Critical Factors for Successful Electronic Health Record (EHR) Implementation

By

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ABSTRACT

Since the 1970s, the healthcare industry has been moving from paper-based documents towards computer information systems in an effort to increase timely access to quality information, with the ultimate objective of wide dissemination and adoption of Electronic Health Records (EHRs). EHRs are electronic collections of patient health information that are recorded by physicians, nurses and patients themselves, before being approved by physicians and shared across diverse settings. EHR implementation can improve care quality and efficiency and physician productivity and reduce healthcare costs. However, implementation often proves to be difficult.

This paper reviews several common issues associated with EHR adoption including negative impacts on quality of care, physicians' productivity, patients' safety and organizations' financials from high maintenance and implementation costs. It then summarizes critical success factors found in the literature. It eventually examines two cases studies of Enterprise Resource Planning (ERP) implementation in the automotive and food and beverage industries and leverages ERP implementation best practices to develop a practical framework for successful HER adoption. Hopefully, it will be useful for future EHR adoption projects in the U.S. and other regions of the world.

Thesis Supervisor: Retsef Levi
Title: J. Spencer Standish (1945) Professor of Management, Professor of Operations Management, Co-Director of Leaders for Global Operations Program

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Introduction

According to the Centers for Medicare and Medicaid Services, "an Electronic Health Record is an electronic version of a patients medical history, that is maintained by the provider over time, and may include all of the key administrative clinical data relevant to that persons care under a particular provider"[1]. Simply put, EHRs are electronic collections of key patient health information that are recorded by different health care professionals and patients themselves, before being approved by physicians and shared across diverse settings. Their implementation can lead to significant benefits including improvement in care quality, care efficiency and physicians' productivity and reduction in healthcare costs. However, successful EHR implementation is a difficult, safety-critical task dependent on many critical success factors.

Over the last ten years, the implementation of EHRs by health delivery systems have been promoted by the U.S. government and got the attention of policymakers and administrators. Since February 2009, the Health Information Technology for Economic and Clinical Health (HITECH) Act provides resources to implement a nationwide paperless health information network and offers, through the Medicare and Medicaid reimbursement systems, over $20 billions in long-term incentive payments for adoption of more comprehensive EHRs to eligible providers, including physicians, hospitals and other healthcare providers, if they can attest their ability to meet "meaningful use" criteria of the EHR technology. These "meaningful use" measures address providers' ability to use EHRs in a meaningful manner, electronically exchange health information and submit clinical quality measures (CQMs) set by the HHS secretary[2]. Moreover, since 2015, non-use of an EHR results in financial penalties.

However, EHR implementation projects often result in delays, interruption, under-utilization or deinstallation due to end-user resistance. The Medical Records Institute (2007) surveyed 819 health professionals, including physicians, nurses and IT staff and

[1] Retrieved from: https://www.cms.gov/medicare/e-health/ehealthrecords/index.html
[2] Retrieved from: https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/

reported that 19% of respondents had previously experienced or were experiencing an EHR de-installation and that 8% of respondents had returned or were returning to paper charting. In a report titled "*A Guide to Hybrid EMR: The Natural Approach to Electronic Medical Records*", the Laserfiche Institute (2011) estimated the rate of EHR de-installations to range between 20% and 78%. Other examples of adoption failure include reductions in care quality process measures, increases in medical errors, increased mortality, staff productivity losses and partial returns to paper charting. Adoption failure is costly given the high installation costs, which can reach hundreds of millions of dollars, and diverts human and financial capital from better utilization.

Physician EHR adoption does not consist in the sole implementation of the EHR. Instead, by adoption, we refer to a state where physicians have developed a good understanding of the EHR functionalities and what/how data should be entered in the system and have redesigned their work processes accordingly. Implementation benefits such as increasing care quality and cost-effectiveness cannot be captured without true physicians' adoption since they organize patient care. Unfortunately, studies that assess the rates of EHR adoption by U.S. health delivery systems solely evaluate the proportion of providers that have installed an EHR and, although the literature acknowledges the need for a better definition of EHR adoption, there is currently no other commonly agreed upon measure of adoption.

Guidelines and approaches to EHR implementation differ frequently by vendors and consultants and are often restricted to their technical aspects while healthcare organizations' leadership is tasked with ensuring physician adoption despite lack of expertise in this area. Success factors found in the existing literature can be very high-level, often lack granularity and specificity and it can be challenging to understand how to map them to operational frameworks. On the other hand, knowledge from leaders who have successfully implemented EHRs remains mostly unpublished.

The goal of this thesis is to study how one could make patient care quality and cost-effectiveness improvements through EHR implementation a reality. The two main

questions an EHR implementation project needs to answer are: can we identify a set of key operational success factors for EHR adoption? How to develop an implementation framework that can integrate these factors into an organization's operational constructs?

Executive Summary

In this paper, we reviewed two case studies of ERP implementation projects in the food and automotive industries and found that, beyond architectural similarities, ERP and EHR implementation projects are very similar in respect to the key challenges they face and the factors critical to their success as presented in the existing literature. Building on this concept, we analyzed several ERP implementation best practices and used basic ERP adoption frameworks to structure key EHR implementation success factors found in the literature into a dynamic multi-level operational model for EHR adoption and expand beyond these existing factors. We partitioned our framework into three consecutive phases: (i) planning, (ii) implementation and (iii) post-implementation EHR use and created a distinct framework for each of these phases. In the planning phase, key findings include (i) the need to identify the specific Meaningful Use criteria the practice wants to meet and (ii) how they translate into specific EHR functionalities as well as (iii) the need to establish a clear project governance structure that promotes physician ownership of the system. In the implementation phase, key insights include (i) the development and deployment of an EHR prototype at small-scale before the full launch to assess technical difficulties and user acceptance, (ii) the continuous reshaping of the project timeline in response to workflow issues instead of the opposite and (iii) a balanced approach between EHR features and workflows redesign that promotes optimal work processes in respect to patient care. Finally, in regards to post-implementation, our key findings include (i) the establishment of information canals for staff to exchange best practices, (ii) the monitoring of physician use and acceptance of the new system and (iii) the public reporting of EHR impact on key care quality and financial metrics.

