TITLE

Title: Regional Approach for THQIT in Rural Settings – Implementation
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Organization: Geisinger Clinic on behalf of the Geisinger Health
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STRUCTURED ABSTRACT

Purpose:
To provide rapid, secure, confidential access to patient information for regional healthcare providers in 31 rural Pennsylvania counties

Scope:
The initial phase was a low-cost, incremental approach to provide information from holders of the largest electronic data stores (hospitals) to the highest-impact users of clinical information (emergency department clinicians and hospitalist physicians).

Methods:
Development: iterative, collaborative governance, design and implementation; interview; survey

Results:

- An incremental approach decreased costs and enabled us to make a significant start but imposed critical usability and usefulness limitations.
- A federated architectural model facilitated partner buy-in but proved unworkable and became irrelevant as partner trust deepened.
- Managing patient identity is one of the largest ongoing operating costs.
- Translation of a community hospital's lab results to LOINC (the standard terminology) achieves significant benefits at modest cost.
- Incorporation of unstructured, high-value clinical documents (e.g., discharge summaries) provided substantial benefit to clinicians.

Key Words:

Health Information Exchange, HIE, Keystone Health Information Exchange, KeyHIE, HIT Standards Development, LOINC, ELINCS

PURPOSE

Executive Summary

Following the completion of Planning Grant #P20HS015457 in 2005, Geisinger began the implementation of the Keystone Health Information Exchange (KeyHIE) under the THQIT implementation grant program. This report focuses on the lessons learned that are most likely to be useful to others carrying out similar projects or funding them.

Because of a limited budget and uncertainty of a sustainable business model, we determined that we would develop the health information exchange (HIE) using an incremental approach, built on existing technology wherever possible. We started with a simple design and expanded functionality and complexity over time. Section 1 describes how the incremental approach decreased costs and enabled us to make a significant start but imposed critical usability and usefulness limitations. Section 2 describes how we arrived at our hybrid technical model and the benefits and weaknesses of this approach. We also share how the incorporation of unstructured, high-value clinical documents (e.g., discharge summaries) has provided substantial benefit to clinicians.

We learned early on that managing patient identity within an HIE has some significant challenges and costs. Section 3 describes how we utilize our Health Information management staff to manage issues with patient linkage and de-duplication.

We improved healthcare efficiency and quality in a specialty clinic by installing an interface from a community hospital laboratory system into an electronic health record system using the LOINC® national standard. Translation of a community hospital's lab results to LOINC requires modest resources. Typical translation time per test is about 30 minutes for an inexperienced person, whereas an experienced person can map a test in about 15 minutes. Of the 526 tests that were initially translated, only 86 (16%) were sent across the interface during a 6-month period. See section 4.0 for a detailed analysis of the skill sets, hours, and most important lab results for translation. Because of KeyHIE's use of a document-repository architecture, which imposes a cost of 6 cents per lab result, incorporation of the lab results into KeyHIE requires substantial technical resources and operational costs. These costs led us to develop a point-to-point approach to sharing regional laboratory results.

Barrier: The point-to-point result delivery approach had the advantage of lower start-up costs but imposed the limitation that exchange users have to navigate multiple EHRs to access complete lab results for many patients.
Solution: We have begun to re-use this point-to-point architecture to develop a many-to-many interface solution in which multiple laboratories can send results to multiple EHRs. We will also be able to use this solution to publish standardized lab results to the HIE when the participating hospitals agree to share the cost. The definition of meaningful use under ARRA as requiring the sharing of discrete lab results with other providers has made this agreement far more likely than it was previously. See section 4 for more details about the community lab interface project.

Our health information exchange went live in April 2007 with three partner hospitals. Section 5 discusses how we brought together a group of healthcare organizations (HCOs) to govern the Keystone Health Information Exchange (KeyHIE)® as a loose collaborative and elected not to immediately incorporate as other HIEs have done. In this section, we share the benefits and challenges of this approach and outline our next steps for KeyHIE's continued development.

Project Goal and Objectives

The goal of the planning and implementation projects funded by AHRQ planning grant and implementation grant # UC1HS016162 was to create a standards-based, sustainable, secure, and confidential health-information exchange (KeyHIE) that will provide rapid, organized access to clinically valuable patient information from every regional healthcare organization (HCO) at every regional point of care.

From the planning grant, we concluded that the need to share patient information across the region was widely felt, reflected in the attendance of 19 (36%) of the 53 hospitals invited to the organizing conference, in the signing by eight HCOs a memorandum of understanding to form the charter membership of KeyHIE, and in the fact that three HCOs agreed to work on the implementation project.

SCOPE

Background

Geisinger received an AHRQ planning grant, #P20HS015457, in 2005 to work with two regional hospitals to improve methods of sharing patient information. We agreed to begin with a pilot between these hospitals, with the intent of expanding to include all the hospitals in central and northeastern Pennsylvania area, which provides healthcare services to approximately 2.6 million residents of 31 rural and underserved Pennsylvania counties. In early 2005, we administered a regional survey[1] to determine how prepared this region was to support health information exchange (HIE), both from a technological and administrative perspective. We held a symposium in May 2005 to review these survey results[2] and hold discussions about how our region should proceed with HIE. In a café workshop, participants from the 26 participating healthcare organizations (HCOs) discussed issues and offered recommendations for regional health information exchange.[3] Eight HCOs agreed to move forward with development of HIE, with the others agreeing to join after the initiative was operational. In November 2005, all eight organizations signed a memorandum of understanding (MOU)[4] to agree to work together on developing a more formal HIE governance and implementation of a regional system.

The goal of the Keystone Health-Information Exchange (KeyHIE) is to provide the healthcare organizations (HCOs) and patients of the region secure, confidential, timely access to the information needed to support optimal care processes and patient outcomes.

