Interconnectivity of Health Information Exchanges Using Patient Access Number (PAN)

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There has been a paradigm shift in the capturing and storage of medical records from paper-based to an electronic format. Various medical providers treat patients, and each provider creates a trail of information. Patient information sharing is essential in delivering continuous care. Health Information Exchanges (HIEs) are a possible solution to a more effective sharing of records. However, there is lack of a consistent design across HIEs: varying layouts across organizations which present barriers for the interconnectivity and sharing of medical records. This paper proposes a solution to enhance the interconnectivity of HIEs using a Patient Access Number (PAN).

INTRODUCTION

According to the United States Census Bureau, as of July 2013 there were around 316 million people residing in the United States (United States Census Bureau, 2014). The number of people per state ranges from 580 thousand to 39 million (United States Census Bureau, 2014). With this growing population, medical facilities need to maintain accurate records while providing excellent healthcare. These providers are also catering to the needs of more patients, which ultimately creates more documentation about diagnoses and medical information.

For centuries, medical facilities in the United States (U.S.) have kept paper-based records of patient's medical information. Electronic Health Records (EHRs) have taken over and continue to evolve. EHRs consolidate patient information, such as diagnoses, medications, and test results in an electronic format (The American College of Obstetricians and Gynecologists, 2010). This allows providers to deliver more

effective healthcare (The American College of Obstetricians and Gynecologists, 2010). However, a problem presents itself because patients see different medical providers for various reasons: out-of-town sickness, injuries, urgent care, among others. Each facility stores its own records and these are now siloed. This siloed approach of storing patient information prevents medical providers from seeing the holistic view of a patient's medical records. Consequently, Health Information Exchanges (HIEs) are established to facilitate the centralization of patients' records. HIEs provide timely care in emergency situations and can potentially prolong one's life. The use of HIEs makes previously inaccessible data available, resulting in the availability of more complete clinical information. This could improve the quality of healthcare for the patient (Vest, 2009, p. 223).

PAPER BASED RECORDS (PBRS)

Since the 1920's, physicians have realized that documenting patients' medical visits and history would provide a tremendous value to the physician as well as the patient themselves (Van Fleet, 2010). Once created, these Paper Based Records (PBRs) are stored within the providers' facility. The problem with this approach is that in order for a patient to have their medical records transferred to or shared with a different facility, the requestor has to fill out a request form and wait a surmountable amount of time (Samsum Clinic, 2014). According to the Health Insurance Portability and Accountability Act (HIPAA), patients are entitled to receive medical records within 30 days of receipt of the request (Robert Wood Johnson Foundation, 2012). Some drawbacks of traditional PBRs are misplaced records, illegible handwriting, and slowness of information retrieval and transmission (Pourasghar, Malekafzali, Sabine, & Fors, 2008, p. 446).

ELECTRONIC HEALTH RECORDS (EHRS) / ELECTRONIC MEDICAL RECORDS (EMRS)

Over the last several decades, medical facilities use EHRs to store patient records (Hoerbst, Ammenwerth, 2010). An EHR is an electronic collection of health information about individual patients (Gunter, Terry, 2005). Generally medical records consist of "daily charting, medication administration, physical assessment, admission nursing note, nursing, care plan, referral, present complaint (e.g. symptoms), past medical history, lifestyle, physical examination, diagnoses, tests, procedures, treatment, medication, discharge, history, diaries, problems, findings and immunization" (Hayrinen, Saranto, Nykanen, 2009).

EMRs are focused on the medical symptoms and issues of a patient rather than the psychological aspects. As a result, EMRs and EHRs are used interchangeably although EHRs are far more in-depth about describing the patient. EMRs typically have difficulty traversing outside of the organization that created the record, so in this way they are not much of an improvement over traditional PBRs (Garrett, Seidman, 2011). For the sake of this paper we will be using both of these terms interchangeably.

