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Final Report

Lessons from the Literature on Electronic Health Record Implementation

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Executive Summary

Despite the potential benefits, health care providers were initially slow to adopt electronic health records (EHRs). To promote the widespread adoption and use of health IT, Congress passed The Health Information Technology for Economic and Clinical Health (HITECH) provisions of the American Recovery and Reinvestment Act of 2009, with the ultimate aim of improving quality, safety, and efficiency of the U.S. health care system. These provisions includes incentive payment programs and technical assistance for eligible health professionals and hospitals to adopt, implement, or upgrade certified electronic health records (EHRs) and to achieve the Meaningful Use (MU) of health information technology (IT).[1,2]

To achieve the ultimate aims of HITECH, health care organizations must not only successfully implement but also optimally and meaningfully use EHRs, a process that involves significant investment, technical complexity, changes in workflow, and numerous other challenges. The purpose of this literature review is to provide examples of how organizations are implementing and optimizing EHRs, and summarize "lessons learned" from peer-reviewed publications and the gray literature.

Common Themes and Lessons Learned

This paper is organized around different stages of the EHR implementation process (planning and vendor selection, workflow and software design, training and user support, and optimization and modification) and explores each stage through multiple perspectives (organizational, professional, and technical perspectives).

Planning and Vendor Selection

The literature suggests the planning stage of EHR implementation is critical to whether or not implementation will ultimately be successful. Selection of systems that will best meet the organization's needs, obtaining staff buy-in, defining the implementation strategy, and determining the pace at which implementation will occur are key issues during this stage. The literature suggests that from the start, it is important for organizations to consider their technical needs, the perspectives of staff from all levels of the organization, and the organizational culture and environment in which the system will be implemented. In addition to relationships with vendors and consultants, partnerships with external stakeholders are also important in order to share and exchange patient information.[3] Smaller organizations with fewer resources have also entered into networks or partnerships to "piggy back" off a larger organization's system. However, some smaller organizations have found the systems of larger hospitals to be too complex for their needs.

Design of Workflows and Software Customization

Planning for changes in user workflow is one of the first and most important tasks for organizations implementing an EHR system. However, a major consensus in the literature is that in general, EHRs are often poorly designed for clinical purposes and need to be continuously customized to meet the needs of the organization. Organizations must address various barriers related to hardware and infrastructure, software customization and usability, and workflow throughout the implementation and optimization process. Several studies found that computerized physician order entry (CPOE) presented greater implementation, customization, and usability barriers relative to other healthcare technologies and remains a major barrier to the receipt of MU incentive payments.[4] Similarly, several studies cited inadequate designs and poor usability of clinical decision support (CDS) systems as major barriers to EHR implementation, or conversely, proper CDS designs and ease of use were cited as facilitators of successful implementation.[5]

Training and User Support

The literature describes training as affecting all professional groups involved, ranging from program planning and strategizing among managers to end-user implementation and participation. Several studies emphasize the importance of investing heavily in and requiring upfront training for all staff members to avoid negative impacts on workflow, costly setbacks, and productivity losses.[6] Some articles also note that post-implementation support is often limited and organizations would benefit from a lengthy post "go-live" period in which hands-on support is available.[7] Training best practices include obtaining organizational commitment to invest in training, assessing users' skills and training needs, selecting appropriate training staff, matching training to users' needs, using multiple training approaches, leveraging the skills of role models (clinical leaders, champions, super-users, training coordinators), providing training support throughout the implementation process, and retraining to optimize use of the EHR.[8,9]

Optimization and Modification

The literature highlights that organizations must continually modify EHR technology to help meet their institution's performance goals. After the system is installed, there are needs for software updates, equipment upgrades and replacement, as well as ongoing maintenance – all of which need to be included in the budget when estimating implementation costs.[10] Resources also need to be devoted to provide ongoing hand-on support long after new technology is initially implemented.[11] Organizations must also continually engage clinicians around using new technology to keep up with changes in the health care system, such as the development of new drugs, devices, procedures and treatments, evidence-based guidelines, and billing and documentation requirements. In addition, organizations have found it important to engage quality improvement (QI) leaders in developing and updating EHRs to facilitate the ability to aggregate data for performance reporting,[12] as well as to develop metrics to track the outcomes associated with QI initiatives utilizing health IT.[13] While evidence to date around the QI movement in health care suggests the effects are positive yet modest, the potential for EHRs and other health IT to enhance quality and provide more comprehensive and timely data for QI may help strengthen the nation's QI capacity.[14]

Conclusion

To promote the EHR implementation and optimization process, planning and modifications are continually needed to address technological, professional, and organizational perspectives. While this review included optimization as a step in the implementation process, one important lesson is that optimization is an ongoing process that needs to be incorporated into each organization's structure and culture. Practically, organizations that successfully implemented EHRs did a number of things early on, such as:

- Engage staff at all levels
- Invest in workflow analysis and careful redesign in order to customize and effectively integrate new technology among users
- Design systems for quality improvement and implementation and information exchange
- Allocate resources for ongoing maintenance and technical support of the system, system adjustments, and continual staff training and engagement

The Institute of Medicine views EHRs as an essential part of a "learning health care system," or a system that is designed to both generate and apply evidence to promote innovation, quality, safety and efficiency in health care.[15] Many also believe that EHRs are critical to the success of payment and delivery system reforms such as patient centered medical homes and accountable care organizations. In order for EHRs to reach their full potential, it will be important to consider how to encourage and support organizations to continually modify and optimize their systems to meet the needs of their organization, their staff, and ultimately their patients.

Introduction/Background

Several evidence-based reviews conclude that some types of health information technology (IT), particularly electronic health records (EHRs) with advanced functionalities, have reduced medication errors and improved care processes, adherence to evidence-based guidelines, patient engagement, and patient satisfaction.[1] Despite these potential benefits, health care providers were initially slow to adopt EHRs. In 2008, approximately 1.5 percent of non-federal acute care hospitals reported having a comprehensive EHR system and 7.6 percent had a basic EHR system.[2] Similarly, approximately 17 percent of office-based physicians used an EHR that met the criteria of a basic system in 2008.[3]

To promote the widespread adoption and use of health IT, Congress passed the Health Information Technology for Economic and Clinical Health (HITECH) provisions of the American Recovery and Reinvestment Act (ARRA) of 2009, with the ultimate aim of improving quality, safety, and efficiency of the U.S. health care system. Through the Medicare and Medicaid EHR Incentive Programs, HITECH makes available an estimated $27 billion to eligible health professionals and hospitals to adopt, implement, or upgrade certified EHR technology and to achieve the Meaningful Use (MU) of health IT.[4,5] HITECH also includes other major programs and activities to support greater provider adoption of EHRs, including the creation of Regional Extension Centers (RECs) to provide local technical assistance to high priority providers to adopt certified EHRs and meet MU requirements, and the State Health Information Exchange Cooperative Agreement Program to facilitate health information exchange.

These ARRA HITECH programs appear to be associated with a rise in the adoption of EHRs. In 2012, 16.9 percent non-federal acute care hospitals reported having a comprehensive EHR system and 27.6 reported having a basic system, representing increases of 15 and 20 percentage points compared to 2008, respectively.[6] Similarly, 39.6 percent of office-based physicians reported using an EHR that met the criteria of a basic system in 2012, more than twice the share of physicians with a basic system in 2008.[7]

To achieve the ultimate aims of HITECH, health care organizations must not only successfully implement but also optimally and meaningfully use EHRs, a process that involves significant investment, technical complexity, changes in workflow, and numerous other challenges. Even though EHR adoption is increasing among providers, little is known about the facilitators of and most promising practices associated with successful EHR implementation and optimization processes. For example, the most recent systematic review that focuses on the effects of health IT concludes that additional research related to technical, human, and organizational factors is needed to fully understand how organizations can implement and effectively use health IT.[8] This type of information is largely absent from other prior reviews as well, although general social and technical barriers are often cited as preventing some providers from realizing the full

potential of health IT, while the "human element" (i.e., managerial and/or clinical leadership and "buy-in") is cited as critical to successful health IT implementation.[9]

The purpose of this literature review is to provide examples of how organizations are implementing and optimizing the use of health IT/EHRs from peer-reviewed publications and the gray literature by examining the context and organization specific factors, barriers and facilitators, and "lessons learned" associated with the successful implementation and optimal use of EHR systems. HITECH states that the "The [Office of the] National Coordinator [ONC] shall prepare a report that identifies lessons learned from major public and private health care systems in their implementation of health information technology, including information on whether the technologies and practices developed by such systems may be applicable to and usable in whole or in part by other health care providers." This this literature review aims to contribute to this report and help answer the following research questions:

- What are the practices that major public and private health care systems use in implementing and meaningfully using health IT?
- How are public and private health care systems implementing health IT and optimizing the use of these technologies? For instance, what are the common barriers to implementation and MU and the best practices to overcome them?
- What are the "lessons learned"? In other words, what can other organizations learn from the strategies and organizational characteristics that have been able to facilitate successful implementation of health IT?

