AHA survey (Bd), whether or not the hospital is rural (R), study group (RCT: Educational intervention; RCT: Control; Not randomized) (G), Time (Pre-implementation; Post-implementation) (T), study group by time interaction (G•T), a random hospital effect (h), and a random hospital by time effect (h•T). The random hospital and hospital by time effects were assumed to be normally distributed and were included to account for the within hospital and within hospital by time correlation, respectively [30]. Finally, the expected number of deaths/events per the AHRQ risk adjustment algorithm (ed) was included as an offset. The expected number of events/deaths was included as a proxy for hospital-specific case severity. This inclusion allowed the model to estimate the standardized mortality ratio (SMR) when the outcome is death or the standardized event ratio (SER) when the outcome is an event, e.g., decubitus ulcer.

Effectiveness of IT was evaluated by testing the significance of the time effect. A p-value below 0.05 was considered significant. All models were fit using PROC GLIMMIX in SAS software (SAS Institute Inc.; Cary, NC).

Phase II (RCT) Analysis: The effectiveness of the educational intervention was assessed by comparing change over time in selected CMS core inpatient process measures between the two study groups (educational intervention; control). This analysis was conducted among the 47 hospitals randomized to one of the two groups. The CMS core measures selected relate to the clinical areas of heart failure (LVF assessment; ACEI or ARB for LVSD) and pneumonia (oxygenation assessment; pneumococcal vaccination; antibiotic administration within 4 hours of arrival) (Table 1). In addition to the individual measures, heart failure, pneumonia, and 'all condition' composite measures were considered. Each composite measure was calculated as the proportion of patients receiving all processes for which they were eligible. In addition to the five heart failure and pneumonia measures, the 'all condition' composite included five AMI process measures (aspirin at arrival; aspirin at discharge; ACEI or ARB for LVSD; beta blockers at arrival; beta blockers at discharge) (Table 1). For control hospitals, the baseline period was defined as the quarter of randomization plus the three previous quarters. The baseline period for hospitals randomized to receive the educational intervention was defined as the quarter where the intervention began plus the three previous quarters. Follow-up consisted of the four quarters immediately following the quarter of randomization and quarter of intervention commencement for control and intervention hospitals, respectively.

To compare the change over time between study groups, a generalized linear mixed model with logit link and binomial error distribution was fit to each measure. These models took the following form

$$\text{Logit}(P) = \mu + G + T + G \bullet T + h + h \bullet T.$$

Here, the logit of the probability of receiving the indicated treatment – or perfect care - (P) is expressed as a function of group membership (G), time (baseline; follow-up) (T), the group by time interaction (G•T), a random hospital effect (h) and a random hospital by time effect (h•T). Because these data were from a randomized trial, no further covariates were considered for the Phase 2 models. As with the Phase 1 model, the random hospital and hospital by time effects were included to account for correlation in the data.

Intervention effectiveness was assessed via the F-test associated with the group by time interaction. All models were fit using PROC GLIMMIX in SAS software (SAS Institute Inc.; Cary, NC).

Table 1. CMS inpatient quality of care Core Measure and AHRQ patient safety and quality indicators considered for the analysis.

Quality Indicators	**Measure/Indicator**	**Analysis**
CHF	LVF assessment	Phase II only
	ACE inhibitor for LVSD	Phase II only
	Composite measure	Phase II only
CAP	Oxygenation assessment	Phase II only
	Time to antibiotics (<4hrs)	Phase II only
	Pneumococcal vaccination	Phase II only
	Composite measure	Phase II only
CHF, CAP, AMI	Composite measure	Phase II only
Inpatient Quality Indicators	In-hospital CHF mortality	Phase I only
	In-hospital pneumonia mortality	Phase I only
	In-hospital stroke mortality	Phase I only
Patient Safety Indicators	Decubitus ulcer	Phase I only
	Failure to rescue	Phase I only
	Selected infections due to medical care	Phase I only

e. **Qualitative studies:** Mid- way through the three year project, we conducted two small studies to obtain feedback from project staff members and hospital staff members to inform the remainder of the project.

   i. We conducted semi-structured interviews with five key staff members of the project. The interview questions focused on the culture of rural hospitals, barriers to implementing IT, motivation, and successes generated. Each interview was audio-taped, transcribed, verified by interviewees for accuracy of content, coded for themes by two independent coders using Ethnograph software, and analyzed.
   ii. We conducted an online survey, querying two staff members from each of the rural hospitals regarding challenges encountered in the project, actual use of the IT, and types of assistance obtained from the project staff. The questions contained rating scales and opportunities for open-ended comments.

