Using IT to Improve Medication Safety for Rural Elders

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Abstract

Purpose: Our goal was to get clinicians on the same page about their patients' medications. Focusing on rural elders in long-term care, the aims were to forge an organizational structure for secure data sharing; implement a technical architecture enabling access to disparate systems; develop a prototype that integrates shared medication information into clinical tasks; and complete a formative evaluation of system impact.

Scope: People with chronic conditions receive care in multiple settings, each with a separate medication list. Discrepancies among lists are a threat to the quality and safety of care.

Methods: Technology implementation and demonstration with community guidance, participatory design, and qualitative evaluation.

Results: We failed to engage all the organizations needed for our vision, and failed to achieve complete integration into existing systems. We succeeded at engaging the community; forging a core of organizations actively contributing data and expertise; implementing a prototype which clinicians found useful for common tasks; and completing formative evaluation of its impact. We identified two formidable barriers: (1) the absence of universally adhered to technical standards for exchange of health data (technical interoperability) and (2) the absence of a policy and regulatory environment that ensures true portability of each patient's health information (organizational interoperability)..

Key Words: medication safety, medication management, interoperability, standards, long term care, rural, elders, chronic conditions

Final Report

Purpose

The overall goal of this project was to enable clinicians to be on the same page about their patients' medications. We initially proposed to implement and evaluate a patient centered medication information system, RxSafe, that could improve the care of frail, chronically ill elders residing in long-term care settings in rural Oregon. The specific aims of the project were:

1. Provide secure access to accurate, complete, and current medication information for patients, clinicians, pharmacists, and nurses involved in prescribing, dispensing, and administering medications to elders;

2. Reconcile differences in medication information in the separate and often discordant information systems of participating clinics, pharmacies, hospitals and care facilities;

3. Reduce medication errors and adverse effects by eliminating interactions, duplications, and age-inappropriate medications or dosing;

4. Provide a platform to support evidence-based decision support and public health monitoring to improve the quality and reduce the costs of care;

5. Assess the benefits and costs of the system through comprehensive evaluation; and

6. Expand and extend this model of information integration statewide and beyond via the Oregon Rural Practice Based Research Network (ORPRN).

Scope

Background

Consider the following case:

> *A sixty nine year old woman was brought to the clinic by her daughter because of problems controlling her diabetes. In the previous twenty four hours the woman's blood sugar had fallen to a dangerously low level of 29 mg/dl, and then risen to over 400 mg/dl. Until recently, the woman had been bright and fully functional, keeping her diabetes and high blood pressure in control with a complex insulin regimen, beta blocker drugs, and the help of an endocrinologist as well as her primary care physician. Unfortunately, she developed progressive cognitive decline with severe memory loss, and had to be moved to a foster care setting. Since then, control of her diabetes had*

been problematic. In the clinic her physicians sought to review her medication list – but which one? There was one medication list at the foster home, another kept by her very attentive daughter, a third in the electronic medical record of her primary care physician, yet another at the office of her endocrinologist, and perhaps others at the pharmacy, hospital, or elsewhere. These medication lists, created and maintained by various clinicians carrying out differing roles within separate organizations, did not match – so it was impossible to be certain exactly what her medication regimen was supposed to be, and how to change it so these dangerous fluctuations in blood sugar could be avoided.

Unfortunately, episodes such as this are all too familiar to nurses, pharmacists, physicians, and others involved in managing medications for patients with chronic conditions. Health information technology (HIT) has been introduced to help address the challenges of medication management, but a major barrier to realizing the benefits of these technologies is the lack of information integration across organizations. The "stove piping" of clinical data into often incompatible information systems creates what McDonald has called "islands of data" [McDonald, 1997 #1]. A recent Institute of Medicine (IOM) report emphasizes this problem in the care of those with chronic illness: "The fact that more than 40 percent of people with chronic conditions have more than one such condition argues strongly for more sophisticated mechanisms to communicate and coordinate care. Yet physician groups, hospitals, and other health care organizations operate as silos, often providing care without the benefit of complete information about the patient's condition, medical history, services provided in other settings, or medications prescribed by other clinicians." [Institute of Medicine (U.S.) Committee on Quality of Health Care in America. 2001 #7]

The availability of complete and accurate clinical data is especially important for medication information, and this is particularly true in the case of frail, chronically ill elders who reside in long term care settings such as Assisted Living and Skilled Nursing Facilities. Older adults, in particular these long term care residents, are at greater risk for medication-related problems by virtue of their advanced age, frailty, use of high-risk medications, and multiple care providers. These issues may be amplified in rural areas, where elders are at greater risk for chronic illness and functional impairment, where health services may be more limited, and where health care systems and facilities are more isolated from one another. Medication related risks may also be magnified in Assisted Living settings, due to problems in providing appropriate medications, providing sufficient staff supported with adequate training, and providing appropriate monitoring of patient care.