Thesis Structure

Chapter 1 will provide some background information on the structure of EHRs and which types of health information they contain. We will review the broad diversity of existing solutions and explain how is the Request For Proposal (RFP) process for EHR selection organized. We will also give a brief overview of the new legislative landscape for EHR adoption since the passing in 2009 of the Health Information Technology for Economic and Clinical Health (HITECH) Act, which set up new incentives for EHR adoption through the Medicare and Medicaid reimbursement systems.

In chapter 2, we will then tackle the rationale for EHR adoption including efficiency savings, enhanced care effectiveness and increased physician productivity as well as future opportunities for big data applications to healthcare. We will also review the current state of the industry in regards to EHR adoption by medical practices.

In chapter 3, we will look into the common issues faced by healthcare providers during and after EHR implementation.

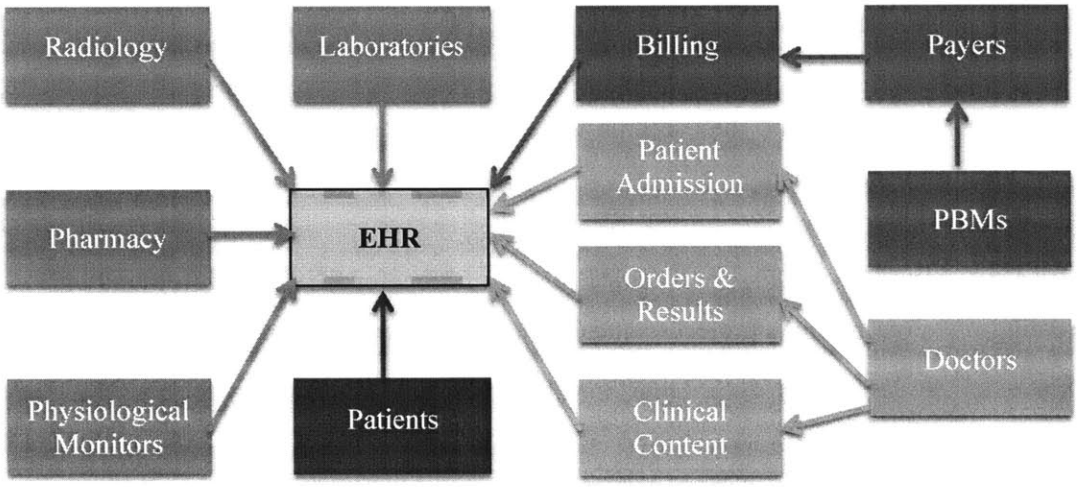
Chapter 4 will present a breakdown of critical success factors for EHR adoption found in the existing literature between project management, organizational, human and technical factors.

Chapter 5 will summarize two case studies of successful Enterprise Resource Planning (ERP) implementation projects. ERPs are suites of integrated modules that allow an organization to manage its supply chain, inventory, product lifecycles and other back office functions. We will build on these case studies to highlight similarities between EHR and ERP implementation projects and make the case that lessons from ERP implementations can be applied to EHRs. We will leverage these lessons and our review of the existing literature on EHR issues and success factors to develop a practical framework for integrating key success factors into a practice's operational constructs.

Chapter 1: EHRs: Content, Selection and Financial Incentives

1.1 Definition, Structure and Content of EHRs

EHRs remain quite undefined due to the broad nature of data categories they incorporate and functions they perform. They typically are electronic collections of retrospective, real-time and prospective patient health key relevant information that is recorded by different health care professionals and patients themselves, as well as administrative and billing data. This information is securely shared across multiple authorized users. EHRs are used in both hospitals and general practice. Administrative staff, physicians, nurses, pharmacists, radiologists and even patients can access diverse components of the EHR data.



The basic patient summary displays patient demographics, past medical history, allergies, active problems, test results and medication administration and aims at promoting eHealth interoperability and data exchange. However, additional clinical data, such as daily charting, progress notes, vital signs, physical assessment, immunizations, life style, laboratory data, physical examination, radiology reports, procedures, treatment and discharge can be included[3]. EHR data consists of both unstructured free narrative text and

