Inf Syst E-Bus Manage
DOI 10.1007/s10257-014-0250-7

ORIGINAL ARTICLE

Understanding process change management in electronic health record implementations

Amit V. Deokar · Surendra Sarnikar

Received: 5 September 2013 / Revised: 28 February 2014 / Accepted: 21 June 2014

Abstract Electronic health record (EHR) implementations involve changes to core organizational processes, and management of these changes is critical to the success of such implementation efforts. This research describes how process change issues relate to implementation of large IT projects in healthcare settings. Specifically, we draw on extant literature and conduct directed content analysis on project reports by past HIMSS Davies Award recipients to present process change related best practices occurring in EHR implementations. The results from this study can influence implementation strategies for future health information technology implementation efforts in the healthcare sector.

Keywords Electronic health record (EHR) implementations · Healthcare · Workflows · Process change management · Content analysis

1 Introduction

In the past decade, healthcare organizations have greatly accelerated their investments in information technology. The US Health IT market in 2011 was estimated to be $40 billion and expected to grow at 24 % annually for the next few years (Lewis 2011). While organizations continue to increase their investments in Health Information Technology (Health IT), the Health IT implementation projects are often characterized by complexity and uncertainty due to several factors

A. V. Deokar (✉)
Sam and Irene Black School of Business, Pennsylvania State University, Erie, PA 16563, USA
e-mail: amit.deokar@psu.edu

S. Sarnikar
Dakota State University, Madison, SD 57042, USA
e-mail: surendra.sarnikar@dsu.edu

Published online: 01 July 2014

including the knowledge-intensive nature of the processes, powerful role of actors such as physicians in determining the use and success of the implementation, and the critical nature of processes dealing as they deal with human health and life critical implications. As a result, it has been observed that Health IT implementations can cause severe service disruptions, errors, and unintended consequences if process change is not effectively managed (Campbell et al. 2006; Poissant et al. 2005).

Over the past decade, Electronic health records (EHR) have emerged as a foundation of health IT implementations in the US. Further, recent incentives and directives from the federal government have led to widespread adoption of EHR implementations. There have been several studies on Health IT implementations in general, and EHR implementations in particular, and they explore the overall success factors for such implementations (Blake et al. 2010; Jensen et al. 2009; Kaye et al. 2010; Ludwick and Doucette 2009). A recurring theme in such literature is the emergence of workflow redesign as a key issue that greatly influences the success or failure of the implementations. An in-depth understanding of process change management is important as many critical EHR implementations often involve changes to core organizational processes in healthcare organizations. For example, the implementation of EHR can influence the clinical processes for diagnosing and treating patients by modifying data flows, task sequences, and creation of new roles and responsibilities.

Process change management has been extensively studied in the context of business process re-engineering (BPR) (Margherita and Petti 2010; Ravesteyn and Batenburg 2010), however there is limited empirical literature that provides process change specific guidance for EHR implementations in healthcare organizations. A unique aspect of the healthcare business model is that while consumers of healthcare are interested in quality of care, they are often removed from the direct payment for the services through third party insurers (Miller 2013; Rosenthal 2008). This aspect of the business model reflects in the distinct administrative and clinical functionalities in healthcare organizations, which complicates process change through varying objectives of different stakeholders such as improvement in patient care and financial goals, distinct clinical and administrative entities and organizational hierarchies, and the criticality of care processes with minimal room for error. Accordingly, there is a need to study factors related to process change in the healthcare context. This study focuses on the research problem of describing the factors that influence process changes in EHR implementations, the impact of various process changes, and recommendations to approach process changes and workflow redesign in organizations.

The aforementioned research problem is addressed in this study by analyzing several successful EHR implementations over the past decade from a process change management perspective. We first begin by analyzing past literature on business process re-engineering, change management, and Health IT implementations. We then use the directed content analysis approach to analyze 10 years of project reports of the HIMSS Nicholas E. Davies Organizational Award of Excellence recipients for Health IT implementations. The key findings from the analysis are presented followed by concluding remarks.

2 Literature review

In this section, we review extant research on process change that can inform best practices for EHR implementations. A core body of knowledge related to process change issues can be found in the business process reengineering literature. In the healthcare field as well, process change management has been identified as an important and relevant topic. We analyze this body of work, and identify the research gap that motivates our study.

2.1 Business process re-engineering success factors

Business process re-engineering has been widely studied in the context of large information technology implementations such as enterprise resource planning (ERP) systems. Davenport et al. (2004) study the relationship between ERP implementation and process change and identify that integration, process optimization and use of enterprise data for decision support are the factors most associated with achieving value for the organizations. Žabjek et al. (2009) study the impact of business process management on the success of ERP system implementation success and find that top management support, change management and BPM positively influence ERP success. ERP led business process redesign implementations significantly impact an organization's structure, culture and processes, therefore attention to change management principles, and proactively addressing complex socio-technical issues during implementation is necessary for ERP implementation success (Aladwani 2001; Huq and Martin 2006). In a more recent study, Tsai et al. (2012) note that fit between the IT system and business process plays a key role towards ERP success.

The findings from individual studies on the relationship between IT implementations and business process change have been reinforced in a study by Grover et al. (1995) who analyze data from 105 organizations to identify problems and issues encountered during BPR projects. These problems were found to be in one of the following six categories: (a) management support problems, (b) technological competence problems, (c) process delineation problems, (d) project planning problem, (e) change management problems, (f) project management problems.

The findings from the Grover et al. (1995) study have been extended in select dimensions in more recent research. More recently, Ravesteyn and Batenburg (2010), performed a meta-analysis of literature and a survey to identify critical success factors for BPM implementations. They identify communication, involvement of stakeholders, management support and governance as critical to success full implementation of BPM systems. In a study by Margherita and Petti (2010), the authors combine several frameworks and develop an integrated framework for information and communication technology enabled and process-based change. They identify several factors at strategy, people, process and enabler levels for effective process change. Jurisch et al. (2014) reviewed 130 case studies on business process change projects and report that project management, change management and IT capabilities have a positive impact on project performance.

While several studies on BPR have been published, the guidance provided is generic and domain independent and do not address the complexities such as those noted earlier in healthcare context. However, these studies provide a good starting point for analyzing success factors in domains such as the EHR context.

2.2 Electronic health record (EHR) implementation success factors

The failure of Health IT implementations in general, and EHR implementations in particular, is an important problem (Heeks 2006) and several researchers have analyzed IT implementations in healthcare and most studies point to the importance of change management and business process change related factors in influencing the success of Health IT implementations. van der Meijden et al. (2003) analyze past literature on Health IT and find that in addition to the IS Success model constructs, factors such as redesign of work practices, communication, training, priorities chosen, technical support and user involvement also influenced information systems adoption, use and net benefits.

Paré et al. (2011) explore the role of clinician perceptions in influencing the implementation success of health information technologies and report that change appropriateness, vision clarity, organizational flexibility, change efficacy, effective project champion and collective self-efficacy are significant predictors of organizational change readiness, which eventually leads to adoption of IT-based changes. Following an extensive review of health information technology implementation literature and a workshop discussion, Kaplan and Harris-Salamone (2009) identify communications, workflow and quality as the key factors that make HIT implementations difficult, and emphasize the need for further research and best practices to handle these issues. Physician concerns regarding workflow has been repeatedly identified as a key issue that influences wide scale health information technology adoption (Ash and Bates 2004).

While many of the aforementioned studies of Health IT implementations identify process change related factors as significantly influencing the success of Health IT implementations, they do not provide an in-depth analysis for the process change factors or provide detailed guidelines for addressing process change issues during IT implementations such as EHR. This remains a critical gap in literature, and knowledge addressing this gap can substantially impact EHR implementation practices as well as add to the knowledge-base on process change.

3 Data and research methodology

The data consists of application reports submitted by recipients of the HIMSS Nicholas E. Davies Organizational Award of Excellence during the 10-year period 2000–2010. The award recipients are in four categories: (a) hospitals and health systems, (b) physician practices, (c) public health organizations, and (d) community health organizations that have demonstrated excellence in health information technology implementation at their site. The emphasis of the award is on providing education to the public in the form of exemplars in implementation of electronic

health records (EHR). In this article, the focus is on analysis of 17 reports submitted by hospitals and health systems, i.e., award winners in the "organizational" category from the years 2000 to 2010. The system implementation covered in the reports includes core EHR functionality (Blumenthal et al. 2006) as listed in Table 1, and in some cases also included the implementation of ancillary systems that feed data into EHR such as those shown in Fig. 1.