The existence of multiple medication lists, and the discrepancies that exist among them may contribute to errors of omission as well as errors of commission. If needed medications are not present on the list being used by the patient or their health care facility, the patient is denied the benefits expected by the prescriber, with the potential for worsening symptoms and functional status and increased service utilization. When discontinued medications remain on the list being used to administer medications the potential for overmedication or unrecognized drug interactions exists. When computer systems providing advanced decision support features are being used, the potential to identify drug-drug interactions, drug-disease interactions, or drug allergies can be limited by incomplete or inaccurate data. Furthermore, in the face of discordant or incomplete information, clinicians currently invest substantial time and energy to identifying and correcting discrepancies in the medication lists of their patients.

To benefit from the decision support features of contemporary health information technology, not to mention the expertise of modern multidisciplinary care teams, a single, accurate, complete, and current medication list must be available. The RxSafe project was meant to help address this need.

Figure 1. Conceptual model of RxSafe—a single accurate, current, complete medication list shared by clinicians involved in prescribing, dispensing, administering, and monitoring patients' medications
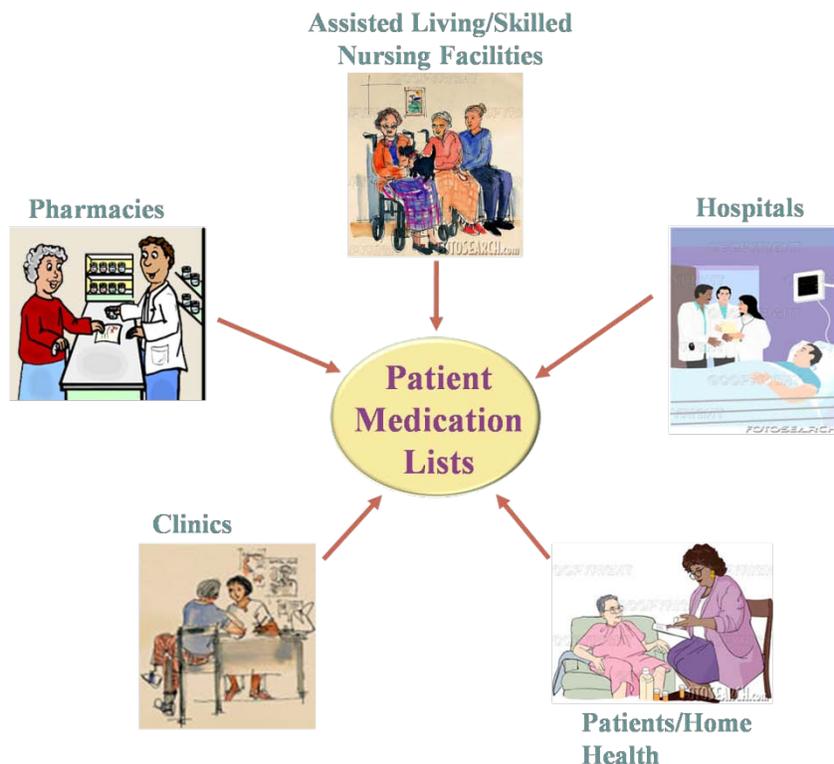
Context

Situated in a rural area on the Oregon coast, this project was the work of a consortium consisting of three main elements: (a) local health care providers and community organizations with a record of effective collaboration and technology implementation; (b) organizational and financial support provided by the Oregon Practice Based Research Network (ORPRN); and (c) scientific and technical expertise from a group of university-based faculty in computer science, medical informatics, family medicine, nursing, pharmacy, and epidemiology.

Although relatively isolated on the Oregon coast, the rural community of Lincoln City enjoys a rather advanced degree of health information technology implementation. The major physician practices in the community have well-established electronic medical record systems in place, and have already attempted such innovations as electronic prescribing, remote connection from the hospital, and some degree of integration through the use of a shared master patient index.Local community groups have obtained funding to install video conferencing equipment in hospital and health facilities. All pharmacies serving elders in the community use organization-specific

software to manage medication dispensing. The local hospital has pharmacy, results reporting, and administrative computer systems in place. And the long term care facilities make extensive use of the services of long term care pharmacies, which are supported by computer based medication management systems. As a result, the community appeared technologically and professionally ready for further innovation in support of medication management.

Leveraging consortium members' existing technology, the RxSafe project was intended to provide integration among these isolated medication information systems to produce a single, shared medication record that could support prescribing, dispensing, and administering medications with minimal disruption of work practices (see Figure 1). A multi-institution planning process led by Samaritan North Lincoln Hospital (SNLH, the lead partner) initiated the project and led to commitments of resources from a critical mass of local health care organizations in order to ensure community-wide implementation and diffusion of the system. We expected that this would result in sustained use and that the project would serve as a model for expansion to other communities, as well as provide a platform for enhancement with decision support, evidence-based prescribing, and pharmaceutical and epidemiologic surveillance.