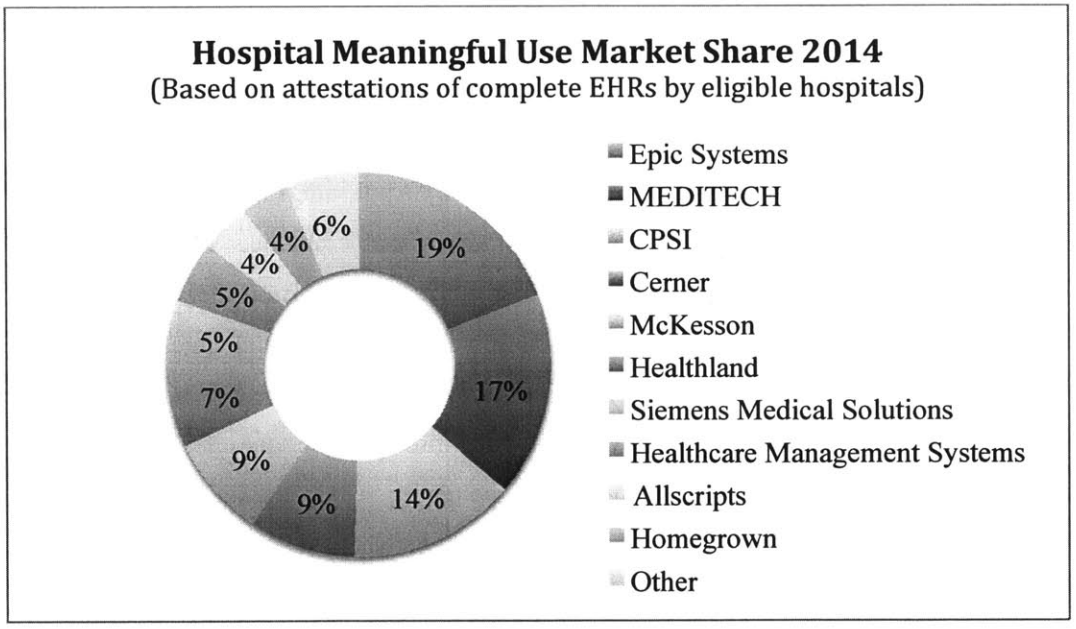
[3] Retrieved from: https://www.cms.gov/medicare/e-health/ehealthrecords/index.html

structured coded information that is used in supporting decision-making in both patient care and management. EHRs integrate 3 types of data: i) time-oriented information (organized in chronological order), ii) problem-oriented information (notes taken for each problem encountered by the patient) and iii) source-oriented information (organized by data source such as patient visit, laboratory result or radiology report).

1.2 Brief Overview of the EHR Selection Process

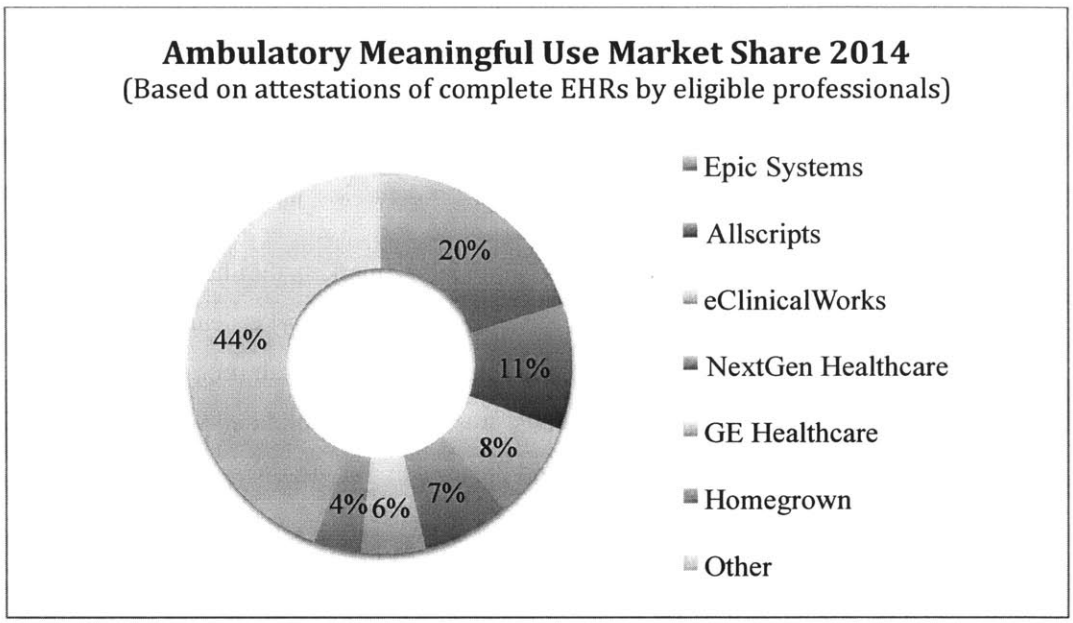
1.2.1 Overview of Current EHR Solutions

The EHR space is split between the inpatient and ambulatory markets that have different dominant vendors, with the exception of Epic Systems who is the market leader in both categories. The hospital market is mature and relatively static with no significant variation in the number of U.S. registered hospitals. It is highly consolidated with the top three players accounting for 50% of the market and the top ten, for 90%[4,5]:



[4] Retrieved from: http://www.softwareadvice.com/resources/ehr-meaningful-use-market-share/
[5] From: http://healthitanalytics.com/news/which-vendors-lead-the-healthcare-big-data-analytics-market

The ambulatory market is more fragmented with over 300 different vendor systems in use, much more than for the inpatient hospital setting. There is no significant change in the dominant players over time. The significant diversity of systems in use often makes the due diligence purchasing process confusing and lengthy for EHR buyers and users.



Broadly speaking, two distinct EHR solutions are available: (i) corporate based installations with traditional licensing agreements and (ii) Application Service Provider (ASP) based solutions hosted via the Internet. ASP models enable practices to download the EHR from the vendor's website. Physicians then run the software on their systems. Data is stored off-site instead of on office-based servers. Small medical practices are increasingly shifting towards ASP solutions since they do not require the healthcare organization to purchase and host new servers and hardware in-house, and thus typically are more affordable than locally hosted solutions. The leader in this market is eClinical Works. Another choice for an ambulatory practice is between selecting one single integrated EHR solution and opting for different non-interoperable solutions from various vendors for the administrative and operational functions.

1.2.2 EHR Due Diligence and Selection Process

The vendor selection process usually starts with a Request For Information (RFI) where vendors are required to give in-depth information on their products and services, usually through a set of marketing materials, an executive summary, a cover letter and a checklist response (i.e., a table with closed Available/Not Available, Yes/No answers to questions and requested features). The RFI enables the healthcare practice to develop a shortlist of potential vendors (typically 2-5 vendors).