HEALTH INFORMATION EXCHANGES (HIES)

As technology continues to evolve in efficiency and reliability, the benefits of sharing information electronically becomes more evident. For instance, in the field of healthcare, data about a patient was previously shared between healthcare professionals via fax, telephone, or courier (Hill, 2014, pg. 13). With current technology, this information can be linked to a patient using the electronic record. Various healthcare professionals can interact with the patient and provide care based on the data contained within the record. Figure 1 (CA. GOV, n.d.) illustrates how an HIE operates. Several providers are shown with the ability to read and/or write to a single source – the HIE. This is important, because a provider can retrieve the data written by others.

The implementation of HIEs presents several benefits to both healthcare providers and the patients they treat (Pevnick et al, 2009, pg. 604). For instance, without the use of an HIE, a healthcare provider must sometimes make decisions without a complete knowledge of the patient's medical background.

Clinicians are of the belief this puts the patients' well-being at risk, while increasing time spent by the medical staff to obtain the patient's medical history (Vest, 2008, pg. 223). In one qualitative analysis, researchers collected stakeholders' responses of the perceived benefits of participating in an HIE. One benefit multiple organizations agreed upon the utilization of an HIE could reduce the redundancy of duplicate testing (Pevnick et al., 2012).

FIGURE 1
HEALTH INFORMATION EXCHANGE (CA.GOV, N.D.)

Besides benefitting caregivers, there is also evidence that consumers support the application of HIEs. In a study of 117 individuals, 76% of the participants supported the sharing of medical records between healthcare professionals, and 90% of the group believed that HIEs creates better communication between a patient and his or her doctor (Patel et al., 2012, pg 1046). With a positive patient outlook, HIEs present an interesting opportunity for medical providers to consider. For instance, medical providers that show an early interest in developing HIEs might appeal more to patients who desire the implementation of this technology. Four sample HIEs from around the U.S. will be discussed in this paper: Centex Systems Support Services (CSSS), Colorado Regional Health Information Organization (CORHIO), Inland Empire Health Information Exchange (IEHIE), and Idaho Health Data Exchange (IHDE).

Centex Systems Support Services (CSSS)

CSSS is a non-profit HIE based in Austin, Texas that provides medical record storage and retrieval services for Austin and 14 counties in the Houston area (About Centex, 2012). As a 2012, the organization has a workforce of 47 employees (New Centex, 2012). CSSS has more than 100 medical health providers as a part of its network and this number continues to grow. These healthcare providers access approximately 1.5 million health records via the CSS network (Samuels, 2014).

Inland Empire Health Information Exchange (IEHIE)

Located in Riverside, California, IEHIE has health records for more than 5 million patients living in the Riverside, San Bernardino, and other California counties (Inland Empire Health Information Exchange, 2014). There are different levels of membership, each having their set requirements. To join with a level 1 membership, the fee is $500.00 per year, but the medical provider has no voting rights. For Level 2, a one-time fee can be paid and is dependent on the amount of doctors as well as the amount of hospital beds (Membership and Participation, 2014).

Colorado Regional Health Information Organization (CORHIO)

CORHIO is based in Denver, Colorado, and is a nonprofit business with more than 50 connected medical providers (CORHIO, 2014). Each of medical providers has different EHR vendors and as a result CORIHO must work closely with them to allow each system be able to communicate between each another (Bowman, 2014). To help build CORHIO, substantial grants of $10 million were given by The Colorado Health Foundation and ARRA HITECH. After these grants have been depleted, CORHIO will make use of a fee-based subscription model (About CORHIO, 2014).

Idaho Health Data Exchange (IHDE)

Started in Boise, Idaho in 2010, IHDE has grown to serve parts of Idaho along with parts of Eastern Washington and Eastern Oregon (History of IHDE, 2014; Get Connected, 2014). The number of patient records that were referenced during 2013 was approximately 3.7 million, which was 20% more than the previous year (Utilization records, 2014). During August and September of 2014, more than 1 million records were referenced meaning there is still potential growth for this HIE (Utilization records, 2014).

