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# Bridging the EHR Interoperability Gap

CAPSTONE REPORT

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### **Abstract**

In order to provide interoperability between healthcare organizations, healthcare IT must provide tools to exchange and coordinate patient information among electronic health record (EHR) systems. This annotated bibliography contains research published between 2005 and 2015 that targets interoperability options for EHRs, with a focus on articles published since the 2010 passage of the Patient Protection and Affordable Care Act (Anderson & Zanzi, 2013). The report identifies best practices in designing the tools to bridge the EHR interoperability gaps.

*Keywords: patient centered medical home, meaningful use measures, and healthcare reform requirements, practice redesign, health reform, health records adoption, PCMH implementation challenges, core quality PCMH measures, care coordination, clinical decision support, healthcare cost reduction, medical informatics, collaborative technologies, communication, computing, safety, social/organizational study, surveys and needs analysis, system implementation and management issues, bridging EHR gap, EHR interoperability solutions.*

**Table of Contents**

Introduction..... 4

    Problem..... 4

    Purpose..... 7

    Research Questions..... 8

    Audience ..... 8

    Search Report..... 9

Annotated Bibliography..... 13

    Background and historical information ..... 13

    Specific EHR Interoperability Issues..... 19

    Possible solutions to resolve the existing gaps ..... 21

Conclusion ..... 33

    Background and Historical Information ..... 33

    Health Information Exchange Approach ..... 34

    The Cloud Computing Approach..... 36

    Incorporation of tools in the clinical practice ..... 37

References..... 38

## Introduction

### Problem

Health care spending in the United States has grown substantially faster than the economy for decades. The health care sector now accounts for over 17% of GDP (McClellan & Rivlin, 2014). Under the current fee-for-service model, care is often fragmented or duplicated (Blackford, 2014). The population is aging and health maintenance requirements continue to grow (Grossmann, Goolsby, Olsen & McGinnis, 2011). The Patient Protection and Affordable Care Act (PPACA) is the main driver behind a shifting healthcare delivery paradigm (Anderson & Zanzi, 2013). The reform is intended to improve safety and quality of patient care and accuracy in the associated measuring of quality and reporting of patient information. Several safety and quality measures focus on basic data entry, including entry of vital signs, patient demographics, drug and allergy lists, updated problem lists, and smoking status (Knox & Brach, 2013). Part of the paradigm shift is the development of a business model which will curtail excessive healthcare spending, eliminate fragmented and duplicative care, and encompass and accommodate the increase in the patient population which has chronic diseases (Grossmann et al., 2011).

In order to promote connected and coordinated health care delivery, the legislation proposes implementation of models to encourage the development of systems that deliver such care, assess the value (i.e., cost and quality) of the care provided, and facilitate the rapid dissemination of better models of care throughout the health care system (Keller, Toomey, Raphael, Sadof & Stille, 2014). While Congress understands that no one model has been proven to be most effective, the Patient Centered Medical Home (PCMH) model is repeatedly highlighted in the legislation as a means of containing cost while maintaining high levels of

patient care and care coordination (Keller et al., 2014). The PCMH model is a newly developed care approach, defined by the Agency for Healthcare Research and Quality as “a model for strengthening primary care through the reorganization of existing practices to provide patient-centered, comprehensive, coordinated, and accessible care that is continuously improved through a systems-based approach to quality and safety” (AHRQ, 2011, p. 2).

The Office for Oregon Health Policy and Research outlines standards and quality measures for the Patient Centered Medical Home model to include the care coordination measure. The care coordination measures require the use of an electronic health record (EHR) system to improve patients’ care and for healthcare facilities to demonstrate the Meaningful Use of their EHRs (Office for Oregon Health Policy and Research, 2010). Meaningful Use is the Health Information Technology for Economic and Clinical Health Act’s (HITECH’s) goal, which specifies that all healthcare providers will use an EHR to achieve significant improvements in patients’ care (Blumenthal & Tavenner, 2010).

The use of an EHR has been shown to improve patient care and demonstrates Meaningful Use by facilitating communication between care teams across all elements of the broader health care system, including specialty care, hospitals, home health care, and community services. Exchange of the patients’ health information, preferences, care plans, and goals for treatment among healthcare providers are examples of EHR facilitated communications (Meyers et al., 2010). Such coordination is critical during transitions between sites of care, such as when patients are discharged from the hospital and transferred to rehabilitation, recovery or primary care facilities (Meyers et al., 2010).

Many healthcare facilities face challenges in implementing the Patient Centered Medical Home care model due to several potential problems. These problems include challenges with the

adoption of an EHR, inability to evaluate EHR proposals and systems, and inability to find systems that meet the practices' care coordination needs (Gourevitch & Shah, 2009). The adoption challenges are due in part to the high up-front costs. The lack of capital resources and concern about the loss of productivity during the transition to an EHR system are rated among the top barriers for practices (Charles, Charles, Gabriel & Furukawa, 2014). The evaluation challenges presumably could be lowered by providing information and decision support to practices (Charles et al., 2014).

Another issue with the adoption of an EHR is a lack of interfaces between different healthcare organizations' systems (Menachemi & Collum, 2011). No single EHR application or system has a complete reach across the health and wellness ecosystem (Blackford, 2014). In order to facilitate the exchange of patient data between healthcare organizations, the EHR systems used by the respective organizations must be able to exchange data, which requires interfaces between the systems (Menachemi & Collum, 2011). The ultimate goal in building these interfaces is to provide interoperability between the systems (Williams, 2013). In health care, interoperability refers to the connections between different software applications that make it possible for unaffiliated providers to directly communicate, exchange data and use the information that has been exchanged. The goal is to connect electronic health record systems to enable care providers to access care information whenever and wherever necessary (Williams, 2013).

In order to provide interoperability, health information technology must provide tools to various providers to interact appropriately to exchange and coordinate information about shared patients. This implies that healthcare organizations appropriately share patient information and

that health information technology developers design products with data-sharing tools in a patient-centered manner (Blackford, 2014).