The EHR purchaser then sends a Request For Proposal (RFP) to the shortlisted vendors who are given a limited period of time to come up with EHR proposals that, unlike the RFI responses, will be specific to the organization's needs and will serve as a basis for a contract. In addition to a product demonstration, proposals include short narrative responses to buyers' questions on start-up price, additional fees for future upgrades, specific functionalities or interoperability with laboratories and imaging centers, license renewal schedule, hardware upgrade requirements, type of support and training provided, transition timeline and EHR certification for meaningful use. The purchaser then proceeds to an evaluation of the proposals, sometimes including a usability test, before ultimately selecting a solution and negotiating the contract.

1.3 Background on the HITECH Act and EHR Payment Incentives

1.3.1 History and Overview of the HITECH Act

Over the last ten years, the implementation of EHRs by health delivery systems have been promoted by the U.S. government and got the attention of policymakers and administrators. The American Recovery and Reinvestment Act (ARRA), passed into law in February 2009 by President Obama, provides a financial package aimed at stimulating investment in the country's infrastructure. Within ARRA, the Health Information Technology for Economic and Clinical Health (HITECH) Act specifically provides resources to implement a paperless national health information network by structuring the

adoption of more-comprehensive EHRs. Specific provisions, published in early 2010 by the U.S. Department of Health and Human Services (HHS), included over $27 billion stimulus payments through the Medicare and Medicaid reimbursement systems, of which $20 billion long-term incentive payments to eligible providers, including physicians, hospitals and other healthcare providers.

The EHR incentive payments program began in 2011. Under these programs, eligible professionals can perceive payments of as much as $44,000 over 5 consecutive years from Medicare and $63,750 from Medicaid between 4 to 8 weeks after they have attested their ability to meet "meaningful use" (see below) criteria of the EHR technology, as set by the ARRA Health Information Technology (HIT) Policy Committee[6]. Eligible professionals include individual practitioners (nurse practitioners, physicians and physician assistants). For ambulatory practices, each practice member is also eligible if he can attest of meaningful use of EHR. However, hospital-based practitioners do not constitute eligible professionals. In this case, the hospital is receiving the payments. The ARRA HIT Policy Committee allocated 75% of Medicare payments over 2012-13, with the remainder over 2014-16 in order to promote early adoption and the fast development of a critical mass[7]:

Medicare versus Medicaid Incentive Programs

	Medicare	**Medicaid**
Organization In Charge	Center for Medicare Services (CMS)	State Medicaid Agency
Maximum Incentive Amount	$44,000	$63,750
Payments Period	Over 5 consecutive years	Over 6 not necessarily consecutive years
Providers Eligibility	Must demonstrate meaningful use every year	Meaningful use not required in first year but required thereafter
Last Year to Initiate Participation[8]	2014	2016

[6] Retrieved from: http://www.ahrq.gov/professionals/prevention-chronic-care/improve/system/index.html
[7] Retrieved from: http://www.sppm.org/wp-content/uploads/2015/09/Federal-EHR-Incentives.pdf
[8] Retrieved from: http://www.cms.gov/EHRIncentivePrograms/

Last Year to Receive Incentive Payment	2016	2021

1.3.2 Meaningful Use

Meaningful use builds on the concepts outlined in the Institute of Medicine study "*Crossing the Quality Chasm: A New System for the 21st Century*". It is based on 14 core measures that must be met by hospitals (15 for eligible professionals) and 10 additional menu measures (of which 5 can be deferred)[9]. These measures address providers' ability to use EHRs in a meaningful manner, electronically exchange health information and submit clinical quality measures (CQMs) set by the HHS secretary. Since 2015, failure to demonstrate meaningful results in financial penalties, at least for Medicare, through reduced reimbursement payments.

Meaningful use entails 3 consecutive stages. Stage 1 started in 2011 and focused on patient demographics, computerized physician order entry (CPOE) for medication orders, vital signs recording and lists of patients' allergies, conditions and medications. Stage 2 was implemented in 2014 and put an emphasis on clinical decision support for high-priority health conditions[10], patients' online access to their health information and electronic exchange of health information for providers. Stage 3 must be implemented by the end of 2016 and is based on demonstration of healthcare quality improvement. Below is an example the evolution of core meaningful use measures from stage 1 to stage 3[11]:

Core Meaningful Use Criteria

Criterion	Stage 1	Stage 2	Stage 3
Use a CPOE system	30% of orders	60% of orders	80% of orders
Maintain up-to-date problem list of current and active diagnoses	At least 1 structured data entry for at least 80% of patients	Same as stage 1	Same as stage 1

[9] See Appendix
[10] Conditions include: CHF, ischemic heart disease, diabetes, stroke, breast cancer, Alzheimer's disease, major depression, chronic obstructive pulmonary disease, colorectal cancer, chronic renal disease, acute MI
[11] Retrieved from: http://searchhealthit.techtarget.com/Briefing-Meaningful-use-criteria-stages-2-and-3

Write and transmit prescriptions electronically	At least 40% of prescriptions	At least 50% of prescriptions	At least 80% of prescriptions
Maintain active medication list	At least 1 entry for at least 80% of patients	Same as stage 1	Same as stage 1
Record language, gender, insurance type and date of birth	Record for 50% of patients	Record for 80% of patients in stratified quality reports	Record for 90% of patients. Include additional categories

Chapter 2: EHR Adoption: Rationale and Current State of the Industry

In this chapter, we will review the benefits of EHR adoption that have been highlighted in the existing literature and case studies in specific settings. They serve as the foundations supporting the EHR incentive payments established by the Obama administration. We will go over the general concepts, their content and ambitions. It will give the keys to understand the recent rapid uptake of these products. We will then focus on the rapid uptake of EHR technology that has taken place in the last decade.