CURRENT STATE OF HEALTH INFORMATION SHARING

There is growing evidence that exchanging and sharing patient data can potentially reduce mortality and even reduce cost" (Miller & Tucker, 2011, p. 29). The need for sharing information is critical in healthcare. Improving access to pre-existing patient information could improve the quality, safety and efficiency of care that can be delivered (Finnel & Overhage, 2010, p. 222). This can also reduce the timeframe of treating a patient. If a patient goes to a different hospital (than his or her regular provider), the medical history is siloed to their original treatment facility. This could cause a hindrance to the treatment of the patient at a different hospital.

PBRs have long been an issue. Dr. Emile Rwamasirabo, a urologist at King Faisal Hospital, Rwanda says "paperwork recordings copy used to take a long time to deal with because one nurse or doctor could spend hours treating one patient along with searching for the patient's file" (Paper-Based vs. Digital medical Records, 2014). The safety and security of PBRs also poses issues (Medical Devices & Surgical Technology Week, 2005). Gradually, PBRs have been transformed into EMRs/EHRs. Although PBRs have transformed into an electronic format, there are issues associated with the transition. With the sensitivity of medical records, people typically have significant concerns regarding the privacy of EMRs (Hwang, Han, Kuo, & Liu, 2012, pp. 3783-93).

Figure 2 illustrates how different medical providers and their facilities silo their patients' information from other providers. Problems can arise if a patient decides to go to a different facility, as the new provider will not be able to retrieve the patients' history (unless the patient brings their medical records themselves). Alternatively, a request could be made to have the medical records sent via fax or courier, which delays the delivery of care. Exchanges in patients' health information across organizational boundaries through the use of HIEs hold the promise of quality improvements for healthcare organizations (Vest, 2009).

FIGURE 2
THE LOCAL SILO EFFECT
OUTLOOK OF HIES AND INTERCONNECTIVITY

Considering the pace at which technology is changing, and the numerous benefits of using HIEs, the outlook for HIEs is rather promising. For example, in 2009, the U.S. Government passed The Health Information Technology for Economic and Clinical Health Act (HITECH) (Miller, 2014, pg. 4). This act provided $19 Billion in incentives for the healthcare community to promote the adoption of EMRs in a manner that fulfilled the standards of meaningful use – essentially using technological standards that allow for the exchange of patient information (Miller, 2014, pg. 4). Due to these incentives, recent data from reporting healthcare providers shows an upward trend in use of HIEs. Results from a published study in the medical journal *Health Affairs* showed an increase of 61% in operational system use from organizations that reported back to the study from 2010 to 2011 (Adler-Milstein, Bates, & Jha, 2013, pg. 1488). While the outlook for HIE implementation is bright, there are several key challenges that will need to be addressed before HIEs can be fully interconnected throughout the U.S. These considerations will be covered in detail in the accompanying sections.

To obtain the maximum benefit from implementing HIEs, individual HIEs need to be interconnected. For systems to be interoperable, data must be exchanged by the different systems. Then and only then can medical providers can retrieve pertinent data about their patients. In the field of healthcare, The Healthcare Information and Management Systems Society (HIMSS), defines this as, "different systems and software applications to communicate, exchange data, and use the information that has been exchanged. Data exchange schema and standards should permit data to be shared across clinicians…pharmacy, and patient regardless of the application or application vendor" (HIMSS, 2014). While HIEs are currently in use, the interoperability of these systems face multiple challenges that need to be addressed. Such challenges are the technical constraints between different vendors, chosen key structures for the patient data, addressing the redundancy in information, and the standardizing of healthcare terms.

Possibly one of the greatest challenges to reaching interoperability of HIEs is the merging of data and utilization of different database schemas and platforms across HIE vendors (Bhansali & Gupta, 2014, pg. 31). One study compared the average query time of Oracle, dBXML, Xindice, and eXist databases of 100 records. The range of time was quite small, with a difference of 0.415 seconds from the quickest to

slowest times; conversely, in a search of 5,000 records, the range grows substantially to 9.412 seconds (De et al., 2012, pg. 921). Table 1 shows the complete results of the study. Considering the substantial number of files that would need to be uploaded and shared daily, the correct equipment configuration is critical to manage thousands of queries, provide optimal speed, and ensure security concerns are met.

