2017

Is interoperability a hindrance to the nationwide health information exchange (NHIE)?

Nitesh Patil
patil3@marshall.edu

Sruthi Katamneni
katamneni@marshall.edu

IS INTEROPERABILITY A HINDRANCE TO THE NATIONWIDE HEALTH INFORMATION EXCHANGE (NHIE)?

ABSTRACT

Introduction: HIE is the exchange of clinical data as well as healthcare data among the providers, healthcare institutions, and data repositories. Nationwide Health Information Network (NHIN), was adopted in the year 2004, under the Office of the National Coordinator for Health Information Technology (ONCHIT) with an objective to share the files electronically securely and in a safe manner.

Methodology: The literature review included 40 references in which information relevant to the purpose of this study was scrutinized; these references met the inclusion criterion. The methodology for this study was an extensive and thorough literature review. The sources utilized in this study encompassed primary and secondary data.

Results: HIE has significantly increased by 41% from 2008 to 2012. Also, the exchange of health information by type of clinical data has risen from 39% to 55% during the same period. NHIN has been widely recognized in the U.S, but the storage of patient data and the data architectures have remained uncertain among two models the patient-centric or centralized model, in which the patient data for a given patient is stored at one central location.

Discussion: To evaluate the effectiveness of the NHIN the hospital exchange activity, costs of implementation and the quality of care were analyzed. From the literature review, there has been a significant increase in the costs spending associated with the NHIN implementation.

Conclusion: The literature has suggested that NHIN could achieve cost savings, increase quality of care and communication between physician and the patient.

Key Words: HIE, NHIN, Interoperability, and Exchange Activity.

INTRODUCTION

Information Technology has marked a significant role with an objective to achieve the diverse requirements of the providers and the consumers in a healthcare setting. Introduction of the newer technology and its adaption in healthcare has been hampered by the increasing costs, inefficiency, poor quality of care and preventable errors (Halamka et al., 2005). The Health Information Management System Society has estimated that the United States hospitals (US)have spent nearly $26 billion on information technology from 2010 to 2014 (Agha, 2014).

The implementation of Health Information Technology for Economic and Clinical Health Act, as a part of the American Recovery and Reinvestment Act of 2009 has initiated the efforts for implementing the Electronic Health Records (EHRs) to enhance the utilization of Health Information Exchange for supporting the Meaningful Use (MU) (Gold, and McLaughlin, 2016). The Center for Medicare and Medicaid services (CMS) has set the objectives for achieving the MU stage 3 by increasing the patient engagement, HIE and public health reporting (CMS, 2016). The EHRs was recognized by the American Medical Informatics Association in 2006 and it has comprised of quality measurement, public health surveillance, and patient's access to the information of health records (Hersh, 2007).

HIE is the exchange of clinical data as well as healthcare data among the providers, healthcare institutions, and data repositories, (Dixon, Zafar, and Overhage, 2010). Nationwide Health Information Network (NHIN), was adopted in the year 2004, under the Office of the National Coordinator for Health Information Technology (ONCHIT) with an objective to share the files electronically securely and in a safe manner (ONCHIT, 2013a). Although the process of exchanging the health information has increased the process flow, it has achieved the better quality of care for the people with the availability of the records (ONCHIT, 2013a). NHIE has

been used as the assemblage of the standards, policies, and specifications that have empowered the HIE in a secure method (ONCHIT, 2013a). The primary concerns of the HIE have been the augmented costs and the efforts needed for establishing the NHIN standards (Dixon et al., 2010).

The ONCHIT was established by President Bush in 2004, within the Department of Health and Human Services, for progressing the broader adoption of EHRs (DHHS June 2008). Interoperability has been the critical component of the ONC strategic framework and Health Information Technology and Standards Panel was initiated to set the common standards for data sharing.

It has been reported by the eHealth Initiative that by 2010, there were 73 operational HIE nationwide for example MedVirginia, Regenstrief Institute, Health Bridge and Kaiser Permanente (Brailer, 2005). In 2012, the NHIN exchange had 30,000 clinical users, 65 million patients involved, and 1 million medical records have been shared with approximately 3000 healthcare providers (Sullivan, 2012).

The Beacon Community program was initiated to utilize the healthcare IT in 2010 for empowering the integration of a varied range of tools and strategies intended for achieving the goals of improvement (Maxson et al., 2010). In May 2010, a grant of $225 million was announced by ONCHIT to 15 Beacon awardees, in addition to the $15 million as evaluation and technical assistance funds to encourage and learn from these efforts (Maxson et al., 2010).

The purpose of this paper was to review the current state of the NHIE, interoperability, motivating factors, and challenges and to determine the increase in quality of care.

METHODOLOGY

The primary hypothesis of this research was: interoperability and costs for operation have been the reasons for delayed implementation of NHIE. The secondary hypothesis was that the NHIE implementation has increased the quality of care. The research framework for this review followed to the steps and research framework used by Yao, Chu, and Li (2010).

The below figure describes the Implementation of NHIE along with the benefits and barriers in HIE for the patients. As the focus of this study is in the process of implementation of NHIE, this research framework is in the process of application of HIE across the nation and is suitable for the current study. To determine whether adoption of NHIE improves access to healthcare services, an assessment of their effectiveness must first be made. As seen with any project, the process of adoption of technology follows a cyclic path. The solution here is the adoption of a NHIE. Prior to implementation of this solution, an assessment of the benefits of and barriers to the adoption of NHIE is necessary and after its institution needs are reassessed and the cycle continues. (see Figure 1). As the focus of this study is in the process of application of new technology in healthcare settings, this conceptual framework is suitable for the current study. Furthermore, the effective reproduction of this approach in previous studies supports its internal validity.