5. RESULTS

a. Principal findings/Outcomes:

i. **Pre-post IT Implementation:** Tables 2 and 3 contain descriptive statistics, model-based SMR estimates, and the p-values associated with the test of the time effect for the IQIs and PSIs, respectively. In spite of an anti-conservative approach that did not adjust for multiplicity, no significant time effects were observed for

any of the considered Phase 1 outcomes. Of potential interest, was the change observed in the in-hospital pneumonia SMR (adjusted SMR from 1.0 to 0.8).

ii. **Randomized Controlled Trial (effects of the additional Educational Intervention:** Tables 4, 5, and 6 contain descriptive statistics and the p-value related to the group by time F-tests for the heart failure measures, the pneumonia measures, and the 'all condition' composite, respectively. Study results showed that there were no significant differences in improvement between the two study groups.

iii. **Qualitative studies:** The principal findings from the interviews can be summarized in two categories: characteristics of small, rural hospitals and barriers to IT implementation.

The characteristics include the following:

- Small size
- Independent/tendency to resist outside influence
- Close-knit: many people related by blood or marriage
- Limited resources/Limited budget and equipment
- Limited human resources – multiple roles for each person; limited number of hours to do a task
- Lack of expertise in basic functions
- Knowledge is broad, but superficial
- Variance in size, role structure, knowledge of data
- Time lapses; slower pace of work
- Different problems of patient safety; familiarity of persons; confidentiality; more work-arounds; premature closure; hand-offs; night coverage; lack of technology; maintenance of computers
- Short term- view focused on revenue to survive

Barriers to IT implementation include:

- Equipment: limited hardware and phones; personal email only
- Computer bandwidth
- Capability – outdated software, insufficient computer capacity to handle new software needed for the project
- Limited IT expertise and personnel
- Limited human resources
- Lack of coding when patients are self-pay
- This project focused only on inpatient whereas the larger volume is out-patient

The project staff developed a number of strategies to accomplish their objectives including establishing trust with hospital staff, communicating goals clearly, procuring additional resources not budgeted in the grant, maximizing resource use, educating any person willing to learn, and giving much more time to accomplish the essential tasks.

Thirty out of 53 hospitals responded to the survey (57% response rate). By year two of funding, 53% of the respondents were actually using COGNOS, the software tool; 68% were using it to analyze their patient data; 50% were creating reports with the analyses. A majority of the respondents had requested assistance from the project staff to use the software, with data extraction, and with data correction. Sixty-seven percent (67%) of the respondents reported that their experience with the IT implementation was excellent or good.

b. **Discussion and Conclusion:** The activities developed through this HIT grant have resulted in 66 small community and rural hospitals obtaining sophisticated quality management tools. Some of them required updated hardware and software acquisition to allow them to participate and use the available tool from CMS in order to report their core data set. Many of them required technical assistance with the implementation of the Information Technology tool: the Cognos software, and with other tools needed to participate in both Phases of the project. In order to accomplish the recruitment and IT implementation, members of the grant team had to travel to provide onsite assistance, develop specific computer-based programs for data extraction, and devote many hours teaching and coaching personnel from rural hospitals.

Forty seven of those hospitals are participating in the randomized trial. One half of those have received the ABC Baylor educational component for Continuing Performance Improvement. One third of them have agreed to continue to participate after the end of the grant, with or without more resources. We are continuing our effort to obtain some financial support for the data collection and analysis. The effort is meant to allow the participating facilities to gradually schedule the needed resources into their ongoing budget. There are 22 of these facilities that are Critical Access Hospitals and they are all now reporting their core data to the Texas Quality Improvement Organization, representing, at least, a one hundred percent increase in facilities reporting their core data set.