TABLE 1
TIME COMPARISON BETWEEN DIFFERENT DATABASES (DE ET AL., 2012, PG. 921)

Number of records	Average Query Time Oracle 10g (s)	Average Query Time dBXML (s)	Average Query Time Xindice (s)	Average Query Time eXist (s)
100	0.065	0.226	0.476	0.061
800	0.069	1.696	1.879	0.066
1000	0.074	2.121	2.541	0.072
5000	0.377	8.617	9.789	0.299

Another concern of connecting HIEs is the interoperability of different systems that define information differently (Dobalian, 2012, pg. 938). For instance, a private practice may assign patient numbers starting at number 1 (and then incrementally), while a hospital may use social security numbers or other unique identifiers for patient records. This could lead to information linked to the wrong patient if there is an overlap of 'unique' identifiers across HIEs. To confront and implement sharing of records through HIEs, this must be addressed and standardized (Dobalian, 2012, pg. 938). Equally important to defining standardized keys for the databases is the standardization of how medical information is entered into the systems. For example, different physicians will use different medical terms to explain the same ailment (Liu, 2007, pg. 17). With this variance, an interconnected system would need to accommodate each of these considerations when returning results to a single query. To effectively develop a system that is efficient and viable, a unified system will need to be implemented.

A study was done in two New Mexico emergency departments, before and after an HIE was installed. The results showed that the rate of redundant chest x-ray testing dropped from 37% to 7% (Parsons, Gunter, Kroth, Fillmore, 2012). This amount significantly reduces the amount of unnecessary usage of hospital resources. The amount of time that a patient has to wait is also reduced, and this can potentially increase the speed that the medical professionals can diagnose an issue. This can be attributed to the fact that an HIE would be able to display the results of a lab that was recently done, and prevents the patient from having to undergo the same test. Issues with the accuracy of patient's information could occur from their date of birth being entered incorrectly resulting in the creation of a separate record thus compromising the integrity of the HIE. Since there is not a "standard for patient identity integrity" the medical history of the patient becomes compromised (Just, Fabian, Webb, Hjort, 2009). With more attention to patient identification, this can make regional and eventually national HIEs connectivity more feasible (Just, et al, 2009).

Organizations will have to find a way to consolidate data that has been created for a patient and to delete the duplicate record. For instance, if a patient was part of an HIE in city A, and then moves to city B (where the HIEs is different), this would result in the creation of a new health record. If in the future these two HIEs were to be connected, there would be two records for the same patient, unless there was a system in place to merge duplicate patient information. It is the responsibility of the healthcare provider to catch these redundancies.

Standards for all HIEs across the U.S. need to be developed including a unique naming system as well as having a specific transmission format to avoid errors when attempting to utilize the patient records from one HIE to another (Just, et al, 2009). Redundancy is a necessity for an HIE to function, but having duplicate records is counterproductive. The impact of avoiding repeat testing throughout the U.S. could result in 80 billion dollars a year being saved on healthcare costs (Just, et al, 2009). With redundancy backup systems in place, the HIE is always accessible should an issue arise with the method that is used

to retrieve information from the HIE. Research was conducted to examine what a few HIEs are doing to achieve regional/limited interconnectivity.

Due to the wide variety of HIEs in the U.S., each HIE has its own method for connecting a patient to a record. For instance, the Indiana Health Information Exchange (IHIE), shares information through the Docs4Docs service. Within the Docs4Docs service, medical providers share information in two ways; either pushing the data to another provider, or by using a search function of records sent in the last two years. When conducting a search for patient records, medical providers search by patient's name, report type, hospital Medical Record Number (MRN), provider, or by specifying specific dates (Indiana Health Information Exchange, n.d.). Conversely, Maine's state designated HIE HealthInfoNet is searched slightly different, by using the facility MRN, last name and date of birth, or first and last name (HealthInfoNet, 2014).