In this paper, we first briefly present and describe the conceptual framework used to structure this analysis and the presentation of relevant findings. Second, we describe the methodological approach to this literature review, covering such key issues as what databases and search terms were used to identify relevant articles, inclusion and exclusion criteria, and the process for determining the final list of papers for review. Third, we discuss the findings, including the common themes and lessons learned related to these three research questions. Finally, we summarize key results and conclusions and highlight topics that were not sufficiently covered in the existing literature, since these gaps indicate where further research is needed.

Framework

We modified and refined an existing conceptual framework to guide this review of selected published and gray literatures around the implementation and optimization of EHRs (see Figure 1). Specifically, we combined the Multiple Perspectives model[10], a systems-based theoretical framework for understanding complex organizational systems, with a hospital-focused framework[11] on the stages associated with EHR implementation and use. This framework is intended to incorporate different perspectives throughout the implementation process, particularly different levels of decision-making and types of users and can serve as a practical tool for major private and public health systems that are in various stages of the EHR

implementation process. We selected a hospital-focused framework as the starting point because hospitals play a major role in local markets and organized delivery systems, and can be influential in shaping the choices of other providers.

The four rectangles representing implementation stages in Figure 1 were adopted from American Hospital Association (2010).[12] This figure highlights how EHR implementation is a multi-stage, continuous process:

- The initial phase is planning and vendor selection. The key components of this stage include identifying the potential uses and benefits of the system, analyzing costs and financial metrics, communicating with staff and articulating goals, conducting vendor and system research, choosing a vendor/system and negotiating a contract, and obtaining the commitment from the staff.
- The second stage, workflow and software design, and third stage, training and user support, are highly interrelated. These stages involve developing new workflows, customizing the system where necessary, installing and testing the system, converting paper charts, informing patients, and training staff.
- The final stage, optimization and modifications, is a continuous process. During the early stages of this process, hospitals will need to troubleshoot their system and find solutions. To optimize the use of the EHR system, the hospital will need to continuously customize and update the system to meet user and patient needs, train staff on an ongoing basis, compare projected and actual costs, and use the system to meet organizational goals and improve outcomes (e.g., utilize a dashboard).

The arrows running through the implementation stages represent the organizational, professional group, and technological perspectives that must be considered at each successive stage of implementation. This element of the framework is borrowed from the Multiple Perspectives model as adopted by Ash et al. (2012).[13] These perspectives or factors are:

- Organizational factors, including organizational type (e.g., academic hospital, rural hospital, physician practice, organized delivery system, accountable care organization, etc…), policies and procedures of the organization, and organizational vision, goals, politics, and culture (e.g., leadership).
- Professional group perspectives, which include the thoughts and behaviors of individual users from different professional groups (e.g., physicians, nurses, administrative staff, informatics team, etc…), teams or departments, as well as management.
- The technical perspective, representing aspects of the EHR system or technology type themselves.

The research team classified and summarized studies using this framework while conducting the literature review. This model is particularly useful, as it covers key organizational dynamics and provides the flexibility to categorize and describe various interrelated factors grounded in

organizational behavior and management theories related to implementation, change, and ongoing learning or optimization. This framework may also be a useful tool to identify areas for future research.

Methods

We made several assumptions to guide the literature review process. First, we focus on the dynamics within major hospitals and organized delivery systems, including the provider experience of health IT adoption and optimization. We define "major public and private health care systems" as individual hospitals or hospital systems that may include owned or affiliated medical groups, managed care plans that own and operate their own hospitals, or other facilities (e.g., accountable care organizations and organized delivery systems ranging from centralized health care systems to independent hospital networks). Second, we emphasize recent experiences in health IT adoption and optimization since the HITECH Act was passed, focusing on the peer-reviewed and grey literature published from 2010 to 2013. Finally, we focus on U.S. health care systems and only evaluate health IT implementation experiences that are 'related or similar to' MU, for example, comprehensive adoption of an EHR or adoption of specific EHR functions that are part of the MU criteria.

The final search terms incorporate phrases used in prior health IT literature reviews and expert opinion from Urban Institute and ONC staff members (Table 1). We searched the online journal database Web of Knowledge for the period spanning January 1, 2010 to March 20, 2013. Web of Knowledge is a research platform and search engine provided by Thomson Reuters that covers the sciences and medicine, arts and humanities, along with the social sciences (e.g., organizational management), providing a slight advantage over other search engines such as PubMed which only primarily focus on medicine and health. We also searched additional grey literature for relevant articles, incorporating publications from a list of government agencies, foundations, academic and research organizations, advocacy groups, and accreditation vendors compiled by ONC project officers.

Figure 2 illustrates how the research team selected the final articles for review. Based on the search term criteria, we identified 1,397 articles for potential review. We then screened the titles and abstracts of each paper to determine if they should be included in the final list of articles. We eliminated all but 104 articles during this phase, keeping those that had a primary focus on implementation and optimization issues and dropping out-of-scope studies (e.g., those that did not meet our assumptions outlined above) along with studies that focus solely on the predictors of adoption or the effects of health IT on specific outcomes. Most of the excluded studies did not focus on implementation and optimization process or did not include sufficient detail on organizational context. We then conducted a full text review of remaining articles and excluded additional papers that were deemed out-of-scope upon further review (e.g. duplicate articles,

studies with international setting, and editorials). This left 75 articles that met our inclusion criteria, 50 of which were peer-reviewed articles and 25 were grey literature articles.

We summarize all of the final articles based on article purpose, setting or context (public vs. private systems, type of provider or organized delivery system, etc…), health IT function ("What"), implementation practices ("How"), implementation barriers and facilitators, and key findings and lessons learned that are applicable to and useable by other providers ("Spread"). Each article was characterized by key themes, which we organized around the framework domains using NVivo software for qualitative data analysis.[14] The discussion of the results centers on these categories (planning and vendor selection, workflow and software design, training and user support, and optimization and modifications), while emphasizing key differences across organizational, professional group, and technical perspectives.

Results

Categorization of Articles

We categorized the final 75 articles by study design, theoretical/conceptual framework, organizational setting, health IT type or function, and study perspective and implementation stage.

We found that the research articles used a wide range of study designs, including literature reviews, quantitative, qualitative, and mixed methods, including case studies or profiles of single and multiple organizations, and cross-sectional rather than longitudinal data and analyses (Table 2). We differentiated between case studies and profiles of organizations by classifying articles that had more rigorous study design (with a stated methods or framework, for example) as case studies, and those that did not as profiles. More than half of our final 75 articles were either case studies of multiple organizations (20) or single organizations (11), or profiles of single organizations (nine). We also found that 15 articles used a mixed methods approach, 10 used quantitative cross-sectional methods (such as descriptive and multivariate analyses), and five were literature reviews. Finally, five articles used other types of study designs that did not fit into our specified categorizations, including an application of a theoretical model (one article discussed theories of influence in the context of two organizations where health IT implementation failed[15]), reviews or guides to health IT design and workflow decisions, an annual report, and a workgroup discussion white paper.

The majority of the articles (65) included in our final analysis did not include a formal theoretical or conceptual framework, although they may have been guided by one. The formal frameworks we identified include organizational management theory, institutional theory, Plan-Do-Study-Act (PDSA) model which is a particular quality or process improvement technique, social cognitive theory, diffusion of innovation, technology use mediation, Multiple Perspectives model, socio-technical theory, and implementation stage framework.

Table 2 also shows the various organizational settings of the articles included in the final analysis. We found that 16 articles were cross-sections of multiple public or private hospitals (using qualitative, quantitative, or mixed methods analysis), 13 were set in individual private, not-for-profit or for-profit hospital systems, five were in rural or Critical Access Hospitals (CAHs), and two took place in a Veterans Affairs (VA) medical center. Three articles focused on hospital issues, but were not institution-specific and did not make a distinction between public/private ownership,14 articles focused on ambulatory settings, and 11 had mixed organizational settings (hospital and ambulatory). Three articles did not indicate a particular organizational setting, and were labeled "N/A". One article focused on a nursing home.

As part of our organizational setting categorization, we identified seven articles that focused on the experience of various "health IT leaders" or health care organizations (hospitals, health systems, ambulatory practices, and community health centers) that were early adopters of health IT, as classified by the authors. These health IT leaders include a variety of organizations such as a children's hospital in Houston (Texas Children's Hospital), a gynecology practice in Florida (Palm Beach Obstetrics and Gynecology), a network of community health centers in the Bronx (Urban Health Plan, Inc.), and a national managed care consortium (Kaiser Permanente).

In terms of the type(s) of health IT functionality discussed in each article, Table 2 shows that a majority of the articles (48) discussed the implementation or of EHRs with multiple functions or health IT systems in general. Nine articles specifically targeted clinical decision support (CDS) technology and six focused on computerized provider order entry (CPOE). Two articles were specifically about the MU criteria and one article focused e-prescribing. The final nine articles focused on other specific EHR or health IT functions, including secure messaging, diagnostic kiosk, electronic lab order entry management, barcode medication administration, mobile technology, and patient web portals.

