Building a Production-Ready Infrastructure to Enhance Medication Management: Early Lessons from the Nationwide Health Information Network

Linas Simonaitis, MD[1,2], Brian E. Dixon, MPA[1], Anne Belsito, MS[1], Theda Miller, BS[1], J. Marc Overhage, MD, PhD[1,2]
[1]Regenstrief Institute, Inc., Indianapolis, IN
[2]Indiana University School of Medicine, Indianapolis, IN

Abstract

Poor medication management practices can lead to serious erosion of health care quality and safety. The DHHS Medication Management Use Case outlines methods for the exchange of electronic health information to improve medication management practices. In this case report, the authors describe initial development of Nationwide Health Information Network (NHIN) services to support the Medication Management Use Case. The technical approach and core elements of medication management transactions involved in the NHIN are presented. Early lessons suggest the pathway to improvements in quality and safety are achievable, yet there are challenges for the medical informatics community to address through future research and development activities.

Introduction

Appropriate management of the prescribing process, polypharmacy, medication administration, patient compliance, and adherence pose challenges for modern health care. These challenges are components of the more commonly described construct of medication management or concordance.[1] According to the Institute of Medicine, poor medication management practices often lead to serious erosion of health care quality and safety.[2] Because of these risks, several groups, including the Joint Commission, promote techniques to help health care providers improve the safety and effectiveness of their medication management practices.

In 2007, the U.S. Department of Health and Human Services released its harmonized Medication Management Use Case,[3] establishing a model for the electronic exchange of health information in support of medication management practices. Components of the model outlined in the use case include clinical decision support, medication reconciliation, electronic prescribing, formulary benefits checking, and online consumer renewal of prescriptions.

To advance the model, the Office of the National Coordinator of Health Information Technology (ONC) provided resources for development of medication management services within the Nationwide Health Information Network (NHIN). The NHIN has been described as a network of networks.[4] This network provides an infrastructure upon which various core technical services support health information exchange across health care regions, states, and communities.

Four contracts were awarded by ONC to develop production-ready services for the NHIN to support the Medication Management Use Case. One of these contracts was awarded to Indiana University and the Regenstrief Institute. Other contracts were awarded for the development of additional use cases as well as core NHIN services.

Production-ready services are those which are operational and have been tested but are not used in a production environment. The services described in this paper have been tested at a "connect-a-thon" hosted by ONC and demonstrated at the 5th NHIN Forum ("NHIN Trial Implementations: A Path to Production") in December 2008.

However, these services are only in production within the local HIE because the NHIN has yet to execute a data sharing agreement with all of its participants for the exchange of "live," personally identifiable health information. All of the data used for the development, testing, and demonstration of the NHIN medication management services involved test patients and data developed by a committee of NHIN participants with oversight from ONC and HITSP (the Health Information Technology Standards Panel).

This paper describes our development of medication management services that utilize the NHIN. We emphasize the technical architecture and approaches used to develop the services. Policy and governance discussions concerning health information exchange and the NHIN exist elsewhere in the literature.[5] Then we discuss early lessons based on this development work. These lessons address important concepts for discussion as the NHIN moves forward with putting these services into production.

Technical Approach

Our approach to the development of Medication Management Use Case services utilizing the NHIN involved three core elements: 1) a NHIN gateway to retrieve information from disparate clinical sources; 2) clinician use of the retrieved data during medication reconciliation; and 3) decision support using the retrieved data when prescribing new medications.

1. Data Retrieval and Integration

Supporting the Medication Management Use Case requires the capability to retrieve data from disparate information systems and integrate that data into local health information exchange and electronic health record systems. This requirement stems from a health care system that today is fragmented with patient data located in numerous information systems located at multiple provider organizations.