2.1 The Case for EHR Adoption

Many believe that the transition from paper record to EHRs can help closing the geographic variations in quality of care among small physician practices and that EHR adoption is key to improve both U.S. healthcare efficiency and effectiveness. Additional benefits could be captured in the future by applying big data analytics to EHR data.

2.1.1 Enhanced Efficiency

EHRs can theoretically help decrease long-term costs and increase efficiency, for hospitals especially and, to a lesser extent, physician offices. Potential benefits over paper-based medical records include cost containment through process standardization and clinical decision support (CDS), which can alter physician behavior by suggesting evidence-based specific operations that are more efficient and effective. CDS can decrease opportunities for medical errors and the time to follow-up actions as well as help prevent adverse drug events and forecast patient outcomes, thereby generating significant savings. EHR can also enhance provider productivity through prepopulated fields, shared health information among providers, faster availability of laboratory and radiology results and one-click ordering of diagnostics tests and procedures.

By aggregating all of an individual's health information in a single source/system, EHRs reduce physician likelihood to order and review duplicate or unnecessary tests and medical procedures. They can also reduce paper record handling and the nursing administrative time dedicated to chart administration, claims processing and billing and filling out forms, which accounts for a large share of healthcare costs. They can also decrease hospitals' and intensive care units' length of stay and ventilator days for patients. EHRs can also help improve radiology, laboratory and drug utilization and scheduling. Several research papers have attempted to estimate annual potential savings from EHR adoption. These estimates range between $3 billion and $80 billion, mostly due to the scarcity of data for the assumptions on which they are based (Adler-Milstein et al., 2013). We provide below a summary of the methodology used by one such model.

Bigelow et al. (2005) calculate net efficiency savings from national EHR adoption by estimating both the efficiency savings that would result from adoption and the costs incurred to achieve these savings. However, it does not capture additional potential savings from greater effectiveness of healthcare interventions on patient outcomes (e.g., preventing adverse drug events, chronic disease management, etc.) from EHR adoption.

Sources of efficiency savings in the ambulatory setting are reductions in administrative time (transcription and chart pulls) and drug and laboratory tests usage. In the inpatient setting, efficiency savings come from reductions in administrative time (medical records), hospital length of stay and drug and laboratory tests usage. For each of these cost centers, the authors estimated yearly expenditures per provider ("baseline cost") **B** and a percentage **s** of this baseline cost that could be reduced by EHR adoption. Based on the number of U.S. healthcare providers and the current fraction of these providers that had already adopted an EHR, they were able to calculate future potential national efficiency savings for each cost center under the assumption of a future adoption fraction of 90% and aggregated these savings to obtain the general national potential savings. To estimate **s** and **B**, they used evidence of savings reported at a provider level by peer-reviewed articles, conducted Monte-Carlo simulations and reported the mean value of the range of savings generated.

2.1.2 Enhanced Effectiveness

EHRs can theoretically help improve (i) patient care, (ii) patient outcomes and (iii) care coordination:

Patient Care

EHRs can improve healthcare quality through enhanced CDS, clinical alerts, real-time quality reporting, more reliable prescribing (paper-based prescriptions sometimes get lost or misread) and reminders to improve preventive care. They also have the potential to improve convenience for providers (easy access to patient records from home or any other remote location and interfaces with labs) and patients (patient portals, prescriptions electronically sent to a pharmacy, electronic referrals to specialists and reduced need to complete same paperwork at each doctor visit)[12]. As discussed above, EHRs can also help reduce drug complications and adverse drug reactions thanks to better allergy warnings, dosage monitoring and built-in safeguards. They limit the risk of handwriting errors and make the identification of operational problems substantially quicker than in a paper-based environment.

Patient Outcomes

EHRs also have the potential to help predict patient outcomes and enable physicians to make better decisions. For instance, Ramchandran et al. (2013) retrospectively collected demographic and laboratory data[13] as well as 30-day survival data for a cohort of 3,062 patients admitted to the oncology department of Northwestern Memorial Hospital in Chicago over 2008-2009. All this data was readily available through the hospital's EHR. The authors used a sample of the observations ("derivation sample") to train a predictive model of 30-day survival based on five variables and obtained favorable sensitivity and specificity values when applied to the remaining observations ("validation sample"). They concluded that this model could be used to detect individuals at higher risk of 30-

[12] Retrieved from: https://www.healthit.gov/providers-professionals/health-care-quality-convenience
[13] Included sex, age, admission type, temperature, systolic blood pressure and heart and respiratory rates

day mortality. We argue that EHRs could be leveraged to develop similar tools that identify patients at increased risk of complications in other contexts.

Tepas et al. (2013) provide another good example of how evidence-based clinical decision support derived from large EHR databases can be used to reduce delays in diagnosis and improve patient outcomes. Similarly to Ramchandran et al. (2013), they used data collected through an EHR from clinical and biometric sources for 124 patients undergoing colorectal procedures and compiled this data using the Rothman Index (RI), an existing predictive model for risk of organ dysfunction. Patients were stratified based on their scores. Retrospective analysis of the patient outcomes showed risk-related differences across the patient categories. They concluded that early intervention based on EHR could improve pre-emptive management of adverse events.

Care Coordination

Finally, EHRs have the potential to increase care coordination. They can facilitate continuity of care for individuals receiving care from sources other than their primary care provider. Not only can they enable providers to share electronic information and can they promote better coordination and communication between them, but they can also increase patient participation through Personal Health Records (PHRs). PHRs are electronic applications used by patients to access health information from office visits, record new information or access health resources. The information can be filled in by the patient or directly imported from his primary provider's EHR.