The methodology for this study was an extensive and thorough literature review. The sources utilized in this study encompassed primary and secondary data, combined with a semi-structured interview of the Director of Information Technology at Cabell Huntington Hospital. In this research, a comprehensive and exhaustive review was not possible because of the availability of plenty of studies of diverse nature. The literature review was described in three distinct stages, which included the following: 1) to determine the search strategy and literature

identification and assortment, 2) to establish inclusion criteria, search the information for relevancy, and literature analysis of the data, 3) identification of suitable information.

Figure-1

Step 1: Literature Identification and Collection

The stages in the search included 1) defining the Health Information Exchange, OR 'Nationwide Health Information Network,' AND 'Cost,' OR 'Quality,' OR 'Interoperability' OR 'Patient Safety' OR 'Exchange Activity.' Electronic databases searched were: Academic Search Premier, EBSCOhost, Google Scholar, Proquest, and PubMed. Websites of ONC, AHIMA, the Centers for Medicare and Medicaid Services were also mined. A total of 60 references were reviewed, with 40 selected for this research.

Step 2: Establishing inclusion criteria and Literature Analysis

Letters and editorials, as well as original papers and reviews, were all included, including primary and secondary data. The literature review included 40 references in which information relevant to the purpose of this study was scrutinized; these references met the inclusion criterion. All the references that were analyzed in this study were written in English. To obtain current research, references from years 2007-2017 were included in this study. The literature study was conducted by NP, SK and validated by AC who acted as a second reader and verified that the references meet the search criteria or not.

Step 3: Literature Categorization

The relevant articles were then categorized following the adopted research framework. The main categories from this research framework that emerged from the literature were: Cost

Estimates in NHIE Implementation, Hospital Health Information Exchange activity, Interoperability, Quality of care, Barriers and challenges.

RESULTS

Cost Estimates in NHIE Implementation:

Maryland Chesapeake Regional Information System for our Patients (CRISP), spent $8.5 million on capital investments of HIE, together with $8 million on technology and $500,000 on capital equipment in 4 years. Also, it was reported that Maryland CRISP had spent nearly $8 million in administrative costs which have included $1.5 million on direct staffing, consultants and $6.5 million towards contracted labor (ONCHIT,2013b). According to another study conducted in 2005, nearly $156 billion were required as an initial capital investment for the 5 years of period usability of NHIE, which approximated to the 2 percentage of healthcare spending in the same time (Kaushal et al., 2005).

In 2007, according to Frisse and Holmes the savings of $3.7 million have been estimated due to reduced hospitalization for a five-year period from 2005-2009, and the overall savings were expected to be $7.5 million (Rathlev et al., 2007). The utilization of commercially available EHR systems by physicians has resulted in savings of $5.14 per patient per month (Information Management Journal 2013).

Figure 2

Hospital Exchange Activity:

HIE has significantly increased by 41% from 2008 to 2012. Also, the exchange of health information by type of clinical data has risen from 39% to 55% during the same period (Furukawa, Patel, Charles, Swain, and Mostashari, 2013).

According to Figure 3, in 2012 around 51% of hospitals were involved in exchanging clinical information with unaffiliated ambulatory care providers, and only 36% exchanged their information with the hospitals out of their organization (Furukawa et al., 2013).

Figure 3

Interoperability of HIE:

NHIN has been widely recognized in the U.S, but the storage of patient data and the data architectures have remained uncertain among two models the patient-centric or centralized model, in which the patient data for a given patient is stored at one central location. The second is the institution-centric or distributed model, someplace the patient data is stored at the place of entry and recorded, (Lapsia, Lamb, and Yasnoff, 2012). The distributive model has been proved to be less efficient from the stimulation studies that aimed to analyze the data availability, integrity, and retrieval failure rates, (Lapsia et al., 2012). The major challenge for the U.S health information technology has been lack of interoperability with a standard language, structured nomenclature for the data in healthcare that has restricted the effective and efficient communication of organizations for information exchange across a nationwide network (James, 2005).

According to Figure 4, NHIN can be achieved through EHR adoption, meaningful use and by the participation of additional components such as biomedical learning system in the U.S,

(Friedman, Wong, and Blumenthal, 2010). The federal agencies such as the Social Security Administration through its association with Med Virginia, have been able to minimize the turnaround time for medical disability determination from 84 days to 46 days accounting for 45% improvements (ONCHIT, c). The Regenstrief Institute has been sharing de-identified patient data across 80% of the Indiana's population with the support of CDC to encourage the tracking of influenza and pneumonia (ONCHIT, c).

Figure 4

Increased Quality of Care:

Errors in medication have been the third common cause of death in the U.S in 2013, which has accounted for 210,000 deaths (James, 2013 and Carter, 2014). The introduction of HIE has increased the operating functionality of medical prescription and has resulted in improved quality of care provided to the people (Hillblom, Schueth, Robertson, Topor, and Low, 2014).

HIE has decreased the occurrence of adverse drug reactions caused for known allergic reactions by prompting the pharmacist and the providers regarding the allergic history of the patient (Kaelber and Bates, 2007). For example, according to these authors from the predictable 770,000 adverse drug events that have occurred every year in the US, 30% to 70% of the adverse events could be avoided by enhancing the patient safety through HIE. Also, the implementation of the NHIN has been supportive for the physicians for accessing the patient medical records and to provide care for the patient remotely resulting in increased quality of care offered (Crane and Crane, 2008).