Finally, articles covered multiple perspectives and stages of the implementation process (Table 3). For example, 48 papers included information related to EHR technical perspectives, 65 papers included information on professional perspectives, and 25 covered organizational perspectives. Similarly, the studies in this review covered all of the EHR implementation stages, with more papers falling into the planning and vendor selection (46) and workflow design and software design (52) stages compared to the training and user support (37) and optimization and modification (30) stages. The numbers in Table 3 do not add up to 75 because many articles are included in more than one category.

Common Themes and Lessons Learned: Planning and Vendor Selection

The literature suggests the planning stage of EHR implementation is critical to whether or not implementation will ultimately be successful. Selection of systems that will best meet the organization's needs, obtaining staff buy-in, defining the implementation strategy, and determining the speed or pace at which implementation will occur are key issues during this

stage. The literature suggests that from the start, it is important for organizations to consider not only their technical needs, but the perspectives of staff from all levels of the organization and the organizational culture and environment in which the system will be implemented.

Technical Perspective

A number of articles addressed considerations made during the EHR/health IT selection process, as well as strategies for how this technology would be acquired and integrated into existing systems. These choices also take into account important partnerships that providers form in this process, such as with vendors or other health care organizations with whom they might share technology and data. By design, federally funded RECs are available across the country as a resource for small practices or providers working in safety-net settings in need of assistance during the planning stage and all other stages of the implementation process, focusing on issues such as vendor selection, privacy and security, workforce development, and MU. While RECs have been an important resource for smaller physician practices and CAHs that may not be connected with any larger hospital, they did not show up as a key theme in our review, as our focus was on larger health care systems.

System and Vendor Selection

Organizations have taken multiple approaches to selecting a system, from purchasing an entire, fully functional system to piecing together different systems to developing one on their own. In addition to the development of homegrown systems or components (discussed below), the following three approaches were widely cited in the literature:

- Single-vendor strategy: Systems are designed to integrate clinical and administrative data over multiple locations and settings. This strategy is the most common and simplifies purchasing by allowing for one contract, but also allows for less flexibility and gives the single vendor a lot of bargaining power once the system is in place.
- Best of breed strategy: With this approach, software components are incorporated from multiple vendors, either deliberately or because limitations in resources force the organization to build their system gradually over time. While this approach allows for greater customization and avoids the need for major reengineering of business processes, the result could be a technically fragmented system that reinforces functional silos in the organization. The incorporation of different pieces also requires a wider range of skills from the staff and increased health IT support.
- Best of suite strategy: This strategy is a combination of the prior two, starting with either a clinical or administrative suite and then integrating all other applications from there. This allows some flexibility to customize, but still gives the leading vendor some bargaining power over the provider.

One study found that facilities that utilize the best of suite strategy were more likely to have a fully implemented EHR system than those who chose the other two approaches, even after

controlling for tax status, system affiliation, accreditation, and teaching status. Their success may speak to the importance of balancing deliberate planning while allowing for EHR system flexibility. However, the article notes that because of the increasing rate of mergers and acquisitions among vendors and the increasingly consolidated vendor market, the single vendor strategy will likely continue to be the most common.[16]

As a few dominant vendors continue to expand their footprint, there are some concerns that their products do not adequately reflect the needs of healthcare providers. One paper listed a number of examples where EHRs were poorly designed for clinical purposes, designed often based on accounting software which heavily relies on spreadsheets.[17] There are also often clauses in vendor contracts that present barriers to remediating software errors.[18] Other studies noted that some vendors do not support higher-level functionalities such as e-prescribing, reporting measures, electronic test results, and alerts[19] and cannot meet an organization's quality reporting needs.[20]

While reliance on the vendor can make the system less flexible, organizations that chose to locally develop their own system are faced with a number of challenges as well. One article found that among organizations with locally developed CDS systems, without the assistance of a vendor, it was often difficult for these organizations to handle knowledge management—the process of developing and translating information so it is available in the system, ranging from drug information for CDS[21] to information needed for technical support of the system[22] — as well as to keep track of system updates and maintenance needs.[23] However, organizations with locally developed systems can overcome these barriers by having access to skilled information systems staff and robust computer tools and having a well-developed consensus development and decision-making structure.

Hardware Selection

While less commonly discussed than the selection of the clinical information systems themselves, there were a couple articles on the selection of devices used to enter and view data such as computers and handheld devices. Considerations during hardware selection include minimal use of space, electrical capacity, ability to document both at the bedside and outside the patient room, and the number of devices needed to accommodate peak staffing times.[24] Flexibility and ease of use has also been considered,[25] with one organization distributing personal digital assistants (PDAs) that were not required but available to supplement use of the desktop computer system.[26] Providing remote access to the system from home and having a computer in the exam room have been strategies to help ease the transition as well.[27]

Standards

One common challenge when selecting an EHR system is identifying standards to use in terms of system functionality, data and interoperability.[28] While certified EHR systems are required to meet MU criteria, certification is not yet available for more specialized systems such as those for

the emergency department.[29] Lack of interoperability standards between EHRs has also been a major barrier to implementation.[30] For example, those planning to participate in an accountable care organization (ACO) will have to deal with a number of issues with data sharing and interoperability between different organizations, and must incorporate the flexibility to do this up front. Among the participants in a small survey of ACOs, one concern was the lack of data and exchange standards, for which they felt providers should pressure IT vendors.[31] In the absence of national interoperability standards, health care providers have been left to coordinate on their own within and across local health systems. One article briefly described the approaches taken by several independent physician associations (IPAs) to address interoperability, which ranged from delaying adoption until the major hospital system selected a system to developing a health information exchange (HIE) portal to connect diverse EHRs already in place among members.[32]

Professional Group Perspectives

The perspectives of front line clinical, ancillary (pharmacy, radiology, etc.) and administrative staff (ultimate end-users), clinical units, and managers are also important to consider in the planning stage. Much of the literature was written from the perspective of managers or leaders in the organization who must communicate and coordinate the implementation of health IT. Many papers described the general needs and concerns of various professional groups and emphasized the importance of obtaining buy-in from the end users of the EHR system from the start.

End User Engagement/Buy-In

Organizations that were able to engage end users and all ancillary personnel during the planning and development stage had more success selecting an EHR system that staff would accept and successfully work with.[33] End users can be engaged from the start by including clinicians on the oversight committee or project team that is responsible for decision making and implementation progress.[34] Involvement of all ancillary personnel during the planning and development of CPOE implementation has also been found essential to successful system acceptance.[35] One article describing two instances of failed CPOE implementation attributed both failures to adoption without provider input and mandating immediate physician compliance. One of these organizations, Cedars-Sinai, suspended privileges of non-compliant providers, who then led an active revolt against use of the system. In the other organization, Kaiser Permanente (Hawaii), physicians were more passive in resisting implementation, but productivity still declined.[36]

User attitudes towards the system were often mentioned as a critical factor for adoption.[37] Staff fears related to change, including fear of losing control or of layoffs from increased efficiency, disciplinary actions due to increased ability to monitor workers, as well as concerns over patient and provider confidentiality have been found to be common barriers to implementation.[38] In addition, different understanding and interpretations of the purpose of specific types of health IT among different levels of the organization may present a barrier to implementation. For example, while technology may be viewed by management as promoting efficiency and evidence-based

medicine, some clinicians may view them as usurping their decision-making authority and as "cookie-cutter medicine".[39] In one instance where staff rejected the use of a new technology, it was perceived as "just a research project" and therefore not worth the disruption to their work.[40]

How EHR installation is framed when presented to the staff and all relevant stakeholders is very important.[41] Connecting with clinicians about EHRs in terms of quality has been found to be helpful,[42] as well as making implementation less about the technology and more about a larger strategic plan to promote better patient care.[43] Leadership must frame new technology as a vehicle to promote clinical practice change rather than as an end in itself.[44]

Physician Champion

The literature finds that identification and involvement of a physician champion— someone respected among his/her peers who can influence the attitudes of others— is an important strategy for obtaining the buy-in of other physicians.[45] The VA's Cardiovascular Assessment, Reporting and Tracking (CART) for catheterization labs illustrates implementation led by a group of clinician champions involved in a quality improvement project. This team initially identified VA sites for early implementation and technical champions from the IT departments at each site. After successful implementation at these initial sites, it was mandated that CART be implemented in all VA catherization labs. During this wider-scale installation, sites where a clinical champion was identified and engaged were able to implement the system more quickly.[46] However, not all organizations have a physician champion readily available and lack the time and resource to train or hire one. In this case, efforts may be better used to engage the nursing staff.

Nurse Leadership

Nurses have also played key roles in helping plan for EHR implementation because they play a central role at the front line of care, are often responsible for quality improvement work, and continually interact with other departments. Additionally, because nurse leaders have established relationships with other ancillary departments (e.g., pharmacy, information technology, labs, etc…), they are able to consider the needs of various stakeholders during the initial planning.[47] With the number of technologies related to medication (such as e-prescribing and medication barcode scanning), it is particularly important to coordinate with the pharmacy.[48]

Implementation Speed

An important decision organizations must make is whether implementation should occur fully at once across all units of the organization, often referred to as the "big bang" approach to implementation,[49] or if partial/gradual implementation, where all or parts of the EHR system are gradually implemented across units, would be more suitable. It should be noted the speed selected for initial implementation does not mean ongoing efforts to optimize use of the EHR are not needed, as described in the fourth stage in this paper. Regardless of the implementation speed, continuous quality improvement and other ongoing work to train staff are required.