The analysis of the data was conducted using qualitative content analysis, with a goal of focusing on the content and contextual meaning of the text in the reports. This research method provides "the subjective interpretation of the content of text reports through the systematic classification process of coding and identifying themes or patterns" (Hsieh and Shannon 2005). In particular, the 'directed content analysis' approach (Hsieh and Shannon 2005) was adopted in which existing theory and prior research is used as a starting point for data analysis in further extending and refining theory of a phenomenon, i.e., in this case the best practices and success factors in implementation of EHRs in hospitals and health systems. Directed content analysis uses a more deductive approach. In this approach, an organizing framework consisting of an initial set of codes is first created based on prior research, which is then used for validating and integrating concepts already well-studied in the field, while also allowing for new inquiries and insights to be drawn by introducing new codes in the framework (Bradley et al. 2007; Miles and Huberman 1994; Potter and Levine-Donnerstein 1999). This approach is closely related to the "method of deconstruction" because the author(s) of the text are "de-coupled" from the analysis and the focus is on deconstructive analysis of the content through multiple readings and interpretations (Beath and Orlikowski 1994).

Based on these principles of directed content analysis, a three-step process was systematically followed as shown in Fig. 2. First, an initial coding scheme was developed based on the business process reengineering and health IT implementation literature. Specifically as a starting point for initial coding, we used the Grover et al. (1995), study which includes a comprehensive BPR framework based on 105 organizations, Margherita and Petti (2010) study which combines various frameworks in the process change domain, and van der Meijden et al. (2003) study

Table 1 EHR functionality

Electronic clinical information	Computerized provider order entry	Results management	Decision support
Patient demographics	Lab tests	Lab reports	Clinical guidelines
Physician notes	Radiology tests	Radiology reports	Clinical reminders
Nursing assessments	Medications	Radiology images	Drug allergy results
Problem lists	Consultation requests	Diagnostic test results	Drug-drug interactions
Medication lists	Nursing orders	Diagnostic test images	Drug-lab interactions
Discharge summaries		Consultant reports	Drug dosing support
Advance directives			

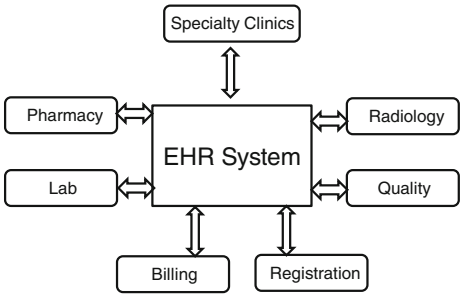

Fig. 1 EHR and ancillary systems

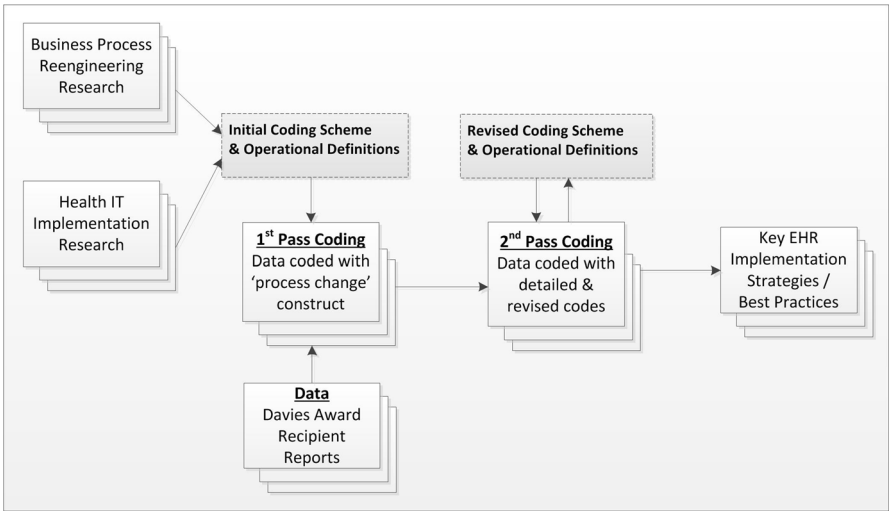

Fig. 2 Data analysis framework

which reviews several studies on clinical information systems. Second, operational definitions of codes were developed based on prior research. Last step involved analyzing and coding the reports through couple of iterations. In the first pass, all occurrences related to the "process change" construct were highlighted. In the second pass, all highlighted passages were coded, either using predetermined codes where possible, or creating new codes where needed. After coding was complete, the resultant quotes and codes were analyzed to reconcile key strategies/best practices for successful health IT implementations.

4 Study findings

We now discuss the study findings from the analyzed reports that help highlight process change factors as well as provide guidelines for addressing process change issues during health IT implementations. Each of the subsections represent first level codes, which further consist of second level codes. Figure 3 provides an overview of

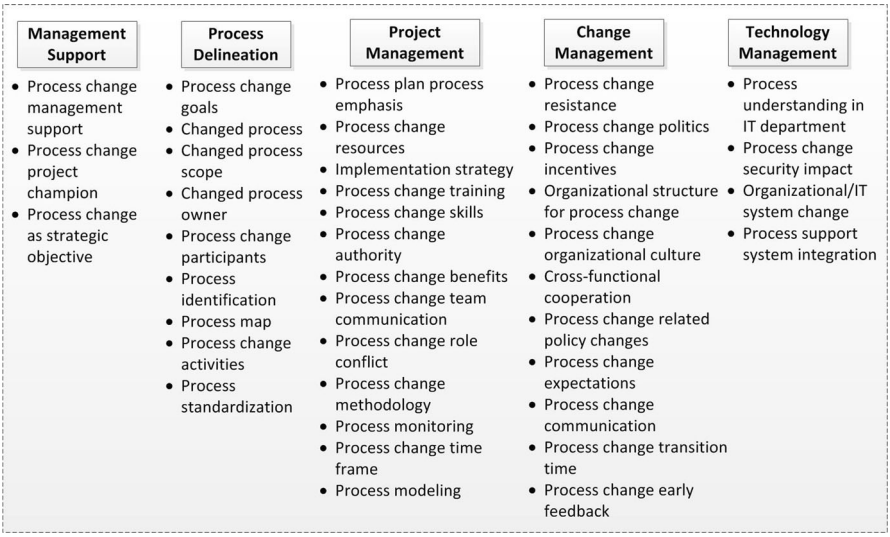

Fig. 3 Overview of codes

first and second level codes used in the analysis. The findings from each code category are summarized in Tables 2, 3, 4, 5 and 6.

4.1 Code category 1: management support

4.1.1 Process change management support

Management Support for Process Change is critical for achieving successful adoption of changed and re-engineered processes and realizing the objectives of process change. We have observed that management support for process change from both the clinical and administrative branches of the organization is critical for comprehensive re-engineering of processes and for obtaining buy-in from

Table 2 Management support: summary of findings

Code	Key findings and implications for EHR implementation
Process change management support	Given the distinct organizational hierarchies for administrative and clinical branches in healthcare organizations, management support needs to be established from both branches. However, executives from administrative branch often need to play a larger role due to the operational nature of IT implementation-driven process changes
Process change champion	It is critical to have a Physician champion(s) for process change. Champions from within each major sub-group (such as different specialties) of clinician may be necessary
Process change as strategic objective	Process improvements needs to be key project level objective and driven by quality of care goals in addition to process efficiency

employees. We see that such support has been provided in a number of different ways. In some cases, process change initiatives were led by senior management executives. For example, the Chief Operating Officer or a Vice President of Patient Services was in charge of organization wide process re-engineering initiatives in conjunction with the major IT implementation project. In other cases, process change was led by mid-level executives but with strong support of the chief executive throughout the project for improving process outcomes. Management support for process change was made evident through provision of needed resources such as hiring of external consultants, compensating physicians and other employees for participating in process improvement teams, support for process change through public endorsement and newsletters, insistence on quick resolution of process change related issues, and strict enforcement of rules that prevented employees from reverting back to old processes and ensuring mandatory adoption of the re-designed IT enabled processes.

4.1.2 Process change champion

A champion for process change advocates for re-engineering processes and its benefits and advantages to the stakeholders. Often times this role is fulfilled by the project champion. The typical approach in many organizations is to use Physician champions. This is critical and effective since physicians play a key role in clinical processes and are among the most affected by workflow changes. Also, in many cases resistance to process change has been from physicians. Many organizations had multiple project champions that represented different groups. For example a large multi-specialty hospital had representatives from Pathology, Surgery and Hospitalists serve as Physician and MIS Advocates. Another approach was to select two Physician champions, one from the salaried staff and one representing voluntary community-based physicians. The champions were chosen carefully based on personal attributes and a leadership position within the physician community. The physician champions were deeply involved in the design, redesign and changes to processes and systems. In some cases the physician champions were part of a larger physician teams that were involved in the design of the screens, forms and processes. While a majority of the organizations relied on a Physician champion, some organizations also recruited a Nurse champion in addition to a Physician champion, and was seen as a successful approach as a significant portion of the clinical process are executed by Nurses.