Barriers and challenges:

According to the Table 1, the barriers and challenges observed in the implementation of the NHIE have been interoperability, technical support, cost of implementation, security and privacy of the personal health information, legal liability, impairment or different type of workflow for the different organization. Inadequate or missing data has been one of the barriers for NHIN. In 2011 barriers like cost, workflow, technical gap, value of HIE, privacy and security concern, missing the data, usability, and liability were recorded total of 8 out of the 10 barriers were recorded by the various articles (Table 1).

The technical problem also observed in the literature review before 2011, after the introduction of the Regional Extension Centers (RECs) as a part of the HITECH Act provided technical support to the organization implementing EHR and participated in the HIE (Kruse, Regier, & Rheinboldt,2014).

The leadership of the organization and the lack of value found in the exchange the information (Adler-Milstein, Bates, & Jha, 2011). Similarly, a cross-section study done in 2011, emphasized on the efficiency of the HIE, lack of tech support and missing data during the integration process has been barriers and challenges (Gadd, et. al., 2011).

According to the Director of Information Systems at Cabell Huntington Hospital, the main issue for NHIN implementation is whether it will take away all the state-wide HIE and connect them to make it national or is it separate HIE that is outside of the state. State HIEs have a unique functionality that the federal would not possess. The main challenge faced by HIEs currently is the lack of state to state connection, relevance of data, use and key functionalities. Local HIEs are currently struggling with issues in network, connectivity and funding. State HIEs offer benefits such as Continuity of Care Document (CCD), HL-7, ENS (ADT based alerts),

results, and images. Barriers faced by the Cabell from the state level are the shared partners, implementation timeliness, duplication of data (Director of Information Systems Cabell, 2017).

DISCUSSION

The purpose of this research was to review the current state of the NHIN, interoperability, motivating factors, and challenges and to determine the increase in quality of care.

To evaluate the effectiveness of the NHIN the hospital exchange activity, costs of implementation and the quality of care were analyzed. From the literature review, there has been a significant increase in the costs spending associated with the NHIN implementation. The Maryland CRISP has estimated the implementation costs of HIE over 4 years, and it has fluctuated based on the ongoing operation and model of HIE adopted, number of data types and sources, ease of exchange of information (ONCHIT, B). The NHIE has accomplished success with a substantial increase in HIE from 2008 to 2012, irrespective of the type of the organizational affiliation of the provider or the hospital exchanging the information or category of data being transferred. The HIE has resulted in a significant increase from 39%-55% across all types of HIE and exchange with the hospitals outside the organization was more significant than doubled. Although there has been a considerable increase in HIE among all categories, EHR adoption in association with the participation of HIO has revealed the highest exchange activity across all types of organizations and affiliations (Furukawa et al., 2013).

From the literature review, the performance of the NHIN was analyzed using the transaction volume. It was evaluated that the distributive model has been substandard concerning the transactions volume required for presenting a complete patient record. Furthermore, data retrieval failure was a significant factor that has affected the performance of the NHIN. The

challenges at the point of care were caused due to the fragmentation of data, seasonal migration, and travel (Lapsia et al., 2012). The relationship of patient-physician was identified to be a significant factor in communication between them as a critical factor, which was improved by combining NHIN with HIE's e-mail messaging system between them.

The implementation of NHIN has a positive effect on enhancing the quality of care being provided for patients. Increased physician-patient communication, access to the patients past medical history could help in improving the access of care by the patients and ultimately the care being provided. Although NHIN has many advantages, there were many challenges to be confronted with its efficient implementation. The principal challenge for the NHIN implementation might be because of the increased costs and the physicians' reluctance to participate in HIE. The NHIN together with MU criteria has resulted in significant data exchange for supporting the care coordination, patient interaction/engagement, and submission of the quality data to decrease the costs, (Kibbe, 2010).

There is a constant discussion of the cost spent on the implementation on the NHIE, which has been observed a general barrier for the implementation (Dixon, Jones, & Grannis, 2013). Although cost have been discussed more, the other obstacles have also caused to obstruct the implementation of NHIE, as interoperability, security, and privacy of the EHR data, the workflow of the different healthcare organization, were the other barriers to implement the NHIE. The implementation of the NHIE was aimed to the increased quality of care and the improving the efficiency, but it seems not promising in the study of the several literatures (Steward, Koester, Collins, & Myers, 2012 and Karlewski, Zink, & Boyal, 2012). As the Health Information Portability and Accountability Act, gives more importance to the patient's personal information security, it has been observed that the privacy and security also a concern in the

implementation and the protection of the personal health records has been casing barriers to the implementation.

The principal limitation of this study was that the minimal amount of literature available on the topic, as the implementation of NHIN across the U.S was not fully obtained as it is still in trial stage. This literature was limited because of the constraints in the search strategy utilized for the study, researcher bias, predominantly the number of databases searched because publication bias might have altered the availability and caliber of research available during the search.

Practical implications of literature review discussed the various aspects of the NHIN implementation, which helps to identify the important components of the process. Implementation of HIE could help to develop cost saving opportunity after implementation. It can help in increasing the quality of care in patient care, and help to increase communication among providers, to provide the care at any point of care. NHIN is an ongoing growing technology and yet to implement in all parts of the US. The future study should focus on certain research areas, in order to overcome barriers and challenges for successful implementation.