Theories of organizational behavior and innovation suggest different conditions may be better suited for each speed of implementation. Often there are technical, organizational, or political demands that may dictate which approach is selected.[50] One benefit of the phased approach is that successful implementation at initial sites mitigates reluctance among sites where implementation is later.[51] Gradual implementation may better allow staff to adapt, but is also less efficient. It may involve installation of a few computers at a time or in a few units at a time, allowing for voluntary use of the system at first, and also duplication of paper and electronic records during a transitional period.[52]

While physicians at Everett Clinic, an independent Medical Group in Washington, found voluntary use helped to ease implementation to CPOE and e-prescribing, other staff on whom the burden of entering prescriptions felt this complicated the transition.[53] An analysis of survey data from hospitals implementing electronic lab order entry management systems found that those with partially implemented systems that had not completed the roll-out experienced negative impacts on productivity. However, the greatest loss in short-term productivity was experienced by those who went with the "big bang" approach and fully implemented the system within one year. Use of a hybrid approach starting with limited introduction and then followed with a complete roll-out the next year was associated with significant productivity gains.[54]

Staffing

The staffing and skills needed to implement and maintain health IT is an important consideration for leaders in health care organizations. While technical skills are important, it is also important that the IT director has the ability to collaborate with other departments and effectively communication with clinicians.[55,56] Differences between the work culture of IT professionals and clinicians must also be reconciled.[57]

Individuals with both IT and clinical backgrounds are needed in order to better work with clinicians as well as to understand the unique needs of system functionality.[58] Part of the challenges is that people with this combination of skills are in short supply and great demand, particularly if they have experience with installing an EHR system already. Rural and underserved organizations have particular difficulty retaining IT staff, since after they develop a certain level of experience, they are often recruited by larger organizations.[59] In addition, organizations often want anyone with clinical skills to spend most of their time clinically practicing, limiting the time of individuals with this skill set to devote to implementation of new technologies.[60] The use of consultants is common during all phases of health IT implementation,[61] in part due to limited availability of IT staff.[62] However, while some organizations found it helpful to have an independent person evaluate their system or quickly acquire expertise without hiring additional staff, research around the decision to "make" or "buy" services suggests lack of commitment can be a problem in the long run with use of consultants.[63] Organizations must consider the costs of bargaining and opportunism in managing their relationship with the consultant when making this decision.[64]

Resource Allocation

The literature also emphasizes the importance of allocating sufficient resources for implementation. Budgets must be flexible and take into account the time needed for training, productivity loss during the transition, and unexpected issues or setbacks that may arise.[65,66] For example, in the experience of the VA, allocation of adequate resources for equipment and infrastructure, hands-on support, and additional support staff was essential to their success when implementing new technology.[67] Similarly, a majority of grantees in AHRQ's Transforming Healthcare Quality Through Health IT (THQIT) program—a program where 118 grantees from a wide range of care settings planned, implemented, and studied health IT implementations—reported having to discontinue or never implement an initially planned technology due to the cost of ongoing maintenance, lack of a business case, and lack of funds.[68] Financial issues have been a major barrier to health IT implementation, particularly for rural and underserved areas.[69]

Defining the business case has been a major challenge for health IT adoption. While many believe health IT will ultimately reduce costs and improve quality, some IPA leaders remain skeptical about the return on investment, particularly in the short term with the significant start-up costs.[70] Even in an integrated health care system, commentary from one vice president of information services described the additional effort needed to ensure a return on investment from EHR implementation, including the engagement of business staff from the beginning, as well as leadership focused on driving true clinical transformation.[71]

Organizational Perspective

Examples throughout the literature talk about how implementation strategies must be selected that are most appropriate for existing organizational structure and culture, but also about how implementation will require changes to the organization. Considerations discussed in this section may begin during the planning stage, but remain important throughout all stages of the implementation process.

Culture

While a number of technical and resource challenges have been barriers to implementation, culture change has by far been the most challenging aspect of implementing new technology.[72] Organizational politics may further complicate implementation and increase concern over loss of decision-making power,[73] particularly as competing organizational priorities are negotiated.[74] For example, while physicians are generally a powerful influence in health care organizations, they are often at odds with the chief medical information officer, who is tasked with influencing clinical users of the IT system.[75] In another example, concern over who could take credit for improvements was a barrier to implementing new technology in the emergency department.[76] The existing culture of the organization in terms of hierarchy and team work may present barriers throughout the implementation process, particularly if there is lack of trust and

cooperation.[77] Previously mentioned strategies such as engaging staff and use of a physician champion can be helpful in facilitating culture change.[78]

Leadership

In addition, the importance of leadership support and commitment from the top levels was often emphasized,[79] as well as bottom-up physician leadership and input.[80] Up front, honest communication with staff about implications for their workflow and workload throughout implementation is also helpful.[81] The stability of the organization and ability to manage change will ultimately determine the success of implementation.[82] Recognizing organizational characteristics and past experiences with implementing new technology should be considered in the planning stage.[83]

External Partnerships

External partnerships are also important during health IT implementation. In addition to relationships with vendors and consultants, partnerships with external stakeholders have been important in order to share and exchange patient information.[84] Some CAHs have found it useful to have a liaison with nearby hospitals to help facilitate information sharing.[85] Perhaps due to the focus on organized delivery systems, articles in this review addressing HIE tended to refer to coordination between individual providers and organizations.[86] However, regional and statewide HIE efforts likely play a larger role in facilitating information exchange among organizations as well, particularly those unconnected with other health care organizations.

Smaller organizations with fewer resources may also enter into networks or partnerships in order to "piggy back" off a larger organization's system. There were a few articles describing these types of arrangements and the associated advantages and disadvantages. In one case, seven CAHs were able to partner with Mercy Medical Center – North Iowa (MMC-NI) to implement the same EHR and CPOE systems. Throughout the planning and implementation process, staff from MMC-NI met regularly with teams from the CAHs and were onsite for go-live. Sharing of health IT expertise and personnel across the network made implementation more rapid and effective.[87] Particularly for organizations with fewer resources, having a well-resourced partner can be very helpful in providing opportunities for shared learning as well as facilitating health information exchange. It is particularly helpful when partnering organizations are built on a common goal (such as quality improvement) and trust one another.[88]

However, some smaller organizations might find the systems of larger hospitals too complex for their needs. Some CAHs who prefer not to partner with a larger system or nearby hospital have been able to partner with one another to work with smaller vendors, who may provide systems better suited for smaller hospitals who may require greater flexibility. Other hospitals have also partnered with one another to take advantage of economies of scale. One paper described an arrangement where a "technology group" of 15 hospital IT directors got together via video conferencing to pursue group purchasing as well as share ideas, education and training.[89]

Common Themes and Lessons Learned: Design of Workflows and Software Customization

The results from the prior section highlight how appropriate planning is critical to whether or not EHR implementation will ultimately be successful. However, organizations must still address various barriers related to hardware and infrastructure, software customization and usability, and workflow throughout the implementation and optimization process.

Technical Perspective

Hardware and Related Issues

- The literature suggests that all organizations could face various hardware and infrastructure challenges while installing their EHR systems. Several organizations reported that lack of equipment availability, the acquisition of an adequate supply of health IT-related devices, and the physical placement of technology were barriers to implementation.[90] For example, a full service medical center in Chicago faced facility issues, such as finding locations to house devices (patient rooms, closets, alcoves) and medication dispensing stations, and budgetary concerns over replacing old or ineffective equipment. Hardware and infrastructure complexities, including network connectivity, were also more challenging for CAHs and other small rural providers to deal with, especially if they are not part of a broader network.[91]

Software Customization and Usability

A major consensus in the literature is that general EHR designs are often poorly designed for clinical purposes and need to be continuously customized to meet the needs of the organization. Single vendor's solutions sometimes do not necessarily reflect what is best for healthcare providers and clinical work, as some EHR designs come from accounting software (e.g., to capture finance, billing, and claims work), which often rely on spreadsheets and conflict with the needs of users. Clinicians, on the other hand, must be able to quickly review a wide range of information in accessible formats. For example, in some systems clinicians may have to scroll through screens of empty cells in order to find where patient data has been entered. In other examples where summary information is displayed, it may be done in a misleading fashion or may not show all relevant information on the screen at once.