### **Purpose**

The purpose of this annotated bibliography is to present literature that informs the identification of best practices in the design and development of tools between electronic health records applications and the electronic health records applications used at other care facilities. The research performed explores three main categories of the problem: (a) background and historical information, (b) specific EHR interoperability issues, and (c) possible solutions to resolve the existing gaps.

The Patient Protection and Affordable Care Act in the spring of 2010 proclaimed a new era for the health care industry (Anderson & Zanzi, 2013). Hospital adoption of EHR systems has increased more than five-fold since 2008 (Charles, Gabriel & Furukawa, 2014). Given that no single application or system will ever have complete reach across the health and wellness ecosystem, this implies that next-generation health information technologies will need to provide means to interact appropriately with remote, disparate systems to exchange information about shared patients, and to access an array of tools and services via APIs (application programming interfaces) to support care (Blackford, 2014). The purpose of this annotated bibliography is to provide literature that describes the history and current status of the issues caused by the lack of interoperability between EHR systems, provides a context for and specific examples of EHR interoperability issues, and finally details potential solutions that address the interoperability gaps.

## Research Questions

**Main question.** As EHR systems become larger in scope and more complex and move from regional to national scale (Coiera, Aarts & Kulikowki, 2012), what are best practices for healthcare providers and health information technology professionals in designing the tools to bridge the interoperability gaps between different EHRs?

**Sub-questions.** What tools are available to bridge the interoperability gaps between different EHRs? How can healthcare providers incorporate these coordinated tools into clinical practice?

## Audience

In the field of information management, the concept of healthcare reform and its effect on the current and future states of the healthcare industry fall under the topic of change management. Considering the patient-centered focus of the PCMH model, the building of tools and workflows to achieve the care coordination quality measures becomes important for the following personnel at all levels of the healthcare delivery system: (a) care providers, including doctors, nurses, medical assistants, and various technicians involved in direct patient care; (b) healthcare Information Technology management and leadership, including CIOs, IT directors, and IT managers; and (c) IT support personnel, including systems and business analysts and healthcare engineers.

The care providers evaluate symptoms, order and conduct diagnostic tests, and prescribe medication or treatment to remedy the patient's illness or injury. The care providers also counsel patients and/or members of the community on how to prevent illness (BLS, 2014).

Administrators and managers at all levels in health care organizations spend significant amounts of time and place high value on communication, problem solving, decision making, collaboration

with other disciplines, people development, and cost containment (Purnel, 1999). The support personnel are responsible for analyzing, compiling, and validating crucial medical data. They prepare monthly status reports, aid in organizational projects that deal with health care, compare medical budgeting to their prior analyses, and assist in customer service issues (Health Care Analyst, n.d.). Each group is responsible for and contributes to the care for ill patients.

Knowledge of the care coordination tools and workflow best practices that will be facilitated by this literature review benefits care providers because they will be using the tools and workflows.

Healthcare IT leadership and support personnel have a different vested interest in care coordination tools, interfaces, and workflows (Monegain, 2012). These stakeholders are responsible for building and maintaining the tools and interfaces; they need to deliver higher agility and drive business revenue (IBM, 2014). They must meet these goals while maximizing operational efficiency, lowering costs, and managing growth requirements resulting from cloud, mobile, social, Big Data and analytics (IBM, 2014).

## **Search Report**

**Data collection.** A reasonable amount of effort via the University of Oregon Library site (UO Library) is required to discover information concerning the concept of Primary Care Medical Home. The UO Libraries VPN server is installed; once connected, the initial Quick Search for Primary Care Medical Home search is conducted. The search returns an ample amount of articles, text resources, print books, conference proceedings, e-books, government documents, e-audio and e-video, DVD videos, dissertations, microform, videocassettes, newspaper articles, and legal documents that are applicable to the topic. In addition, the search is expanded to include Google Scholar search engine, which allows for direct access to the full text peer-reviewed articles and scholar books.

**Search strategy.** Narrowing the information related to the Patient Centered Medical Home is accomplished through the use of keyword searches. At first, the default search scope of UO, Summit, and Articles is conducted, which includes the following databases: JSTOR, Project Muse, and Web of Science. The following keywords are used: *patient centered medical home*, *meaningful use measures*, and *healthcare reform requirements*. The search returns a mixture of books, articles, and other formats. To focus the search within article databases on the healthcare industry, further use of the “Search by Subject” option is applied. This focused search returns more refined results, yet still contains a large amount of information. The additional research via specific databases contains the most relevant information; these databases are: (a) Health and Wellness Resource Center, (b) Health Reference Center, (c) Health Source Consumer Edition, (d) Health Source: Nursing/Academic Edition, (e) Health Finder, (f) MEDLINE, (g) Medline Plus, (h) Nursing and Allied Health Collection, and (i) Nursing Resource Center.

In order to find credible literature regarding the specific research problem and potential information about alternative solutions to the problem, the Google Scholar search engine is used to examine existing literature in addition to the UO Library. The following keywords are used: *practice redesign*, *health reform*, *health records adoption*, *PCMH implementation challenges*, *core quality PCMH measures*, *care coordination*, *clinical decision support*, *healthcare cost reduction*, *medical informatics*, *collaborative technologies*, *communication*, *computing*, *safety*, *social/organizational study*, *surveys and needs analysis*, *system implementation and management issues*, *bridging EHR gap*, *EHR interoperability solutions*.

**Reference evaluation criteria.** The selected and categorized full text articles are evaluated using the criteria of relevancy, quality, authority, objectivity and currency in order to build out the credible annotated bibliography (Bell & Frantz, 2014). The reference criteria are

used to evaluate the scholarly sources. The relevancy of a source is determined by comparing it to the main research question. The articles are deemed relevant if the information provides background on the research question, addresses specific issues, or provides alternative solutions to the research problem. The quality is assessed based on the logical structure, clearly expressed main points, logical flow of text, the use of good grammar, and absence of spelling and typographical errors. The articles are deemed to be of sufficient quality if information is written in an informative, clear and logical manner. The authority is assessed based on the author's credentials and citation in scholarly publications, as well as the author's experience, specialization, and association with reputable institutions and organizations, such as state and national medicine and information technology offices (Bell & Frantz, 2014). The articles are deemed authoritative if the author holds advanced degrees and the publishers produce scholarly and peer reviewed research reports.