Table 1. Clinical provider organizations

Organization	Project Status
Samaritan North Lincoln Hospital	core
Lincoln City Medical Center	core
Samaritan Coastal Clinic	core
Bayshore Family Medicine	core
Lincoln City Rehabilitation Center	core
Hillside House Assisted Living Facility	inactive
Lincolnshire Assisted Living Facility	partial
Senior Pharmacy	core
Preferred Pharmacy	declined
Safeway Pharmacy	partial
BiMart Pharmacy	declined
Rexall Pharmacy	closed
Rite Aid	declined

Setting and Participants

To make such a project feasible, we initially chose to contain the problem by limiting it to one patient group that would stand to benefit most from improved medication management: elders with chronic conditions residing in long term care facilities. The community includes three such institutions: one skilled nursing facility and two assisted living centers, with a combined census of up to 150 residents. The initial aim was to include all organizations involved in prescribing, dispensing, administering, or monitoring medications for these 150 people. This geographically limited setting includes three long term care facilities, one hospital, four physician practices, four retail pharmacies, and two long term care pharmacies.

To provide needed clinical and technical expertise, the project drew on academic resources of Portland State University, the College of Pharmacy at Oregon State University, and multiple elements of Oregon Health & Science University including the Department of Medical Informatics and Clinical Epidemiology and the Department of Family Medicine in the School of Medicine, as well as the School of Nursing and the School of Science and Engineering. To

connect these disparate and distant organizations, the Oregon Rural Practice Based Research Network and Samaritan Health Services provided administrative and logistic support.

Methods

Design

In reviewing options for achieving the goal of a single, current, accurate, and complete medication list for every patient, we believed that the two approaches with the highest chance for success suffered from limited generalizability. The first of these would be to confine the project to a single health care system, allowing for coordinated organizational efforts that could lead to integration of work processes and technologies, whether single-vendor or best-of-breed, resulting in integrated medication information across an enterprise. The second of these would be to confine the project to a single health IT vendor, allowing for potentially easier technical integration, provided the organizational barriers could be surmounted. Examples of both of these approaches exist, although full integration of medication information has been difficult to achieve, even with these constraints. We assumed that for the most part, physician practices, pharmacies, hospitals, and other organizations would continue to operate independently, choosing a variety of health IT solutions to meet their varying needs. Under this assumption the more challenging but more generalizable approach would be to attempt to achieve integration across both organizational and technical barriers. We chose to focus our efforts on this more risky but hopefully more generalizable approach.

During the first year of the project as we made the transition from the Memoranda of Understanding that we developed at the time of our proposal, to the full Business Associate Agreements and Data Use Agreements required to share patient data among participating institutions, it became clear that we would not have enough participation by the requisite organizations to achieve our initial vision of fully integrated medication information with two-way flow of information across organizational and technical boundaries. We therefore revised our aims from the complete implementation envisioned in the Specific Aims in our proposal and listed above, to a demonstration project which, if successful, might entice or compel non-participants to get involved. Under this revised plan developed during year two of the project, our approach was to focus on a core group of participating provider organizations with the aims to:

1. create and maintain an organizational structure that would permit secure sharing of patient data across disparate institutions;

2. design and implement a technical architecture that could enable clinicians to view medication list information from multiple sites at the same time;

3. create a useful and usable prototype application integrated into clinical workflow that could take advantage of this shared medication list system;

4. conduct a formative evaluation of the impact of this system on clinical users.

Intervention

Overview. The RxSafe system is meant to help nurses, doctors, and pharmacists to be on the same page when it comes to the medication lists of these residents. To do this RxSafe is designed to connect the disparate medication information systems of clinics, pharmacies, and facilities, employing the evolving national e-prescribing standards, and where possible working within the Common Framework that has been developed by the Connecting For Health initiative. Currently the system successfully incorporates data from multiple systems, providing the ability for a clinician to review and compare the medication information for a single resident from a hospital, care facility, pharmacy, or physician's clinic.

Technology. RxSafe is targeted at providing a consolidated view of mediation information for a patient, even though that information may be in disparate formats and held by a variety of sources, including hospitals, clinics, pharmacies and assisted living facilities. RxSafe maintains a repository of patient medication information from these primary sources, providing a single-point of interface for presentations of this collective information.

The current RxSafe system has three main components: handling data acquisition, repository management, and information presentation. Data acquisition covers extraction, transport and upload of patient medication information from participating sources. There is no single approach that works for the full range of systems we have encountered, and thus we accommodate a variety of mechanisms for acquisition, including data export interfaces, direct database access and message-stream monitoring. The repository maintains acquired records in both original form and in a common structure. It tracks the origin of all data it manages, and also provides authorization and use-auditing services. Our presentation layer provides a web-based interface to the data in the repository. It currently supports a Consolidated Medication List (CML) interface to patient medication information from multiple sources, and is being extended with other capabilities, such as generating a base-point medication list to support medication reconciliation tasks.