Participating HCOs

The three HCOs that participated in the grant, Bloomsburg Hospital (referred to as “Bloomsburg” in this report), Geisinger Health System (referred to as “Geisinger”), and Shamokin Area Community Hospital (referred to as “Shamokin” in this report), share in the care of significant numbers of patients. Though Sunbury Community Hospital was one of the partners in the AHRQ planning project, they were purchased by a for-profit company, Community Health Systems. They subsequently withdrew from the AHRQ implementation project and were replaced by Bloomsburg.

In addition, Geisinger provides specialty care to Bloomsburg and Shamokin and their communities. Geisinger led the planning and implementation grants.

- Bloomsburg is a 72-bed hospital in a college town of 12,375 people.[5]

- Geisinger is an integrated health system that includes two hospitals (664 beds) and 42 physician practices.
- Shamokin Area Community Hospital is a 70-bed hospital in a coal-mining town of 10,628 people.[5]
- Sunbury Community Hospital is an 82-bed hospital in a town of 10,610.[5]
- When Sunbury was purchased by a for-profit hospital chain, they withdrew from the implementation project.

The AHRQ-funded planning and implementation HIE projects were led by Geisinger, an integrated healthcare delivery system including two hospitals and 42 clinics. Geisinger physicians provide specialty care at both Shamokin and Bloomsburg Hospitals.

In parallel with the AHRQ-funded projects, nine additional HCOs joined KeyHIE. These KeyHIE participants are:

- Community Medical Center Healthcare System – Scranton, PA
- Evangelical Community Hospital – Lewisburg, PA
- Family Practice Centers, P.C. – Mifflinburg, PA
- Grandview Health Homes, Inc. – Danville, PA
- Jersey Shore Hospital – Jersey Shore, PA
- Moses Taylor Health Care System – Scranton, PA
- Presbyterian Senior Living – Dillsburg, PA
- Schuylkill Health System – Pottsville, PA
- SUN Home Health Services – Northumberland, PA

Another HCO joined KeyHIE, but subsequently withdrew, citing small numbers of patients shared with the other participating HCOs as the reason.

METHODS

Project Design

The initial planning was completed in 2005 as part of the AHRQ planning grant project. During that time, we administered a regional survey to assess the readiness of HCOs to participate in health information exchange. We also held a regional symposium to review the survey results and identify the barriers to HIE in our region as well as possible solutions. We concluded that competition among providers and lack of trust were the greatest barriers, but there was strong agreement that patient information should be used to care for patients and not used as a competitive advantage.

There were five major components of this project. The first being the development of a governing body to oversee the development and management of KeyHIE. The second was the standard technical architecture used to identify and match patients as well as store their demographic information (name, address, phone, etc.). It also included a list of visits for each patient and a portal to display this information to authorized clinicians according to each patient's consent. The third component was a single sign-on (SSO) feature that allowed clinicians to link from the KeyHIE portal to an HCO's EHR without requiring the clinician to login a second time. The fourth component was the implementation of a clinical document store that permitted authorized clinicians to access clinical documents published by each HCO with information about their patients, so they could quickly access care information without requiring access to another EHR. The final component was a community lab interface to take lab results from a hospital lab system and file them into a different HCO's EHR, using nationally recognized standards to translate the lab test names.

Data Sources/Collection

Interviews

We used physician interviews as an informal method to gather information that could be generalized and incorporated into surveys. The clinicians also help us refine and validate these questionnaires. We also used interviews to help us understand clinical needs, and to give us immediate feedback on various stages of our exchange development. Leaders from the emergency department of Geisinger Medical Center played a key role in guiding the development of our KeyHIE clinical viewer.

Survey questionnaires

There were numerous surveys developed and used throughout the grant period. These were designed to gather information for a several purposes, to determine HIE readiness, to inform our development, to access our progress, and to determine our future direction.

Readiness Survey 1 – This survey was administered in 1Q 2005 for the purpose of determining our region's readiness to participate in HIE.[1] We surveyed all the 53 hospitals in our 31-county area, requesting that the survey be completed by one administrative leader, one clinical leader and one technical leader. We learned that there were significant information gaps. Only 70% indicated that their physicians had ready access to clinical information determined to be important.

Readiness Survey 2 – This second survey was administered in 3Q 2007 to help us determine if any changes were evident in terms of the region's readiness to participate in HIE.[6] It was sent to the same group we surveyed in 2005. In addition to understanding whether clinicians had ready access to specific information, we also asked them to rate how important that information was to their care delivery.

Community Lab Interface Survey – We administered this survey in 4Q 2008 to evaluate the effectiveness of the lab interface deployed between Shamokin Area Community Hospital and Geisinger's EHR system.[7] We surveyed the physicians who received lab results in the prior year from the Shamokin lab plus a few members of the specialty clinic office staff who previously received the paper lab results and scanned them into the Geisinger EHR for physicians to view.

KeyHIE Portal Survey – We administered this survey in 3Q 2009 to determine the effectiveness of our health information exchange portal design.[8]

Symposium

We held a regional symposium in May 2005. During this conference, we reviewed the results of our first readiness survey and facilitated a café style discussion that helped us identify the benefits and barriers to HIE in our 31-county region.[3]

Governance meetings

Since our first meeting in September 2005, we have held quarterly in-person governance meetings for all KeyHIE members. These meetings are rotated to each member's facility and last approximately 4.5 hours, including a lunch (provided by the host member). Generally, the KeyHIE Project Director hosts the meeting, which includes presentations and work sessions for KeyHIE development. The members have asked that Geisinger staff develop the agenda and presentations plus facilitate the meetings, where all members provide their input into major decisions. Each member is permitted one vote regardless of the size of their organization. One or two teleconferences are typically held between the quarterly meetings to provide updates and request feedback on items that require more immediate decisions.