CONCLUSION

The implementation of NHIN is an ongoing project, which can be achieved by technical, legal, and governance frameworks in the near future. The literature has suggested that NHIN could achieve cost savings, increase quality of care and communication between physician and the patient. Furthermore, the HIEs will be able to support the providers by following the framework for achieving the Meaningful Use and to qualify for the incentives. Future research should aim to evaluate the models, services, and the standards for supporting the implementation of nationwide HIE.

REFERENCES:

Adler-Milstein, J., Bates, D. W., & Jha, A. K. (2009). US Regional health information organizations: progress and challenges. *Health Affairs*, *28*(2), 483-492

Agha, L. (2014). The effects of health information technology on the costs and quality of medical care. *Journal of health economics*, *34*, 19-30.

Brailer, D. J. (2005). Interoperability: the key to the future health care system. *Health affairs*, *24*, W5-19-W5-21

Carter, J.H. (2014, September). How EMR software can help prevent medical mistakes. *In American College of Physicians.* Retrieved from http://www.acpinternist.org/archives/2004/09/emr.htm

Center for Medicare and Medicaid Services (CMS), (2016). *Stage 3 Program Requirements for Providers Attesting to their State's Medicaid EHR Incentive Program*. Retrieved from https://www.cms.gov/Regulations-and Guidance/Legislation/EHRIncentivePrograms/Stage3Medicaid_Require.html

Crane, J. N., & Crane, F. G. (2008). The adoption of electronic medical record technology in order to prevent medical errors: a matter for American public policy. *Policy Studies*, *29*(2), 137-143.

Department of Health and Human Services (DHHS) (2008, June 3). *The ONC-Coordinated Federal Health Information Technology Strategic Plan:* 2008-2012. Accessed on 12/06/2017 from https://www.healthit.gov/sites/default/files/hit-strategic-plan-summary-508-2.pdf

Dixon, B. E., Zafar, A., & Overhage, J. M. (2010). A framework for evaluating the costs, effort, and value of nationwide health information exchange. *Journal of the American Medical Informatics Association, 17*(3), 295-301.

Dixon, B. E., Jones, J. F., & Grannis, S. J. (2013). Infection preventionists' awareness of and engagement in health information exchange to improve public health surveillance. *American Journal of Infection Control*, *41*(9), 787-792.

Friedman, C. P., Wong, A. K., & Blumenthal, D. (2010). Achieving a nationwide learning health system. *Science translational medicine*, *2*(57), 57cm29-57cm29.

Frisse, M. E., & Holmes, R. L. (2007). Estimated financial savings associated with health information exchange and ambulatory care referral. *Journal of Biomedical Informatics, 40(*6).

Furukawa, M. F., Patel, V., Charles, D., Swain, M., & Mostashari, F. (2013). Hospital electronic health information exchange grew substantially in 2008–12. *Health Affairs, 32*(8), 1346-1354.

Gadd, C. S., Ho, Y. X., Cala, C. M., Blakemore, D., Chen, Q., Frisse, M. E., & Johnson, K. B. (2011). User perspectives on the usability of a regional health information exchange. *Journal of the American Medical Informatics Association*, *18*(5), 711-716

Gold, M., & McLaughlin, Catherine. (2016). Assessing HITECH implementation and lessons: 5 years later. *The Milbank Quarterly, 94*(3), 654-687.

Halamka, J., Overhage, J. M., Ricciardi, L., Rishel, W., Shirky, C., & Diamond, C. (2005). Exchanging health information: local distribution, national coordination. *Health Affairs, 24(*5), 1170-1179.

Hersh, W. R. (2007). Adding value to the electronic health record through secondary use of data for quality assurance, research, and surveillance. *American Journal of Managed Care, 13(6)*, 126-128.

Hillblom, D., Schueth, A., Robertson, S. M., Topor, L., & Low, G. (2014). The impact of information technology on managed care pharmacy: today and tomorrow. *Journal of Managed Care Pharmacy*, *20*(11), 1073-1079.

Hincapie, A. L., Warholak, T. L., Murcko, A. C., Slack, M., & Malone, D. C. (2010). Physicians' opinions of a health information exchange. *Journal of the American Medical Informatics Association*, *18*(1), 60-65

Information Management Journal. (2013). Study shows EHRs Do Lower Costs. *Information Management Journal*, *47*(5),10.

James, B. (2005). E-health: steps on the road to interoperability. *Health Affairs, 24*, W5-26-W5-30.

Kaelber, D. C., & Bates, D. W. (2007). Health information exchange and patient safety. *Journal of Biomedical Informatics*, *40*(6), S40-S45.

Kaushal, R., Blumenthal, D., Poon, E. G., Jha, A. K., Franz, C., Middleton, B., et al., (2005). The costs of a national health information network. *Annals of Internal Medicine*, *143*(3), 165-173.

Kibbe, D. C. (2010, May 5). NHIN Direct: Getting to Health Internet, Finally! Retrieved from http://thehealthcareblog.com/blog/2010/05/05/nhin-direct-getting-to-the-health-internet-finally/

Korst, L. M., Aydin, C. E., Signer, J. M., & Fink, A. (2011). Hospital readiness for health information exchange: Development of metrics associated with successful collaboration for quality improvement. *International Journal of Medical Informatics*, *80*(8), e178-e188

Kruse, C. S., Regier, V., & Rheinboldt, K. T. (2014). Barriers over time to full implementation of health information exchange in the United States. *JMIR Medical informatics*, *2*(2).

Lapsia, V., Lamb, K., & Yasnoff, W. (2012). Where should electronic records for patients be stored? *International Journal of Medical Informatics*, *81*(12), 821-827.