4.1.3 Process change as strategic objective

The emphasis on process change as a strategic objective was seen at two different levels in many organizations. In almost all the organizations, we have observed a focus on process improvement as a key project level strategic objective for a Health IT implementation project. This is evident through inclusion of statements such as "Improve service efficiency by streamlining health care processes and workflow to reduce costs and medical errors", "strengthening the service delivery process", "efficient provision of care and efficiency", and "work process improvement" in

the strategic objectives or goals of the Health IT implementation project. In addition to efficiency and effectiveness of processes, organizations have also focused on process simplification as a key process related project objective.

In some organizations however, we have observed a focus on process improvement and service efficiency not only at the project level but also as a part of the organizational overall strategic objective or value system level. For example, the value statement of a large healthcare organization include statements such as "We consistently look for ways to deliver the highest quality and most efficient healthcare" and "Be effective stewards of our assets, continually improving them to advance our Mission" and other statements that indicate a focus on continuous improvement of processes and quality as part of their organizational culture. We have observed that many such organizations have a culture of continuous quality improvement and have established structures in place for continuous processes improvement and re-engineering. The project level process change initiatives in such organizations were also more comprehensive, structured, had clear measurable outcomes, and were almost always driven by end-users.

4.2 Code category 2: process delineation

4.2.1 Process change goals

In most Health IT implementation projects, quality of care, reduction in errors, improving patient satisfaction, access to information, and reduced costs through efficient operations were recurring themes. Other project objectives included improving enterprise wide data integrity, improved documentation, flexibility for future growth, monitor performance, improved regulatory compliance, and improved data collection. We note that most of the key project goals were to achieve process related objectives such as improving process efficiency (for e.g., process redesign to reduce errors and improve data integrity, improve regulatory compliance) or process outputs (for e.g., quality of care, information quality, and patient satisfaction).

The process change goals listed in the reports can be classified into two distinct categories. One category relates to patient safety and quality and included goals such as reducing medication errors, reducing length of stay, improving patient safety, and improving patient satisfaction. The other category of goals were related to productivity and costs and included goals such as reducing turn-around time, increasing employee productivity, eliminating waste, and reducing redundancy. While the goals could be classified into distinct categories, many organizations see them as interrelated and impacting each other. For example, reducing medical errors not only improved patient safety but also reduced costs for the organization. Similarly, reducing turnaround time not only improved productivity but also improved patient satisfaction as well. A group of data and communication related goals that are driven by technology enabled process change include improved accuracy and timeliness of data, access to patient information, improved communication among care team, better support for handoffs, and better communication across shifts. These goals lay at the intersection of these categories that impact productivity as well quality concerns.

Table 3 Process delineation: summary of findings

Code	Key findings and implications for EHR implementation
Process change goals	Process change goals need to be primarily driven by quality of care goals. However, even when non-clinical goals such as productivity and costs are treated as secondary, they are critical for financial success
Changed process	The key consideration for identifying process re-design candidates is to ensure seamless care provisioning and co-ordination following EHR implementation. Other triggers to consider include error-rates, standardization/best practices, and process efficiency
Changed process scope	The scope of process change needs to take into account handoffs and care co-ordination across departments keeping safety and reduction of errors and bottlenecks as primary goals
Changed process owner	In order to minimize process change resistance, fostering physician ownership of process change initiatives is recommended. In case this is not feasible, a super-user owned approach is suggested
Process change participants	Process change teams should be cross-functional involving clinicians, IT and administrative personnel. Involvement of Physicians is critical for successful process change
Process identification	Given the domain intensive nature of clinical processes, involvement of a person with clinical experience is necessary for identifying and documenting processes. Observation of patient flows can guide process identification
Process map	In order to develop accurate mapping of workflows participants with deep knowledge of clinical processes within and across departments and good workflow modelling techniques such as hierarchical decomposition and walkthroughs are required
Process change activities	Re-design of forms, clinical documentation templates, and flowsheets need to be included in process change activities for effective process change. The process re-design activities should be ideally led by a medical informatics team with input from a large base of end users
Process standardization	Identify erroneous perception of clinical uniqueness to drive clinical process standardizations. Standardization should be approached as a norm and objections to standardizations should be analyzed by considering impact to patient safety, the continuity of the patient's record, impact to workflow and impact on the build timeline and system maintenance

The reason for which process change was initiated had a significant effect on the outcomes. In most cases, process re-design and change was initiated to meet quality and productivity goals and IT was seen as a tool to exploit to achieve those goals. For example, one of the reports included the following quote related to a process change objective "Eliminate waste and exploit system functionality to greatest advantage". In a few cases, however, we observe that process change was initiated to primarily to match the functionality of the system, but not with productivity or quality goal in mind. In all such projects, we observed significant resistance to process change and many process re-design activities post implementation of the system.

4.2.2 Changed process

Since most of the projects involved the implementation of computerized order entry systems and electronic medical record suites, the processes targeted for change were

predominantly order entry, scheduling, medication prescription, and results reporting. In cases where such implementations were in large multi-specialty multi-department organizations, the process also included patient tracking, care documentation, care co-ordination and discharge. While this is not a comprehensive list, in general the processes targeted at a high level were billing, scheduling, diagnosis, treatment, medication administration, and patient monitoring.

Aspects of each of these high level processes within specific departments where then identified for change. For example, the redesign of triage process in the emergency department, or the redesign of scheduling process in primary care from a back office operation to a front office operation. The department level processes can then be further broken down into individual workflows that were redesigned such as the data entry process, a nurse's workflow for checking for new orders, re-design of order fulfillment process by lab technicians etc.

The processes to re-design were identified based on one of several criteria. For example in some cases processes were targeted due to existing problems of efficiency or high error rates. Another trigger for process change was standardization and adoption of best practices for a specific process across an organization. For example, the scheduling process in each department was identified for process change to implement a standardized process model.

Most process changes were at the individual workflow level and are due to automation and the provision of superior technological capabilities. For example, the documentation, medication management and other data entry process were changed to utilize enhanced data capture technologies such as voice recognition, optical character recognition, barcoding etc. Rules and triggers used to create tasks and alert nurses to work items that were generated due to automation of processes and someone else's interaction with system. Clinical support staff had to modify individual workflows to use electronic task list where previously task assignment was based on verbal communications. We observe that many processes were changed through the addition of rules to reduce errors and validate data.

4.2.3 Changed process scope

The scope for process changes were determined in a number of different ways including analysis of previous systems, department level self-assessments to identify process improvements and impact of the new system, and in some cases were end user defined when the end users were involved in documenting current processes and then re-envisioning ideal processes.

In terms of the scope of the changed process, since most of the changes were at an individual level, they involved changes to how tasks were performed or addition of rules to reduce errors and validate data. However, the changes to a process in one department in many cases led to process changes in other departments. For example, order entry automation greatly reduced the order communication time, therefore the order fulfillment process in labs had to be redesigned to prevent bottlenecks. The scope of the changed processes typically spanned across departments when the process change goal involved patient safety and reduction of errors. Examples include processes involving handoffs and care coordination.

4.2.4 Changed process owner

We observed a range of process change ownership structures in the Health IT implementation projects. At one end, the process change initiatives were owned and driven by a centralized implementation team. At the other end, the process change initiatives were owned and driven by end users and process participants themselves. In cases where the process change initiatives were owned by end users, the organizations reported that the users were eager to transition to new processes and faced minimal resistance to change. This was specifically the case with Physician users. In between the centrally owned and the end user owned approach, is a super user owned approach. In this case, the process changes are initiated and championed by super users within each end user group.

4.2.5 Process change participants

All the projects reported some involvement of Physicians, IT, and administrative personnel in the process change process. We see a wide variation in terms of the clinicians and clinical support staff involvement in process change initiatives. At one end of the spectrum, a few organizations included only Physicians, whereas at the other end of the spectrum were organizations that involved Physician, Nurses, Pharmacists, Lab Technicians, Dieticians, Health Information Management and a wide range of clinical support staff. Based on the organization and scope of the IT project, external service contractors and independent physicians were consulted for process change as well. In organizations with a culture of process and continuous quality improvement, internal quality and performance improvement departments were also involved in the process change activities. Risk management representatives were also typically involved in process change activities.