The objectivity of the author is based on the stated purpose and goals of the publication and the author's unbiased, informative and explanatory writing style. The author's unbiased perspective is demonstrated when both sides of the issue are presented (Bell & Frantz, 2014). The articles are deemed objective if the author acknowledges opposite points of view, arguments and conclusions are supported by evidence, and authoritative sources are cited. The currency is assessed based on the date of publication. Selecting current sources is important due to the emergence of the relevant legislation in the last 10 years, and most recently the passage of the Patient Protection and Affordable Care Act in the spring of 2010 (Anderson & Zanzi, 2013). Articles published within the last ten years are deemed current for the purposes of this research study.

**Documentation approach.** A table is created with the *background*, *specific problem*, and *solutions* categories. Full text articles are selected, downloaded and saved with accompanying information including APA reference, abstract, and URL links documented in the table, according to each relevant category. The AIM Capstone favorites folder is created under the Chrome Browser. The full text links are saved in the folder as a backup.

### **Annotated Bibliography**

This report presents the annotated bibliography with 15 relevant and credible references. The references address the research problem of identifying best practices for healthcare providers and health information technology professionals in designing the tools to bridge the interoperability gaps between different EHRs. The selected references are organized in categories of background and historical information, specific EHR interoperability issues, and possible solutions to resolve the existing gaps. The annotated bibliography is organized according to the above categories. Each annotation consists of three elements: (a) the full bibliographic citation, (b) an abstract, and (c) a summary describing the relevance to this study for the needs of the audience. The ideas presented in the Summary are those of the author(s) of the references. The summaries present a discussion of *health information exchange* and *cloud computing*, which are two main care coordination approaches to bridging the gap between electronic health records. The explanation of these approaches provides a foundation for IT leadership, system analysts, support personnel, and care providers to better understand how to build care coordination tools and implement them into clinical workflows.

#### **Background and historical information**

Agency for Healthcare Research and Quality (AHRQ). (2011). Patient centered medical home resource center. *Defining the PCMH. What is the PCMH?* Retrieved from URL: <http://pcmh.ahrq.gov/page/defining-pcmh>.

**Abstract.** The article describes and defines the medical home model, which holds promise as a way to improve health care in America by transforming how primary care is organized and delivered. Building on the work of a large and growing community, the Agency for Healthcare Research and Quality (AHRQ) defines a medical home not simply

as a place but as a model of the organization of primary care that delivers the core functions of primary health care.

**Summary.** This article focuses on defining the concept of Patient Centered Medical Home and its components to include comprehensive care, patient-centeredness, care coordination, services accessibility, quality and safety. The elements concentrate on the team approach to providing the care, linking physical and virtual tools to provide coordinated care, focus the care on the patients' needs, provide patients with the ability to access the care team around the clock, and use evidence-based medicine and clinical decision-support tools to guide shared decision making with patients and families. Comprehensive care is defined as care provided across the continuum of any disease and as such includes a large variety of healthcare professionals; thus, it is important to link them together to provide care in an interconnected manner. Patient-centeredness is defined as a relationship-building approach to interconnecting patients, families and care teams. Coordinated care is defined as care coordinated across various health services, which includes clear and open communication among all involved in a patient's care. The term service accessibility is defined as having the care team available and having access to the patient's care plan information. Quality and safety are defined as activities which are committed to "using evidence-based medicine and decision-support tools" (AHRQ, 2011) to improve patient treatment outcomes. This article relates to the research question because it includes information on the important key elements of the PCMH components, which provide a foundation to build the interoperability tools and interaction processes to appropriately exchange and coordinate information about shared patients.

Anderson, C. & Zanzi, F. (2013). Responding to the paradigm shift in health care delivery:

Health system affiliation strategies. *Insights*, 41. Retrieved from URL:

[http://www.willamette.com/insights\\_journal/13/winter\\_2013\\_6.pdf](http://www.willamette.com/insights_journal/13/winter_2013_6.pdf)

**Abstract.** While health care reform has created a paradigm shift in the payment of health care in the United States, it is the redesign of the care delivery systems that poses the greatest challenge in the years to come. Combined with an increased focus on integration, access to individual patient data, and reductions in payment rates, the change has created a paradigm shift in the payment of health care services from payment for volume to payment for quality. That paradigm shift results in the redesign and consolidation of the entire health care delivery system. Affiliation agreements specify funding of certain capital projects, such as purchasing new equipment and technology, including information technology, such as electronic health records.

**Summary.** This article describes how “the passage of the Patient Protection and Affordable Care Act in the spring of 2010 proclaimed a new era for the health care industry” (Anderson & Zanzi, 2013, p. 39). The article describes traditional hospital contracts with insurance payers, the positions of hospitals in the market, and how individual hospitals can access capital once they enter into affiliations with each other. The importance of hospital affiliations is described, to include shared resources, common paths to improving quality of care, increased level of care coordination, increased physician recruitment and retention, increased leverage in contracting with insurance payers and supply vendors, and increased access to capital to strengthen and grow healthcare services. The article provides examples of successful affiliations and collaborations recognized as best practices, which focus on cost savings, quality improvements, and improvements of patient and care team communications. Although

this article does not specifically address the EHR interoperability issue, it addresses the main drivers in the healthcare paradigm shift, which results in the redesign and consolidation of the entire health care delivery system to include EHRs and billing systems built into EHRs.