We have been working on incorporating drug information from national standards such as NDC codes (drug packages), RxNorm (drug nomenclature), and NDF-RT (drug class, mechanism of action, physiologic effect). This supplemental knowledge will support the development of additional RxSafe capabilities, such as a) Record linking (e.g., via a mapping from NDC number to drug name, or between generic and brand names); b) Enhanced information display (e.g., alternate names, ingredient lists), or c) Alternate presentation (e.g., medications grouped by drug class).

Figure 2. RxSafe same page view
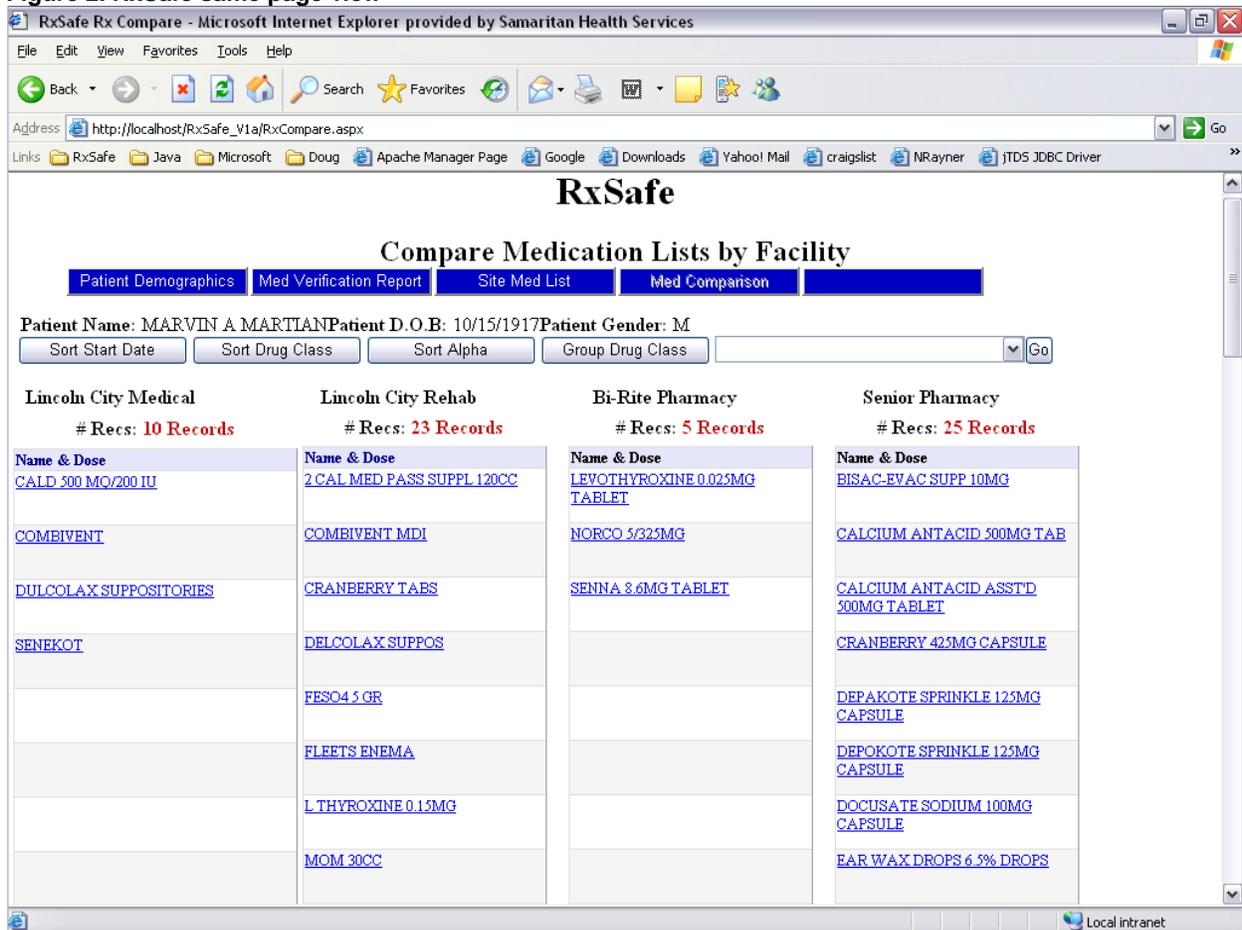
We could have made our lives much easier if we had chosen to develop an RxSafe prototype in a laboratory setting with simulated information sources. However, the applicability of results obtained in that context to real-world settings would be tenuous. Instead, we have chosen to locate our development efforts in the field, and work with data from actual facilities, in order to understand and address the organizational, architectural, data quality and standards issues that arise in practice.

For example: In the area of RxSafe software design, we are often asked why we have not adopted an approach using a Record Locator Service (RLS) to dynamically retrieve medication information on a patient on demand, in a peer-to-peer manner, instead of our current approach of replicating that information in a repository. Our experience is that a fully dynamic approach is not currently feasible due to a variety of factors, including:

1. The participating information sources are not always available on-line outside of business hours.

2. The participating organizations are concerned about extra processing load on their systems from frequent external accesses, which might interfere with normal operations.