One study covering several community clinics and health centers in California concludes that the process of configuring the system (e.g., managing and configuring documentation templates and determining whether certain data fields should be structured or unstructured) never ends.[92] Several of these organizations convened a clinical standards committee to define and vet templates and documentation standards. In another case study, a hospital radiology department found that a customized wiki can be used to allow staff members to view and contribute to the historical technical memory of the unit, and to build and update online documentation in a real-time manner.[93]

In contrast, in some cases, such as during the implementation of an EHR in the Children's Hospital of Pittsburgh, vendors can provide customized technology (e.g., clinical dashboards) for hospitals, drawing upon systems that have been implemented in other hospitals and customized for a variety of clinical departments.[94] Planned Parenthood also found that their vendor consultant provided effective ongoing software and data customization and management support, in addition to providing online support during system go-live, onsite training specific to their organization, and regular visits to health centers to provide onsite training, help redesign workflows, and work with staff to ensure efficient system use.[95]

Several studies found that CPOE presented greater implementation, customization, and usability barriers relative to other healthcare technologies and remains a significant barrier to the receipt of MU incentive payments.[96] One analysis of AHA survey data linked with CMS data on MU payments found that hospitals reporting CPOE MU criteria as a primary challenge were 18% less likely to receive a MU payment in 2011, even after controlling for standard hospital characteristics.[97] Results from a randomized crossover trial, where seven surgeons at a pediatric hospital at different levels of training were randomized to use either a historical control or a systematically developed order set for postoperative management of appendicitis in children, found that lack of understanding of how to customize CPOE led to poor usability and unintended consequences. This study also found that systematically designed order sets (customized CPOE) reduced cognitive workload and order variation in the context of improved system usability and improved guideline adherence.[98]

Similarly, several studies cited inadequate designs and poor usability of clinical decision support (CDS) systems as major barriers to EHR implementation, or conversely, proper CDS designs and ease of use were cited as facilitators of successful implementation.[99] A targeted review of best practices concluded that desirable CDS system attributes include:[100]

- perceptual grouping and data relationships;
- consistent terminology;
- consistent wording;
- acceptable density of information on screen;
- workflow integration;
- cultivation of trust;
- advice rather than commands;
- alternatives rather than stops;
- intermediate states;
- system logs;
- interoperability and data standards;
- patient record maintenance;
- third party access.

Results from a cross-sectional survey of community hospitals also finds that most noted technical barrier associated with CDS was over-alerting.[101] Overall, the literature suggests that health care organizations should invest in usability to improve health IT implementation and ongoing use and improvement. While CPOE and CDS were the most widely cited functions, the technical and usability barriers were also cited in the context of

- exchanging information across different computer systems and providers;[102]
- generating data for quality reporting and meeting particular quality-reporting needs;[103]
- maintaining problem and medication lists;[104]
- tracking health maintenance information;[105]
- ordering laboratory and radiology tests;[106]
- switching from faxed prescriptions to e-prescribing;[107]
- fitting secure messaging into the workflow as implementation continued.[108]

Professional Group Perspectives

The perspectives of managers, nurses, and physicians are also key factors to consider during the workflow redesign process. Much of the literature was written from the perspective of managers or organizational leaders who must properly plan for workflow changes during the implementation of health IT. Many papers also emphasized the importance of overcoming workflow barriers among physicians and other end-users.

Management Perspective: Workflow Analysis and Planning
Planning for changes in user workflow is one of the first and most important tasks for organizations implementing an EHR system. Planning for and understanding workflow redesign from a managerial perspective can improve EHR implementation and use by helping organize the process, gain staff buy-in, facilitate staff readiness, coordinate between processes, and improve adherence to operational and clinical protocols. During this stage of the implementation process, some key lessons for managers include[109]:

- Sufficiently allocating time and resources for detailed workflow analysis, user training and planning.
- Systematically evaluating how patients and information flow through the organization to identify redundancies, workarounds, and handoffs. For example, when mapping a process, the organization should consider both the clinician workflow and flow of the patient and document workflows within the practice such as appointment scheduling, unscheduled visits, patient visit activities.
- Understand the office culture and functionality (e.g., interactions between physicians and other practice staff) and address any redesign issues, for example, by transferring some provider responsibilities to nurses or medical assistants and incorporating into standard workflows.

- Linking workflow analysis with health IT applications, plan for workflow efficiencies and inefficiencies, and identify and test workflows before implementing an EHR system to mitigate problems.
- Developing a well-designed chart abstraction strategy to mitigate the loss in productivity and increase user acceptance, and plan for the potential need for outside assistance from vendors or consultants. Important decisions include what patient information should be entered into the new system, when, and by whom. Abstraction may occur through scanning, electronic migration from old systems, or manual data entry.[110] Organizations might need to maintain both paper and electronic records during implementation period.
- Being patient during the process to avoid workarounds, allowing time to test redesigns and correct for mistakes.
- Foster communication between IT, nursing staff, and physicians throughout the implementation process.

A number of the above-named planning activities may also need to occur at the unit level since the work differs from department to department. For example, one article describes the process taken by a neonatal intensive care unit (NICU) unit to develop standard order sets for their CPOE system that addressed how they work 80 percent of the time based on an analysis of their workflow. Along with the nurses, unit secretaries were instrumental in this development because of their experience with processing the paper orders.[111] Instances where unit-specific needs were not addressed upfront are described in the optimization and modification section as additional customization was subsequently needed.

User Perspectives on Workflow

Several studies emphasized the importance of nursing during the workflow redesign process. Nurses face several workflow changes related to coordination, such as coordination with other hospital units not using an EHR and coordination with the nursing staff on the prior and subsequent shift. Nurses should also be involved throughout the implementation, customization, and troubleshooting processes, as they will be using the technology, know the work processes that will be affected, and can develop strategies to overcome barriers.[112] For example, a nurse-driven team was able to effectively lead a tertiary hospital medical center's EHR upgrade to incorporate a barcode medication administration (BCMA) system. During this process, the nursing-led implementation team minimized the negative consequences of workflow changes by addressing these coordination problems, integrating the physician workflow into everyday practice, managing barcodes, including patient transfers among units on different medication documentation systems, and helping other nurses understand new potential risks created by the system, such as the risk of an inaccurately coded barcode and the need for visual inspection of the dose.[113]

With respect to physician workflow, there are four general themes to draw from the literature that can be generalizable across organizational settings. First, general workflow barriers, such as

changes in work process and routines, general inconveniences and time costs, and lack of physician desire to change their ways, were widely cited.[114] Specific examples include focusing on transforming physician work processes to effectively utilize e-prescribing and the challenges of incorporating EHRs in busy work environments such emergency departments. Second, chart extraction conversion to EHRs is a workflow challenge and barrier among physicians due to the potential of errors and losses in efficiency during the transition period.[115] Third, knowledge management can be a significant workflow barrier for physicians.[116] These barriers include managing the number of alerts and decision processes, capturing data in a timely fashion, and integrating EHRs with other technologies. For example, during the Vanderbilt University Hospital's implementation of an EHR and computer-based intensive insulin therapy, the complex interaction between clinicians, blood glucose testing devices, and CDS may have contributed to workflow inefficiency and error.[117] Finally, transforming from traditional face-to-face interactions to new work ways with the EHR can contribute to physician resistance and workflow barriers, as physicians are concerned that EHRs and inputting data could interfere with the delivery of care.[118]

Common Themes and Lessons Learned: Training and User Support

This section emphasizes the importance of effective training throughout the EHR implementation process. Training affects all professional groups involved, ranging from program planning and strategizing among managers to end-user implementation and participation.

Several studies emphasize the importance of investing heavily in and requiring upfront training for all staff members in order to avoid negative impacts on workflow, costly setbacks, and productivity losses.[119] However, there are several ways that managers and organization leaders can plan and implement training programs. One case-study used cognitive and learning theories to investigate the training practices in six organizations reputed to have "best practices" in ambulatory care EHR system implementation, but did not incorporate the experiences of a comparison group, such as non-leading organizations. They found that training programs that incorporate observation and active learning (i.e., scenario-based training, where clinicians interact with the EHR for a hypothetical patient, and preloading of patient records, where physicians are required or encouraged to abstract patient charts and create an electronic record) lead to better learning outcomes and optimal use of EHR systems in all six sites. They also found that leveraging the skills of role models (clinical leaders, champions, super-users, training coordinators), recognizing an organization's past experience with IT implementation, and taking into account characteristics of a particular community of practice contributed to better learning outcomes and meaningful use of EHR systems in most sites.[120] Other training best practices include obtaining organizational commitment to invest in training, assessing users' skills and training needs, selecting appropriate training staff, matching training to users' needs, using multiple training approaches, providing training support throughout the implementation process, retraining to optimize use of the EHR.[121]

Community clinics and health center grantees in California found that training staff and clinicians involve a tradeoff in early loss of productivity and revenue against a smoother and faster EHR transition period. These early losses stem from closing the clinic, reducing hours or working over the weekend, hiring temporary staff to fill gaps, obtaining training facilities, paying overtime, and developing customized training materials. However, during this process, they identified several key training lessons that other organizations can learn from, such as: identifying and training super users and clinical leaders created a core of knowledgeable staff members to champion the change process; having separate training and implementation for different EHR functions to improve effectiveness; entering data from existing paper charts as an effective hands-on training tool; and prioritizing inputting data on patients that are chronically ill or with co-morbidities.[122]

There were also several other approaches identified in the literature. Sparrow Health System found that providing adequate training ending with a proficiency examination to be effective during this process.[123] One NICU used a nurse-driven team in planning, building, training and implementing CPOE. They found it useful to train nurses on the unit to use the system first to serve as resources for the physicians, who were trained later one-on-one.[124] Premier Health Care Alliance found that hands-on training for all medical staff was more effective than classroom-style training.[125] Two community health centers, Howard Brown Health Center and Heartland Health Outreach, also found that hands-on training for technical support and system updates was helpful throughout the implementation process, although some users thought the materials were too basic and were offered too far in advance.