PHRs offer an attractive solution to the issues of patient engagement and being able to care for the patient at home. Increasing patient engagement has become an important issue in recent years as it enables to reduce length of hospitalization, doctor shopping and poor clinical outcomes. In respect to home care, PHRs can help address the rising issue of managing chronic disease cases (currently accounting for roughly 75% of all national healthcare expenses) that is fueled by the aging of the baby boomers generation, providers' improvements in treating acute problems and the reduction in primary care physicians. Home care solutions currently are very limited and do not yield significant

results. With PHRs, patients with chronic diseases can monitor from home various measures of their conditions and make sure they and their providers are aware of medical appointments, test results and medication changes.

2.1.3 Future Opportunities in Big Data Analytics

It can be argued that, so far, compared to other industries such as online retailing, the healthcare industry has been relatively slow in the adoption of big data tools to make optimal use of the rich data found in EHRs. However, the rapid uptake of EHRs by providers (discussed below), the payment reform strategies derived from the Affordable Care Act (ACA) such as accountable care or bundling and the progress in clinical analytics provide unprecedented opportunities to apply data analytics to healthcare throughout EHR use. These opportunities include knowledge dissemination (e.g., CDS tools that build on real-time patient data rather than policy-based decision trees) and the integration of personalized medicine into clinical practices (e.g. integration of genomics with EHR data). Another significant potential is the use of predictive analytics for patient management such as triage. For instance, Puopolo at al. (2011) collected objective maternal data on 350 newborns at twelve Kaiser Permanente Medical Care Program hospitals and combined this data with clinical findings to develop a predictive model for newborn sepsis. This new model has subsequently been used to significantly reduce the number of newborns receiving systemic antibiotics for early-onset sepsis every year without adverse outcomes.

Big data analytics could also be used for knowledge generation. Computational exploitation of EHRs' unstructured data, through natural language processing for instance, would generate an observational evidence base for addressing clinical questions that are extremely costly to answer through collection of structured data. Detection of postoperative complications based on discharge coding is an example of such use of EHR data. Big data could also help mitigate the common generalizability issues associated with clinical trials conducted on a small population of individuals whose conclusions cannot be applied to individuals with very different characteristics.

2.2 The Rapid Uptake of EHR Adoption

The implementation of HITECH's incentive payments, combined with the anticipated potential benefits of EHRs and the increasing shift towards risk contracts and other payment schemes that require a higher level of integration (e.g., bundled payments[14]) have resulted in significant widespread adoption of EHR technology in the last decade. Over 2008-2014, the number of office-based physicians who used an EHR doubled, increasing from 42% to 83%, with the proportion of basic EHR users going up from 17% to 51%[15]:

Percentage of Office-based Physicians with EHR System (2004-2014)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Any ERP	21%	24%	29%	35%	42%	48%	51%	57%	72%	78%	83%
Basic ERP			11%	12%	17%	22%	28%	34%	40%	48%	51%

As of end of 2015, 95% of all eligible and critical access hospitals and 56% of all office-based physicians had demonstrated Meaningful Use of certified health IT through participation in the Centers for Medicare and Medicaid Services (CMS) EHR incentive programs.

[14] Reimbursement model where providers get paid for the treatment of a patient for an acute event (e.g. stroke, hip fracture) and support alone all hospital, rehabilitation and follow-up care costs for this patient

[15] Retrieved from: http://dashboard.healthit.gov/quickstats/pages/physician-ehr-adoption-trends.php

Chapter 3: Adoption Issues And Barriers to Physician Acceptance

Most academics that focused on EHRs in the early 2000s agreed to acknowledge the significant value creation generated by these systems. However, the recent research on the question is far less conclusive. In this third chapter, we will discuss the main issues commonly associated with EHR implementation in regards to care quality, patient safety, physician access to patient information and productivity and workflow redesign. We shall then go over the main costs associated with EHR implementation since it will provide an understanding of the key issues that lead to costly adoption failures. Finally, we will focus on physician resistance to new EHR implementations, present the main barriers to physician acceptance of these systems and discuss the differences between implementing an EHR in a practice that already use an EHR and a paper-based practice.

3.1 Issues Associated with EHR Implementation

Several attempts have been made to analyze and classify EHR-related problems reported by healthcare organizations. Sittig and Singh (2010) analyzed specific examples of various HIT interventions through a mixed approach of quantitative methods and qualitative and semi-structured interviews with primary care prescribers and laboratory and information technology personnel. They used their work to build upon previous HIT sociotechnical systems models and develop a framework to understand the generic challenges associated with EHR implementation. They partitioned HIT-related issues across 7 categories (2 machine-related and 5 human-related):

Categories of HIT-Related Errors

Category	Examples
Hardware or Software Issues	Output device down, record unavailable, display error, network down or slow, system interface issues
Clinical Content	Loss in entered data, incorrect default dose for a medication
Human-Computer Interface	Incomplete patient data on review screen, wrong decision from poor data presentation, data entered for wrong patient

People	Incorrect merger of 2 patients' data
Workflow and Communication	Discontinuation of a medical order by computer without notifying a medical personal
Organizational Policies and Procedures	Critical abnormal test result alerts not followed-up
External Rules and Pressure in Contradiction with Personnel Capability	1 pharmacist tasked to verify all orders entered via CPOE in a large hospital
System Measurement and Monitoring	Incorrect interpretation of quality measurement data, erroneous reporting from incomplete or incorrect data aggregation

Using a different approach, Magrabi et al. (2010) examined reports of patient safety incidents by hospital clinicians over 2003-2005 in Australia and searched the narrative text descriptions of the incident reports for a number of predetermined keywords. They developed another classification of EHR-related errors in which issues were divided into 4 categories: (i) hardware/software, (ii) input, (iii) transfer and (iv) output. They then further characterized these as either human or machine related. Interestingly, they identified a fifth category: socio-technical factors contributing to errors (e.g., staffing, multi-tasking, interruption during task).