3. Those organizations would also prefer to have a single, well known external system accessing theirs, rather than having to provide direct access to multiple end-user systems.

4. The information we are given access to is not always in the form of a stored database that supports a query interface. For example, with a local hospital, we are getting information by monitoring their internal message stream of medication orders.

We have found, interestingly enough, that systems pointed out to us as examples of a dynamic-access RLS architecture actually turn out to use data replication. (We note that the RxSafe architecture does not rule out the use of RLS services for data acquisition, nor of on-demand refresh of a patient's information in the future.)

In terms of data, we are addressing several issues. One is that the same information can manifest itself in non-identical forms in different systems. For example, a prescription may appear in a clinic's order-entry system, as a dispensing record at a pharmacy, as an authorization message to a prescription benefits manager (PBM) clearing house, and as an entry on a medication administration record (MAR). These different "traces" of the same prescription may vary, for example, because a pharmacist is allowed to make certain substitutions (two 10mg tablets for one 20mg tablet, generic equivalent for brand-name drug), or because some information is suppressed. (For example, messages to a PBM might not include the SIG--frequency, dose and route of administration--but might include the NDC number of the specific drug package, which was not part of the original physician's specification.) Connecting information from different sources about the same prescription is also complicated by the wide variation in the granularity to which health information is divided. For example, at one of the retail pharmacies, a single prescription record can contain multiple transactions that represent initial dispensing, modification of prescription, refills and discontinuation. At the other extreme, at the hospital, what is conceptually one prescription repeatedly appears in the message stream we monitor as distinct daily dispensing orders to the pharmacy.

We have also been coping with a variety of information models across our different sources. Some representations of medication information (e.g., in prescription orders and medical histories) are very lightly structured, especially in systems used in individual offices and clinics. The medication description can be a single text field with no reliable delimiter between drug name, strength, dose form, etc. Other systems, particularly at pharmacies, divide this information among structured fields, though often labeled differently (or more vexing, with similar field names meaning different things). Even when information is structured, there may not be consistency among users in terms of how fields are used or consistency in values (e.g., drug names).

In our efforts to incorporate national standards for representation and coding of medication related information we have uncovered compatibility issues. The designated standards for e-prescribing were developed independently and are not always easily connected. For example, RxNorm from the National Library of Medicine is the standard for drug nomenclature, giving both generic and related brand names. The National Drug File – Reference Terminology (NDFRT) from the Department of Veterans Affairs contains drug classification information, connected with generic names. In trying to connect brand names from RxNorm, through generic names to drug classes in NDF-RT, we found that only 54% could be readily connected. As a second example, in comparing the 18,000 trade names in the National Drug Code (NDC) data from the FDA with the 7,600 brand names in RxNorm, we found fewer than 500 exact matches.

Scripting formats being standardized for prescription messaging sometimes omit important information. For example, the "medication history message" in the National Council for Prescription Drug Programs (NCPDP) SCRIPT standard allows querying a PBM for all prescription authorization requests for a given individual. However, that message does not contain any SIG information for the prescriptions, which is essential for the context of our system, day-to-day patient level medication management.

Currently we have adopted RxNorm at least partially, having extracted a table out of RxNorm that contains a list of drugs along with drug classes. We have begun using this table to explore the possibility of assigning the medications to a drug class for subsequent work (see Research Plan). This table includes brand names and ingredient names from RxNorm (in one drug name field for seamless lookup) linked to classes from NDF-RT. Only single ingredient drugs are included. We are still working on a way to deal with multi-ingredient drugs.

Security and Privacy. Privacy and security are integral pieces of RxSafe, and will continue to be in the ongoing project from proposal development and project organizational development through system planning, design, development, operation, data analysis and post-project cleanup. We considered security as an integral part of our proposal. Following the award, one of our first actions was to establish contact with all the entities whose participation was needed to acquire copies of their security and privacy policies and forms and begin discussions toward developing data use and business associate agreements. We assessed the relative computer sophistication of our participants and their understanding and experience with protecting the privacy and security of electronic protected health information (phi). We contacted key security and privacy officials of the primary participants and began developing a risk assessment using National Institute of Standards and Technology (NIST) 800-30, "Risk Management Guide for Information Technology Systems" as our guide early in the design phase even before hiring our software engineer. Our view is that risk management in general and the risk assessment in particular are not only required to comply with regulations and our grant but are also a fundamental part of ensuring that we view the project holistically and that all the participants are able to confidently and competently share sensitive data without incurring excessive risk.

While we have already completed our initial pass through the recommended steps to develop a risk assessment (system characterization, threat identification, vulnerability identification, control analysis, risk determination and control recommendations and action plan), we view this as a necessary ongoing process to ensure we have current and effective technical, administrative and physical controls. Our risk assessment was a key consideration in developing our system architecture, which is characterized by defense in depth to prevent failure or penetration of any single piece from risking the confidentiality, integrity or availability of phi.