Results from Phase I and Phase II analyses seem to suggest that IT implementation had little impact on improving patient safety and inpatient quality performances in the 66 rural and small community hospitals considered for this study. Likewise, the educational program did not seem to improve quality of care among the participant 47 hospitals.

Positive results were achieved in regard to the quality of the rural health data, through considerable external support to include assistance obtaining needed updated hardware and software, identifying the appropriate data, obtaining and using the appropriate electronic tools for reporting the core data set, obtaining data extracts and data cleansing.

With the time and considerable efforts required to obtain rural hospital data for measurement purposes, it is too early to draw definitive conclusions regarding the impact this project has had on measuring and improving patient safety and inpatient quality.

Debating why both of these considerable efforts (IT implementation and the Educational Intervention) seem to have made no measurable impact to date is necessary if we are to understand and improve healthcare in smaller facilities such as critical access or rural hospitals. This debate should include the evaluation of the differences in facilities that succeed in implementing care improvement and those that do not. Answering the debate requires more time and evaluation specific to how the individual facilities utilized the data in their quality improvement initiatives. If they did not utilize the tools, the reasons need to be discovered.

It may well be that something in the environment such as obsolete information systems, lack of financial resources to upgrade such systems, and the lack of local resources to provide information technology support prevents the utilization of technology and tools in the absence of mandatory requirements. Due to the time required to obtain data and provide appropriate programming and data cleansing support, this collaborative intends to continue to pursue the collection of data for a minimum of two more quarters of data (6 months). The effort will be limited if we are unable to obtain the necessary resources.

At this time, members of the project are engaged in enrolling the participating facilities in a subscription process to continue supporting their efforts in data collection and implementation of quality improvement. It is significant to note that approximately one third of the participating hospitals in the randomized control trial have signed letters of participation in the subscription series, indicating their perception of significant value. The subsequent data received outside of the grant process may enable us to discern differences in the current data by having a longer period of time for data analysis. It will also allow us time to work with the participating hospitals to determine what they are doing with the data and how we might encourage them to use the data. It will also allow the investigators to evaluate the potential differences in those who were randomized to receive the educational component and discern lessons from their experience with the projects they complete and those who were not randomized to the educational arm.

The debate should also include first the evaluation of the reliability of data that comes from small facilities claims data. As noted above, the majority of these facilities have limited personnel trained to accurately code or check coding for various patients, and even fewer trained with information technology expertise to validate external vendors' efforts on their behalf, and fewer well trained clinical leaders who can lead a project or implement successful changes in their environment. The first half of the grant period was required to basically teach the hospital personnel working with the grantees what was needed to submit and how to submit a clean claim, and how to validate that it was clean. Verifying data quality before and after the use of the Data Quality Analyst© for processing and data cleansing was also a challenging task. An indicator for the measurement of data quality was created (Data Quality Measure) for each hospital, based on the percentage of claims without errors divided

by total claims. Findings indicated that for all hospitals, the post-processing DQM percents were higher than the corresponding pre-processing DQM percents. Some hospitals improved from a 40 percent pre-processing DQM to a post-processing DQM of 95 percent.

Another limitation of the data is the very small number of events in any of the elements used for measurement. In compliance with CMS policy, the core data set was sent to us by the Texas Quality Improvement Organization, at aggregate level. Therefore; we are limited in our ability to be certain we have all the information needed for this analysis or understand the data at a very granular level. To be compliant with the current state of HIPAA regulations in regard to data files with small numbers of patients, we had to work at aggregate level. We do not know, for example, if one or two hospitals dramatically improved care and if so, what or how did they do that.

Potentially, the low patient volumes characteristic of rural and small community hospitals in the United States in these hospitals may have prevented detection of improvement due to the educational intervention (over and above improvements expected with information technology implementation) on a number of the measures. The measures currently available for comparing quality of care over time and between facilities may be inadequate for low-volume hospitals [27].

In working with participants, we noted certain hospital characteristics that warrant further study. Three of the most obvious were exposure to the data, length of implementation, and amount of trended data.