The Great Lakes Health Connect (GLHC) is the result of a merger of two different organizations: Michigan Health Connect and the Great Lakes Health Information Exchange (GLHIE) (Michigan Health Information Network, nd). GLHC is one of the providers that fall underneath the Michigan Health Information Network (MiHIN). With this combination, the exchange allows for secure exchange of over 5 million records (Michigan Health Information Network, nd). In this exchange MiHIN provides services through the Health Information Services Cloud (HISC), which allows for sharing of information across the entire state of Michigan (Michigan Health Information Network, nd). This network does not use a national patient identifier. Instead they use patient information, such as name, social security number and address (Michigan Health Information Network, nd).

PROPOSED SOLUTION

As early as the 1990's, the Federal Government began encouraging the medical industry to digitize patients' PBRs to EHRs and EMRs. As digital records become common practice, the next logical step is to find a way to share the information between providers through the implementation of HIEs. Unfortunately, the government has relied heavily on the private sector to develop and define the standards of health information technology instead of regulating the growth (Blumenthal, 2011, pg. 2430). Allowing the private sector to establish its own set of policies and guidelines has led to different HIEs, with varying implementation standards and format of operation. However, the recent passing of the Affordable Care Act provides an opportunity for the Federal Government to control standardization of health information technology and an opportunity to move toward interoperability of HIEs.

One major obstacle toward interoperability of HIEs is defining a standard for identifying patients within the interconnected systems. A viable option that has worked in other countries is the development of a unique identification code for each citizen. For example, Taiwanese citizens are each given an identification number that is printed on their National Health Insurance cards (Huang, Tseng, Chang, Pan, & Liou, 2010, pg. 30). In Italy, data registers were created that used information such as the citizen's tax code within the system (Barbarito, 2012). Under the new Affordable Care Act, the U.S. is requiring each citizen to obtain medical insurance. This presents an opportunity to issue a unique identification number to each citizen in the U.S.

The proposed number displayed in Figure 3, referred to as the Patient Access Number (PAN), will comprise of two identifying codes concatenated together to create a unique 11 digit number. The first two digits represent the patient's state of origin in which the initial request for a PAN occurred. Each state code corresponds to the year the state received statehood as shown in Table 2 (United States Census Bureau, 2013). This convention allows the addition of any new state or territory to the U.S. (to be easily integrated with a coding system that sequentially grows). The subsequent nine unique digit portion is auto generated by a central database each time the database is queried for a new patient identifier. With nine digits utilized, the potential number combinations would amount to 999,999,999 per state, making it highly unlikely that any state would ever exhaust all of its unique number combinations.

FIGURE 3
SAMPLE PAN

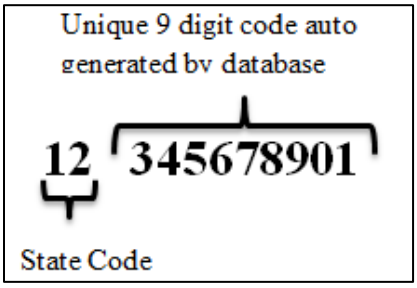

TABLE 2
STATE CODES (UNITED STATES CENSUS BUREAU, 2012)

State Codes					
Code	State	**Code**	State	**Code**	State
01	Delaware	**18**	Louisiana	**35**	West Virginia
02	Pennsylvania	**19**	Indiana	**36**	Nevada
03	New Jersey	**20**	Mississippi	**37**	Nebraska
04	Georgia	**21**	Illinois	**38**	Colorado
05	Connecticut	**22**	Alabama	**39**	North Dakota
06	Massachusetts	**23**	Maine	**40**	South Dakota
07	Maryland	**24**	Missouri	**41**	Montana
08	South Carolina	**25**	Arkansas	**42**	Washington
09	New Hampshire	**26**	Michigan	**43**	Idaho
10	Virginia	**27**	Florida	**44**	Wyoming
11	New York	**28**	Texas	**45**	Utah
12	North Carolina	**29**	Iowa	**46**	Oklahoma
13	Rhode Island	**30**	Wisconsin	**47**	New Mexico
14	Vermont	**31**	California	**48**	Arizona
15	Kentucky	**32**	Minnesota	**49**	Alaska
16	Tennessee	**33**	Oregon	**50**	Hawaii
17	Ohio	**34**	Kansas	**51**	Washington D.C.