The involvement of the process change participants can be categorized into three phases that include analysis and documentation of current process, design of new process, review and refinement of the re-designed process. In most organizations, end users were involved in the analysis and review phases, while the design phase was predominantly handled by a central cross functional implementation team. In a limited number of cases, the end users were only involved in the documentation of current processes but no feedback was solicited for re-design or review of new designs. Those organizations also reported going through a post-implementation process redesign phase to correct process errors and problems. In a few of the organizations, some with established structure and a culture of continuous process improvement, end users were predominantly involved in analysis, design and review phases of process change.

Varying structures were created for process change participation. In many cases all process changes were reviewed by a clinical council before implementation. When physician involvement was achieved through a Physician group taking primary responsibility for process change, they were compensated for it, and were tasked with gaining consensus from peers. In such cases the transition to new processes faced less resistance from Physicians. In one particular organization a Nursing council was also implemented similar to a Physician council. In many

organizations, where a central implementation team was tasked with re-designing workflows, such a team was structured as a medical informatics team with significant representation from IT savvy clinicians. Such a team served as an interface between clinical and IT domains. Other mechanisms for end user involvement included formation of ad hoc groups of end users to solve specific process re-design problem, and requiring each physician to review process re-design and provide input. The structures used for process re-design participation varied from formation of ad hoc groups, groups lasting throughout the duration of the project, and permanent structures for continuous process improvement.

4.2.6 Process identification

The organizational processes were discovered and documented using a number of different methods. One approach involved self-assessment by all departments affected by IT implementation to identify process improvements and impact of the new system. When the IT project involved replacing a legacy system with a new IT system, the processes were analyzed by analyzing an existing legacy system used by the organization. In cases where process change was owned by end users, a team leader from each operational area was identified for process identification. The team leader was someone with clinical experience, process re-design and performance improvement experience, and trust of the operation staff. The most common tool used for identifying and delineating process was flow charting. When a centralized team was tasked with process re-design, the processes were identified by the team using an interview process and observing patient flows.

In phased implementation approaches, lessons learned from early pilot sites helped identify workflows to change. Many organizations also actively solicited feedback post implementation to identify process change needs based on user feedback and initiation. The real time data generated post implementation also provided a mechanism for identifying processes that need improvement.

4.2.7 Process map

Most organizations did not have a process or practice in place to create and maintain an organization wide process map. The techniques used for process delineation and documentation during the large Health IT implementation projects formed the basis for creating a map of process affected by system implementation. As noted earlier, the techniques include self-assessment by each department, based on analysis of previous system, or creating an interdisciplinary team dedicated to identifying and mapping all workflows. In some cases when a top down approach was used to identify all processes, the process maps were incorrect due to incorrect assumptions of the process mapping team or incomplete data collection during the interview process with end users.

In one successful example of a process mapping approach, a large quality focuses healthcare organization used a hierarchical decomposition method where high level workflows were broken down into hundreds of departmental workflows which were further decomposed into thousands of unit level and individual workflows. In order

to ensure accuracy of the developed workflows, a workflow walkthrough with all employees session was used to verify accuracy and create a comprehensive map of workflows.

4.2.8 Process change activities

At a minimum, the process change activities conducted by the organizations include mapping current workflows and re-designing forms and templates in the Health IT system to meet the workflow requirements. A more detailed approach included process analysis and charting, gap analysis between current and optimal processes designs, re-engineering and IT design.

In organizations where process re-engineering was a major focus of the IT implementation project, IT capability understanding preceded the process analysis phase. This was beneficial in the design phase, as users had a better understanding of IT capability and could leverage the technology to design more efficient processes. In majority of the organizations the process re-design activities were led by a medical informatics team with input from a large base of end users. The process change activities included developing high level workflows, and then expanding each into more detailed workflows. Redundancies, workarounds, and handoffs were then identified within each workflow and targeted for re-design.

Development of new policies and procedures, training, system planning and build, communications and change management planning activities to support the redesigned processes took place in parallel with the process redesign activities. End user involvement in process re-design included feedback for process re-design, validation of workflows, participation in walkthroughs, and training. The validation of the re-designed workflows typically included a review and verification by a clinical council or a change control group with experienced and experts with knowledge of processes.

4.2.9 Process standardization

A major component of process re-design was process standardization. Process models were identified for standardization when multiple variations of the same process existed in each department although they had a similar goal, (e.g., appointment scheduling). The processes were then standardized across departments and automated. Process standardization for clinical processes was targeted when process variation was driven by "erroneous perception of clinical uniqueness". A key part of standardization was standardizing forms and record formats. Organizations approached standardization as the norm, and any objection to standardization was analyzed in terms of "impact to patient safety, the continuity of the patient's record, impact to workflow and impact on the build timeline and system maintenance".

In some cases, specifically when process mapping was conducted by an external team with limited involvement from end users, standardized workflows led to problems in specialized units where it did not fit the nature of work. Balancing standardization with local flexibility in specific departments was necessary to obtain buy-in and better match with local requirements.

4.3 Code category 3: project management

4.3.1 Process emphasis in project plan

Almost all projects plans for the Health IT implementations included a workflow analysis and process re-engineering activity. However, the organizations varied in the emphasis on process change in terms of time and resources dedicated to the activity. In some project plans, process change activities were specifically emphasized as a major portion of the project with activities labeled "Clinical workflow analysis and process re-design" within the project plan. In other cases process change was embedded along with various assessment activities within generically labeled analysis and system design phases of a project. In most of these cases, we also noted resistance reported from care providers, likely because the project goals did not explicitly convey the implications and expectations of process changes to the stakeholders.

Project plans that emphasized process changes did so in one or more areas. For example, vision and objectives of the project were used to emphasize impending process changes as key to the implementation efforts. One of the reports mentioned the following as a strategic objective: "Improve service efficiency by streamlining health care processes and workflow to reduce costs and medical errors." Also, operational planning and change control planning aspects of implementation plan laid out specific steps for tackling workflow changes. Examples of such steps include needs assessment of current patient care flows, care provider workflows, and opportunities for improvement by integrating information gathered across different departments. Infrastructure and hardware preparation planning is another area where considerations of workflow processes and related data storage requirements have been reported.

4.3.2 Process change resources

Implementing process changes were either a primary goal or an important subordinate goal of Health IT system implementation noted by most organizations. Technology adoption research and best practices have noted adequate resource allocation as a key strategy for successful implementation and adoption of general IT systems. This awareness resonated in most report not only in regards to the Health IT system that was being implemented, but also for the accompanying process changes that were occurring. The kind of resources varied and ranged from financial commitment to external consultation.

Given that Health IT processes are inherently cross-functional, in most of the projects new interdisciplinary teams were formed to consider inputs from management, technical and direct care staff on process changes. Also, in larger organizations, board of directors were supportive of approving hardware, software, consultation, and training resources necessary to support process changes. Project or organizational leadership provided similar kind of support in smaller organizations. A common theme noted in most projects was the recognition that the faster the help could be provided to staff and care providers, the less frustration they experienced during

Table 4 Project management: summary of findings

Code	Key findings and implications for EHR implementation
Process emphasis in project plan	In order to explicitly convey the implications and expectations of process changes to care providers and minimize their resistance to change, project plans should explicitly include clinical workflow analysis and re-design activities
Process change resources	External resources such as consultant physicians should be recruited to assist with projects given their process expertise and credibility among their peers. Resource commitments should also be made for post implementation and continuous improvement of care processes
Implementation strategy	If it is not feasible to phase-in the process changes and new systems in a sequential manner because of the extensive impact on patient care and care provider workflows, then the one shot (big bang) implementation approach should be used
Process change training	In additional to customized training for different healthcare roles, clinical personnel in each clinical area should be trained as "super users" for providing first line of support
Process change skills	Physician and clinical leadership for process change should be selected based on skills for conflict resolution and to provide strong guidance to clinicians through major process changes
Process change authority	The authority for deciding which processes to change and to what extent should rest with a physician task force or a planning committee which includes physician staff
Process change benefits	In order to evaluate process change success, benefits to patient flow and service quality should be measured in addition to cost metrics
Process change team communication	Direct care staff members from respective clinical areas need to be part of each implantation team to assure good communication and minimal disruption to patient care quality during workflow changes
Process change role conflict	Based on care-flow process needs, local flexibility in specialized clinical areas should be provided to address role and process conflicts that arise during enterprise-wide process standardization
Process change methodology	The process change methodology adopted should involve clinical user communities and be amenable to continuous improvements in clinical quality, service quality and cost effectiveness
Process monitoring	EHR data should be leveraged to monitor care process at various stages in the post implementation phase
Process change time frame	When using a phased implementation approach, the process change time frame should include time for pilot projects followed by clinical specialties and processes selected through prioritization. In a "big bang" the time frame should include a significant planning and ground work component
Process modelling	Clinical workflow models should include clinical protocols and clinical guidelines. The re-design of processes should be leveraged to review protocol guidelines and aligning them with workflows

process changes. Accordingly, variety of immediate resources were made available throughout different phases of Health IT implementations including help desk, on-site personnel with system and process expertise, external personnel resources (e.g., specially-trained medical students, vendor personnel), training staff for intensive onsite support of changed processes (e.g., onsite training, one-on-one training). In

some cases, IT departments also recruited physicians, either part-time or full-time, on their payroll to assist with projects because of their domain expertise and first-hand experience with the processes, as well as credibility among their peers.