Regarding exposure to the data, we provided over 550 patient safety and quality reports to participants throughout the grant period. Some hospitals requested additional and more detailed reports on a consistent basis whereas other did not. In the future, we should explore the relationship between the volume of these reports and improvements in patient safety and quality initiatives.

Length of time to complete the technology implementation is another variable in need of further exploration. For example, we experienced a technology implementation range from over one year for some hospitals to less than one month for others. We wondered if those with longer implementations experienced better or worse patient safety and quality improvement.

Loading of historic files from 2003 and 2004 was necessary for hospitals to view a trend over time of their patient safety and quality performance. Some hospitals were able to provide 12 out of 12 quarters of these historic files while others, most commonly due to resource constraints, were only able to provide 1 or 2 quarters of their historic files. In the future we should explore the relationship between amount of trended data available and extent of patient safety and quality improvement.

We agree with a recent article by Berwick, where he calls attention to the "…very complex, socio-technical intervention, in which inescapable variation and nuance in local settings in both detailed mechanisms of implementation and detailed factor of context likely have profound effects on the degree to which certain patients benefit. In this sense, aggregation and even, frankly experimental control in the classic sense, impede important learning and blind us to important ideas. The same can be said of collaborative improvement approaches. If we are to learn what we most want to know about complex interventions in human systems with layers and layers of nonlinear cause-and-effect patterns in an ever-changing environment, we will need, I think, to broaden our view entirely of the ways in which we study change, and indeed, of the nature of "evidence" itself." [31]

c. **Significance:** This trial represents the first application of a formal improvement education program in a rural hospital setting in the United States.

   We think we accomplished a great deal conducting this project; however, much work remains to implement IT, measure outcomes, and improve quality of care in rural hospitals

d. **Implications:** Further research is needed with regard to the educational intervention and the means by which quality of care is assessed. The rapid cycle clinical process improvement methodology used in the present study has been deployed by many large hospitals' systems across the United States. While case reports and observational studies have demonstrated success of quality improvement education programs like that used in this study, this is the first randomized controlled trial investigating the effectiveness of such an intervention.

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   There are policy implications regarding the use of data sets with small number of patients/events, in that the granularity needed to determine individual hospital improvements is not always allowed due to privacy issues. This could have a significant impact on mandated measurement efforts.

   Considerably more time and resources will have to be dedicated to IT implementation in rural facilities than is expected from projects with urban and suburban facilities.

Table 2 – Pre-Post analysis of AHRQ inpatient quality indicators.

AHRQ IQI		Baseline	Post-Implementation	P-value*
In-Hospital CHF Mortality	Hospitals (n)	63	61	0.941
	Eligible Admissions†	57.0 (85.0)	45.0 (74.0)	
	Deaths†	3.0 (5.0)	2.0 (3.0)	
	Expected Deaths†	2.0 (3.0)	1.5 (3.3)	
	Adjusted SMR (95% CI)‡	1.3 (1.0, 1.5)	1.3 (1.0, 1.6)	
In-Hospital Stroke Mortality	Hospitals (n)	48	44	0.457
	Eligible Admissions	23.0 (33.0)	17.5 (30.5)	
	Deaths	2.0 (3.0)	2.0 (4.5)	
	Expected Deaths	2.0 (2.8)	1.4 (3.4)	
	Adjusted SMR (95% CI)	1.5 (1.2, 1.9)	1.7 (1.3, 2.1)	
In-Hospital Pneumonia Mortality	Hospitals (n)	64	61	0.061
	Eligible Admissions	83.5 (110.0)	58.0 (85.0)	
	Deaths	3.5 (6.0)	2.0 (3.0)	
	Expected Deaths	3.6 (6.2)	2.7 (4.5)	
	Adjusted SMR (95% CI)	1.0 (0.9, 1.3)	0.9 (0.7, 1.1)	

*The p-value is associated with the F-test for the time effect in a generalized linear mixed model that also contained effects for acute care admissions, acute care bed size, study group membership, group by time, hospital (random), and hospital by time (random).
†Median (Interquartile Range)
‡The adjusted time-specific standardized mortality ratio when other model covariates are held fixed at their average value (continuous covariates) or at one divided by the number of covariate levels (discrete covariates)

Table 3 – Pre-Post analysis of AHRQ patient safety indicators.