Charles, D., Gabriel, M. & Furukawa, M. (2014). Adoption of electronic health record systems among U.S. Non-federal acute care hospitals: 2008-2013. The Office of National Coordination for Health Information Technology. *ONC Data Brief, 16*. Retrieved from URL: <http://healthit.gov/sites/default/files/oncdatabrief16.pdf>

**Abstract.** This brief describes trends in adoption of EHR systems among non-federal acute care hospitals from 2008 to 2013. Hospital adoption of EHR systems has increased more than five-fold since 2008. Hospital adoption of EHR systems varied significantly by state.

**Summary.** This article describes an adoption of EHR systems by non-federal acute care hospitals, which has steadily increased since the Health Information Technology for Economic and Clinical Health Act (HITECH). In 2013, nearly six in ten (59%) non-federal acute care hospitals had adopted at least a basic EHR system with clinician notes. This represents a 34% increase from the previous year and a more than five-fold increase in EHR adoption since 2008. In addition, a vast majority of acute care hospitals (93%) possess EHR technology certified as meeting federal requirements for Meaningful Use objectives. Hospital adoption of EHR systems varies across U.S. states. Rates of hospital adoption of at least a basic EHR system are significantly above the national average in fifteen states and significantly below the national average in eleven other states. In addition to growth in EHR adoption overall, hospital adoption of advanced EHR

functionality has increased significantly. This article relates to the research question because it includes information on the increased need for advanced EHR tools to be built to close the interoperability gap.

Office for Oregon Health Policy and Research. (2010). Standards and measures for patient centered primary care homes. *Final Report of the PCOCH Standards Advisory Committee*. Retrieved from URL:

<http://www.csi.or.gov/medicalhomes/Standards%20for%20PCMH,%20Oregon.pdf>

**Abstract.** The report describes the development of core Patient Centered Medical Home measures. To assist in developing strategies to identify and measure patient centered primary care homes, the Standards Advisory Committee made up of a diverse group of Oregon stakeholders including patients, clinicians, health plans and purchasers was put together. The committee developed six core attributes (Access to Care, Accountability, Comprehensive Whole Person Care, Continuity, Coordination and Integration and Person and Family Centered Care) and a number of standards that describe the care delivered by patient centered primary care homes. The committee articulated its core attributes and standards in patient-centered language in order to help communicate the benefits of this new model of care to the general public. The committee also developed a set of detailed patient centered primary care home measures. The core attributes, standards and measures are intended as a tool for the Oregon Health Authority, policymakers and other Oregon stakeholders seeking a common framework to assess the degree to which primary care clinics are functioning as patient centered primary care homes and promote widespread adoption of the model.

**Summary.** This report describes the passage of House Bill 2009 during the 2009 Oregon Legislature session, which created the Oregon Health Authority (OHA) and established a Patient Centered Primary Care Home Program within the Office for Oregon Health Policy and Research (OHPR). The report describes the work of the Patient Centered Medical Home standards advisory committee to include tasks and products, core attributes and standards, measures and guiding principles. The tasks include defining essential elements of the PCMH, establishing comprehensive PCMH implementation processes, and developing standard PCMH quality measures and policies that cultivate the growth of the PCMH and primary care providers. The products produced by the committee include a proposal of the core attributes and standards, quality core measures, and guiding implementation principles. The core attributes and standards include the access to care, accountability, comprehensive whole person care, continuity of care, coordination and integration of care, and education and clear communication with the patient and the patient's family. The core measures include a number of functional tools divided into Tiers one through three to allow primary care transformation to occur incrementally. The incremental transformation accommodates the building, testing and implementation of PCMH interoperability tools.

The implementation guiding principles include strategies for payment reform to allow the reimbursement for coordination services, strategies for developing the incentive programs to support the PCMH implementation and EHR interoperability tools, strategies for implementation of PCMH measure, guidelines for sustaining the culture of continuous improvement, and most importantly, strategies for aligning the PCHM programs across the health care systems. This article relates to the research question because it includes

detailed information about the Patient Centered Primary Care Home core measures which drive the advanced EHR functionality build to address the interoperability gap.

### **Specific EHR Interoperability Issues**

Blackford, M. (2014). Chairman's column: Health informatics and healthcare transformation entering the post-EMAR era. *Journal of the American Medical Informatics Association*, 21(6), 1141-1142. Retrieved from URL:

<http://jamia.oxfordjournals.org/content/21/6/1141>

**Abstract.** This article describes the changing healthcare environment. Given that no single application or system will ever have complete reach across the health and wellness ecosystem, this implies that next-generation health information technologies will need to provide means to interact appropriately with remote, disparate systems to exchange information about shared patients, and to access an array of tools and services via informatics and the information and communications technologies to support care (e.g. clinical decision support, phenotype extraction from clinical data, population health).

**Summary.** This article describes a path forward in the post-electronic EHR era. The author describes the future goals which are yet to be achieved, to include enhancing of the healthcare information exchange tools. The purpose of the article is to describe the tools and approaches needed in order to reach the ability of clinical knowledge sharing for the purposes of patient care and clinical research. The passage points out that the tools include an array of technologies such as health information exchange, informatics, and big data synthesis. In order for the new technologies to work together seamlessly, the new standards of information exchange and manipulation must be developed. Such proposed standards are the application programming interface standards which allow for the

healthcare ecosystem function as one entity. This article relates to the research question because it includes detailed information on the current needs for sufficient metadata analysis, which includes the need for results to be user-friendly and easy to understand. The article also describes the need for healthcare organizations to share clinical data for the purposes of clinical research and patient care. In addition, it points out that IT developers of the health information technologies build the tools which allow for closure of EHR interoperability gap via “sharing of data in a patient-centered manner” (Blackford, 2014).

Gourevitch, C. & Shah NR. (2009). Medical homes: Challenges in translating theory into practice. *Medical Care*, 47(7), 714-722. Retrieved from URL:

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2790523/>

**Abstract.** The concept of the medical home has existed since the 1960s, but has recently become a focus for discussion and innovation in the health care system. The most prominent definitions of the medical home are those presented by the Patient-Centered Primary Care Collaborative, the National Committee for Quality Assurance, and the Commonwealth Fund. These definitions share: adoption of health information technology and decision support systems, modification of clinical practice patterns, and ensuring continuity of care.