Resources for tackling process change issues were not only required during the actual implementation phase, but also post-implementation. These resource commitments were made early on in the projects to ensure smooth transition of changed processes and continuous improvement of care processes. Example of such resources includes permanent on-site operational personnel for providing guidance with new process and system changes on an ongoing basis.

4.3.3 Implementation strategy

Project implementation strategies varied across organizations, but in general they can be categorized as either a "phased" approach or a "big bang" approach. In a phased approach, organizations typically selected a subset of processes and then thoroughly reviewed and re-engineering them, along with any functions and data that support them. The phased approach allowed the implementation team to focus on specific clinical areas without their efforts and energy becoming too diffused or fragmented. The big bang approach was more suited where it was not feasible to phase-in the process changes and new systems in a sequential manner because of the extensive impact on patient care and care provider workflows. The amount of time needed for care providers to enter and retrieve information in two different systems supporting the care processes had to be minimized, and so the one-shot approach was preferred to achieve this objective in the shortest amount of time. In such cases, extensive support staffing was essential to successfully transitioning the process. The decision to select a phased approach or a one-shot approach was made by implementation teams, which were cross-functional and were suited to judge the implications of each alternative from both process and IT system standpoints. A recurrent implementation strategy regardless of the approach was extensively involving physicians during the planning and implementation process.

Pilot projects were also used in many cases as a test bed for process and system changes (e.g., order entry process) and then communicated the results of these projects within the organizations to set expectations about large scale implementation. The goal of focusing on manageable smaller processes was gaining 'quick hits' that could be demonstrated to the stakeholders to gain credibility. Marketing the success of pilot projects through go-live celebrations and sharing the success stories and lessons learned was noted as a key strategy noted for leveraging the pilot projects to gain wider organizational support. On the other hand, any instability or failure in pilot projects can leave a negative impression on stakeholders. To compensate for that, organizations reported quick and personal contact after any problem resolution giving a sense of accountability and direct involvement in the project's success.

4.3.4 Process change training

Training about changes in processes associated with Health IT implementations is a major consideration reported in almost all project reports. Most projects involved

extensive training and certification programs for staff and physicians. Organizations noted considerations such as designing distinct curricula for different stakeholders depending on their participation and perspective within the workflow process. For new employees, training modules catered to the kinds of services provided by the employees were newly introduced, in additional the general curriculum. Many projects noted to rely on accepted education principles from external agencies, and including computer based training tools where suitable.

Several organizations emphasized the training focus on process improvement and how the Health IT system would be used as a tool for that purpose. Given that new processes demand tremendous operational and cultural changes from the physicians and clinical staff, process training was exclusively provided in some projects in tandem with the ongoing implementation efforts to familiarize the stakeholders early-on about the upcoming changes to their routine processes. Further, clinical personnel in each clinical area who would be participating in the project as the first line of support were provided extensive training on re-engineered processes as "super users".

The timing of training varied between different projects. As noted earlier, while some projects involved early and extensive training, others used the just-in-time training with individualized one-on-one, on-the job training as possible. The rationale behind just-in-time training was to maximize user competence. This involved accommodating clinical staff schedules to provide as much individualized training on-the-job as possible, providing them with additional resources such as personalized versions of training manuals for their clinical specialties in the form of reference pocketbooks.

4.3.5 Process change skills

In most projects, strong physician and clinical leadership in the project implementation team was critical in emphatically communicating and supporting the organizational goals and vision of the Health IT implementation, particularly including key changes to workflow processes. This person cannot be seen as "wedded to the old way" and should have the skills to take up the challenge to guide physicians through major process changes involved in the project. Such leadership is noted in many projects to bring enormous credibility to the project.

In addition to the leadership, the overall IT team is most effective when the staff are "clinically-focused", i.e., they have a thorough understanding of the care processes and view Health IT systems as a tool for enabling them. Another key quality that surfaced in several projects was conflict resolution skills along with the ability and readiness to offer support and issue resolution. This is critical particularly in process change implementation efforts where it is important to be able to successfully diffuse volatile situations when stakeholders get emotional about major changes to their daily work processes.

Often termed as "super users" in many projects, these individuals are experts in the medical domain who offer their services for on-the-job training or support, especially at the critical go-live time. The success of the project often hinges on

their skills, which include commitment to changing service delivery, ability to work with physicians, and high level of enthusiasm with a positive outlook for change.

4.3.6 Process change authority

The authority of deciding which processes to change and to what extent typically rests with a Physician Task Force or a Planning Committee which includes physician staff, representatives from various clinical areas, and nursing staff practitioners as key members. This group has authority and oversight on the strategic project directions and is responsible for making decisions on key issues affecting physicians and other stakeholders in the clinical work processes, resolving project conflict, establishing policies and direction, and facilitating physician involvement and acceptance. The Chief Technology Officer or IT champion of the project works with this group to fulfill their directives.

In some projects, the project implementation team, consisting of cross-functional team members was noted to collectively decide on the aforementioned issues. Even in such teams, there is a distinct physician leadership in the team that led the direction on process change issues. In most projects, there were extensive efforts from the outset of the project to demonstrate that the Health IT implementation and corresponding changes in processes were "owned" by the clinicians and not the IT department.

Even in post-implementation phases of the projects, the Physician Task Force or a similar team was noted to regularly convene for reviewing new process changes or system changes that can have major operational impacts on patient care flow as well as clinical work processes.

4.3.7 Process change benefits

The benefits of improvements to the process of service delivery were clearly evident in almost all projects, ranging from cost benefits to better regulation compliance. Many projects report drastic reductions in costs (as much as 70 % or more) associated with the transcription and documentation of patient care episodes during their treatment. For example, moving caregivers away from dictating notes decreased the amount of time to get the information in the patient records and made it immediately accessible for other personnel in the later stages of the process. Similarly, the reduction in back office staffing required for data entry throughout care processes resulted in major savings. The accuracy and integrity of the service encounters billed and/or reported is also improved. In most projects, the re-engineered processes ensured explicitly reducing deficiencies in the client records discovered in routine audits, thus improving the compliance levels. Effectively, these projects also reported drastic reduction in repayments to payers for noncompliant documentation or ineligible services.

The most important benefit of process improvements is in the improved patient care flow and service quality. For example, consultations to specific clinical specialties are communicated electronically through the new process alerting the recipient to a requested consult. The re-engineered physician order entry process

automatically triggers such notifications. Similarly, alerts and flags cue the physicians to act on orders awaiting their action on specific functional areas in the process such as pre-admit, post operative, post transfer, and so forth. Communication across departments and sites is improved. For instance, orders from ancillary departments such as Lab and Radiology display appropriate order indicators and status changes. The use of such systematic and accurate information flow through the process is reflected in multiple areas. For example, in hospital settings, the generation of physician round reports is improved where up to date critical patient data and service information is accessible to help the physician make informed decisions during rounds. Overall, the technology enabled process changes have been noted to help to facilitate best practice through evidence based on clinical practice guidelines and electronic order protocols implemented in these new processes.

4.3.8 Process change team communication

Communication among team members responsible for planning and implementing process changes is emphasized in all projects. We noted that the mechanisms of team communication vary in different projects. A recurrent theme was that the project team maintained constant communication with various departments to ensure that their minimal disruption to patient care quality during workflow changes. Project teams used various opportunities such as pilot project celebrations, sponsored lunches to gather together stakeholders to provide project updates.

In many projects, project team members used regular newsletters frequently published on the intranet site as a mechanism to announce key updates, and changes to processes. In few projects, we also noted that top organization leaders, CEO and Vice Presidents served on the Leadership Council as well as different project implementation teams dealing with different clinical specialty processes. Direct care staff members from respective clinical areas were also part of each team to assure good communication relayed through clinical staff representatives. Another pattern observed was the regular participation of project team members, particularly project lead members, as guest speakers in monthly meetings of various medical specialties where both staff and physicians attended. Such opportunities allow project team members to provide ongoing project updates as well as hear any specific concerns first-hand from clinical professionals.