Lluch, M. (2011). Healthcare professionals' organisational barriers to health information technologies—A literature review. *International journal of medical informatics*, *80*(12), 849-862

Maxson, E. R., Jain, S. H., McKethan, A. N., Brammer, C., Buntin, M. B., Cronin, K., & Blumenthal, D. (2010). Beacon communities aim to use health information technology to transform the delivery of care. *Health affairs*, *29*(9), 1671-1677.

Myers, J. J., Koester, K. A., Chakravarty, D., Pearson, C., Maiorana, A., Shade, S. B., & Steward, W. T. (2012). Perceptions regarding the ease of use and usefulness of health information exchange systems among medical providers, case managers and non-clinical staff members working in HIV care and community settings. *International journal of medical informatics*, *81*(10), e21-e29

Office of National Coordinator for Health Information Technology, [ONCHIT], (2013 a). *What is the NHIN? Health IT.GOV* Retrieved September 10,2017, from https://www.healthit.gov/sites/default/files/what-Is-the-nhin--2.pdf

Office of the National Coordinator for Health Information Technology, [ONCHIT]. (2013b). Enabling Health Information Exchange to Support Community Goals. Retrieved November 2, 2017, from https://www.healthit.gov/sites/default/files/onc-beacon-lg4-clinical-transformation-via-hit.pdf

Office of the National Coordinator for Health Information Technology, (ONCHIT). (c). *Nationwide Health Information Network Exchange.* Retrieved September 27, 2017, from https://www.healthit.gov/sites/default/files/pdf/fact-sheets/nationwide-health-information-network-exchange.pdf

Patel, V., Abramson, E. L., Edwards, A., Malhotra, S., & Kaushal, R. (2011). Physicians' potential use and preferences related to health information exchange. *International Journal of Medical Informatics*, *80*(3), 171-180

Pevnick, J. M., Claver, M., Dobalian, A., Asch, S. M., Stutman, H. R., Tomines, A., & Fu, P. (2012). Provider stakeholders' perceived benefit from a nascent health information exchange: a qualitative analysis. *Journal of Medical Systems*, *36*(2), 601-613

Rathlev NK., . (2 Time series analysis of variables associated with Daily Mean Emergency Department Length of Stay. *Annals of Emergency Medicine*, *49*(3):265-271.

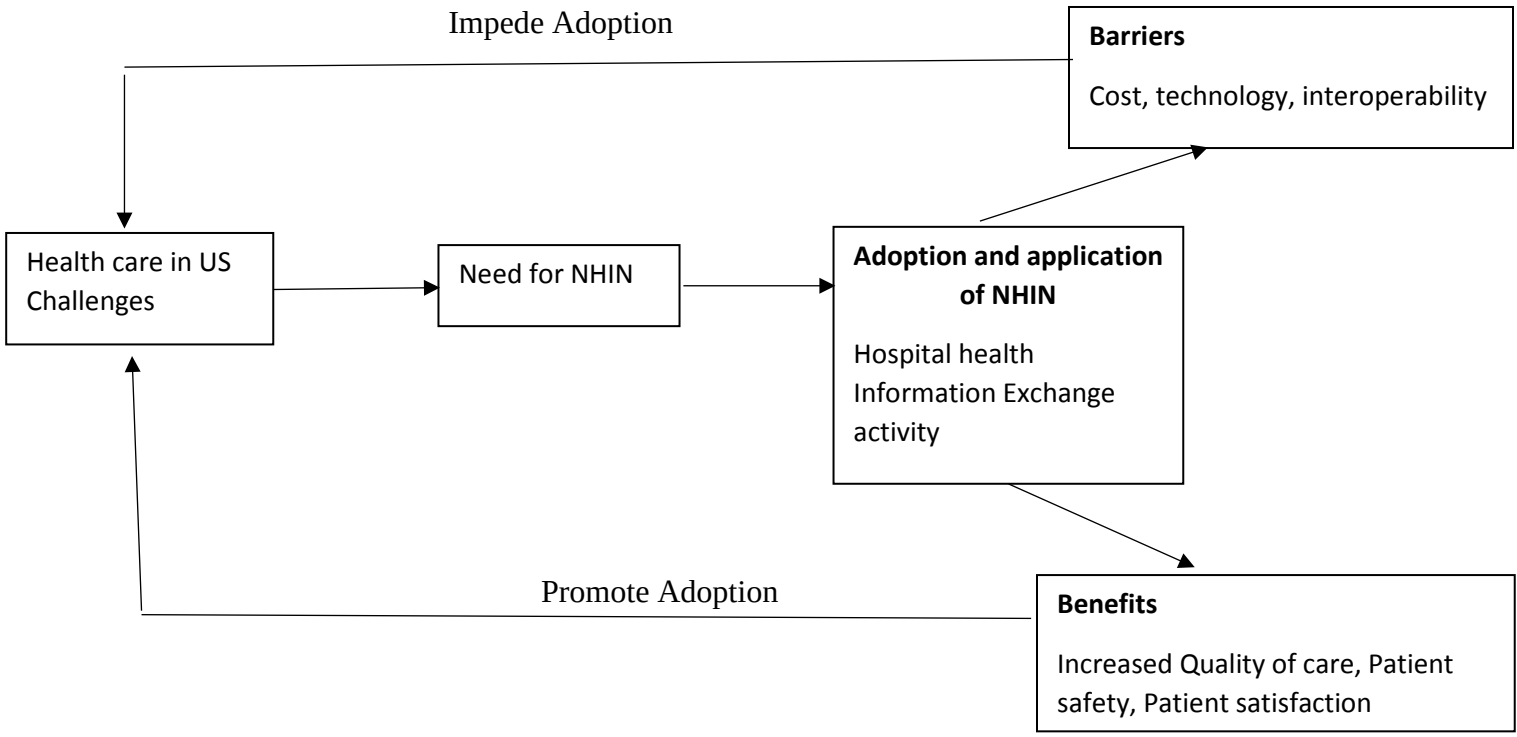
Rathlev, N. K., Chessare, J., Olshaker, J., Obendorfer, D., Mehta, S. D., Rothenhaus, T., et al., (2007). Time series analysis of variables associated with daily mean emergency department length of stay. Annals of emergency medicine, 49(3), 265-271.