Participant meetings

Besides governance meetings, KeyHIE technical calls were established to occur on a bi-weekly basis. These calls allowed all KeyHIE members to provide input into the development of the HIE portal and other technical issues. This call had very limited participation from non-Geisinger members and was eventually discontinued.

Information Systems

Numerous reports are generated on daily, weekly, and monthly bases. Most of these are rolled up into a monthly dashboard report that contains statistics by participating facilities.
Sample monthly statistics by facility:

- Number of patients added to database
- Number of patient-matching problems generated
- Number of registrations (inpatient, outpatient, emergency)
- Number of documents published
- Number of new patient authorizations given/declined
- Number of KeyHIE portal users
- Number of user accesses
- Number of different patients accessed
- Number of single sign-ons performed

RESULTS

Because our implementation project spanned multiple areas, we have grouped our results into five sections to report specific findings and discussion, followed by a general section of conclusions and implications. These sections relate to key lessons learned from the interventions we applied through our project. These interventions include development of a regional portal using an incremental development approach. A major component of the HIE and lesson learned is the cost of managing patient identities. The portal was implemented in emergency departments, in clinics, and to hospitalists, with additional stakeholders identified for even greater adoption. With additional funding from the Pennsylvania Department of Health in 2007, we were able to build a regional clinical document repository and add four new hospitals to the exchange. The KeyHIE organization currently consists of 13 member organizations, including several acute care facilities, primary care practices, home health facilities, and long-term care facilities. More than 360,000 patients have authorized their information to be shared through the exchange, which processes more than 4 million encounters annually from eight hospitals and 42 clinics. Geisinger employs five FTEs to operate this exchange on behalf of KeyHIE.

Section 1.0 Incremental Approach to HIE

In order to achieve maximum early benefits, we identified care settings, healthcare IT (HIT) users, and information types (for example, Discharge Summaries and History & Physicals) for which availability of regional information was likely to provide the greatest benefit (thus motivating both HCO participation and clinician and patient use). Next, we identified the types of HCOs most likely to have patient information in electronic form. The results of this analysis suggested that hospitals had the most information that would be readily shareable. *(Note: Though semantically interoperable information is useful and the goal of KeyHIE as soon as it is cost effective, the primary goals of a low-cost technical infrastructure and full accessibility to all regional organizations [hospitals, physician practices, home health organizations, skilled nursing facilities, first responders, and case managers] dictated sharing of most information in electronic, but not semantically interoperable, form at the outset; the one exception is the exchange of lab results expressed the standard terminology, LOINC.)*

The analysis also suggested that ED clinicians (because they care for patients who need timely, focused care for what are often critical illnesses and because information essential to care is unavailable in 15% of ED visits[9]) would be the clinicians to whom KeyHIE would be useful first. The analysis suggested that hospitalist physicians likely would be early adopters for many of the same reasons.

To keep costs to a minimum, the pilot organization conducted a technical assessment to identify the resources available to develop an HIE. After an inventory of our combined resource among the pilot hospitals in 2006 (see Table 1), we started with a web viewer that simply had the log-in pages for the web-based EHR viewers of the three pilot hospitals displayed from a single web page.

Table 1 Initial Pilot Technical Inventory

Resource	Organization(s)	Proposed Use
Enterprise master patient index	Geisinger	Community MPI
Interface engine and programmers	Geisinger	Translate information from sending systems to populate MPI and patient visits
Oracle database	Geisinger	Maintain list of patient visits
RSA Cleartrust Security platform	Geisinger	Control user access and single sign-on
Web programming resources	Geisinger	Develop and maintain KeyHIE web viewer
Web-based EHR viewer	Bloomsburg, Geisinger, Shamokin	Provide clinicians with access to clinical information

Although easy to set up, this initial version required our emergency department (ED) clinicians to remember user IDs and passwords for two systems in addition to their own, so it was not used. Our next version, delivered in April 2007, incorporated our community master patient index (MPI), record locator service (RLS), and single sign-on (SSO) tools. This allowed the clinician to log in one time to the KeyHIE web viewer, look up their patient, see a list of visits their patient had at participating facilities then using the SSO, and launch the web viewer for whichever EHR had information about their patient. It did not require additional log-in, but it did require the clinician to look up their patient a second time in the remote EHR system. Eventually, we made it possible to pass patient context to one of the EHR systems so that patient could automatically appear, but the other EHRs did not have tools to support that same functionality. Consequently, many of the clinicians complained that the process was still too “clunky” and slow.

In 2008, we added a clinical document store that allowed each facility to begin publishing clinical documents for others to view. We started with discharge summaries and history & physicals, and then we added radiology reports. Some hospitals were able to publish the required documents, some could produce them but had difficulty transporting them to the HIE, and some could not generate them at all.

This incremental approach produced several effects:

- It enabled a very-low-cost structure, which was particularly important in the widely experienced absence of a compelling business case for HIE during this project (2005 to 2009--prior to the inclusion of information sharing in the definition of meaningful use of HIT under ARRA).
- It enabled us to build trust among participating HCOs as the project evolved.
- It enabled individual users and HCOs to experience the benefits of initially rudimentary information and become supporters of increasingly complete and interoperable (and expensive) information.

A downside of the incremental approach was an initial absence of a “critical mass” of information that would reward HIE use. The resulting low user satisfaction makes it hard for HCOs to justify expenditures for HIE, particularly in the face of multiple competing needs in a difficult financial period. This two-edged sword is likely one reason for the relatively low success rate of deployed HIEs. In our second release, the KeyHIE clinical viewer had the ability to connect clinicians to all the clinical information each facility maintained, yet the fact that it was difficult to obtain made it less desirable.