Some users also noted that post implementation support was limited and organizations would benefit from a lengthy period post go-live in which hands-on support is available.[126] Several organizations also found that outside consultant or vendor training and 24/7 customer service support helped organizations implement fully integrated and functional EHR systems, but the short supply and cost of these experts can also serve as a barrier.[127] The importance of user support is also emphasized in other sections of the review, as discussed in prior sub-sections on end user engagement/buy-in, staffing, and user perspectives on workflow.

Common Themes and Lessons Learned: Optimization and Modification

While many organizations focus on complete installation of new technologies as a goal in itself, some articles highlighted organizations that continually modified technology for optimal use as better able to use technology to meet their institution's performance goals. One article observed there were some organizations that reflected on what they could have done differently when sharing their implementation experience, while others were still optimizing even a year after go-live.[128] For such organizations, the process of configuring and improving the system never ends.[129] However, it should be noted that very few studies were identified through this review that tracked the evolution of health care systems and their EHRs over longer periods of time to

better understand how the implementation and optimization process connect with outcomes such as productivity, quality, and cost.

Technical Perspective

As emphasized in the prior section on workflow and software customization themes, all organizations face various EHR usability challenges throughout the EHR implementation process. As such, the process of EHR customization never ends as organizations continuously modify their systems to optimize use. After the system is installed, there are needs for software updates, equipment upgrades and replacement, as well as ongoing maintenance – all of which need to be included in the budget when estimating implementation costs.[130] EHRs and workflow also have to keep up with changes in the health care system, such as the development of new drugs, devices, procedures and treatments, evidence based guidelines, and billing and documentation requirements. Resources also need to be devoted to provide ongoing hand-on support long after new technology is initially implemented.[131]

Continual adjustments to the interface and data configurations have also been needed as clinicians use the system to do their work. One study found errors were common in EHR data for test management due to technical issues such as an interface that resulted in logic errors, system settings, and inadequate redundancy built into the system to allow for flexibility. Organizations need to continuously monitor for systematic errors and may need to make adjustments to software itself.[132]

Professional Group Perspective

- Once installed, individual users, units, and managers have all played important roles in identifying areas for system improvement. Optimization includes integrating technology to improve interaction with patients as well as overall quality. System adjustments to better integrate technology with unit-specific work, as well as accountability at the provider, unit, and organizational level, have been successful strategies to encourage widespread use among clinicians and other staff.

Patient Interaction

In addition to helping clinicians use the EHR system to enter and retrieve data during the initial implementation, a few articles described how organizations focused on the integration of technology into interactions with patients – both in-person and online. For example, Kaiser Permenente encouraged use of secure messaging between physicians and patients by providing specific training around use of this function for clinicians, as well as by providing user-friendly templates where lab results and prewritten handouts were easy to include. Patient resources and access to data through the Kaiser Permanente website also encouraged patients to use the system.[133] Group Health also encouraged physicians to interact with patients online and saw a high adoption of online visits.[134] A number of organizations are also building patient portals where patient can view portions of their medical records online and even make appointments or request prescription refills electronically.[135] There is increasing interest in patient portals as Stage 2 of MU requires not only that organizations have the capacity for patients to access their

data in electronic form, but also that they ensure at least 5% of their patients actually use it. A number of physician organizations have stated that this rule is unfair, particularly in light of the large investment required to achieve this level of patient use.[136]

Clinicians also need to adjust to incorporating use of the computer into their patient visits. In one case, physicians in an outpatient center were initially concerned about how having a computer in the exam room would affect their interactions with patients, but incorporated computers by positioning the monitor so that patients could see the data as well, aiding with discussion. Initial resistance was also ameliorated by increased efficiency that allowed physicians to spend more time with patients.[137] However, at times EHRs have resulted in changes in the interaction with patients that physicians were unprepared for – resulting for the need or unexpected educational initiatives at one medical group after implementation of CPOE.[138] One article recommends dedicated resources to monitor the unanticipated effects of health IT on patient care through staff surveys and other mechanisms for feedback.[139]

Retraining

Additional education is often needed after the initial training as staff work with other departments in new ways as a result of new technology, such as pharmacies.[140] In addition, in some cases the initial training was too basic or offered too far in advance, resulting in staff forgetting how to use the system once it was actually implemented. Hands on technical support available to assist staff as they learn to use the system, and to provide follow-up training has been found useful, particularly after system updates occur.[141]

Ongoing integration into unit-specific work

Specific units will have different system customization needs. The literature included several examples of how technology was customized for intensive care units, where the urgent and complex nature of the work requires systems to be extremely well integrated in order to be used. For example, a case study of Vanderbilt University Medical Center found surgical intensive care unit (SICU) staff were only entering blood glucose and insulin data in the clinical data repository around 40% of the time. Further investigation revealed that SICU staff needed to collect this information from the laboratory and enter it into the system, and were often too busy to do so. At the same time, the laboratory was not checking for compliance. As a work-around, physicians had been using paper charts instead of the EHR to obtain glucose and insulin patient data. The hospital was successfully able to increase system use by adjusting nurse workload, physician involvement, procedures for blood glucose testing, and further development and support of the electronic system.[142]

Other ICUs have also been able to identify solutions to improve usability of EHRs in their work. In one hospital, clinicians in the ICU were the most resistant to EHR use due to the length of time taken to log on to the computer, as well as the fact that key patient data was not easily accessible. The hospital's IT staff approached the vendor to propose shorter log on times as well

as a clinical dashboard (or a visual display of key pieces of information on one screen) with key patient information specifically for the ICU. The vendor was willing to develop this solution and made it customizable for a variety of clinical departments, facilitating its subsequent implementation in six other hospitals.[143] In another example, after development of order sets during the implementation of CPOE, a list of problem issues was kept at the unit's front desk and discussed during the scheduled meetings with IT staff. Order sets were then refined over time, removing orders that were not frequently used.[144] Ongoing monitoring, staff feedback, and communication with IT staff is needed to optimize use of health IT in specific units. Coordination between units and departments is also needed to create a system-wide approach to identifying errors and taking action to improve future performance.[145] Providing multiple mechanisms for user feedback on clinical information systems has also helped identify issues that need to be addressed in order to optimize system use.[146] User empowerment to improve the system has facilitated the ease of implementation and encouraged optimization.[147]

Clinician accountability for appropriate system use

Organizations have taken a number of approaches to holding clinicians accountable for using new technology. Examples include posting unit "scan rates" of bar codes during medication administration,[148] regular distribution of incomplete notes or unsigned charts with the medical director contacting clinicians who were not providing timely documentation,[149] and ongoing measurement of health IT use.[150] However, even with publication and distribution of incomplete charts, one residency-based clinic continued to have challenges getting residents and part-time faculty to meet documentation standards, presumably because these clinicians were more transient and less connected with the clinic.[151] In the same way, it may be more difficult to hold physicians who are not employed by the organization accountable because they lack incentive to comply.

In addition to highlighting instances where use of new technology is less than optimal, leadership recognition of successful use has also been helpful.[152] Leaders must understand the human element in EHR use in order to promote uniformly high use across all clinicians and other staff.[153] While allowing time in the beginning to allow clinicians to become comfortable with the system is important, the next step is to focus on standardization and structured data entry. Some organizations have convened committees to develop and vet templates and documentation standards in order to insure that clinicians are entering usable data that can be retrieved, classified, and linked to other data sources.[154]

Quality Improvement

EHRs do not automatically guarantee improvements in quality, but are part of a bigger strategy used for quality improvement. When clinicians sufficiently enter data, EHRs can be used to examine patterns in performance and to identify problem areas. They can also be used to improve quality by incorporating checklists, alerts, predictive tools, clinical guidelines for evidence-based practices, and to reduce duplication.[155] Organizations have found it important to

engage quality improvement (QI) leaders in developing and updating EHRs to facilitate the ability to aggregate data for performance reporting,[156] as well as to develop metrics to track the outcomes associated with QI initiatives utilizing health IT.[157] While evidence to date around the QI movement in health care suggests the effects are positive yet modest, the potential for EHRs and other health IT to enhance quality and provide more comprehensive and timely data for QI may help strengthen the nation's QI capacity.[158] However, turning EHR data into information that can be used for quality improvement or research—on a single institution and/or across institutions—also requires data extraction, coding/cleaning, and various quality checks.

One example of an organization that has invested considerable effort to ensure their EHR data is widely used to improve quality is Montefiore Medical Center in Bronx, New York. Initially, their EHR data was too large to query, so they developed a software query system designed for epidemiologic and longitudinal analysis that includes the ability to compare groups. In addition, they widely trained clinicians, researchers, administrators, and managers to use this software, which has resulted in more than 500 active users utilizing the data to help improve the quality of care.[159] In another example, Marshfield Clinic developed a visual dashboard that displays population level clinical data in graphic form to engage physicians and encourage changes to improve quality.[160]

Organizational Factors

At the organizational level, various incentives and partnerships have been instrumental in promoting optimization of health IT use.