Rudin, R., Volk, L., Simon, S., & Bates, D. (2011). What affects clinicians' usage of health information exchange. *Applied Clinical Informatics*, *2*(3), 250-262.

Steward, W. T., Koester, K. A., Collins, S. P., Maiorana, A., & Myers, J. J. (2012). The essential role of reconfiguration capabilities in the implementation of HIV-related health information exchanges. *International Journal of Medical Informatics*, *81*(10), e10-e20

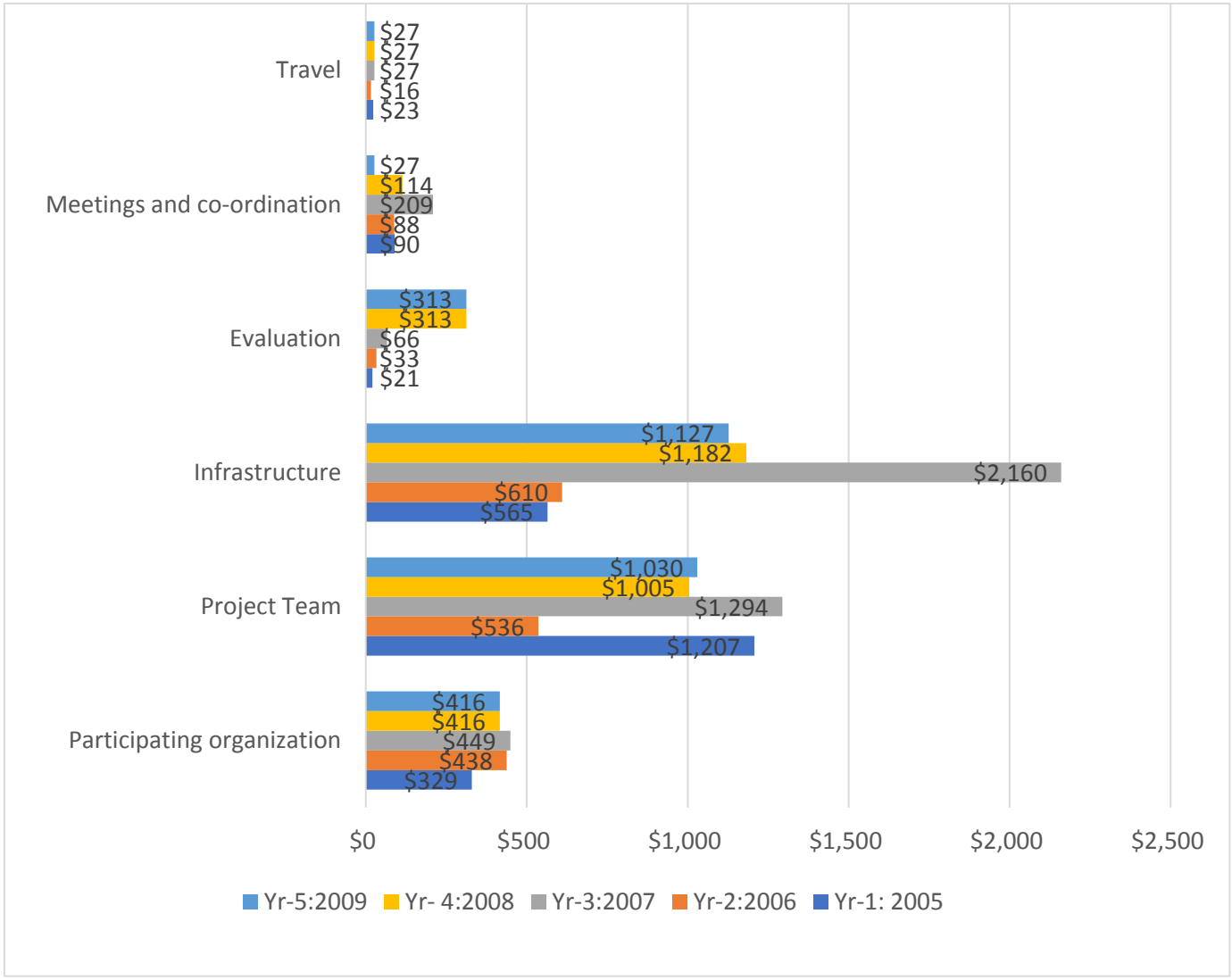
Sullivan, T. (2012, March 15). ONC to stand up NwHIN Exchange in October. *Government HealthIT*. Retrieved September 28, 2017 from http://www.govhealthit.com/news/onc-stand-nwhin-exchange-october

Yao, W., Chu, C. H., & Li, Z. (2010). The use of RFID in healthcare. Benefits and barriers. In *RFID-Technology and Applications (RFID-TA),2010 IEEE International Conference*, 128-134.