This defense in depth approach led us to segregate the database containing phi from the web server, which also provides separate data communications between the data base and remote data sources. The database and web servers are implemented using fundamentally different technologies (Windows and Linux) to minimize risk of a successful "zero day attack" and are separated by firewalls, and there is additionally a firewall between the web server and the Internet. The web server and all web pages use Java and follow best practices. The web server process itself runs as an unprivileged user and directory permissions are set to help prevent a hacker from breaking out of the web directory should they somehow find or exploit a new hole in the web application.

No phi is stored on the more exposed web server. All communications with the web server are encrypted. All data access requires a user name and password, which are retained on the more-protected database server. Data transfer from remote databases is automated using unprivileged processes on the remote database to securely transfer data to directories on the web server where a separate process immediately transfers the data to the database server and scrubs the local directory. Research data is electronically de-identified before being deposited in directories that are available only to participating researchers with current user names and passwords. We anticipate further reviews of the technical, administrative and physical controls once the project moves past the prototype stage, and for the life of the project.

Authentication and Access Control. Our overall design includes the use of open source tools wherever possible, adherence to evolving and emerging standards, and alignment, to the extent possible, with the Connecting For Health Common Framework developed by the Markel Foundation. For authentication and access control, we chose to employ the Opener approach. Opener bases their Authentication and Access Control Service (AACS) module on Java Authentication and Access Service (JAAS). They made their AACS module far more involved and complicated. Based on advice from Browser Soft - the company implementing and supporting Opener in the Mendocino County NHIN demonstration project - the current AACS module would be overkill for our project at this time. They advised us to use the JAAS module for the time being. We have employed this approach, using the JAAS module as a building block, with a plan to fully implement AACS when the need arises.

Within JAAS we have a USERNAME which is required to be at least 6 characters long and unique within the system. The PASSWORD is required to be STRONG. That is to say our passwords must be at least 6 characters long, requiring a combination of alpha and numeric characters along with special characters and upper and lower case letters. Access to our system is prevented without correct authentication. Each web page verifies there has been an authenticated user logged in. If not, the page gives an authentication error and prevents access to any information on that screen. Our patient inquire screens are based on search algorithms to prevent SQL injection. Over and above the JAAS module we have built in RIGHTS which grant or deny a user the access/ability to functions within our system.

Organizational Interoperability

To be successful, the RxSafe project must enlist the support and maintain engagement of diverse organizations which are not only operationally independent, but often are commercial entities more accustomed to competing than collaborating. It is a special challenge to surmount the logistic issues, regulatory and privacy concerns, and proprietary and commercial interests that serve as barriers to 'organizational interoperability," which must be effectively dealt with before technical interoperability and workflow integration can be achieved. In this respect, the RxSafe project is less similar to health IT projects within integrated delivery systems, but perhaps more similar, and therefore generalizable, to the broader healthcare landscape and the interoperability challenges that reside there. A major accomplishment of the RxSafe project to date has been developing and maintaining support among the leadership of a core group of organizations and community leaders. While some organizations, such as retail pharmacies that are part of large national chains, have chosen to remain 'waiting in the wings,' the support of the core group and the active 'pull' from community leaders involved in the local Chronic Care

Committee have helped to ensure the project's continuing success, and will be essential to the success of future development.

At a more local level another major challenge to implementation has been turnover. We somewhat expected the lower wage employees in facilities might have significant turnover. But to our surprise there has been continuous turnover throughout the project, from individuals to organizations. Personnel turnover at each of the organizations has been such that we are regularly meeting new personnel at our site visit meetings, from staff level to management level, in pharmacies, assisted living, and other organizations. This turnover even exists for organizations themselves, as one of the pharmacies we initially engaged closed and has been replaced by another with which we are now negotiating. Beyond the organizations themselves there has been turnover in ownership; at least one of the organizations has changed hands, affecting the ability of local management to obtain approval and backing to participate from senior management, often located across the country in another city.

This continuous turnover underscores the need for (and the cost of) more or less continuous relationship building. It is not enough – not enough by far – to obtain an agreement and move on. Without continuous engagement, and often face-to-face encounters, the close working relationships required to deploy a complex new technology in diverse organizations simply could not be maintained. Projects should budget appropriately to support this activity.

Results

Quantitative Summary of RxSafe Use

The table summarizes data reported from system logs regarding overall system use. As the table indicates, about 80% of system uses called upon a single source of patient medication information, while about 20% of the time users called upon two or more sources, suggesting that some degree of comparison of lists was taking place. The table also indicates that the medication information from the physician's office was the most often used source. It should be kept in mind that in these instances, users were most often calling up the medication list in order to print a Medication Reconciliation form, prior to taking the form to the bedside to complete the medication verification process with patient or family.