Our implementation of services to support the Medication Management Use Case utilizing the NHIN was conducted within an operational health information exchange – the Indiana Network for Patient Care (INPC).[6] Operational since 1995, the INPC stores information on 10 million patients and allows for the exchange of health information among nearly 10,000 clinicians at 22 institutions in central and southern Indiana. It has been described as one of the most successful and sustainable health information exchanges in the U.S.[7] Because the INPC was operational before the start of the project, it already possessed an infrastructure to support the exchange of clinical data between health care providers.[8]

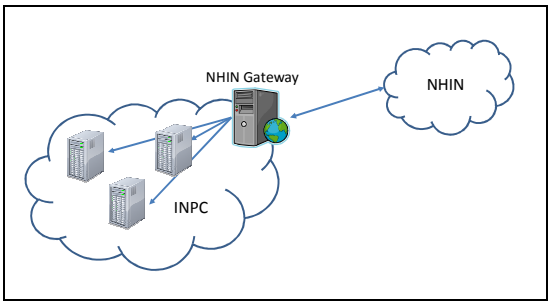

Figure 1: The NHIN gateway.

The NHIN has been designed to be a network of networks. Because of this philosophy, the external, national infrastructure to exchange data between HIEs on the NHIN is independent of the internal, local infrastructure that exchanges data between individual providers inside of each HIE. Therefore, we created a gateway to connect the INPC to the NHIN. We implemented the core NHIN services within this gateway to process and route NHIN transactions on the periphery of the INPC. The gateway interacts with various INPC sub-systems when sending or receiving data to HIEs that are part of the NHIN. (Figure 1)

In our implementation, we send a request to the NHIN to gather information from other HIEs on the network when a patient arrives at a provider and is registered within a health information or electronic medical record system. Registrations at INPC member organizations generate HL7 ADT (Admission/Discharge/Transfer) messages that are sent to the INPC. These messages trigger a process to retrieve and aggregate medication and allergy data for that patient: the "Medication Hub".[9]

Prior to the NHIN project, the Regenstrief Medication Hub was developed to send and receive medication-related data with the SureScripts network. For each patient, our Medication Hub sends a request to the SureScripts PRN interface. Within seconds, an "Eligibility Response" (identifying that patient's formulary) is returned followed by a "History Response" (listing all medication claims adjudicated by pharmacy benefits management organizations for that patient within the preceding 12 months). To approach the development of NHIN medication management services, we started with an expansion of the data provided by the Medication Hub.

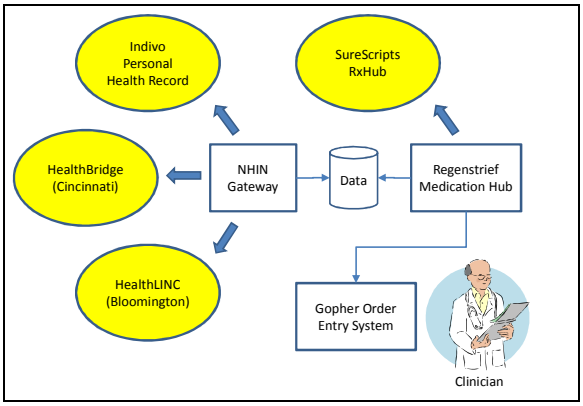

Figure 2: Data retrieval from sources external to the INPC.

Data retrieved from the NHIN is stored in a clinical data repository. The Medication Hub queries that repository in addition to SureScripts. The data are aggregated by the Medication Hub and delivered to the requesting INPC application or service. (Figure 2)

When we demonstrated the functionality of the NHIN Gateway at the NHIN Forum, we exchanged data with two other NHIN participants: HealthBridge, a health information exchange serving the Cincinnati, Ohio area; and HealthLINC, a health information exchange serving several counties in south central Indiana. These entities were selected for participation

given their regional proximity to the INPC to demonstrate a realistic scenario involving patients that receive care in nearby geographic areas, regardless of county or state lines.

We further demonstrated the capability of the NHIN Gateway to also exchange data with other types of health information sources, such as personal health record systems. We worked with Children's Hospital Boston to connect the gateway to the Indivo Personally Controlled Health Record (PCHR), which is made available to employees of several major U.S. companies through the Dossia Consortium.

The standard for all NHIN data exchange transactions is the Continuity of Care Document (CCD). The CCD is a specialization of the Clinical Document Architecture (CDA), which is derived from the HL7 version 3 data and message specification. The CCD describes the document content summarizing a patient's medical status for the purpose of computer-based exchange. This content is broken down into 16 content modules. Two of these content modules (the Medication Module and the Allergy/Drug Sensitivity Module) provide for most of the data of interest in the Medication Management Use Case.