Source: Yao, Chu, and Li (2010).

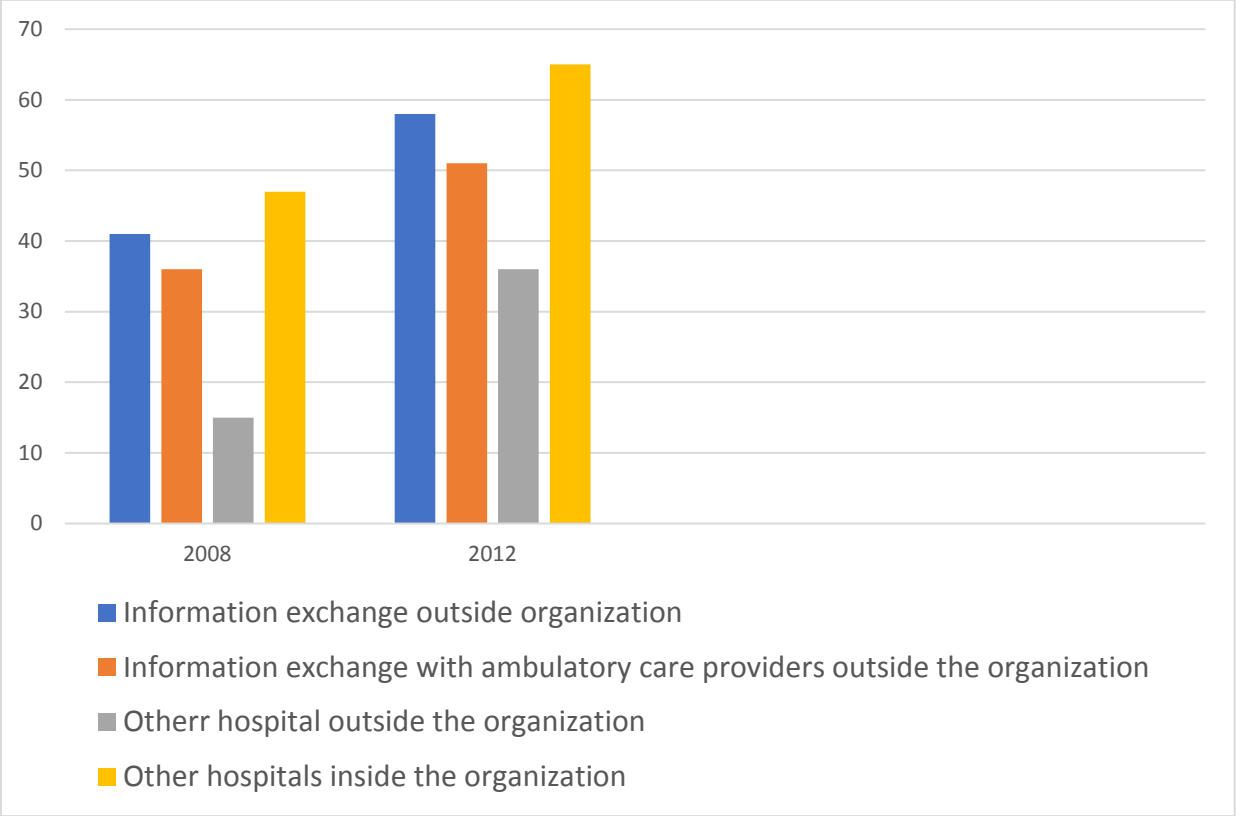
Figure 1: Conceptual Framework.



Source: Frisse, & Holmes, (2007).

Figure 2: Projected costs for the HIE Implementation in a five-year period (2005-2009)

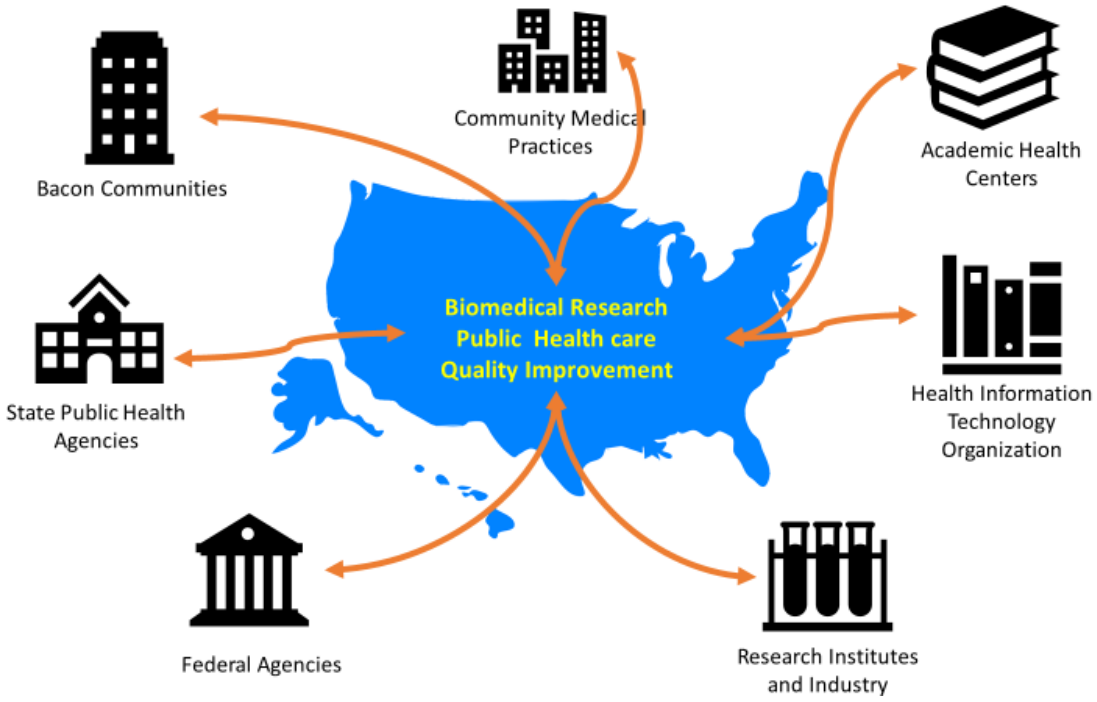
Figure was recreated from the original source