Lack of fit with time-pressured workflows and existing reimbursement arrangements
Even having prior knowledge of the availability of high-impact information in KeyHIE was not necessarily enough to motivate use of KeyHIE. In one case that we know of, an ED physician was informed of such information by a patient's family member, who offered to show the physician how to access the information. The physician deferred, instead ordering a potentially redundant and expensive radiology test.

Section 2.0 Evaluating HIE Technical Models

In general, there are three distinct approaches to HIE architecture, the federated model, the centralized model, and the hybrid model. We have found there to be much more variation in the options and approaches to exchanging health information, given the varieties of how each model can be deployed. In fact, our model changed over time, based on user feedback.

A critical advantage of the federated, and most hybrid, HIE models is the fact that each participating HCO maintains control of their information. We employed a hybrid model that allowed each HCO to maintain control of their information. Early in KeyHIE's history, this control reassured participating HCOs that their information would not be misused. As working relationships matured, this reassurance became irrelevant, and the limitations imposed on user access by the version of the hybrid model that we used became relatively more unacceptable.

One limitation that our hybrid model imposed is that it made it harder to integrate the data into displays that help users interpret the data rapidly and accurately. Initially, KeyHIE used a single sign-on (SSO) into the EHRs of participating HCOs to provide users access to patient information. This met the requirements of a federated model, because the individual organization maintained control of who accessed the clinical information they produced. Unfortunately, the requirement that users be able to navigate multiple EHRs was unacceptable, particularly because the difficulty increased as more HCOs participated in the exchange. On the technical side, changes in participants' EHRs frequently required reconfiguring the SSO, creating an insupportably expensive maintenance demand. This problem was compounded in the frequent case that the IT personnel at the participating HCO were unable to resolve the problem in a timely manner, making the user's experience of the HIE so unpredictable that future use was often discouraged, according to user interviews. Thus, although our version of the hybrid model may enable HCOs with little shared trust to participate in an HIE at the outset, the approach may not be sustainable over the long term.

Other federated versions employ edge servers that are usually hosted by each participating organization (behind a firewall) and often contain the data in a standard format that can be accessed by the HIE when requested by a clinician. This may offer greater functionality and organization control but, usually, at a much greater cost. Each organization must pay hardware and maintenance fees to operate the edge server equipment, which may not be feasible to smaller HCOs. Centralized models store aggregated information in shared repositories that usually allow fast access and low costs, with less control for the organizations publishing the information. Hybrid models usually store the information in a shared facility, with the data segregated and sometimes managed by the publishing organization.

Our experience with the hybrid model:

- Federated information can delay access to clinical information, create technical challenges, and limiting data availability.
- Unstructured data in a shared repository (centralized model) is not a problem, because it cannot be mined.
- When structured information is added, they have the option of using a federated document storage model.[10]
- The transition from unstructured information occurs over time, so it makes sense to start with a more centralized approach to contain costs until a clear value proposition can be identified.

Access to Regional Patient Information (pull)
One goal of health information exchange (HIE) is to provide access to all of a patient's information in single, usable, useful displays within clinicians' standard workflows.
Barrier: Organizational, resource, and technical constraints limited KeyHIE's ability to achieve this goal in many cases.
Solution: Incorporation of unstructured, high-value clinical documents (e.g., discharge summaries) into the exchange provided substantial benefit to clinicians. KeyHIE's technical design enables the incorporation of standardized, structured information as vendor products become more capable of providing that information.

Delivery of Regional Patient Information (push)
A second, equally important, goal is to deliver new patient information within clinicians' standard workflows.
Barrier: Current limitations imposed by interfaces provided by HIT vendors often require customization for transmission of clinical information (including lab results).
Solution: Although we were unable to identify an installed instance of ELINCS (the standard for electronic transmission of lab results to EHRs), we used the ELINCS specification to guide our interface development wherever possible.

Low-Cost, High-Impact Design
After interviewing potential participants and analyzing their technical and organizational capacities, we concluded that any HIE that would be successful in this region must have a low-cost technical and administrative infrastructure and require only minimal IT and organization-change capabilities of participating HCOs. This simplicity would enable financially and technically constrained HCOs to participate; it would also enable KeyHIE to sustain its operations until it demonstrated enough benefit to participating HCOs to support the development of a sustainable business case.

By this time, we had already implemented our clinical document store solution, but it was not in widespread use. The responses and comments seemed to reflect ongoing frustrations about the earlier portal version, which relied on a slow, single sign-on process that allowed clinicians to view clinical information in the EHR of another HCO. Despite some negative sentiment about ease of access, 55% of respondents indicated that information in the exchange helps them work more efficiently, and 60% indicated that information from the exchange helps them provide higher quality patient care.

At the outset, we anticipated that summary clinical documents, such as discharge summaries, and critical test results, such as lab results, imaging results, and EKG traces, would be among the highest-

impact information sources. Survey questionnaires administered to regional physicians and nursing staff produced the following prioritization:

Table 1. Physician Prioritization of Clinical-Information Types

Information Type	Selected as Important (%)	Selected as first priority (%)
Lab Results	100	60
History & Physicals	100	15
Medication Lists	100	0
Radiology Reports	88	25
Allergies	88	0
Discharge Summaries	75	0
Consult Notes	75	0
Pathology Reports	50	0
Problem Lists	50	0
Patient Summaries	50	0
Transfer Summaries	50	0

After demonstrating care quality and efficiency benefits with these information types in these highest-impact care settings, we planned to extend KeyHIE to all other regional HCOs and patients and to include increasing numbers of information types in increasingly semantically interoperable form.