For the PAN implementation to work, several systems will need to be updated. The proposal is that every number will be generated by a database housed at the Department of Health and Human Services (HHS). HHS will manage the database to enforce data integrity so that no person can receive a duplicate number from his or her insurance provider. Table 3 shows what the database will be comprised of, although not exhaustive. Each PAN record in the database will have information associated with it such as SSN, name, address and insurance code. In order for the insurance providers to login to the database, they will need to request a unique login from HHS. Once the login is received, the insurance providers can then request PANs for their customers. Once the request is made by the insurance provider and is approved, the PAN is transmitted back. When the insurance providers receive the PAN, it can now be printed on the new insurance card of the patient. The insurance provider will now issue new insurance cards to each customer via mail. Adding the PAN to the card, the patient will simply need to present the card during his or her next visit. When the medical provider receives this card, the staff can then update

the existing electronic records with the new unique PAN. This will allow for patients data to be exchanged in conjunction with the unique PAN.

TABLE 3
PROPOSED DEPARTMENT OF HEALTH AND HUMAN SERVICES PAN DATABASE

PAN	Ins Code	SSN	DOB	Name	Address	City	State	Zip
12-345678901	345	***-**-****	1/2/2000	John Doe	111 Circle Dr.	Raleigh	NC	27699
01-987654321	422	***-**-****	1/1/2000	Jane Doe	222 Lone Dr.	Wilmington	DE	19805

In the United States there is a specific window of time when a person can obtain health insurance, known as the Open Enrollment period. For example, healthcare coverage starting in 2015 this period starts November 15th 2014 and ends February 15th 2015. These dates may change from year to year (Important Marketplace deadlines, 2014). If an individual changes insurance provider and had a preexisting PAN, the new insurance provider must issue a card with the same PAN. The reason for this is that the patient may have changed insurance providers but their PAN stays the same. To retrieve a PAN that has been lost a patient will need to contact HHS either through phone or email and provide their SSN and other pertinent information to prove their identity.

CONCLUSION & FUTURE WORK

Patients rely on medical facilities to provide them with efficient healthcare. They need to be assured that when they walk into a facility, the medical staff can provide them with the proper treatment they deserve. HIEs will help facilities provide that type of care by having access to a holistic view of patient information. The adoption of HIEs will reduce misinformation and minimize errors in healthcare facilities. Allowing a patient to walk into any hospital and receive ongoing and emergency care is not only beneficial to the patient but to the medical providers as well.

In this paper we proposed the idea of introducing PANs that would be printed on insurance cards. These PANS would be associated with each patient's social security number in the HHS's database to insure data integrity. HIEs that are not connected are no better than PBRs in their inability to share information in a timely manner (almost real-time). Without an HIE, a patient might have been treated with a fatal procedure. Finally, this is why it is imperative that we have a nationwide HIE system in place to enable all HIEs to be connected to facilitate information sharing.

Once HIE interoperability is achieved, connection between the medical providers and the patient needs to be considered. One solution to explore is creating Personal Health Records (PHRs). A PHR is a personal record that can include patients' records of medical progress, along with records from each of their healthcare providers (Stead, Kelly, & Kolodner, 2005, pg. 114). In Italy, this implementation is already in existence with the development of life-long PHRs that depicts all medical activity for a patient. With these records, patients can manage their own records, including who can access them. If an emergency occurs, the record can be retrieved with a complete medical history for the patient (Barbarito, 2012, pg. 737). PHRs provide even greater opportunity for medical care in America that needs to be explored once HIE interoperability is accomplished.

Additionally, work needs to be done in order to standardize the language that is used in HIEs to enter information. Unified Medical Language Systems (UMLS) would be able to solve this issue by being able to "understand the language of biomedical and health" (Liu, 2007). The UMLS Metathesaurus would allow for various names and relationships between health related concepts to be displayed, thus solving the issue of information being indecipherable to an individual who uses a different naming standard. However, to implement UMLS, all preexisting infrastructures in HIEs would have to be conformed to this

standard, and thus starting from square one of interconnectivity and communication. Further research would need to be done in order to determine if there a better solution to solve the naming convention issue as well as a standard language.

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