Following retrieval, the data are integrated into systems that support the core services of the INPC. Drugs are mapped to local Regenstrief terminology used by the INPC, and aggregated into a single list. The Medication Hub then exports this summary as an HL7 version 2 message to a computerized provider order entry system when requested.

2. Using NHIN-Accessed Data for Medication Reconciliation

The Gopher Order Entry Application has been used at Wishard Memorial Hospital (the county hospital of Indianapolis) and affiliated ambulatory clinics since it was introduced in the 1980s. Clinicians use Gopher during and after each patient visit to retrieve information, enter progress notes, and write orders including prescriptions. In the outpatient setting, the largest group of Gopher users are resident physicians, followed by attending staff, nurses, nurse practitioners, and pharmacists, in that order. In addition, students represent a large group of Gopher users, but must have all their work co-signed.

Gopher receives all of its medication and allergy information from the Medication Hub during the time interval between the patient's arrival and the patient visit. Providers use Gopher to perform medication reconciliation, viewing a list of the patient's current medications then discussing that list with the patient during the visit. (Figure 3) Patient allergies are also made available for review (on a separate screen).

With the enhancements to the Medication Hub to support NHIN information retrieval, physicians can now view an integrated list of medications retrieved from NHIN entities as well as the medication history provided by the SureScripts (formerly Surescripts-RxHub) network. Furthermore, physicians have access to patient allergy lists across NHIN entities, including personal allergy lists created and maintained by the patient. The additional information has the potential to improve the medication reconciliation process, providing a more complete picture of the patient's past medical history in an efficient manner.

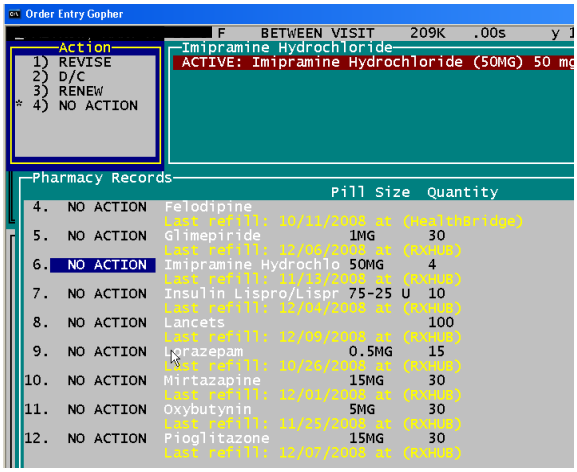

Figure 3: Medications are collected from external entities (this screenshot displays data made available by HealthBridge and by SureScripts). Each medication is an actionable item that can be converted into a new prescription by the clinician.

3. Decision Support Using NHIN-Accessed Data During E-Prescribing

Gopher allows the clinician to take action on each of the medications on the aggregate list. Each medication is eligible to become an electronic prescription. These prescriptions can be "REVISED" and given a different strength, instructions, quantity, or refills; or they can be simply "ORDERED" using the same attributes. For example, an Imipramine record provided by SureScripts could be the starting point for a new Gopher-initiated prescription.

As each prescription is created, Gopher decision support rules are executed. For example, an Erythromycin allergy reported by an Indivo PCHR would warn the prescriber against a new prescription for Azithromycin, a related antibiotic. Similarly, a drug-drug interaction would be detected between an Imipramine record provided by SureScripts and the clinician's intention to prescribe Levofloxacin. Finally, drug-formulary alerts would react to a Felodipine, an anti-hypertensive medication, record provided by HealthBridge if it were not on the

formulary provided by SureScripts. (Each of these three examples was demonstrated to the NHIN Forum.)

Once ordered, prescriptions are converted from the Gopher's HL7 version 2 export format to the NCPDP (National Council for Prescription Drug Programs) Script 8.1 format and sent to the SureScripts Pharmacy Health Information Exchange. This final step of e-prescribing completes another aspect of the Medication Management Use Case, although it is not NHIN dependent. Furthermore, although we used Gopher to carry out medication reconciliation and decision support functions as a part of the NHIN project, any CPOE or e-prescribing system could be integrated to receive this information.