Three years into the project, informal interviews with insurers suggested that case managers are another group of clinicians who would be highly motivated to use regional patient information. This is the case because case managers often learn about a patient's hospital stay several weeks after discharge—too late to optimize the transition from inpatient care to home and often only after the patient has suffered an adverse effect of poorly coordinated care.

Information Completeness

The low-cost design of KeyHIE had the effect that the information available for any one of the patients in the patient index was likely to be sparse at the outset. (This sparseness was only partially mitigated by the addition of Geisinger's extensive electronic information on 2.5 million patients in the region.) We hypothesized that this information sparseness would discourage clinician users in most clinical situations except those in which regional information was most needed, such as the ED and hospitalist services.

To make more information available early in the project, we enabled KeyHIE users to access the participants' EHRs directly from KeyHIE (using single-sign-on technology into web-based EHRs). Despite resulting access to substantial information, relatively few patient records were accessed by the ED-physician pilot group; with all three participating hospitals connected, only 250 patient records (0.22% of ED encounters 114,284) were accessed in 2008. Although the slow pace of patient consents (264,058 in 2008) contributed to slow adoption, physician interviews revealed that 23.8% found it too difficult to navigate through the various interfaces of the participants' different EHRs to gather information.

Usability, and Usefulness, and Adoption (Use)

TAM (Technology Acceptance Model) is the theory of technology adoption best supported by scientific studies.[11] It predicts that technology adoption is determined primarily by the usability and usefulness of the technology for accomplishing tasks important to the users. To measure KeyHIE's usability and usefulness, we invited clinicians in participating HCOs to complete a survey questionnaire in July/August 2009.

We measured clinician rates of KeyHIE use by reporting the number of patients accessed in a given quarter (Fig. 1). Because we were also signing up new users during this time, we also reported the number of user accounts set up at each facility (Fig. 2) so that a realistic correlation could be made. The number of accesses to patient records remained relatively flat until April 2009, when the new document version of the KeyHIE web viewer was introduced. At this time, Geisinger also began setting up new users in its clinics for the first time. We believe that this combination, plus a growing awareness of the benefits of HIE, has led to increased accesses that has continued over the past 8 months.

Figure 1.

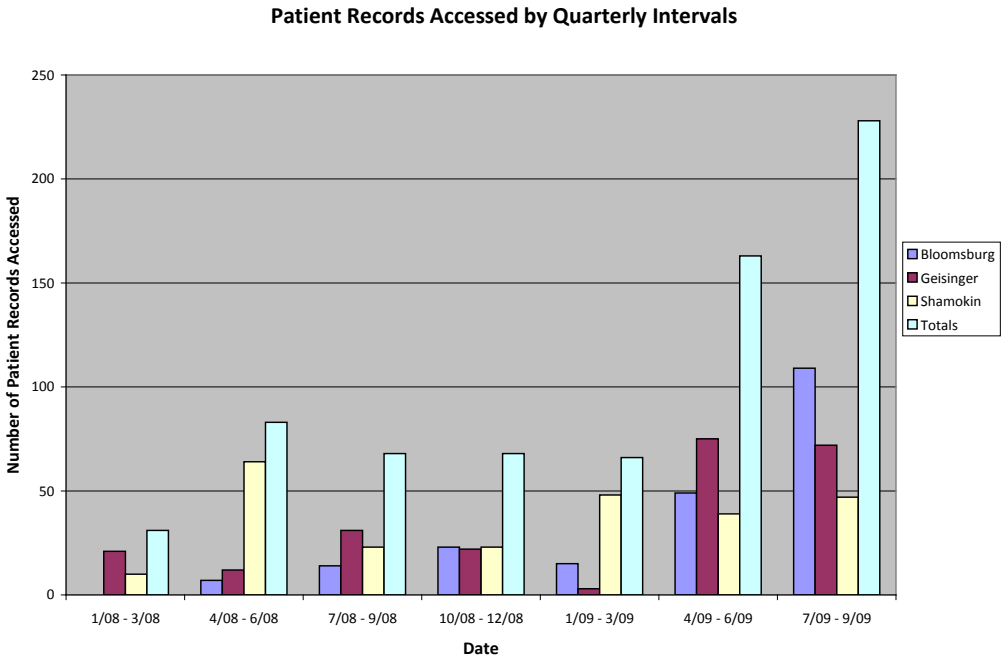
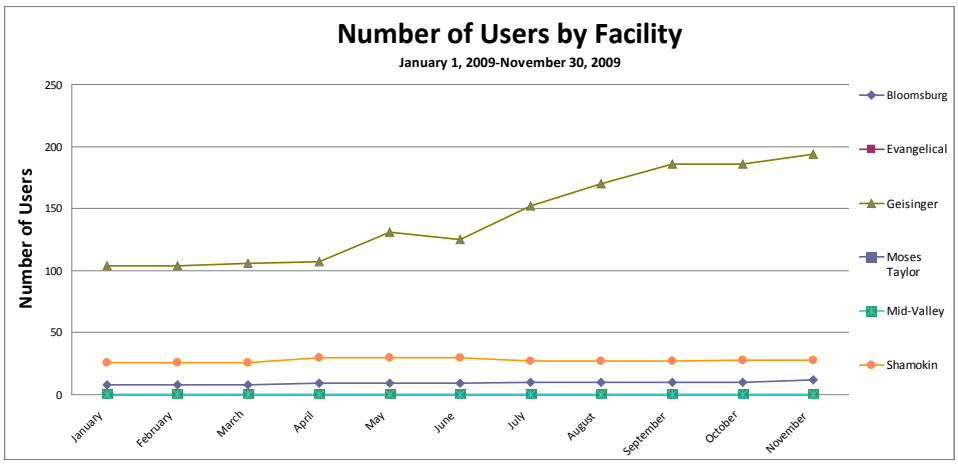


Figure 2.