**Summary.** The article describes the history and the founding of the Patient Centered Medical Home and its components. The passage points out that in order to manage the increasing patient population with chronic diseases the PCMH becomes the viable approach to accommodate the patient needs and to achieve the quality measures as outlined by the Patient Protection and Affordable Care Act. The article aims to address

various questions important to healthcare leadership, practitioners, and IT support personnel to understand. These include the healthcare policy-making community impact on the definition and implementation of the PCMH, the medical practices, and the continuum of care. The passage delves into the health information technology current state, the needs for EHR interoperability to manage the increasing population of patients with chronic diseases, the needs for seamless and more accurate billing processes, and the needs to meet the National Committee for Quality Assurance standards which are driven by the Patient Protection and Affordable Care Act. It outlines the benefits of the PCMH which include open patient access and scheduling, coordinated continuum of care, and patient centered principles of delivering the care. This article relates to the research question because it includes detailed information on the development of medical homes, challenges in evaluating and implementing the medical home model into the clinical practice workflows, and the development of communication and collaboration tools targeted to improve care, decrease costs, and close the EHR interoperability gap.

### **Possible solutions to resolve the existing gaps**

Caspi, H. 2015. How waived EHR data fees could make interoperability a commodity.

*HealthcareDive*. Retrieved from URL: <http://www.healthcaredive.com/news/how-waived-ehr-data-fees-could-make-interoperability-a-commodity/389913/>

**Abstract.** Several major electronic health record vendors have announced they will be waiving their data sharing fees (most recently Epic); it's up to IT departments to make sure their organizations can leverage this new level of interoperability. Several leading healthcare IT experts weighed in with Healthcare Dive as they simultaneously champion

the end to a major interoperability roadblock and warn organizations that it will still take effort to facilitate the free flow of data—and that now it will be expected.

**Summary.** The article presents current positive changes in the area of service fees paid for services provided by EHR vendors. Some vendors such as Epic waived their data sharing fees in order to encourage EHR interoperability integration into clinical practices. As external and internal factors increase the pressure to connect and coordinate care, the responsibility for developing interoperability tools falls on healthcare IT. The two main aspects which drive health information exchange and its use are the functioning interoperability services and real-time access to the data. This article relates to the research question because it includes information on approaches to close the interoperability EHR gap via building the necessary interconnectedness tools into EHRs in order to make data available in real time; it also suggests that health IT developers share their Application Programming Interface (API) frameworks to allow for standardized information exchange.

Coiera, E., Aarts, J. & Kulikowki, C. (2012). The dangerous decade. *Journal of the American Medical Informatics Association*, 19(1), 2-5. Retrieved from URL:  
<http://jamia.oxfordjournals.org/content/19/1/2>

**Abstract.** Systems will be larger in scope, more complex, and move from regional to national and supranational scale. Yet we are at roughly the same place the aviation industry was in the 1950s with respect to system safety. Even if information and communication technology (ICT) harm rates do not increase, the increased ICT use will increase the absolute number of ICT related harms. Factors that could diminish ICT harm include adoption of common standards, technology maturity, better system development,

testing, implementation and end user training. Factors that will increase harm rates include complexity and heterogeneity of systems and their interfaces, rapid implementation and poor training of users. Mitigating these harms will not be easy, as organizational inertia is likely to generate a hysteresis-like lag, where the paths to increase and decrease harm is not identical.

**Summary.** This article describes how more information and communication technology (ICT) will be deployed in the health system. It analyzes the behaviors and risks of the ICT adoption. The authors list benefits to include improved quality and safety, patient care outcomes, and improved effectiveness of clinical decision due to care coordination and timely health information exchange. The authors list risks as well, including the coexistence of manual process along with the rapid ICT adoption and the lack of proper interfaces in between the two. Overall, the demand of healthcare reform is the main driver for ICT implementation on the large scale, yet there is a lack of advanced interoperability tools, lack of knowledge for effective implementation approaches, and lack of standard governing policies. The passage presented the summary of the report issued by the Institute of Medicine of the USA's National Academy of Sciences, which recommends the building of complex ICT tools and management of the implementation risks in real time. This article relates to the research question because it includes detailed information on the design of complex ICT interoperability tools, the risks and benefits, and the implementation approach.

Grossmann, C., Goolsby, A., Olsen, L. & McGinnis, M. (2011). Engineering a learning

healthcare system: A look at the future. *Institute of Medicine and National Academy of Engineering*, 117-170. Retrieved from URL:

<http://www.ncbi.nlm.nih.gov/books/NBK61963/>

**Abstract.** Workshop discussions in this article consider a number of process inefficiencies, structural barriers, and system failures that are significant impediments to quality and that preclude the delivery of highly effective, highly efficient, evidence-based health care. In addition, the focus turned to the areas of underperformance that may need the most attention and correction from an engineering perspective. Presenters in this session examine select obstacles inherent in multiple healthcare system components and certain flawed processes that particularly affect the generation and application of evidence. The goal of the session is to frame suggested ideas for how systems engineering might address some of health care's most troublesome shortfalls.

**Summary.** The article summarizes the workshop discussions during which participants explored barriers to care delivery, lessons in transformation from other organizations, and harnessing the technical talent of the engineering field to inform the development of necessary decision support, feedback mechanisms, and infrastructure. The article presents the introduction to the current state of the national healthcare, outlining the number of shortcomings, barriers, and inefficiencies which preclude the delivery of high-quality evidence-based care; the healthcare culture, which is centered on clinicians, their behaviors and personal practice preferences, as well as competing stakeholders, who work against each other to obtain competitive advantages at the expense of others. In addition, the passage suggests that healthcare must be transformed in a collaborative manner to achieve the requirements set forth by the healthcare reform. Furthermore, the

article takes a look at the future of clinical data systems and clinical decision support. The authors recommend that healthcare leadership, health IT builders and clinicians review and work toward not only integrated care delivery systems but also to transform the organization culture, processes, healthcare environment, data management and technology. This article relates to the research question because it includes detailed information on building an information infrastructure required to close the EHR interoperability gap, to aggregate clinical data and to facilitate the coordination of care and to register the metadata into the clinical registries.