Table 2. RxSafe source list selection and comparison

Medication List Source	Single Source	Two Sources	Three Sources	Total Uses
Clinic 1	1911	204	42	2157
Hospital	57	200	42	299
Clinic 2	16	1	1	18
Home health	7	12	7	26
Pharmacy	14	15	34	63
Total	2005	432	126	2563

Formative Evaluation by Qualitative Methods

We carried out a qualitative evaluation of the impact of the RxSafe system. Post-implementation interviews of RxSafe users were conducted with clinic, hospital (Emergency Department and Day Surgery & Recovery Department), and residential care facility staff. The 13 user interviewees included nurses and technicians, mid-management hospital and residential care facility staff, and a private practice physician. Two upper management hospital staff also were interviewed for their experiences with and perspectives on the implementation of RxSafe in the hospital. Interviews were conducted by a senior research associate and the research associate who is the local study coordinator. The project PI interviewed the two upper management hospital staff together. The interviews lasted 30-60 minutes each and were audio-recorded. Users were asked to describe their experiences with RxSafe, including how they learned to use it, confidence and comfort level with using it, the kinds of tasks they use it for, when RxSafe has been really helpful, problems with using it, and what they'd like to change about it. Transcriptions of the interview recordings were reviewed both independently and then collaboratively by four members of the research team.

Preliminary results can be summarized in the following categories:

Direct Access Users / Uses. Direct users include staff from ED, Day Surgery & Recovery, and the residential care facility. ED triage nurses query RxSafe to assist with reconciling differences among medication lists and/or patient self-reports, while ED primary nurses having post-triage patient responsibility use RxSafe to resolve other medication questions. Day Surgery & Recovery nurses' direct use of RxSafe include pre-op chart preparation of patient medication lists; using information about which medications patients are taking to issue pre-surgery medication instructions to patients; warning surgeons of potential medication-related adverse events which could occur; and to generate post-surgery medication lists in the recovery room. Direct users in the residential facility use RxSafe to clarify medications when patients return from the hospital and for updating the facility charts.

Indirect Access Users / Uses. Indirect users of the medication lists printed by other staff include hospital admissions staff, ED techs, day surgery/recovery nurses, and clinic providers. Admissions staff use the lists to generate admission medication lists and to reconcile differences in their EHR medication data. The ED techs use the lists to reconcile differences with EHR data as well as to fill in missing EHR information, and for determining the appropriateness of lab tests. Some Day Surgery & Recovery staff who are not direct RxSafe users employ the lists generated and printed by RxSafe users to do pre-op chart preparation. Surgeons use the RxSafe lists to order post-surgery discharge medications, and admitting physicians use RxSafe lists to determine post-surgery medication orders. The floor nurses use the lists to reconcile orders for post-surgical patients who are admitted. The provider physician reported using the printed lists to update clinic records for his residential care patients.

Medication Management Problems That RxSafe Addresses. Interviewees noted several medication management problems that RxSafe addresses. These included: difficulty obtaining accurate, complete, current medication lists; the significant amounts of staff time and effort involved with obtaining and reconciling medication lists; diminished readability of handwritten lists.

Positive Impacts of Implementing RxSafe. Interviewees reported numerous positive impacts of implementing RxSafe. They included things such as better data access; reduced time and effort for, and simplification of, medication management tasks; improved data quality; decreases in medication errors; enhanced task integration; support for medical decision-making tasks; increased patient education; improved staff communication. Interviewees valued RxSafe in particular for increasing patient safety, noting that patient safety is increased as a result of the many positive impacts RxSafe provides.

More specific examples of how RxSafe contributes to the above impacts include the following: RxSafe provides a simplified, readily accessible starting point for documenting a patient's medications. RxSafe reduces the time and effort to do medication management tasks such as reconciling a patient's discrepant medication lists and generating a reconciled list. RxSafe medication lists can fill in gaps in the EMR medication data. ED staff use RxSafe to more readily obtain medication information in emergent situations. RxSafe also reduces the need to research other sources for medication information or to ask patients to recall their medications. As a result of time and effort saved by using RxSafe, staff has more time for patient care. Interviewees mentioned that increased safety results when medication errors are decreased during transitions in care, when many medication errors can occur.

The ability to inform clinics of the need to update their medication information increases communication among staff from multiple facilities. RxSafe medication lists can help decrease patients' confusion about what medications they're taking, and staff used the information to educate patients about potential drug interactions and the reasons for the medications. The ability to generate a printed reconciled list saves time from handwriting lists, increases the certainty of what's written and decreases the potential for misreading information in illegible handwritten lists. Staff use the printed lists as decision aids for tasks such as identifying allergies, preventing over-prescribing, and assisting with ordering appropriate lab tests. Knowing what medications a patient is taking allows pre-op nurses to make more appropriate pre-surgery medication recommendations.

Limitations and Problems with Using RxSafe. Several types of issues were mentioned as limitations or problems with using RxSafe. Issues related to usability and applicability; organizational and technical interoperability; information and technology overload; source data issues; integration with workflow and tasks; executive buy-in, and senior management and lower level staff support; the time involved to establish security policies and develop the software; lack of access to every partners' data.