4.3.9 Process change role conflict

Role conflicts in execution of re-engineered processes were noted that arose due to issues balancing process standardization requirements and local flexibility. A degree of local flexibility is necessary to implement departmental processes within a broader framework of enterprise-wide standardized processes. For example, in the obstetrical department, nurse-midwives are authorized to dispense medication, and document. Last, but not least, conflicts can also arise during process identification, mapping, and reengineering where proposed process changes often reveal work processes that are redundant or in conflict with other departmental practices.

Sometimes, the needs of caregivers providing and reviewing the data during the care flow process may also conflict.

Regardless of the source of conflict arising, tackling them in an amicable manner is essential to project implementation success. For example, some projects have relied on forming Physician Task Force and Nursing Council to resolve process and data conflicts related to the key issues affecting physicians and nurses. In other cases, project implementation team leadership stepped into resolve conflicts and facilitating trade-off decisions between stakeholders.

4.3.10 Process change methodology

Health IT implementation projects involve major overhaul of work processes. As such a systematic approach in planning and implementation is desired to maximize success and reduce failure risks. Projects have used different kinds of methodologies in undertaking process changes.

During needs assessment and project planning phases, different variants of prioritization processes have been used in projects to select the priority of the processes to be re-engineered. The emphasis in prioritization processes is to identify key metrics and payback associated with the process changes, efforts involved, and other related factors such as technology needs, and ties to overall organizational strategy.

Quality management methodologies have been adopted in several projects. For example, Lean methodology has been successfully used during the process redesign stage to eliminate waste and non-valued processes. In addition to using such methodologies for strategizing and implementing process change, projects have also used quality management methodologies in post-implementation stages. For example, Continuous Improvement Cycle is another notable methodology in which post-implementation user committees are created as a continuing vehicle to raise process change issues, prioritize implementation and updates. These user committees are spin-off of the constituency groups, and project implementation teams to maintain continuity, and an ongoing cycle of constant process improvement, consensus, and agreement among all hospital stakeholders. In some projects, new process implementations provided opportunities for gathering process meta-data and analytic information that is then utilized to improve the dimensions of quality such as clinical quality, service quality, and cost effectiveness.

4.3.11 Process monitoring

Process monitoring in post-implementation project phases can yield several benefits in terms of deriving continued value from new process and system changes. Projects have demonstrated success with engagement in varied activities. One common approach is monitoring of systems at various stages of the process to record key process metrics, along with outcome metrics. This has implications even during project planning stages because the stakeholders and project teams need to agree up front on which are key metrics to monitor, which data to collect, the data source, and the process for collecting and analyzing the data. EHR data and system logs can

specifically be leveraged for this purpose. Projects have also reported setting up on-site operational coordinators and end-user committees as noted in prior findings. Their role is to regularly meet and bring forward any issues from their individual care units for resolution or future enhancements and priorities for improving the processes further. Ticket tracking mechanisms have also been widely used to capture immediate issues and enhancement requests.

Monitoring user satisfaction with the modified processes through user surveys and interviews is also a critical part of process monitoring. In few projects, it was noted that user dissatisfaction was high for several months after process re-engineering and system implementation, which was attributed to the significant changes required in processes and workflow as well as the steep learning curve. These findings point to the needs of setting right process change expectations and appropriate process change training early-on in such projects.

4.3.12 Process change time frame

Process change time frame typically varied widely between organizations, depending on the organizational context and implementation strategy adopted. In large-scale projects where phased approach was followed, process changes were often initiated through pilot projects, and then clinical specialties and processes were selected through prioritization. While this implied that the projects as a whole was extended over a much longer time frame (usually few years), it also allowed for more time for gradual adoption of changed processes and systems across the enterprise. Notably, few if any resistance issues to re-engineered processes were noted in such projects. In few occasions, one-shot implementation approach was adopted which amounted to few weeks to months of process change implementation time frame. However, there was significant groundwork and planning that was involved before the actual implementation took place. Additionally, projects recorded round the clock intensive help desk and training resources required when using such an approach. This approach is selected only in cases where phasing of processes is not an option because of potentially significant disruptions that may be introduced in care flow with changes and redundancies in processes. For example, in a project phase-approach was selected for outpatient settings, but it was not an option for the inpatient settings and so "big bang" approach was selected to deploy greatest amount of changes in least amount of time.

4.3.13 Process modeling

Process modeling techniques were consistently followed by projects to document as-is processes and record new re-engineered processes. Flowcharting is the most commonly used technique in majority of Health IT implementation projects because of relative simplicity. In many projects, custom templates for recording workflow patterns in clinical areas have been developed. These patterns were then translated and combined into larger care processes for standardization.

Protocols and clinical guidelines are critical in defining clinical workflows. In re-designing processes, many projects note leveraging the opportunity to review

protocol guidelines and aligning them with workflows. Use of flowcharts and data flow diagrams are common techniques used for this purpose. In few cases, process simulations were used to visualize new processes and conduct what-if analysis from various perspectives such as resource allocation, cost, and patient care flow.

4.4 Code category 4: change management

4.4.1 Process change resistance

Changes to conventional processes often imply major changes to daily routines for process owners and related knowledge workers. Many organizations note anticipating significant staff resistance to computerization and changes to routine workflows. In response, these organizations have taken proactive steps to minimize process change resistance.

Almost all projects report representation and active involvement of physicians, nurses, and clerical staff (from all clinical areas) in the project implementation team as a key strategy to minimize change resistance. We noted that an equally important strategy is making sure that their voice is heard and their feedback incorporated to the extent possible (resolving conflicts where needed). We noted—"One example of little items that went a long way in providing value to physicians and gaining their buy-in was providing physicians the ability to look up current beeper numbers. This feature let a physician enter their beeper number once and it would show whatever pathway needed to have that number."

In many projects, regular meetings of project implementation team were essential with agenda items devoted to attending issues that might interfere or impede clinician's service delivery process. Along with addressing concerns, projects noted that it is essential to effectively communication how the changed processes would benefit each user community. For example, physicians need to gain confidence that the processes and associated IT system would save them time and money while improving patient care. They need to be convinced that the process would help deliver essential information and alerts that they would not know or be able to find quickly otherwise. In a project, a potent argument that seemed to work with obstetricians was the ability of the OB record in implemented care processes to help reduce potential lawsuits. Some projects also engage consultant firms to handle enterprise-wide re-engineering projects. In such projects, establishing trust among partner entities has proved to be critical to success.

4.4.2 Process change politics

Process changes are situated in organizational context, which imply that several different environmental factors are likely to impact these implementations. An example worth noting was in a project where due to financial pressures facing the hospital during the project, the executive team was fragmented on several issues and disinterested in project implementation. An external consultant hired to address the financial issues led to replacement of several key leaders by interim consultants 6 months prior to project implementation. The management turmoil and underlying

Table 5 Change management: summary of findings

Code	Key findings and implications for EHR implementation
Process change resistance	The project implementation team should include active involvement of physicians, nurses, and clerical staff (from all clinical areas) to minimize change resistance. Incorporation of early feedback from clinicians and quick resolution is key in gaining buy-in and minimizing resistance
Process change politics	When deviations from standard implementation approach arise due to internal politics, trade-offs may be necessary to obtain stakeholder buy-in. The project champion should understand the nuances of the enterprise and its internal politics
Process change incentives	Recognition of members for being early adopters, for providing valuable inputs, for sharing use cases about modified processes, serves as incentives for other employees to participate more actively
Organizational structure for process change	New and permanent organizational structures such as "Clinical Councils" for "Clinical Informatics Departments" are needed to serve as a bridge between the IT team and care providers during implementation and post implementation
Process change organization culture	When a top down approach is used to foster a new organizational culture, it needs to be espoused by joint medical and administrative leadership during operational planning
Cross-functional cooperation	Cross-functional teams consisting of physicians, nurses, pharmacists, and other medical professionals in addition to IT professionals needs to be leveraged for creating efficiencies in re-engineered processes and corresponding EHR systems
Process change related policy changes	Modification of bylaws to mandate the use of EHR and EHR-enabled processes is need to ensure consistency of organizational policies and practices
Process change expectations	Clinical department leaders need to build a strong argument to clarify the benefits of process changes, and escalate situations that arise when caregivers become emotional at the thought of giving up regular routines, and these emotions are carried over to other caregivers
Process change communication	Regular communication is needed that highlights successes, upcoming process changes, and testimonials from influential members of the clinician community
Process change transition time	If fallback mechanisms are used during transition time, careful considerations need to be given to reconcile potential data redundancies stemming from multiple processes. When pilot projects are used to slowly transition portion of the clinical processes, the remainder of the processes can be transitioned quickly building on initial success
Process change early feedback	Early feedback needs to be solicited from each clinical area through mechanisms such as focus groups and de-briefing meetings

politics led to lost opportunity to positively influence the stakeholders. Nevertheless a strong implementation team with physician leadership was able to turn things around with incredible commitment and training efforts. Projects have reported benefiting from a project champion who is committed to achieve the desired results, knows the enterprise, its services and various nuances, and most importantly its politics inside and out.