Incentives

In addition to federal Medicare and Medicaid MU payments, other incentives have helped facilitate optimization of health IT. For instance, some organizations have found that more complete clinical data can translate into more complete capture of charges to claim from payers.[161] Concrete benefits such as increasing reimbursement can help an organization articulate the business case for EHRs in order to engage additional practices.[162] However, there is some concern that EHRs may lead to overbilling and fraud in attempts to capture additional reimbursement, as recent examples have received considerable attention in the media.[163]

Some health care systems such as Sparrow Health System have further incentivized adoption by offering independent physicians a financial support package as well as training for EHR adoption. Exceptions for EHR donation within federal laws prohibiting self-referral or rewards for referral (e.g. the Stark Law and federal Anti-Kickback Statute) allow hospitals and health systems to provide physicians with financial support for EHR adoption.[164] Incentives are also needed to encourage users to adopt certain EHR functionalities, such as secure messaging. For example, because Group Health is an integrated delivery system, they are able to pay their physicians for visits that occur by phone or secure messaging, increasing use of non-office visits.[165] However, for many organizations, lack of reimbursement incentives to use secure

messaging or e-consults is a barrier to use.[166] In addition, organizations with more transient providers such as resident-based clinics have had difficulty enforcing appropriate use of EHRs due to lack of incentives for these providers to take ownership of patient care.[167]

External Partnerships

External partnerships continue to be important in the optimization and modification of health IT. Organizations have engaged with consultants and vendors to help continually upgrade? And customize systems to better fit with their own work.[168] In addition to relationships with vendors and consultants, health care organizations have also joined partnerships or networks to participate in research using EHR data,[169] as well as to learn to organize and use EHR data more effectively.[170] In addition, partnerships with external stakeholders have been important in order to share and exchange patient information.[171] Some CAHs have found it useful to have a liaison with nearby hospitals to help facility information sharing.[172] Organizations wanting to participate in HIEs must also work with the state coordinators and participants to ensure their data conforms to the appropriate format and standards and that their software is compatible. [173,174] While the ability to share patient information has the potential to reduce negative outcomes due to lost information or lack of coordination, lack of standardization continues to make this a challenge.[175]

Discussion

Key Results

This report addressed the following priority research questions:

- What are the practices that major public and private health care systems use in implementing and meaningfully using health IT?
- How are public and private health care systems implementing health IT and optimizing the use of these technologies? For instance, what are the common barriers to implementation and MU and the best practices to overcome them?
- What are the "lessons learned"? In other words, what can other organizations learn from the strategies and organizational characteristics that have been able to facilitate successful implementation of health IT?

To frame the results of the literature review around these key overlapping questions, we combined a systems-based theoretical framework for understanding complex organizational systems, with a hospital-focused framework on the stages associated with EHR implementation and use. Although organizations are taking a variety of approaches to EHR implementation, their activities can be categorized into the four implementation stages identified for our framework. Organizing the literature with an eye towards the technical, professional group and organizational perspectives also proved to be a useful lens. Within the user group perspectives, the needs and concerns of different levels of the organization (e.g. users, units, and management or leadership) are important to consider and at times conflict. However, these differences were

difficult to distinguish in the organization of this paper as they may have often reflected two sides of the same coin (i.e., the importance of engagement from a user's perspective and buy-in from management's perspective).

Overall, we find that EHR implementation does not occur in a stepwise fashion with discrete phases, but is rather an ongoing process with overlapping stages that occur simultaneously and involve a wide variety of activities. We found that key results can be organized under the three perspectives and apply to more than one of these inter-related research questions to provide valuable "lessons learned" for private or public health systems involved in the EHR implementation process. These key results and "lessons learned" are described below. Table 4 summarizes the key themes by the four implementation stages and perspectives.

Technological

- A number of options exist for how an organization can acquire new technology – from purchasing an entire system from a single vendor to piecing together different systems or developing their own—and the pace at which they can implement their system, with various pros and cons associated with each option.
- From the start, systems must be designed for quality improvement and information exchange. In addition, resources must be allocated for system upgrades (including new versions), ongoing maintenance and technical support of the system, system adjustments, and continual staff training and engagement.
- A major consensus in the literature is that purchased EHRs are not individually tailored and need to be continuously customized to improve usability and meet the needs of the organization. The process of optimizing and modifying the system never ends.
- Most papers focused on the implementation of EHR systems as a whole, but a number of articles described challenges associated with the implementation of CPOE and CDS. These challenges range from lack of interoperability standards to integrate these technologies with the EHRs to workflow issues and staff resistance.

Professional Group

- Staff buy-in at all levels is critical to success throughout all stages of implementation. Strong leadership from both the top-down and the bottom-up (physician champions and nurse leadership) are needed the facilitate buy-in.
- Software customization and flexibility is required for each organization and clinical unit. Organizations that have successfully implemented EHRs have invested a lot of time in workflow analysis and careful redesign to effectively integrate new technology among users.
- Availability of skilled IT staff who can work well with clinicians can reduce barriers during the implementation process. Many organizations have chosen to use consultants rather than hire and manage their own IT staff. However, organizations must consider the costs of

bargaining and opportunism in managing their relationship with the consultant when making this decision.
- When considering which implementation speed to select, trade-offs between efficiency and ease of adoption must be considered. While less efficient, gradual implementation may facilitate greater acceptance among staff by allowing a greater amount of time for the transition. The literature shows that organizations are likely to be less efficient in the beginning, but better implementation and ongoing attention to issues like usability, workflow redesign, etc. means a greater likelihood of real efficiency gains in the longer run. Even with MU incentive payments, upfront costs continue to present challenges as organizations consider the business case for EHR implementation.

Organizational

- A number of system characteristics such as the organizational culture, leadership style, and hierarchy will affect the ease and success of implementation.
- Technology should be viewed as part of a broader strategy to improve quality that does not end once the system is installed.
- Health care organizations have been facilitating information exchange with one another on a local level by adopting the same systems, coordinating with one another, or building their own exchanges to allow data sharing from different EHRs.

Limitations

As with any literature review, there is considerable variation in the academic rigor of quality of the articles reviewed. Despite the uncertainty over quality of these articles, we still find that our key results and themes were prevalent across multiple studies, organizational settings, and EHR system types.

Although we attempted to be as systematic as possible in identifying articles to review, we may not have found all relevant studies. For example, by design, we did not include studies that focus on the effects of EHRs/health IT on various outcomes; therefore, any "lessons learned" from these studies related to implementation and optimization are not incorporated in our results. Similarly, a bias in the literature towards successful implementation may limit our ability to capture some of the challenges that many organizations may face.

Finally, in addition to these limitations, there are several components the literature that were lacking in this review. These gaps in the literature include:

- Local market factors (e.g., level of provider, insurer, or vendor competition, population/patient characteristics, health reform activities like ACOs and related provider payment and quality incentives etc…) that can influence the success or failure of EHR implementation and optimization;

- Specific implementation and optimization barriers related to Stage 2 MU, as well as information on how to overcome these barriers;
- How to best engage patients, families, and communities with health IT and understand which patient characteristics, are associated with a willingness and ability to take advantage of EHR tools;
- Patient privacy and confidentiality concerns as they related to information exchange and EHR-based research;
- Specific lessons on how providers can optimize EHR systems and health IT to improve the quality of processes and outcomes
- How to use health IT to support participation and success with provider payment and delivery reforms, like shared savings or capitation payment models or new delivery system models such as ACOs and primary care medical homes;
- Information and data specific to physician or nurse characteristics (such as whether they are employed by the organization) and staffing models, what incentives (financial and non-financial) they have for EHR adoption and use, and how these differences relate to implementation and optimization barriers.

New research or research underway may provide insight into these topics and other important implementation issues.

Conclusion

Throughout the EHR implementation process, planning and modifications are continually needed to address technological, professional, and organizational perspectives. These perspectives must be incorporated at each stage to promote implementation and optimization of a system that is technically functional, integrated into the workflow of its users, and is part of a larger strategy to meet organizational quality goals. Practically, organizations that have successfully implemented EHRs did a number of things early on, such as:

- Engage staff at all levels
- Invest in workflow analysis and careful redesign in order to customize and effectively integrate new technology among users
- Design systems for quality improvement and implementation and information exchange
- Allocate resources for ongoing maintenance and technical support of the system, system adjustments, and continual staff training and engagement

While this review included optimization as a stage in the implementation process, one important lesson is that it is an ongoing process that needs to be incorporated into each organization's structure and culture, and could be the focus of a whole review of its own.

The Institute of Medicine views EHRs as an essential part of a "learning health care system," or a system that is designed to both generate and apply evidence to promote innovation, quality,

safety and efficiency in health care.[176] Many also believe that EHRs are critical to the success of payment and delivery system reforms such as patient centered medical homes and accountable care organizations. In order for EHRs to reach their full potential, it will be important to consider how to encourage and support organizations to continually modify and optimize their systems to meet the needs of their organization, their staff, and ultimately their patients.