Discussion

As the NHIN moves into production, we reflect on our experiences in developing initial medication management services for the NHIN to highlight lessons for other seeking to participate in future development activities.

Clinical Workflow Is Paramount. Indiana University and the Regenstrief Institute have years of experience in developing health information interventions that are used by clinicians in day-to-day health care delivery systems. These interventions are successful because we pay close attention to integration into clinical workflow.

Some other institutions have chosen to require that a clinician manually initiate a query to retrieve NHIN data. However, we knew that we would have limited success with such a design given physician resistance to modifications to workflow. In our approach, available NHIN information is queried and received without any manual initiation from the clinician. We have had previous success with processes that are triggered by an HL7 ADT message, so we chose to continue to employ such a trigger.

Reaching Out Through a Single Gateway. The NHIN Gateway is a crucial component to enabling the INPC to communicate with other HIEs in a uniform way. If we attempted to avoid a gateway, we would have to build highly customized interfaces between every INPC application which needed access to external data and each entity that can supply that data. Such an approach would be costly to develop and maintain, and it would require complicated processes for resolving connectivity issues. (Figure 4)

The use of a NHIN gateway avoids this. Each INPC application has only a single interface to the NHIN. Similarly, each external HIE has only a single interface to the INPC. (Figure 5) All interfaces share common protocols and transactions. Building an interface to a new HIE is almost as simple as adding a record to a database table.

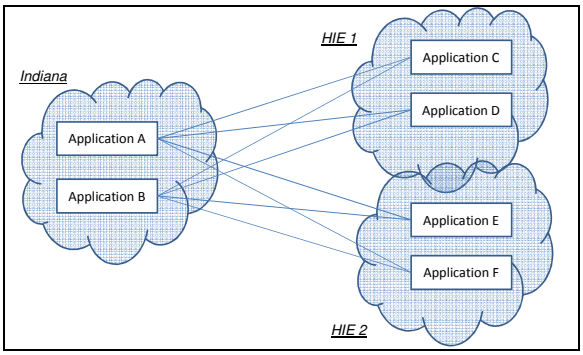

Figure 4: Multiplicity of peer-to-peer interfaces in the absence of an NHIN Gateway.

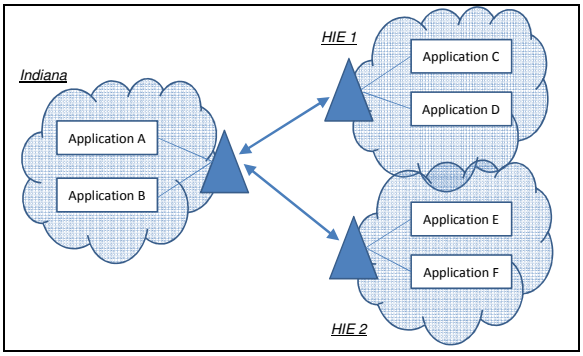

Figure 5: Use of a gateway to simplify transactions.

Reuse of Existing Systems. We reused existing software connections and expanded others where possible. This philosophy of reuse is an important element of the INPC's success.[8] Although a gateway was necessary to maximize the efficiency of NHIN transactions, we took advantage of existing medication management applications, leveraging their capabilities to develop an enhanced approach to support the use case.

Coding of Medication and Allergy Data. One of the most important challenges and barriers we encountered was the coding of medications and allergies. INPC applications use local Regenstrief Dictionary Terms.[6] All clinical decision support rules at our institution are written in units of Regenstrief Dictionary Terms; new or revised prescriptions are indexed by Dictionary Terms; displays are organized by Dictionary Terms.

In previous work using the Medication Hub, we received drug information indexed by National Drug Codes (NDCs) from SureScripts and Medicaid. In order to incorporate such drug information into our system, the NDCs must be translated to Regenstrief Dictionary Terms. This is accomplished via a two-stage process. First, the NDCs are translated to Medi-

Span Generic Product Identifiers (GPIs), relying on tables provided weekly by the Wolters Kluwer company. Second, our institution maintains a table mapping GPIs to Dictionary Terms.