Projects often have to tread uncharted waters in face of internal politics. For example, "In the case of the emergency department, the chairman had strong views about the implementation and even decided to hire his own project team. This was a major departure from the usual MIS implementation approach; however, MIS accommodated the emergency department to obtain maximum buy-in on process redesign and change." In this project, a trade-off had to be made between stakeholder buy-in and a standard implementation approach.

4.4.3 Process change incentives

Motivating and developing a positive outlook among knowledge workers about new process changes seemed to be emphasized in almost all projects. In some projects, specific programs and methodologies were followed aimed at gaining physician participation, buy-in, and ownership. In some projects, we noted that when key members from user communities share stories about how they used the implementation efforts as an opportunity for individual growth and learning, it influences other employees in positive manner. Recognition of members for being early adopters, for providing valuable inputs, for sharing use cases about modified processes, served as incentives for other employees to participate more actively in the project.

4.4.4 Organizational structure for process change

In several projects, new organizational teams with clinical expertise with names such as "Clinical Council" are created and they are mainly responsible for serving as a bridge between the information systems team and care providers. Such teams are reported to bring expertise on best clinical practices and regulatory requirements and to undertake activities such as providing initial input on care processes and system design, providing early feedback on user interface issues reflecting processes and data flows, and raising or conveying stakeholders' concerns on specific aspects of process change implementations.

Given that new processes and Health IT systems require ongoing changes and maintenance, permanent support structures are created in many organizations that are committed to providing training and on-site production support.

Recognizing the likelihood of employee turnover, few organizations proactively allocated multiple knowledge workers to key roles to avoid weak links during process change implementation. For example, in one project the organization, "designated multiple Application Administrators (AA's) to ensure that no one member of the staff became irreplaceable" during critical process changes.

Majority of the projects involve process changes are enabled by large-scale IT systems that are procured from external vendors. In some cases, organizations have prior established relationships with these vendors as partners, or as centers of excellence for vendors to showcase their technology. In other cases, organizations do not have such prior relationships and efforts in establishing them is seen as instrumental in building vendor confidence within the organization as well as ensuring the strong external support that organizations in successfully infusing new technologies in work processes.

4.4.5 Process change organization culture

Organizations have noted culture to play an important role in the success of EHR implementation projects, and ignoring this aspect poses a significant risk to project success. In many projects, a positive culture and outlook for process changes is fostered with commitments such as deep involvement of corporate leadership throughout project planning, implementation, and post-implementation.

In most projects, a culture of change is espoused by joint medical and administrative leadership during operational planning. Carrying this forward, projects also acknowledge the usefulness of a strong change control plan during implementation planning. Transition to new processes with implementation is deemed challenging mainly because the impact is so huge. With new processes, operations and cultural changes expected from physicians and clinical staff are drastic. To mitigate this learning curve and dampen the impact of cultural change, phased-in approach is preferred over a one-shot implementation approach. Consideration of process needs from all stakeholders throughout the project is a central idea that emerges from our findings.

4.4.6 Cross-functional cooperation

Forming cross-functional teams is a recurrent theme observed across all projects. Formation and engagement of active cross-functional teams, comprised of members from frontline staff to corporate leadership, throughout the projects is a key strategy for avoiding fragmentation and achieving enterprise-wide change. Cross-functional teams, when successfully facilitated by strong leaders, are able to contribute effectively to successful re-engineering of work processes.

Organizations have taken different approaches at achieving such cross-functional collaboration. For example, some projects created multiple cross-functional teams for smaller sub-projects, which eventually were integrated after realization of deep interconnectedness between the sub-projects. In some projects, the IT teams hired physicians, nurses, pharmacists, and other medical professionals to leverage their know–how and expertise for creating efficiencies in re-engineered processes and corresponding IT systems. Despite the variations, it is seen that most approaches were successful as long as the culture of change and strong commitment for collaboration among project team members was present.

4.4.7 Process change related policy changes

In many organizations, bylaws were modified to mandate the use of new health information technology such as electronic medical records. In some projects, policy changes were proposed during the process re-engineering phase when process needs were clarified and organizational policies revisited. Typically, the project implementation team, consisting of representatives from administration as well as clinical staff, collaborates on proposing new policies that are in line with proposed process changes. Also, during post-implementation, in some projects, policies found inconsistent with new work processes are modified.

4.4.8 Process change expectations

Almost all projects note that they anticipated greater resistance for process change if the expectations from the process change were not communicated well to the stakeholders. A key strategy in that regard is the emphasis placed during training on clarifying and explaining the new way of working introduced with changed processes. This provides a platform for shaping mental models and setting the expectations that old processes are not being replicated, but instead replaced by more efficient and effective processes. Questions and concerns should be addressed in a satisfactory manner at this stage.

One of the challenges is that many caregivers become very emotional at the thought of giving up regular routines, and these emotions are carried over to other caregivers through communication exchanges. This is a critical juncture where clinical department leaders in the project team need to step in, build a strong argument to clarify the benefits of process changes, and escalate these situations as needed. Another challenge is that the re-engineered and "planned" process changes spawn some unanticipated and un-communicated process changes during adoption. The project team needs to be cautious about such changes and intervene to clarify expectations and further alter the processes where appropriate.

4.4.9 Process change communication

Communication is vital in any project, and process change implementations are no exception to this. Projects have adopted several formal and informal mechanisms to ensure effective communication among stakeholders, conveying project updates, and so forth. In some projects, marketing teams are specifically charged with conducting promotions activities for stimulating interest in and support for the new process changes. Communication of results from pilot projects is another strategy used to provide a preview of how the processes will be changing throughout the enterprise. Physician and clinical leadership on project teams act as a communication bridge between IT and clinical specialty areas, sharing end user concerns and feedback as well as communicating project updates. Regular debriefing meetings in various departments is used as a channel for communication as well. During the project implementation, these meetings are conducted more frequently, as compared to planning and post-implementation phases. In a number of projects, organizations circulated biweekly or monthly newsletters describing salient activities in the project, highlighted success, upcoming changes to processes, testimonials from influential members of the community and representative end users on benefits and challenges in embracing process changes, and lessons learned.

4.4.10 Process change transition time

Transition time for implementing process changes varied based on the process change implementation time frame and strategy adopted. Phased approaches are adopted in most projects where clinicians and staff have few months to transition to new processes. In few projects, old processes were kept available during the

transition time as a fallback mechanism. However, in these cases, additional considerations have to be given to reconcile potential data redundancies stemming from multiple processes. In some projects, select pilot projects in each clinical area are used to slowly transition portion of the clinical processes, and upon demonstrated success, a rapid transition of remainder of the processes in a short time frame of few weeks to months takes place.

4.4.11 Process change early feedback

Nearly all projects report success gained from engaging physicians early during the process to seek their feedback and concerns. The major benefits include physician buy-into the new processes, allowing transition time for knowledge workers to create and clarify mental models of new processes, and leverage feedback to improve patient care processes. Toward that end, projects report conducting focus groups, and debriefing meetings in each clinical area to solicit input during planning and implementation phases. Other techniques such as questionnaires and interviews are also used very effectively to solicit user feedback.

4.5 Code category 5: technology management

4.5.1 Process understanding in IT department

Understanding of the complex clinical and operational processes by the Information Technology implementation team is necessary for ensuring that the technology functionality meets the needs of the processes. Given the complexity of the medical domain, such understanding typically requires intensive domain knowledge and some clinical experience. The most common approach for achieving this was to reconstitute the Information Technology implementation team with clinical representation. The IT departments within organizations hired physicians, nurses and also had active hospital physicians on IT payroll for their time. Such members served as both physician and IT advocates and helped process design and transition to new processes. Another approach was to form a specialized Medical Informatics team in addition to an IT team. The medical informatics team then lead the process re-design, training and transition components of the implementation.

Understanding of IT capabilities by the clinical members of an implementation team and by clinicians in general was observed to be very helpful in successful process re-design. IT Training for clinicians to understand the range of capabilities of IT helped them envision the best use of technology to improve processes. In some organizations such training or demonstrations of IT products was provided to all end users and were then asked "What can IT do for you to improve processes?"