Jensen, P., Jensen, L. & Brunak, S. (2012). Mining electronic health records: Towards better research applications and clinical care. *Nature Reviews, Genetics*, 13, 395-403. Retrieved from URL: [http://www.dartmouth.edu/~cbbc/courses/bio270/PDFs-13S/Tim\\_Byounggug.pdf](http://www.dartmouth.edu/~cbbc/courses/bio270/PDFs-13S/Tim_Byounggug.pdf)

**Abstract.** Integrating EHR data with genetic data will give a finer understanding of genotype–phenotype relationships. However, a broad range of ethical, legal and technical reasons currently hinder the systematic deposition of this data in EHRs and its mining. Here, we consider the potential for furthering medical research and clinical care using EHR data and the challenges that must be overcome before this is a reality.

**Summary.** The article presents the health information technology transformation, pointing out that when the transformation is coupled with clinical decision support systems, patient outcomes and research outcomes will be improved as the clinically important data will be coordinated and available in real-time. The authors note the benefits of the health IT transformation to genetic research. The authors present a baseline for the current state and operability of an EHR system. The article then focuses

on “how data-driven knowledge discovery on cohort-wide health data can fill knowledge gaps and assist informed clinical decision making” (Jensen, Jensen, & Brunak, 2012).

This article relates to the research question because it includes detailed information on the benefits of the EHR and its integration with clinical decision support systems, which facilitate quality improvement of care outcomes. In addition, the article discusses the structural and political challenges to be addressed as EHR adoption and integration move forward.

Meyers, D., Peikes, D., Genevro, J., Peterson, G., Taylor, E., Lake, T., Smith, K. &

Grumbach, K. (2010). The roles of patient-centered medical homes and Accountable Care Organizations in coordinating patient care. *Agency for Healthcare Research and Quality*, 3. Retrieved from URL:

<http://pcmh.ahrq.gov/sites/default/files/attachments/Roles%20of%20PCMHs%20And%20ACOs%20in%20Coordinating%20Patient%20Care.pdf>

**Abstract.** In this brief the goals of care coordination and the central role for primary care are described first, followed by the specific activities involved in care coordination. Next, the evidence on the effectiveness of different care coordination activities that PCMHs and ACOs can pursue is summarized. Finally, roles for PCMHs and ACOs in coordinating care and summarize key points are suggested.

**Summary.** The article outlines the goals and the importance of care coordination, which is an important function of the Patient Centered Medical Home. The author defines the care coordination activities, which include investment in Health IT structures, team-based care models, appropriate payment reimbursements and associated processes to capture the charges for the coordination of care. Finally, Grumbach provides role

recommendations for medical homes and accountable state organizations in coordinating patient care. This article relates to the research question because it includes information on how to coordinate care activities and how to integrate coordination activities into the clinical workflows and EHRs, as well as recommendations on how to develop high-quality care coordination programs.

Monegain, B. (2012). How the cloud is transforming EHRs. Navigating the Cloud.

*Health IT*, 21. Retrieved from URL:

<http://www.medtechmedia.com/files/navigatingthecloud/navigatingthecloud.pdf>

**Abstract.** Cloud computing holds great promise for healthcare. The industry's tech-laggard status makes healthcare ripe for the cloud model, be that public, private, hybrid or virtualized and consolidated datacenters. Navigating the Cloud published by Healthcare IT News and *Government Health IT*, dives deep into health-centric trends such as Big Data, Bring Your Own Device, Health Information Exchange, hosted EHRs, privacy and security, and the federal government's cloud progress and problems – and how those trends intersect with the cloud computing model already so prevalent in most other industries.

**Summary.** The article outlines the current need for EHRs to become part of the cloud computing model. As legislation is requiring healthcare organizations to deliver value-based care, the EHR's interoperability becomes a critical component. The article discusses the value of interconnected EHRs in the growing healthcare IT ecosystem. The author connects the dots by outlining the terminology and options when considering cloud computing, including application service providers (ASPs), managed hosting, and software as a service (SaaS). The article provides data in graphical format, which shows

that in order to improve patient care outcomes, the integration of clinical data is required. This data supports the need for cloud computing in healthcare.

This article relates to the research question because it includes detailed information on the current hospital EHR adoption trends and the need to share healthcare resources. As quality measures become the driving force for big data mining, the data and bioinformatics reveal the crucial hidden information important to improving care coordination and patient care outcomes. This article also includes information about the importance of EHR interoperability in order to have a complete set of data. The article's focus on cloud-based services notes that they are inexpensive and provide real-time and easier access to patient information than the traditional model of hosting in-house. In addition, the article describes how cloud-based services facilitate big data mining, which is important for quality trending, care and compliance improvements.

Schweitzer, E. (2012). Reconciliation of the cloud computing model with US federal electronic health record regulations. *Journal of the American Medical Informatics Association*, 19(2), 161-165. Retrieved from URL:

<http://jamia.oxfordjournals.org/content/19/2/161>

**Abstract.** Cloud computing refers to subscription-based, fee-for-service utilization of computer hardware and software over the Internet. The model is gaining acceptance for business information technology (IT) applications because it allows capacity and functionality to increase on the fly without major investment in infrastructure, personnel or licensing fees. Large IT investments can be converted to a series of smaller operating expenses. Cloud architectures could potentially be superior to traditional electronic health record (EHR) designs in terms of economy, efficiency and utility. A central issue for

EHR developers in the US is that these systems are constrained by federal regulatory legislation and oversight. These laws focus on security and privacy, which are well-recognized challenges for cloud computing systems in general. EHRs built with the cloud computing model can achieve acceptable privacy and security through business associate contracts with cloud providers that specify compliance requirements, performance metrics and liability sharing.