Source: Furukawa, Patel, Charles, Swain, & Mostashari, (2013).

Figure 3: Hospitals Electronic Health Information Exchange participation, 2008 and 2012.

Figure was recreated from the original source



Source: Friedman, Wong, & Blumenthal, (2010).

Figure 4**:** A National Health Information Exchange Network

Figure was recreated from the original source

Table 1: List of the Articles and Summarized Barriers**.**

Author	**Type of study**	**Barriers Found**
Rudin, et. al., 2011	A qualitative study. Data collection by interviewing clinician-users and HIE staff of one operational HIE which supported aggregate patient record functionality. 15 clinicians were interviewed 5 HIE staff	Gaps in data, Workflow Usability Cost,
Patel, et. al., 2011	A survey was conducted of physicians affiliated with institutions that are stakeholders of a regional health information organization in the United States (U.S.).	Costs, Tech support, Workflow, Usability
Korst, et. al., 2011	Cross-sectional design, Used an on-line survey of hospitals in a large	Strong leadership, Tech support, Value of data
Adler-Milstein, Bates, Jha, 2011	A survey of health information ex-change organizations in the United States	Cost, Leadership, Lack of value
Lluch, 2011	Systematic literature review. A total of 31 sources were searched.	Ownership, Workflow, People policies, Cost, Tech support
Gadd, et. al., 2011	A cross-sectional survey of individuals given access to the HIE at participating organizations	Efficiency, Tech support, Data missing
Hincapie, et. al., 2011	Qualitative data were analyzed using analytical coding. A focus-group guide was developed and included five domains: perceived impact of AMIE on (1) quality of care; (2) workflow and efficiency; (3) healthcare	Lack of value, Technology gaps, Missing data

	costs; (4) system usability; and (5) AMIE data content.	
Pevnick, et. al., 2012	Semi-structured interviews with organizational representatives.	Legal concerns, Data security, Costs,
Steward, et. al., 2012	111 semi-structured interviews with project staff and information technology (IT) specialists	Cost, Technology gap, Value, Workflow
Kralewski, Zink, Boyle, 2012	A purposive sample of 8 small medical group practices in 3 experimental HIE regions were interviewed to determine the extent of clinical information exchange with other health care providers and to identify the factors influencing those patterns.	Cost, Lack of value, Technology gap, Privacy
Myers, et. al., 2012	Qualitative interviews and Quantitative web-based surveys to assess the systems' perceived usefulness and ease of use shortly after the HIEs were implemented.	Value, Tech support, Workflow
Dixon, Jones, Grannis, 2013	An online survey of IPs was conducted in states with HIE networks. A total of 63 IPs was invited to participate; 44 IPs (69%) responded.	Lack of awareness, Workflow, Usability, Interoperability Missing data
Campion, Edwards, Johnson, Kaushal, 2013	A cross-sectional study in three communities in New York State using system access log files from January 2009 to May 2011 to measure usage patterns of a query-based HIE web portal system with respect to practice sites, users, patients, and data.	Workflow
Ben-Assuli, Shabtia, Leshno, 2013	This study used a track log-file analysis of a database containing 281,750 emergency department (ED) referrals in seven main hospitals in Israel. Log-files	Costs, Missing data, Workflow, Leadership

	were generated by the system and provide an objective and unbiased measure of system usage	
Thorn, Carter, Bailey, 2014	A qualitative study using grounded theory principles was conducted in 4 urban emergency departments that had health information exchange access for 4 years. Data were collected with unstructured interviews from 15 emergency physicians.	Workflow, Usability

APPENDIX A

INTERVIEW QUESTIONS:

1) How do you think NHIN policy will affect the local HIE? WHY?
2) Do you think the hospitals are more reluctant to participate in local vs national HIE? WHY?
3) What technology choices are made by Cabell for NHIN and what are the implications? WHY?
4) What are the mechanisms for data aggregation?
5) What operational costs are involved by Cabell for implementing NHIN? WHY?
6) How is the standards harmonization achieved between NHIN recommended standards and Cabell? WHY?
7) What are the costs incurred for achieving the harmonization? WHY?
8) How much data does Cabell receive through NHIN? WHY?
9) Is the data received from NHIN complete? WHY?
10) What % of data is available as a clinical result?
11) How often do the consumers of the HIE need access to data from other HIEs?
12) Is the care being improved by using NHIN? WHY?
13) What are some of the barriers encountered during NHIE and how did Cabell overcome them?
14) How does government help to implement NHIE?
15) How are privacy and security of patient's health and personal information insured by Cabell during NHIE?
16) How is quality measure reporting handled by Cabell during NHIE?

17) How does health information exchanges handle the transition of care?

18) Why do you think is the delay for the NHIE implementation?

19) What are the benefits of Nationwide HIE? WHY?