In this project, some NHIN participants provided medication data indexed by NDCs, which were coded by the above method. However, the Indivo PCHR relies on free text entry by the patient to create a medication list; no coding scheme is used. Medications provided by this source could only be mapped to a miscellaneous category. Unfortunately, such medication information cannot be used for decision support, quality measurement, or categorization, all of which require specific codes.

Allergy data presents an even greater challenge, because there is no ubiquitous coding system for allergies which would be analogous to NDCs. We examined the allergies included in two million ADT messages of the INPC – a total of 389,178 allergy segments – and discovered that most allergies are sent as free text fields, although some coding systems, such as the American Hospital Formulary Service, occur regularly.

In order to translate these free text allergy data to computer-interpretable codes, we developed a two stage mapping process. In the first stage, we match the free-text names to MeSH (Medical Subject Headings) descriptors and codes. Work by our colleagues has demonstrated that the MeSH vocabulary is appropriate for coding allergy data.[10] In the second stage, we manually map MeSH codes to Regenstrief Dictionary Terms for drug categories. Using this two stage process, we are able to map free text allergy names to the local terminology used for allergy checking in decision support rules. This process was manually validated for the most commonly occurring allergies.

Limitations. The approach we present is production-ready, meaning that is has not been thoroughly tested in a production environment. This is one model for discussion and validation with the greater medical informatics community. Additional NHIN implementations and validation work is necessary to advance the NHIN and the Medication Management Use Case.

Conclusion

In conclusion, the NHIN attempts to provide an infrastructure for supporting various health information exchange services in the U.S. One of those services, medication management, holds great promise with respect to improvements in health care quality, safety, efficiency, and effectiveness. The pathway to production has begun, and the experiences to date show that the pathway will require vigilance. However, the journey is feasible and promises to be an important direction for informatics research and development in the future.

Acknowledgements: This paper is derived from work supported under a contract with the U.S. Department of Health and Human Services, Office of the National Coordinator for Health Information Technology (HHSP23320074102EC). The content of this publication does not necessarily reflect the views or policies of the Department of Health and Human Services, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government. We are very grateful to Andy Frantz (Software Engineering Professionals, Inc.), and Cy Colvard, Larry Lemmon, and Bill Bollinger of the Regenstrief Institute, Inc. for development of the systems to carry out this work.

References

1. Snowden A. Medication management in older adults: a critique of concordance. Br J Nurs. 2008 Jan-Feb;17(2):114-119.

2. Aspden P, Wolcott JA, Bootman JL, Cronenwett LR, editors. Preventing Medication Errors. Washington (DC): National Academies Press; c2007.

3. Department of Health and Human Services. Medication management use case [Internet]. 2007 [cited 2009 Mar 3]. 47 p. Available from: http://www.hhs.gov/healthit/usecases/medicationmgmt.html

4. Rishel W, Riehl V, Blanton C. Summary of the NHIN Prototype Architecture Contracts. Washington, DC: U.S. Department of Health and Human Services; 2007.

5. DeBor G, Diamond C, Grodecki D, Halamka J, Overhage JM, Shirky C. A tale of three cities--where RHIOS meet the NHIN. J Healthc Inf Manag. 2006 Summer;20(3):63-70.

6, McDonald CJ, Overhage JM, Barnes M, et al. The Indiana network for patient care: a working local health information infrastructure. Health Aff. 2005 Sep-Oct;24(5):1214-20.

7. Grossman JM, Kushner KL, November EA. Creating sustainable local health information exchanges: can barriers to stakeholder participation be overcome? Res Briefs. Feb 2008(2):1-12.

8. Zafar A, Dixon BE. Pulling back the covers: technical lessons of a real-world health information exchange. Stud Health Technol Inform. 2007;129(Pt 1):488-92.

9. Simonaitis L, Belsito A, Overhage JM. Enhancing an ePrescribing System By Adding Medication Histories and Formularies: the Regenstrief Medication Hub. AMIA Annu Symp Proc. 2008 Nov 6:677-81.

10. Schadow G. Structured product labeling improves detection of drug-intolerance issues. AMIA Annu Symp Proc. 2008 Nov 6:646.