**Summary.** The article describes the high costs associated with EHR adoption and the complex and inflexible issues associated with the traditional EHR build. Further, the author outlines the EHR criteria required with the cloud computing model, such as enabling interoperability and being economical, useful, agile, secure and compliant. The article defines five essential characteristics of cloud computing including on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service. In addition, the various service models are defined to include the Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), and Infrastructure-as-a-Service (IaaS). Schweitzer describes the variability of service combinations and the service provider's ability to support a full cloud based EHR system and / or its separate components, including off site storage, back up, and disaster recovery services. The article describes the federal security and privacy regulations, which lack appropriate standards. The author also outlines the 42 Health Information Technology for Economic and Clinical Health Act (HITECH) requirements needed to ensure compliance with the security rules for the cloud service providers. This article relates to the research question because it includes information on various ways to develop and implement a HIE infrastructure and EHR systems which are capable of interfacing and sharing patient information.

Unerti, K., Johnson, K. & Lorenzi, N. (2012). Health Information exchange technology on the front lines of healthcare: Workflow factors and patterns of use. *Journal of the American Medical Informatics Association*, 19(3), 392-400. Retrieved from URL: <http://jamia.oxfordjournals.org/content/19/3/392>

**Abstract.** This article describes the study conducted by the authors and supported by National Library of Medicine Training Grant and Agency for Healthcare Research and Quality. The goal of this study was to develop an in-depth understanding of how a health information exchange (HIE) fits into clinical workflow at multiple clinical sites.

**Summary.** The article outlines the goals of the presented study, which are to understand the emerging health information exchange (HIE) technology and how it fits into the clinical practice workflows. The materials and methods of the study are outlined and are completed with the ethnographic qualitative study; the data collection is accomplished by direct observations and interviews. The results of the study include descriptions of the HIE workflows, the common patterns and the differences of the HIE workflows across several sites. In addition, the passage provides descriptions of HIE implementation into clinical practices. Further, the article outlines the discussion about various uses of the HIE model and identifies the need to streamline the role-specific functions within the HIE model to improve its effectiveness and promote HIE adoption and use. This article relates to the research question because it includes detailed information about HIE benefits, various existing HIE tools and interoperability issues which must be addressed, and outlines the successful elements of HIE use and implementation into the healthcare ecosystem.

Williams, C. (2013) SHARE: Bridging the interoperability gap between EHRs.

A closer look at quality. *Journal of the Arkansas Medical Society*, 249, 232.

Retrieved from URL:

<https://mmcs.afmc.org/Portals/3/AFMC%20AMS%20Closer%20Look%20Oct2013%20HIE.pdf>

**Abstract.** Health information technology holds great promise for improving the quality and safety of health care. Two tools that can help deliver on this promise are electronic health/medical records (EHRs/EMRs) and health information exchange (HIE) — both the act of exchanging clinical data with outside health care entities through an EHR, and the organizations (HIEs) that facilitate the sending and receiving of data. Health care providers may question why they should participate in an HIE when they already use an EHR system that is “capable” of sharing patient data with other providers. The answer lies in the costs and value of interoperability, and understanding what it actually takes for one health care organization with an EHR system to exchange data with myriad hospitals, specialists, labs, pharmacies, public health registries and other external partners.

**Summary.** The article describes the need for interoperability between EHRs and the issues caused by the gaps between EHRs, pointing out that the gaps are one of the main causes for medical errors. Williams describes the trends in EHR adoption and its increase since 2009. He summarizes the tools available to close the gaps and notes the implementation obstacles, such as high capital and operational costs and the lack of industry-wide standards for building the interoperability tools and implementing the health information exchange systems across the healthcare ecosystem. Finally, the State Health Alliance for Records Exchange (SHARE) model is proposed and the benefits are outlined to include common EHR interfaces, patient care alerts, and delivery of

diagnostic testing results, all of which allow for coordination of care and interoperability of EHRs. This article relates to the research question because it includes detailed information about the health information exchange model, which requires the development of a standard infrastructure to allow unaffiliated EHRs to interface with each other and share common patient information.

## **Conclusion**

This annotated bibliography includes 15 scholarly references that address the topic of best practices for healthcare providers and health information technology professionals in designing tools to bridge the interoperability gaps between different EHRs. The target audience for this research includes (a) care providers, including doctors, nurses, medical assistants, and various technicians involved in direct patient care; (b) healthcare Information Technology management and leadership, including CIOs, IT directors, and IT managers; and (c) IT support personnel, including systems and business analysts and healthcare engineers.

The literature review reveals two main approaches to address the research question of how to bridge the interoperability gap between EHRs. The first approach is the Health Information Exchange network. The second approach is through the use of cloud computing services.

## **Background and Historical Information**

Two recent legislative acts, one at the state level and one at the federal level, have had significant impacts on the delivery of healthcare for Oregonians. “The passage of House Bill 2009 during the 2009 Oregon Legislature session, which created the Oregon Health Authority (OHA) and established a Patient Centered Primary Care Home Program within the Office for Oregon Health Policy and Research (OHPR)” (Office for Oregon Health Policy and Research, 2010, p. 1) and “the passage of the Patient Protection and Affordable Care Act in the spring of 2010” (Anderson & Zanzi, 2013, p. 39); both pieces of legislation proclaimed a new era for the health care industry.

The Patient Centered Medical Home and its components concentrate on the team approach to providing care, linking physical and virtual tools to provide coordinated care, focus

the care on the patients' needs, provide patients with the ability to access the care team around the clock, and use evidence-based medicine and clinical decision support tools to guide shared decision making with patients and families (AHRQ, 2011). The key elements of the PCMH model provide a foundation to build the interoperability tools and interaction processes to appropriately exchange and coordinate information about shared patients. Successful hospital affiliations and collaborations focus on cost savings, care quality improvements, and improvements of patient and care team communications (Anderson & Zanzi, 2013).