Several interviewees stated that the less experienced one was with using computers and understanding query structures, the more difficult it was be to learn and use RxSafe. Some felt that the system was overly complex – too many steps or keystrokes, too much information and technology for their needs. Interviewees noted that frequently there are duplicate medication entries, which make it more cumbersome to sort through the lists. RxSafe wasn't always viewed as saving time and effort. When the medication list is short users find it can be faster to just handwrite the list. ED staff reported that sometimes it was quicker to get medication information from other sources, such as EMTs or family members, and that any saving of time is critical in highly-emergent situations. The lack of integration of RxSafe with the EHRs can sometimes require double entry of medication information, which increases time and effort.

Source data problems included inaccurate, incomplete, inconsistent, and old data. Users find that sometimes data from sources other than RxSafe are more reliable, such as patient self-

reports. In the case of recently-hospitalized patients, the hospital EHR may be more reliable because of more current updates.

Technical interoperability issues included system interconnectivity problems to the partnering sites, and lack of necessary IT staff support at the sites to address such issues. Organizational interoperability involved the unwillingness or inability of all of the partners to participate and share their data. Some of this was due to concerns with organizational privacy and competition. The positive impact of RxSafe is significantly limited by not having access to data from more than one pharmacy and one clinic. Medication information for patients not part of those participating systems cannot benefit from RxSafe, and patients who are in the participating pharmacy, clinic and/or hospital systems may also have medication information in non-participating systems, in which case RxSafe will have incomplete information for them.

There were some limitations with the software. It doesn't always perform predictably when doing queries, so users sometimes have to try different ways of entering a patient's name before the system produces the patient name they are seeking. This increases the time and effort it takes to use the system. Because the printed list is entered into the hospital's form, whenever the form is modified the RxSafe system also needs to be modified. This requires good communication to ensure that the programmer is aware ahead of time that modifications are being made. This also points to the need for ongoing technical support to maintain RxSafe. Another limitation several interviewees mentioned was that they often need other information that they can get from the EHR but not from RxSafe, such as history and physical, last clinic progress note, allergies, and the last date and time a medication was taken. Given that the EHR also has medication information, it sometimes was more efficient to just get everything from the EHR and not bother with RxSafe.

A couple of interviewees noted negative impacts on patients in addition to safety concerns. Some had experienced a loss of patients' confidence in the staff when they discover medication lists from RxSafe, upon their review, are inaccurate. Some patients expressed annoyance at being asked to review the medication information that they recently provided it to the clinic.

How RxSafe Could Be Improved. Users had several suggestions for how to improve RxSafe. Many stressed the value that would be added by expanding connections to more providers and facilities. One person wanted it to be available to the hospital floor nurses so they wouldn't have to ask sick patients for their medication information. A number of users expressed the need for system integration within and across sites – one system for all sites and the same system for the EHR and RxSafe.

Several mentioned features they would like to see added to the system. These included last date and time medications were taken; medication routes; patient allergies; medication contraindications; hospital discharge medications; history and physical; last clinic progress note; additional items such as oxygen, inhalers, implanted devices, Warfare, Depo-Provera, and birth control methods; and matching medications with diagnoses. Formatting improvements such as changing date of birth to MM/DD/YY and consistency with name formats were mentioned.

Some wanted the software to be streamlined to have fewer steps (for example, make the login more automated for frequent users; get rid of the login question "are you sure you want to go here?"), and a method for flagging duplicate medications in RxSafe to decrease effort. One person suggested having simultaneous online views of the RxSafe medication lists for the hospital and clinic so they wouldn't have to fax lists to one another.

16

Conclusions

To summarize the results of this project, it is fair to say that we failed to engage all the organizations needed achieve our vision, and we failed to achieve complete integration of our system into existing systems. On the other hand, we clearly were successful at engaging the interest and participation of the community, at forging an effective core of committed organizations who actively contributed patient data and professional expertise, at implementing a prototype application which hospital based clinicians found useful for performing common tasks, and at completing formative evaluation of its impact using qualitative methods.

In the course of the project we identified two formidable barriers to effective integration of disparate patient data, whether it be medication information or other health related data: (1) the absence of universally adhered to technical standards for exchange of health data (technical interoperability) and (2) the absence of a policy and regulatory environment that ensures true portability of each patient's health information (organizational interoperability). Each of these is a significant barrier to health information exchange and neither seems likely to become less difficult to surmount in the current health care environment.

Priority Populations

This project was concerned with secondary handling of already collected data (patient medication information), and as such did not involve recruitment of any human subjects, and hence no ethnic or minority status information is collected. The patients whose data was included comprise a small sample of elders with multiple chronic conditions residing in rural long term care facilities.

List of Publications and Products

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Project Website

http://www.ohsu.edu/RxSafe/index.html