AHRQ PSI		Baseline	Post-Implementation	P-value*
Decubitus Ulcer	Hospitals (n)	65	62	0.233
	Eligible Admissions†	231.0 (412.0)	187.0 (334.0)	
	Events†	8.0 (13.0)	6.0 (12.0)	
	Expected Events†	9.1 (13.9)	6.8 (11.6)	
	Adjusted SER (95% CI) ‡	0.9 (0.8, 1.1)	0.8 (0.7, 1.0)	
Failure to Rescue	Hospitals (n)	54	50	0.221
	Eligible Admissions	25.0 (54.0)	22.0 (53.0)	
	Events	2.0 (5.0)	2.0 (4.0)	
	Expected Events	2.7 (5.8)	2.4 (5.9)	
	Adjusted SER (95% CI)	0.8 (0.7, 1.0)	0.7 (0.6, 0.9)	
Infection Due to Medical Care	Hospitals (n)	65	62	0.459
	Eligible Admissions	742.0 (1333.0)	545.0 (837.0)	
	Events	0 (1.0)	0 (0)	
	Expected Events	1.4 (2.2)	1.1 (1.9)	
	Adjusted SER (95% CI)	0.2 (0.1, 0.3)	0.2 (0.1, 0.4)	

*The p-value is associated with the F-test for the time effect in a generalized linear mixed model that also contained effects for acute care admissions, acute care bed size, study group membership, group by time, hospital (random), and hospital by time (random).
†Median (Interquartile Range)
‡The adjusted time-specific standardized event ratio when other model covariates are held fixed at their average value (continuous covariates) or at one divided by the number of covariate levels (discrete covariates)

Table 4 – RCT group by time analysis of heart failure core measures

HF Measure		Period	Education	Control	P-value*
LVF Assessment	Hospitals (n)	Baseline	22	23	0.419
		Follow-up	22	23	
	Admissions†	Baseline	65.5 (92.0)	48.0 (58.0)	
		Follow-up	73.0 (94.0)	49.0 (65.0)	
	Compliance (%)	Baseline	74.8	79.4	
		Follow-up	74.1	84.1	
ACEI or ARB for LVSD	Hospitals (n)	Baseline	22	23	0.552
		Follow-up	22	23	
	Admissions	Baseline	15.0 (24.0)	9.0 (13.0)	
		Follow-up	11.0 (24.0)	9.0 (15.0)	
	Compliance (%)	Baseline	86.7	81.7	
		Follow-up	85.2	86.1	
Heart Failure Bundle	Hospitals (n)	Baseline	22	23	0.349
		Follow-up	22	23	
	Admissions	Baseline	65.5 (92.0)	48.0 (58.0)	
		Follow-up	73.0 (94.0)	49.0 (65.0)	
	Compliance (%)	Baseline	71.4	74.4	
		Follow-up	70.6	80.6	

*The p-value is associated with the group by time effect F-test in a logistic mixed model with effects for study group membership, time, group by time, hospital (random), and hospital by time (random).
†Median (Interquartile Range)

Table 5 – RCT group by time analysis of the pneumonia core measures

PN Measure		Period	Education	Control	P-value*
Oxygenation Assessment	Hospitals (n)	Baseline	22	23	0.909
		Follow-up	21	22	
	Admissions†	Baseline	77.0 (129.0)	70.0 (73.0)	
		Follow-up	83.0 (98.0)	69.5 (100.0)	
	Compliance (%)	Baseline	96.6	98.5	
		Follow-up	99.0	99.4	
Pneumococcal Vaccination	Hospitals (n)	Baseline	22	23	0.516
		Follow-up	21	22	
	Admissions	Baseline	49.0 (75.0)	48.0 (70.0)	
		Follow-up	49.0 (79.0)	48.5 (76.0)	
	Compliance (%)	Baseline	66.4	78.1	
		Follow-up	76.2	83.4	
Antibiotics within 4 Hours	Hospitals (n)	Baseline	22	23	0.689
		Follow-up	21	22	
	Admissions	Baseline	63.5 (108.0)	55.0 (58.0)	
		Follow-up	59.0 (101.0)	48.5 (83.0)	
	Compliance (%)	Baseline	78.3	81.0	
		Follow-up	82.1	82.9	
Pneumonia Composite	Hospitals (n)	Baseline	22	23	0.726
		Follow-up	21	22	
	Admissions	Baseline	77.0 (128.0)	70.0 (73.0)	
		Follow-up	86.0 (104.0)	72.5 (107.0)	
	Compliance (%)	Baseline	65.6	71.8	
		Follow-up	73.8	78.0	