A vast majority of acute care hospitals (93%) possess EHR technology certified as meeting federal requirements for Meaningful Use objectives (Charles, Gabriel & Furukawa, 2014). Meaningful Use is the Health Information Technology for Economic and Clinical Health Act's (HITECH's) goal, which specifies that all healthcare providers will use an EHR to achieve significant improvements in patients' care (Blumenthal & Tavenner, 2010). In addition to growth in EHR adoption overall, hospital adoption of advanced EHR functionality has increased significantly; thus, the overall need for advanced EHR tools to be built to close the interoperability gap has increased (Charles, Gabriel & Furukawa, 2014).

### **Health Information Exchange Approach**

The literature describes common challenges facing healthcare providers today. Health information technology is challenged with the lack of interfaces between EHRs (Menachemi & Collum, 2011) and the lack of data-sharing tools to facilitate the exchange of clinical healthcare information (Blackford, 2014). Other challenges include the rapidly growing need for EHR interoperability to manage the increasing population of patients with chronic diseases who have multiple healthcare providers, the need for seamless and more accurate billing processes, and the

requirement to meet the National Committee for Quality Assurance standards which are driven by the Patient Protection and Affordable Care Act.

Blackford describes an array of technologies that have emerged in response to the large amounts of data generated in healthcare today and the need to securely exchange the associated patient records, such as health information exchanges, informatics, and big data synthesis. In order for the new technologies to work together seamlessly, new standards of information exchange and manipulation must be developed. Such proposed standards are the application programming interface standards, which allow for the healthcare ecosystem to function as one entity (Blackford, 2014).

One promising development in the secure exchange of patient data is the Health Information Exchange (HIE). The HIE offers simplicity to physicians who need to reach outside of their practices to connect with other care facilities (Williams, 2013). Through a single interface between an EHR system and HIE, physicians can exchange data with all of the organizations that participate in the HIE platform and access a more complete view of their patients' clinical records (Williams, 2013). HIE uses a database structure that applies a data-matching algorithm to connect information maintained in separate organizational vaults. The documents included in the vaults are laboratory reports, imaging reports, pathology reports, discharge summaries, International Classification of Disease version 9 admission codes, and claims records. Users retrieve all matching patient data originating from all contributing care facilities (Unerti et al., 2012). HIE's sole purpose is to provide the infrastructure for unaffiliated EHRs and other health information management systems to connect and share patient data in a meaningful way. Physicians who have this capability gain access to more complete health

information, which improves patient safety and quality of care, thus meeting the care coordination measure of the PCMH (Williams, 2013).

### **The Cloud Computing Approach**

The software cost, complexity, and inflexibility issues of traditional EHR systems have burdened healthcare and other business sectors, which need to develop modern and innovative architectures to resolve these issues (Caspi, 2015). The two main aspects which drive the Health Information Exchange (HIE) and its use are the functioning interoperability services and real-time access to the data (Caspi, 2015). The National Institute of Standards and Technology addresses EHR interoperability issues by proposing the use of Software-as-a-Service (SaaS) and Platform-as-a-Service (PaaS) providers (Schweitzer, 2012), two service models that leverage the use of cloud computing solutions. Schweitzer outlines the EHR criteria required with the use of cloud computing, such as enabling interoperability and being economical, useful, agile, secure and compliant (Grossmann, Goolsby, Olsen & McGinnis, 2011; Schweitzer, 2012). The five essential characteristics of cloud computing including (a) on-demand self-service, (b) broad network access, (c) resource pooling, (d) rapid elasticity, and (e) measured service; these characteristics are included as part of the various service models, to include Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), and Infrastructure-as-a-Service (IaaS) (Monegain, 2012; Jensen, Jensen, & Brunak, 2012). Schweitzer (2012) proposes the variability of service combinations among different service providers and their varying abilities to support a full cloud based EHR system and / or its separate components, including off site storage, back up, and disaster recovery services.

Cloud computing service providers offer the hosting of EHR systems and storage of EHR data in a variety of formats; access is provided via a variety of technologies, including desktop

client executables, browsers, and smartphones (Monegain, 2012). Such cloud computing providers facilitate the fulfillment of the federal meaningful use requirement by allowing for big data mining, which is important for quality trending, care and compliance improvements (Schweitzer, 2012); cloud computing also facilitates the exchange of healthcare information by allowing the clinical data to be stored and accessed regardless of their interface (Monegain, 2012). Outsourcing to cloud providers makes EHRs more useful, agile, economical, and interoperable (Schweitzer, 2012).

### **Incorporation of tools in the clinical practice**

As described by the Health Information Exchange (HIE) study, the sites participating in the HIE differ significantly on multiple characteristics including geographical location, organizational affiliation, structure, and Health Information Technology (HIT) infrastructure (Unerti et al., 2012). As such, these different site characteristics lead to different approaches towards HIE implementation. The results suggest that users need assistance with integrating HIE into clinical workflows (Unerti et al., 2012). In order to implement a solution that leverages the HIE, a cloud computing solution selected must be secure, compliant, and adhere to government regulations and industry standards (Schweitzer, 2012). Privacy and security standards are currently under development within the cloud community, including business associate contracts that specify auditable, enforceable performance metrics and sharing of liabilities. These standards must allow a system that leverages the cloud as part of an HIE implementation to achieve compliance with federal privacy and security regulations (Schweitzer, 2012).

The literature review revealed that *health information exchange* and *cloud computing* are two main care coordination approaches to bridging the gap that exists when trying to exchange information between electronic health records systems. The sources in the annotated

bibliography provide a foundation for IT leadership, system analysts, support personnel, and care providers to better understand the best technical solutions for patient care coordination tools. By enabling easy adoption of feature-rich EHR systems, modern IT architectures facilitate the federal government's expressed goals of enhancing patients' access to their medical records, improving data exchange, and reducing healthcare costs (Schweitzer, 2012).

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