4.5.2 Process change security impact

In general, organizations reported that the IT enabled re-designed processes made processes and data more secure than previous paper-based processes. This was

Table 6 Technology management: summary of findings

Code	Key findings and implications for EHR implementation
Process understanding in IT department	EHR implementation IT teams need to include clinical representation for enhancing process understanding
	The IT team should be "clinically-focused", i.e., they have a thorough understanding of the care processes and view EHR systems as a tool for enabling them
Process change security impact	Technical and process flexibility is needed where clearly defined boundaries in terms of roles and permissions may not exist in clinical processes, thus impeding standard access control solutions
Organizational/IT system change	New IT mechanisms for communication among the clinical team should be designed to replace loss of communication processes resulting from task automation and electronic workflows
	Ancilliary services (such as order fulfillment) should be considered to align with efficiency of re-designed processes (such as order entry)
Process support system integration	Health data standard (e.g., HL7) based systems need to be implemented for ensuring inter-operability
	An alternative approach is to use a single vendor provided integrated systems to address integration issues
Process customization	Limit customization to the extent possible to specialized clinical departments. Excess customization can prevent product updates and increase maintenance costs
Vendor process support	Given variability of clinical processes, EHR systems built with flexibility around a standardized set of processes are recommended

specifically due to the better control over data and processes, granularity of access control and audit capabilities provided by IT. In some cases process re-design resulted in access control problems following implementation of the new IT product. Specifically, the clearly defined roles and permissions prevented process execution when such clearly defined boundaries did not exist in practice. We observed that when process change involved end users and was owned by them, process change was successful with clearly defined roles and access control were easily implemented. When a top down approach was followed with limited involvement of end users, many issues with access control arose since there was no clear role clarity.

4.5.3 Organizational/IT system change

Process change during large IT implementation projects has sometimes resulted in changes to organizational structures, or changes to the underlying IT infrastructure to better support the processes. For example, in many organizations, as the re-design of processes and use of technology resulted in the collection of better data, new administrative functions were created for using the data. New processes were also created for data collection, transformation and use. Other examples include moving back office processes to front office/reception due to enabling nature of technology and simplification of the re-designed processes. This was specifically the case with

registration and scheduling processes. In another example, the implementation of a re-designed technology enabled order entry processes speeded up order response, leading to the need for automation of ancillary services for fulfilling orders.

In some cases new work practices had to be created to engage end users with the re-designed processes. For example, new rules such as "check order at least every 2 h" were created to ensure the development of new individual work practices to adapt to the changed processes. The information system also had to undergo changes to support re-designed processes. When the information technology system could not adequately support flexible task execution by Physicians, infrastructure changes such as wireless laptops, and virtual processes such as inactive orders that can be activated as per certain rules had to be developed as workarounds. As moving to an electronic workflow resulted in the loss of communication processes associated with physical flow of paper, new mechanisms and communication flows had to be programmed into the system to support effective communication.

4.5.4 Process support system integration

Effective support of the re-designed processes often necessitated the integration of information systems to enable better flow of data among the systems. Common examples of such integration include the integration of ePrescribing with electronic medical records to reduce data entry. Most organizations followed a single vendor approach to address the integration issue, where the systems supporting the core processes are all purchased from a single vendor with the expectation of seamless data flow among the components. In order to achieve this, organizations often replaced ancillary legacy systems with major new system implementations to ensure integration among technologies supporting intertwined processes. For examples, given the close connection between order entry and results reporting, one organization replaced both systems during a computerized provider order entry implementation.

The other dominant approach involved using a well-developed standard based interface engine for ensuring interoperability across systems implemented in the organization. When such a strategy was used, interoperability and support for health data standards such as HL7 was a key consideration in IT purchase decisions. Many organizations reported that data interoperability and integration was key to efficient workflows as each person doesn't have to use multiple systems to execute a process. When single vendor provided integrated systems were used to replace several fragmented systems, it improved efficiency with similar interface and ease of data transfer across systems.

4.5.5 Process customization

Ability to customize the process model embedded in the information technology product was a key criterion in product selection. Customization was achieved through the implementation of customized screens and more importantly rules embedded with the system for triggering various checks and subsequent tasks. Most Health IT systems supported process execution through a rule based mechanism

when entry of certain data triggered subsequent tasks. Organizations had to achieve a careful balance between customization and standardization to ensure efficiency of re-designed processes. Customization of processes was typically needed for specialized departments when the standard process model in software didn't match with user expectations or need.

However, a downside of customization was increased maintenance costs. When a system was customized to a great extent to meet organizational processes, future updates to the product may not be compatible with the organizations version of system leading to increased costs in the future.

4.5.6 Vendor process support

Vendor support and closely working with vendor was critical for re-design of processes and effective implementation of changed processes. From a vendor perspective, this was most easily provided by building flexibility into the system around a standardized set of processes so each organization could customize the standard process model to suit their needs. Typically small vendors were more willing to provide revisions of their software to meet organizational needs as they saw this as an opportunity to improve their product by working with a client. An advantage in working with large vendors with a large established base of client was to access the community of clients to obtain support and knowledge for effective process change. For example, a healthcare organization implementing a product with a well-established user base commented "Being active within the community of (vendor) customers is of recurring value".

5 Impact analysis

Figure 4 shows the frequency of occurrences of the codes related to process change. Best practices and summary findings corresponding to the codes have been discussed in Sect. 4. These practices point towards process change related factors that are associated with successful EHR implementations.

In analyzing the project reports the following key areas of benefits and impacts were observed across all the organizations. Improved *process efficiency* was a major impact documented in the reports. These included improvements to process cycle times, data and medication errors, admit time performance, patient throughput time, and patient flow metrics. *Quality* improvements were another major impact area. Examples of quality improvements include improved patient satisfaction scores, reduced infection rates, reduction in length of stay, improvements in quality metrics such as timely administration of medication, compliance with clinical guidelines, adverse drug events, and other patient safety metrics. Another key impact area includes resultant *cost savings* examples of which include reduced overtime costs, reduction in transcription costs, and reduction in risk management claims and malpractice insurance premiums due to quality and compliance improvements. Finally, organizations also reported impacts on *revenue* streams such as increased outpatient revenue due to improvements in care and service quality.

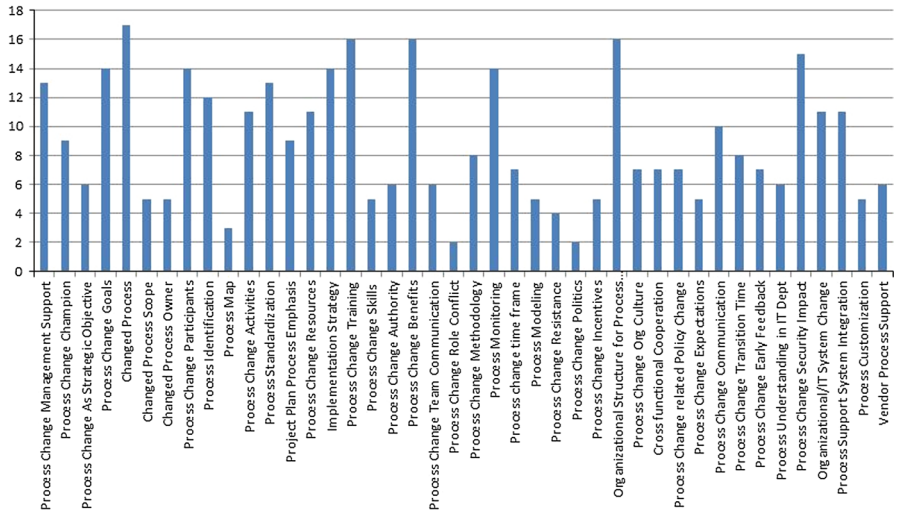

Fig. 4 Summary of code frequency counts

Given that all the organizations studies received awards for successful EHR implementations, these impacts indicate the common salient benefits that can be expected through best practice implementations. While a direct causal link is not claimed, we do see a strong association between the process change related factors identified and the impact observed. This serves as a strong basis for future research studies in this area.

6 Conclusion

Electronic health record implementations are complex enterprise level projects that impact the processes and functioning of a healthcare organization. A key factor that can significantly influence the success of such implementations is the ability of healthcare organizations to change and adapt processes to leverage the functionalities of an EHR and improve healthcare quality and financial performance. Building on business process re-engineering literature that provides general guidance to healthcare organizations for approaching process change, in this study we present healthcare-specific guidelines for process change.

Specifically, this study makes the following contributions: (1) Analyzed process change related practices in successful EHR implementation projects. (2) Provide practical guidance to healthcare organizations for implementing process change best practices. (3) Identified several process change specific factors that are associated with EHR implementation project successes.

A key limitation of this study is the reliance on successful EHR implementation reports. This provides only a partial view of the factors involved in success or failure of EHR implementations. However, the findings help identify common

themes that co-occur across several successful implementations. The findings from this study can be further extended by analyzing failed implementations to provide a useful contrast.

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