Section 3.0 Managing patient identity in an HIE

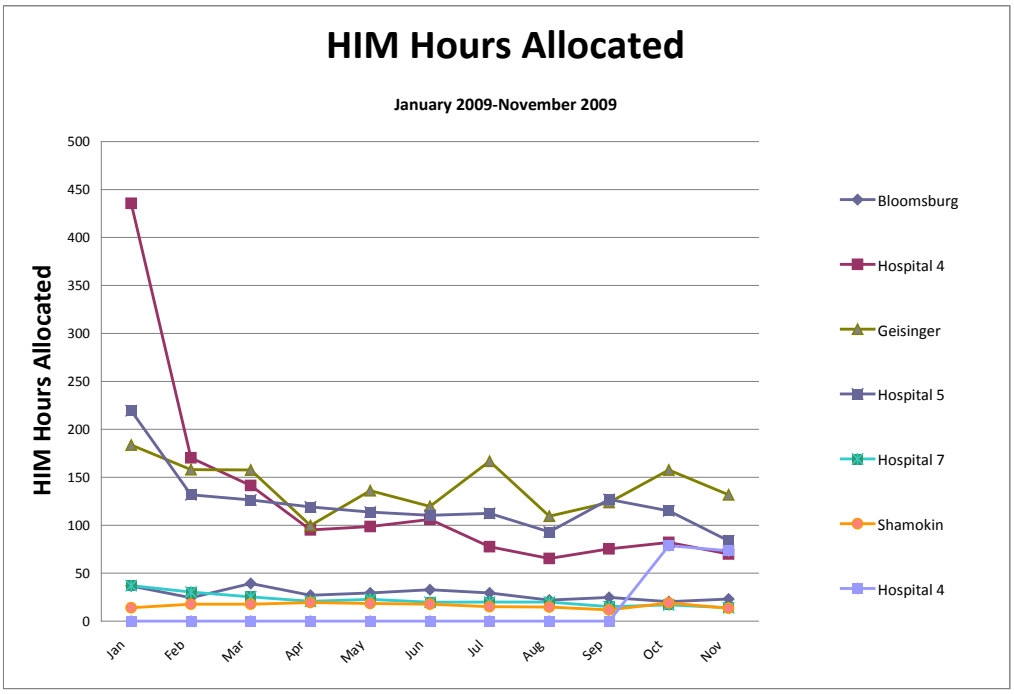
One of the greatest technical challenges of managing health information exchange is the correct identification of patients cared for by multiple organizations. Most HCOs use a medical record number (MRN) to identify patients within their facility. Because patients are registered in a variety of settings, the creation of duplicate MRNs is a common occurrence. Typically, health information management (HIM) staff are employed to review potential duplicate records and correct them by merging duplicate records, usually under the original MRN. The need for this service is compounded when MRNs from multiple organizations must be managed within an HIE.

In our model, when a new patient is registered at a facility, their registration information is sent to the exchange to be linked within the community master patient index (CMPI) using a probabilistic matching algorithm. If the CMPI determines that there is another MRN from the same facility that matches the new record, an error message is generated so that the problem can be reported back to the registering facility for correction. If there is no interfacility duplicate, the CMPI software attempts to link the record from one HCO to records from other facilities. If the algorithm identifies a high-probability match, the record will be linked to the patient record of another facility. If the score indicates that there is no match, it will generate a new record in the exchange database. If, however, the score is high enough to indicate a possible match but too low for an automatic match, the record will be listed in a report of "probable" matches that will require additional manual intervention. By using other software, HIM staff attempt to gather additional information to determine which records can and cannot be linked. We have found that it takes an average of 20 minutes to resolve these duplicate records. At an average HIM salary of $35 per hour (including benefits), we have estimated an average cost of $11.67 to correct each patient record that requires HIM manual intervention.

Figure 3 shows the number of hours of manual intervention required by each facility in 2009 (Jan – Nov). Based on 4,442,894 total encounters in the 11-month period and a total of 5,193 hours needed for HIM manual intervention at a cost of $35 per hour (total cost of $181,755), the cost per encounter is approximately 4 cents ($181,755/4,442,894 = .0409). According to these calculations, KeyHIE needs 2.72 FTEs to complete this work (5,193/1,907). However, due to budget constraints, we are currently limited to 2 HIM FTEs. This means that the staff are not able to keep up with the records needing processing. Our solution is to have HIM staff work on the most recent records, leaving the older records to accumulate with little chance for resolution. Although inadequate, this

approach at least maintains the records that are more likely to be needed by clinicians (those of patients more recently seen at another regional facility).

Figure 3.



Section 4.0 Community Lab Interface to Electronic Health Records

The first community lab interface was implemented with Shamokin Area Community Hospital on January 30, 2007. More than 2,400 results were interfaced from Shamokin's lab into Geisinger's EHR over a 6-month period – ending July 31, 2007. Of the 526 distinct (orderable) tests that were initially mapped for Shamokin's test catalog, only 86 (16%) were sent across the interface during that 6-month period. More details on this project are included in appendices L and M.[12]

Initial development costs were approximately $135,000. Additional hospitals can be added at an estimated start-up cost of $66,000 and annual maintenance cost of $36,500 each. Only 1.2 percent of results require manual intervention, at an estimated cost of $206.25 per 1,000 results processed. Typical mapping time per test is about 30 minutes for an inexperienced person, whereas an experienced person can map a test in about 15 minutes. We received 285 labs in the past 12 months of our study through our interface.[13]

Lessons Learned:

- Some interface customization for each participating organization may be unavoidable. See "Laboratory Interoperability: A Closer Look" for details.[14]
- The community hospital's LIS must be able to differentiate which results will be sent via the interface and which are sent regularly (print or fax).
- One of the participating hospitals volunteered to send results that include the LOINC® value as part of the result. This enables the interface logic to translate directly to the EHR local

code. Hospitals that use LOINC® for their local codes can send those results to any other organization that uses LOINC® with minimal translation.