These issues have resulted in controversies over EHR efficacy and many physicians have reported negative outcomes on efficiency or productivity associated with their EHR implementation. In a 2014 online physician survey sponsored by the American Medical Association (AMA), 42% of respondents reported that improving care efficiency through the use of their EHR was difficult while 43% reported that they still had not been able to solve the productivity issues they faced with their EHR[16].

3.1.1 Care Quality Issues

No Improvement in Care from EHR Use

Although EHRs use can increase quality of care, evidence suggests that EHR adoption does not automatically result in diffusion of improved quality due to poor

[16] Retrieved from: http://www.americanehr.com/research/reports/Physicians-Use-of-EHR-Systems-2014

implementation. In fact, several studies have found no improvement in care quality from EHR use. In a retrospective study of over 50,000 ambulatory visits to more than 1,100 practices in 2003 and 2004, Linder et al. (2007) examined 17 quality care indicators across 5 categories: "medical management of common diseases, recommended antibiotic use, preventing counseling, screening tests and potentially inappropriate prescribing in elderly patients". They found no consistent relationship between EHR use and ambulatory care quality.

More recently, DesRoches et al. (2010) surveyed the adoption of EHRs by U.S. acute care hospitals and spread them across three categories: (i) no adoption, (ii) basic adoption and (iii) comprehensive adoption. They linked their survey results to data from four other primary sources: the Medicare Provider Analysis and Review File (2006), the AHA hospital IT survey of U.S. acute care hospitals (2008), the AHA annual survey (2008) and the Hospital Quality Alliance database (2009) and analyzed performance on efficiency and quality measures. They also found no consistent association between EHR adoption and quality process measures.

Schenarts et al. (2012) retrospectively reviewed demographic information, injury severity and patient complications and outcomes data for admissions to a trauma center 20 months before and after EHR implementation. Although they found improvements for certain complications (e.g., reduction in hospital and ICU length of stay and drug complication, myocardial infarction, renal failure and diagnosis delays), there was no overall effect on the patient population. Mortality rate, in particular, did not change significantly.

Risk of Reduction in Care Quality

Thirukumaran et al. (2014) compared Surgical Care Improvement Project (SCIP) scores between two hospitals that implemented their EHRs with a 3-month time difference and even found that EHR adoption was associated with a statistically significant decline in surgical quality. Although they reported improvements for certain measures, these findings were not statistically significant. They concluded that, in some instances, the

challenges associated with the deployment of an EHR could lead to temporary reductions in the quality of care.

Impact of Sophistication Level of New EHR on Care Quality

We found one study to be of particular interest in that it brings an additional insight of the issue of the effect of EHR adoption on care quality. Appari et al. (2013) reviewed EHR data from the Health Information and Management Systems Society (HIMSS) and process quality measures for four conditions (heart failure, acute myocardial infection, surgical care infection prevention and pneumonia) for 3,921 U.S. acute care hospitals over 2006-2010. Eight different EHR clinical applications were used to partition the hospitals across 5 categories that corresponded to various levels of EHR sophistication. The first category corresponds to the least advanced EHRs and the fifth, to the most advanced EHRs. They found that transitioning to more advanced EHRs yielded an increase in quality for hospitals that were in the three bottom categories with the biggest increases for the least advanced hospitals. However, hospitals in the fourth category suffered quality reductions when transitioning to the last category. This seems to indicate that though EHR implementation can lead to care quality improvements, overly complex EHRs may actually create more problems than they solve.

Copy-Paste Function and Limited Size of Narrative Boxes

Even after implementation, EHRs can still bring numerous disadvantages. One example of this is the copy-and-paste command of EHRs, which enables one physician to use a previous note as a template for his own report. Two grey literature papers from Hirschtik (2006) and Hartzband (2008) discuss potential care quality issues associated with the use of this command, which can lead to addition of diagnostic impressions, rather than their substitutions. They argue that, in some cases of hospital readmissions, old information from the previous admission is used as the first note for the readmission. This generates longer medical notes with decreased effectiveness. Another common issue with some EHRs discussed by Hartzband (2008) is the requirement for the physician to fill out free text narrative boxes of limited size, pushing him to ask close-ended questions to the

patient rather than engage in a dialogue that could be critical to formulating the right diagnosis.

3.1.2 Patient Safety Issues

Beyond care process quality measures, EHR adoption can adversely impact patients' safety. For instance, the interface between the pharmacy and the administration system can cause a medication order to default to an incorrect day start time, resulting in the patient missing one dose. Electronic systems configuration, especially default values, and dual workflows using both EHRs and paper-based records also are particularly problematic in the context of medication order and medication. A physician may not place a stop date in the EHR but instead write instructions in the free-text box for administration of a medication to a patient, resulting in the nursing staff to a administer the drug on an over-extended period of time. Different practitioners can administer several doses of the same medication to a patient due to the failure by one of them to report it in the EHR. Indeed, in a 5-point Likert-type scale survey of Massachusetts's physicians, Love et al. (2012) reported that 30% of respondents thought that EHR use generated new opportunities for medical errors.

Wormer et al. (2013) surveyed 15 surgical residents at a large teaching hospital 24 weeks after the hospital had implemented its EHR and reported that 74% felt their risk of committing a medical error had increased while only 13% stated that their risk perception had decreased.