Tables and Figures

Figure 1. Framework

Figure 1: Framework for "Lessons Learned" Literature Review

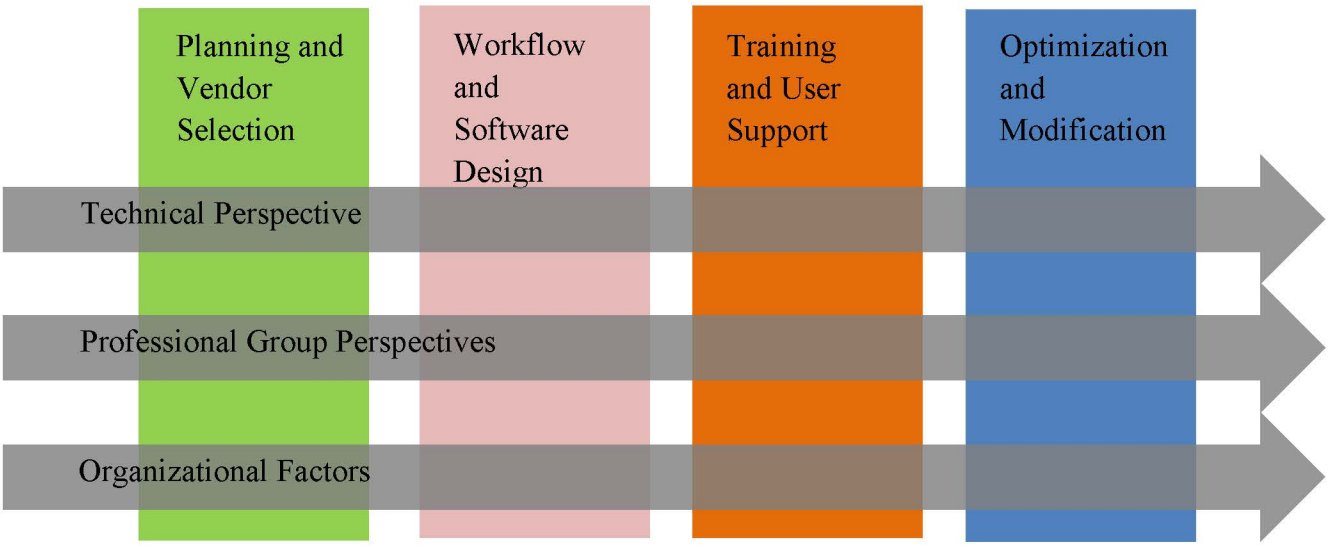

Table 1. List of Literature Review Search Terms

Settings AND	Technologies AND	Implementation Practices
"Hospital" OR "Inpatient" OR "outpatient" OR "organized delivery system" OR "integrated delivery system" OR "ambulatory"	"Health information technology" OR "HIT" OR "electronic health record" OR "EHR" OR "automatic data processing" OR "medical informatics" OR "public health informatics" OR "electronics, medical" OR "information technology" OR "information infrastructure" OR "ehealth" OR "e-health" OR "computerized provider order entry" OR "clinical decision support" OR "CPOE" OR "health information exchange" OR "e-prescribing" OR "personal health records" OR "telemedicine" OR "information retrieval" OR "computerized medical records" OR "patient portal" OR "m-health" OR "patient health record" OR "remote monitoring" OR "meaningful use"	"Implementation" OR "Implementation experience" OR "adoption" OR "adoption experience" OR "organizational setting" OR "process" OR "organizational experience" OR "process assessment" OR "outcome assessment" OR "workflow" OR "workplace" OR "Lesson" OR "barrier" OR "facilitator" OR "best practice" OR "experience" OR "organizational context" OR "innovation" OR "organizational behavior" OR "organizational change" OR "organizational efficiency"

Figure 2. Article Selection Flow Chart

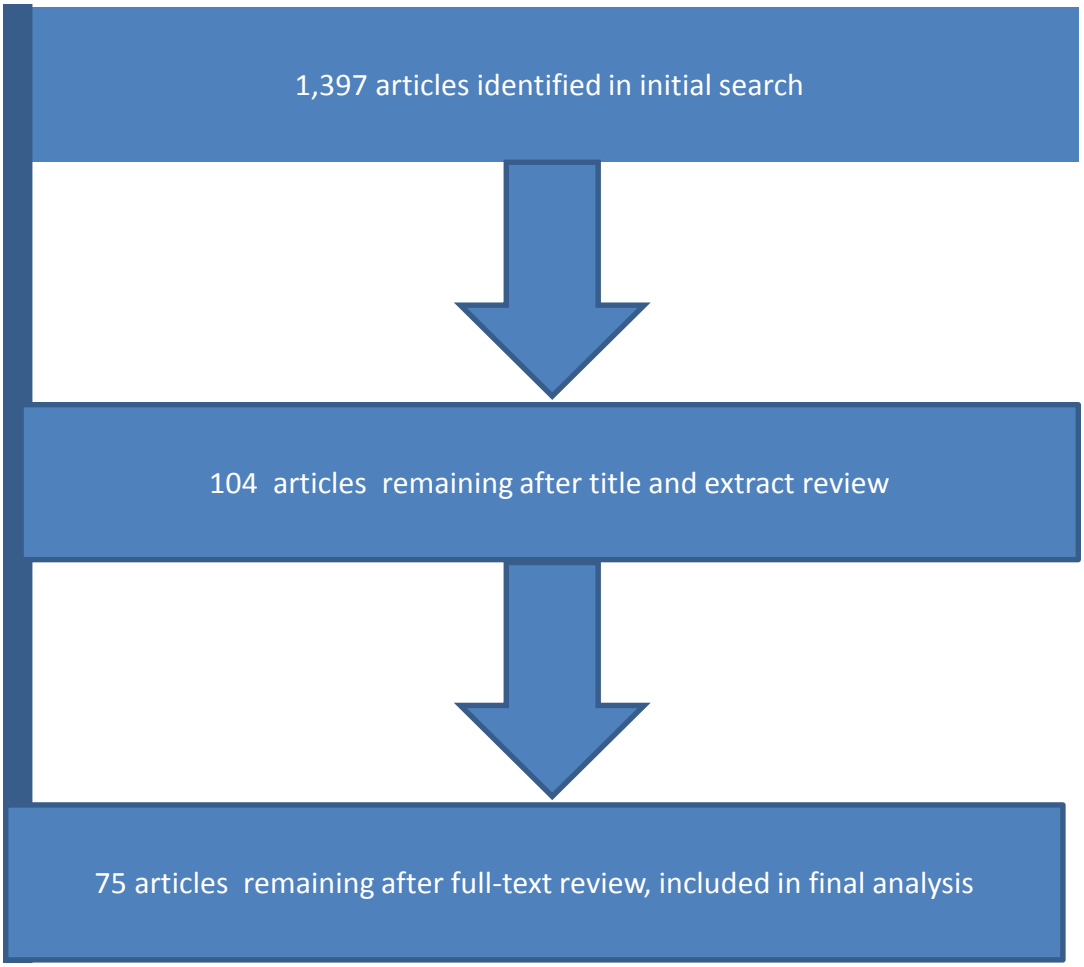

Table 2. Classification of Articles by Study Design, Organizational Setting and Health IT Type/Function

Classification	Number of Articles
Study Design	
Case study, multiple organizations	20
Mixed methods	15
Case study, single organization	11
Cross-sectional analysis	10
Profile of organization	9
Other	5
Literature Review	5
Organizational Setting	
Hospital cross-section	16
Ambulatory	14
Private Hospital System	13
Mixed	11
HIT Leaders	7
Rural or Critical Access Hospitals	5
Hospital, unspecified	3
N/A	3
Public Hospital System	2
Other (Nursing home)	1
HIT Type/Function	
General EHR/HIT/Multiple functions	48
CDS	9
Other	9
CPOE	6
Meaningful Use	2
E-prescribing	1

Table 3. Number of Articles by Perspective and Stage

	Number of Articles*
Perspective	
Technical	48
Professional Group	65
Organizational	25
Stage	
Planning and Vendor Selection	46
Workflow Design and Software Design	52
Training and User Support	37
Optimization and Modification	30

*Numbers do not add up to 75 because most articles fell in multiple categories

Table 4. Themes by Stage and Perspective

Table 4: Themes by Stage and Perspective				
Perspective	**Stage**			
	Planning and Vendor Selection	**Workflow and Software Design**	**Training and User Support**	**Optimization and Modification**
Technical Perspective				
	• System and vendor selection • Hardware selection • Standards for system functionality and interoperability	• Equipment placement • Software customization • Facility design and infrastructure	• Knowledge management • Technical support	• Software upgrades and maintenance • Ongoing support • Adjustments to interface
Professional Group Perspective				
User	• End-user engagement • Physician champions • Nurse Leadership	• Workflow redesign • Usability	• Skill needs • Attitudes	• Patient interaction • Retraining
Unit	• Inter-departmental coordination	• Workflow analysis • Creation of order sets	• Super users • Order of staff trained	• Ongoing integration into unit-specific work
Management	• End-user buy-in • Implementation speed • Staffing • Resource Allocation	• Workflow analysis and planning • Chart Extraction	• Investment in training • Training approach • Assessment • Productivity loss	• Clinician accountability • Quality improvement
Organizational Factors				
	• Organization type • Culture • Leadership • External Partnerships • Incentives • Business case • Market characteristics/Competitive environment			

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