- Maintenance of lab code mappings to their associated LOINC® values requires continuous monitoring. We developed a web-based tool to allow community hospital personnel to notify us of new tests to be mapped.
- This data-level interface requires much more coordination between the IT teams of the participating organizations. Hardware or software upgrades to either hospital information system can degrade the function of the community lab interface.
- Some tests are not performed by the community hospital lab and are referred to another lab. Results from reference labs may complicate a community lab interface, depending on whether those results are received electronically or on paper.

We have developed a low-cost system for electronic sharing of regional lab results along with tools for making the system easy to replicate. A provider satisfaction survey was administered in 4Q 2008 to determine the effectiveness of the community lab interface from Shamokin. Of the 32 respondents, 24 were physicians, three were nurses, and five were office staff. There was strong agreement that the lab interface allowed this work to be completed quickly and efficiently and that it helped clinicians avoid patient care errors, thus delivering higher-quality patient care. See appendix O for complete results.

Section 5.0 Keystone Health Information Exchange Governance

Governance

The first order of business for the KeyHIE leadership team and the initial KeyHIE participants was to establish an evenhanded, transparent, and trusted governance structure. The leadership team spent approximately 20 hours in joint meetings with all participating HCOs and 14 hours in individual meetings with teams from each participating HCO. The purpose of these meetings was to create a shared understanding of the goals of KeyHIE and the strategies we would use to accomplish them. Although the leadership team had personal experience working on small-hospital IT teams, the most surprising and important lesson of these planning meetings was that all three small hospitals' IT teams were even more resource constrained than anticipated. A typical IT team was composed of three people, which meant that, if one was sick or on vacation, it was not feasible to accomplish any work beyond maintaining core IT systems. Because of these resource constraints and at the urging of the small participating hospitals, we developed a working relationship in which the leadership team designed each phase of the project, with the other participating hospitals reviewing the plans as carefully or as little as they wished. Especially as the project progressed and working relationships matured, this working relationship met the needs of the participating hospitals for both meaningful input and efficiency. (As KeyHIE expands, we believe that this face-to-face, trust-based working relationship will need to be increasingly supplemented with more formal governance.)

Market Readiness

In January 2005, to understand the region's readiness for HIE, we invited the CEO, the president of the physician group, and the CIO of every regional hospital to complete a survey questionnaire regarding their perception of their community and hospital's need for, readiness for, and ability to participate in a regional HIE (with up to three follow-up invitations to nonresponders).[1,2] In May 2005, we invited all 53 hospitals in the region to an organizing conference.[3] Finally, in July 2007, we repeated the survey to measure any changes in regional readiness, inviting 47 hospitals to respond.[6]

Both to make the workings of KeyHIE as transparent as possible and to increase market readiness for HIE, we continued to include all hospitals, then (beginning in November 2008) all HCOs, in nonconfidential KeyHIE communications and invitations to participate, in the belief that different HCOs would see a business case for participating (and have the IT and other resources needed to participate) at different times.

Consumer Confidence

We communicated the goals of KeyHIE and the safeguards on information security and patient confidentiality to the public by way of pamphlets distributed by participating HCOs (hospitals and practices initially), press releases to regional newspapers, and public television programs. We measured consumer confidence in KeyHIE by the percentage of patients who were offered a consent form to share their information via KeyHIE and who accepted the offer.

Patient consents:

- Pilot hospitals have an average acceptance rate of 88.5%.
- One post-pilot hospital accepted verbal consent and had an acceptance rate of 95.3%.
- Another post-pilot hospital implemented a written consent form that was different from the pilot hospitals and realized only a 3% acceptance rate.

Success Factors

We anticipated that the following project characteristics would contribute to the project's success:

1. Reliable, publicized patient privacy
    a. A patient must authorize in writing the sharing of their information in KeyHIE. (Only the record of HCOs where the patient has received care can be viewed without a patient's consent. KeyHIE includes no HIV/AIDS clinics, substance abuse treatment centers, or other HCOs whose identity would, by itself, reveal sensitive patient information.)
    b. Only licensed clinicians, who are credentialed by a participating HCO and attest to a treatment relationship with the specific patient, may access KeyHIE information.
    c. These safeguards have been publicized throughout the region through press releases and marketing brochures.

2. Usability.
    a. KeyHIE's low-cost, low-technology-requirement design requires only minimal technical and administrative resources:
        i. The only requirements to access KeyHIE are (electronic) signing of the patient privacy agreement and access to a computer with a web browser and internet access.
        ii. A basic electronic ADT (Admission, Discharge, Transfer) interface through a secure VPN (Virtual Private Network) internet connection.
        iii. Medical records personnel resolve duplicate patient records that cannot be resolved by a computational algorithm. (This cost amounts to 310 person-hours per year, or approximately $10,800 per year for a 70-bed hospital.)
    b. KeyHIE's web portal's user-centered design was intended to make it easy to learn and quick to use.
    c. Facilitated Access to Regional EHRs – We tested the hypothesis that faster, easier access to regional EHRs (through single sign-on) would make KeyHIE more useful to clinicians by

providing access to much more complete patient information than would be available directly from KeyHIE.