*The p-value is associated with the group by time effect F-test in a logistic mixed model with effects for study group membership, time, group by time, hospital (random), and hospital by time (random).
†Median (Interquartile Range)

Table 6 – RCT group by time analysis of the 'all condition' composite measure

		Period	Education	Control	P-value
All Measure Composite	Hospitals (n)	Baseline	22	23	0.462
		Follow-up	22	23	
	Admissions	Baseline	196.0 (216.0)	128.0 (149.0)	
		Follow-up	185.5 (250.0)	129.0 (196.0)	
	Compliance (%)	Baseline	68.8	73.6	
		Follow-up	72.4	79.3	

*The p-value is associated with the group by time effect F-test in a logistic mixed model with effects for study group membership, time, group by time, hospital (random), and hospital by time (random).
†Median (Interquartile Range)

6. LIST OF PUBLICATIONS AND PRODUCTS

a. Filardo G, Nicewander N, Hamilton C et al. A Hospital-Randomized Controlled Trial of an Educational Quality Improvement Intervention in Rural and Small Community Hospitals in Texas following Implementation of Information Technology *Am J of Medical Quality* 2007, November/December 22 (6): 418 - 427.

b. Filardo G, Nicewander N, Hamilton C et al. Challenges in Conducting a Hospital-Randomized Trial of an Educational Quality Improvement Intervention in Rural and Small Community Hospitals. *Am J of Medical Quality* (In Press)

c. Tietze G, Williams J, Galimbertti M, Rural Hospital Information Technology Implementation for Safety and Quality Improvement: Lessons Learned, (Under review by the *Computers, Informatics, Nursing J*)

REFERENCES

1. Moscovice I, Stensland J. Rural hospitals: trends, challenges, and a future research and policy analysis agenda. *J Rural Health.* 2002;18 Suppl:197-210.

2. Kohn L, JM Corrigan, MS Donaldson. *To Err is Human: Building a Safer Health System*. Washington, DC: National Academy Press; 1999.

3. Corrigan JM, Donaldson MS, Kohn LT, Maguire SK, Pike KC. *Crossing the Quality Chasm. A New Health System for the 21st Century.* Washington DC: Institute of Medicine, National Academy of Sciences. National Academy Press; 2001.

4. Health care consumers say they want to know more objective measures about quality. *Qual Lett Healthc Lead.* Apr 2001;13(4):12-13, 11

5. McGlynn EA, Asch SM, Adams J, et al. The quality of health care delivered to adults in the United States. *N Engl J Med.* 2003 6 26 2003;348(26):2635-2645

6. Endsley S, Kirkegaard M, Baker G, Murcko AC. Getting Rewards for You Results: pay-for-performance programs. *Family Practice Management.* 2004;11(3):45-50

7. Keeler EB, Rubenstein LV, Kahn KL, et al. Hospital characteristics and quality of care. *Jama.* Oct 7 1992;268(13):1709-1714

8. Rosenblatt RA. Quality of care in the rural context: a proposed research agenda. *J Rural Health.* 2002;18 Suppl:176-185

9. Sheikh K, Bullock C. Urban-rural differences in the quality of care for medicare patients with acute myocardial infarction. *Arch Intern Med.* Mar 12 2001;161(5):737-743

10. Corrigan JM, Aspden P,Snyder LP, Wolcott J, Wunderlich G, Russell B, ed. *Quality Through Collaboration: The Future of Rural Health*. Washington, DC: Institute of Medicine, National Academies Press; 2004.