3. Usefulness (minimum information adequacy)
    a. Although the information available through KeyHIE for a specific patient might be sparse, clinician interview indicated that even the minimum information that a patient had previously been cared for at another regional HCO can be valuable, prompting a telephone call to that HCO's medical records department if no further information is available electronically.
    b. The initial input Geisinger's substantial electronic information on most of the patients in the region created the likelihood that at least some information was available on most patients.

LIST OF PUBLICATIONS AND PRODUCTS

Walker JM, Younkin JR. Poster: The Right Information, Right Now. First Northeast US Healthcare Trade Faire and Regional Conference, sponsored by Western Pennsylvania Health Information Management Systems Society Healthcare; 2007 May 11; Pittsburgh, PA.

Walker JM, Younkin JR. Web-based tutorial: LOINC for the Laboratory – A Primer for mapping laboratory codes to LOINC. First Northeast US Healthcare Trade Faire and Regional Conference, sponsored by WPHIMSS (Western PA Health Information Management Systems Society Healthcare); 2007 May 11; Pittsburgh, PA.

Younkin JR. Presentation: Regional Health Information Exchange. Nuts and Bolts of Health Information Exchange, sponsored by Geisinger Health System and the Pennsylvania eHealth Initiative; 2007 May 16; Harrisburg, PA.

Younkin JR. Presentation: A RHIO Journey thru Rural Pennsylvania. Health Policy and IT Initiatives, sponsored by Delaware Valley Information Management Systems Society; 2007 January 9; Malvern, PA.

Younkin JR. Presentation: Data in Motion. Data at Rest. . . Data in Motion: Information Management Strategies and Case Studies, sponsored by Delaware Valley Information Management Systems Society; 2007 June 7; Malvern, PA.

Younkin JR. Workshop: Laboratory Interoperability. Laboratory Interoperability Workshop, sponsored by the Geisinger Health System; 2007 September 20; Danville, PA.

Younkin, JR. Poster: Cost Effective Lab Interoperability. AHRQ 2007 Annual Conference; 2007 September 27; Bethesda, MD.

Younkin JR. Presentation: Keystone Health Information Exchange Overview. Pennsylvania eHealth Initiative All-Committee Meeting; 2007 October 24; Harrisburg, PA.

Younkin JR. Presentation: Keystone Health Information Exchange Overview. IHE – North America Connect-a-thon and Conference 2008, sponsored by Integrating the Healthcare Enterprise; 2008 January 29; Chicago, IL.

Younkin JR. Presentation: Keystone Health Information Exchange Overview. Canadian Reception at HIMSS 2008, sponsored by the Ontario Chapter of HIMSS; 2008 February 25; Orlando, FL. February 25, 2008

Younkin JR. Presentation: Keystone Health Information Exchange Overview. Pennsylvania eHealth Initiative All-Committee Meeting; 2008 October 3; Harrisburg, PA.

Younkin JR. Presentation: KeyHIE: IHE Deployment Case Study. HIE Symposium, HIMSS09 Annual Conference; 2009 April 6; Chicago, IL.

Younkin JR. Presentation: Keystone Health Information Exchange Demonstration. Pennsylvania eHealth Initiative All-Committee Meeting; 2009 May 4; Harrisburg, PA.

Younkin JR. Panelist for webinar: Health Information Exchanges (HIEs) in the Real World, sponsored by Health Information Technology Standards Panel; 2009 July 9.

Walker JM, Younkin JR. Brochure: Keystone Health Information Exchange A Growing Pennsylvania Collaborative; 2009 May.

Walker JM, Younkin JR. Flyer: How Much Will A Hospital Know About You When Seconds Count; 2009 May.

FOOTNOTES:

1 Younkin, JR. Regional Health Information Needs Assessment Survey 2005. Keystone Health Information Exchange. https://www.keyhie.org/resources/documents.cfm

2 Younkin, JR. Regional Needs Assessment Survey Results. 2005. Keystone Health Information Exchange. https://www.keyhie.org/resources/documents.cfm

3 Younkin, JR. Café Workshop. May 2005. Keystone Health Information Exchange. https://www.keyhie.org/resources/documents.cfm

4 Younkin, JR. KeyHIE Memorandum of Understanding. November 2009. Keystone Health Information Exchange. https://www.keyhie.org/resources/documents.cfm

5 US Census Bureau. http://factfinder.census.gov/home/saff/main.html?_lang=en (retrieved 12/17/2009).

6 Younkin, JR. Regional Health Information Readiness Survey. 2007. Keystone Health Information Exchange. https://www.keyhie.org/resources/documents.cfm

7 Younkin, JR. Community Lab Interface Survey Results. 2007. Keystone Health Information Exchange. https://www.keyhie.org/resources/documents.cfm

8 Younkin, JR. KeyHIE Regional Portal Survey. 2009. Keystone Health Information Exchange. https://www.keyhie.org/resources/documents.cfm

9 Stiell A, Forster AJ, Stiell IG, van Walraven C. Prevalence of information gaps in the emergency department and the effect on patient outcomes. CMAJ 2003;169:1023– 8.

10 Younkin, JR. KeyHIE Hybrid Model. 2009. Keystone Health Information Exchange. https://www.keyhie.org/resources/documents.cfm

11 Davis, FD. A technology acceptance model for empirically testing new end-user information systems: Theory and results. (Doctoral dissertation, Sloan School of Management, Massachusetts Institute of Technology) 1986.

12 Younkin, JR CLI Implementation Case Study. 2007. Keystone Health Information Exchange. https://www.keyhie.org/resources/documents.cfm

13 Younkin, JR. Most Common Interfaced Tests. 2009. Keystone Health Information Exchange. https://www.keyhie.org/resources/documents.cfm

14 Younkin, JR. Laboratory Interoperability: A Closer Look. 2007. Keystone Health Information Exchange. https://www.keyhie.org/resources/documents.cfm