11. Calico FW, Dillard CD, Moscovice I, Wakefield MK. A framework and action agenda for quality improvement in rural health care. *J Rural Health.* Summer 2003;19(3):226-232

12. National Advisory Committee on Rural Health and Human Services. *Health Care Quality: The Rural Context*. Rockville, MD: US Department of Health an Human Services; 2003.

13. Hibbard JH, Stockard J, Tusler M. Does publicizing hospital performance stimulate quality improvement efforts? *Health Aff (Millwood).* Mar-Apr 2003;22(2):84-94

14. Kiefe CI, Allison JJ, Williams OD, Person SD, Weaver MT, Weissman NW. Improving quality improvement using achievable benchmarks for physician feedback: a randomized controlled trial. *Jama.* Jun 13 2001;285(22):2871-2879

15. Pai CW, Finnegan GK, Satwicz MJ. The combined effect of public profiling and quality improvement efforts on heart failure management. *Jt Comm J Qual Improv.* Nov 2002;28(11):614-624

16. Casey MM, Moscovice I. Quality improvement strategies and best practices in critical access hospitals. *J Rural Health.* Fall 2004;20(4):327-334

17. Westfall JM, Fernald DH, Staton EW, VanVorst R, West D, Pace WD. Applied strategies for improving patient safety: a comprehensive process to improve care in rural and frontier communities. *J Rural Health.* Fall 2004;20(4):355-362

18. Thompson DN, Wolf GA, Spear SJ. Driving improvement in patient care: lessons from Toyota. *J Nurs Adm.* Nov 2003;33(11):585-595

19. Wilf-Miron R, Lewenhoff I, Benyamini Z, Aviram A. From aviation to medicine: applying concepts of aviation safety to risk management in ambulatory care. *Qual Saf Health Care.* Feb 2003;12(1):35-39

20. Berwick DM. Continuous improvement as an ideal in health care. *N Engl J Med.* Jan 5 1989;320(1):53-56

21. Ferguson TB, Jr., Peterson ED, Coombs LP, et al. Use of continuous quality improvement to increase use of process measures in patients undergoing coronary artery bypass graft surgery: a randomized controlled trial. *Jama.* Jul 2 2003;290(1):49-56

22. Lappe JM, Muhlestein JB, Lappe DL, et al. Improvements in 1-year cardiovascular clinical outcomes associated with a hospital-based discharge medication program. *Ann Intern Med.* Sep 21 2004;141(6):446-453

23. Chu LA, Bratzler DW, Lewis RJ, et al. Improving the quality of care for patients with pneumonia in very small hospitals. *Arch Intern Med.* Feb 10 2003;163(3):326-332

24. Sehgal AR. Impact of quality improvement efforts on race and sex disparities in hemodialysis. *Jama.* Feb 26 2003;289(8):996-1000

25. The imperative for quality: a call for action to medical schools and teaching hospitals. *Acad Med.* Nov 2003;78(11):1085-1089

26. Djuricich AM, Ciccarelli M, Swigonski NL. A continuous quality improvement curriculum for residents: addressing core competency, improving systems. *Acad Med.* Oct 2004;79(10 Suppl):S65-67

27. Filardo G, Nicewander N, Hamilton C et al. A Hospital-Randomized Controlled Trial of an Educational Quality Improvement Intervention in Rural and Small Community Hospitals in Texas following Implementation of Information Technology *Am J of Medical Quality* 2007, November/December 22 (6): 418 - 427.

28. Intermountain Health Care. Mini-Advanced Training Program in Health Care Delivery Improvement. http://www.ihc.com/xp/ihc/institute/education/miniatp/. Accessed July 8, 2005.

29. Cognos Inc. The Strategic Importance of OLAP Analysis: A Cognos White Paper. http://www.cognos.com/pdfs/whitepapers/wp_strategic_importance_of_olap_analysis.pdf. Accessed June 14, 2005.

30. Murray DM. Design and Analysis of Group Randomized Trials. *New York: Oxford University Press;* 1998.

31. Berwick DM. The Stories Beneath. *Medical Care,* 2007, Vol 45 (12):1123-25