These errors may potentially cause harm to patients and EHR implementation can sometimes result in increased mortality. Han et al. (2005) monitored mortality data for 1,942 children admitted to a tertiary-care level hospital 9 months before and after a CPOE program was implemented and performed both univariate and multivariate analysis. They found an increase in mortality associated with the EHR implementation and suggested that after EHR adoption, healthcare organizations should track potential mortality effects.

Although EHR use can create conditions in which medical errors are more likely to occur, EHR-related do not necessarily pose major threats to patient safety. Sparnon et al. (2014) reviewed 8,003 incidents reported over 2004-2012 and searched the narrative text descriptions of the reports for EHR-related keywords (e.g., "emr", "ehr", "electronic health"). They conducted manual review of a sample of the reports to exclude irrelevant incidents and used it to train a machine-learning model that was applied to the rest of the reports. They eventually retained 3,099 reports and found that 89% of the incidents did not result in adverse patient outcomes and that 10% had created "unsafe conditions" for the patients but also did not lead to patient harm. Only 1% resulted in a temporary harmful event for the patient.

3.1.3 Physician Productivity Issues

When the EHR incentive payments programs began in 2011, many practices warned that they viewed the expected productivity loss associated with EHR transition as a 'significant' barrier to implementation. In 2011, the Medical Group Management Association (MGMA) surveyed its members and customers and collected 4,588 responses from healthcare organizations on the issue of EHR adoption. 78% of respondents reported they had experienced productivity loss during their implementation process and 67% that this productivity loss had continued even after implementation. Indeed, EHR implementation can reduce physician productivity both on the long and short terms.

Short-Term Productivity Impact

Evidence has emerged that, even on the short-term, EHR implementation, even when successfully conducted, can also adversely impact physician productivity. In a 2013 article for *Government Health* IT, Kimberly Martini, division vice president at AMN Healthcare, a healthcare staffing agency, reported that staff productivity could drop by as much as 15% to 25% during the implementation period and up to one month after

implementation due to training and initial human or machine issues. Academia has generated research going in the same direction.

Wormer et al. (2013) surveyed 15 surgical residents at a large teaching hospital at 1, 4, 6, 8 and 24 weeks before and after the hospital implemented its EHR. They reviewed residents' average duty hours and number of operations per week and the time they dedicated to process patient documentation. They found that, not long after the deployment of EHR, residents were spending more than twice the time they used to spend on documenting patient information than with paper charting. Documentation time per patient took several months to decrease. However, even 6 months after the implementation, it still had not come back to its prior baseline.

Long-Term Productivity Impact

EHR implementation, when poorly executed, can also lead to productivity decreases on the long term. Meyerhoefer et al. (2013) analyzed the impact of the implementation in 2006 of a new EHR by a large health system in Pennsylvania. They used fixed effect regression models and staff qualitative interviews to identify the effect of the new EHR on work Relative Value Units (wRVUs)[17]. The authors found that the adoption of the new system had had a negative impact on productivity, which was still significant even four years after implementation.

However, the literature suggests that, even though adjustments may be lengthy, physician productivity tends to gradually come back to its initial levels on the long run as physicians become more familiar with the new system. Menachemi et al. (2010) conducted a survey of 995 physicians working in ambulatory practices and collected data on EHR use and satisfaction. They found that physicians who had implemented their systems more than two years ago were three times more susceptible to be satisfied with their EHRs in respect to their impact on productivity than those who had been using their EHRs for less than 24 months.

[17] Standard measure of medical services delivered by a physician that takes into account the time, skills and efforts required to deliver these services

3.1.4 Access to Data

Paradoxically, EHRs also raise issues in respect to physicians' access to patient health information. Data must be entered into the computerized system before it can be accessed and used. Data entry completeness and accuracy is negatively impacted by EHR use since physicians find it generally harder to record notes with a keyboard than with paper. Standardized interfaces also limit information completeness (e.g., limited free text space, possibility to report positive symptoms but not negative ones). EHR notes also are generally longer and due to computer-generated text and the excessive clinical data can adversely affect clinicians' ability to quickly find the necessary information they need to formulate their diagnosis. A few academic studies have covered these issues.

Hamilton et al. (2003) retrospectively examined primary care records of all patients aged older than forty years with colorectal, lung or prostate cancer received at 18 medical practices over 1998-2001. They compared the number of symptom codes per consultation and the number of codes that mentioned severity or duration of the symptoms between paper-based records and electronic records. They found that fewer symptoms were quantified with electronic records and that paper reports more effectively recorded the symptoms' severity.

Chiang et al. (2013) examined clinical documents completed by faculty members of an ophthalmology department that adopted an EHR in 2006. The study started five months before the implementation and covered a 3-year time period and compared electronic documents to the paper baseline. They found that data was generally harder to extract from the electronic notes due to several problems: chief complaint descriptions often were too lengthy, "ophthalmic problem lists and medication lists were combined within long lists of systemic problems and medications" and, unlike electronic notes, "most paper charts examined in this study emphasized graphical representation of ocular features, as well as reliance on structured forms with checkboxes to summarize ocular findings".

3.1.5 Workflow Redesign

Another issue commonly associated with EHR implementation is the integration of the new system with the clinical workflow. Ideally, the new EHR should enable the design of new processes that allow clinicians to improve their outcomes and productivity. However, in many instances, the EHR's design is determined by the software cost, technical feasibility and implementation schedule rather than a clear vision of the optimal role of computing in the practice. Consequently, users' workflows are rearranged to fit the constraints of the new system, which might not be adapted to the organization of clinical workflows desired by the practice. This can lead to either the implementation of sub-optimal work processes or the need to perform additional overhead tasks. This conflict between the conventional feature-based design paradigm and an optimal evidence-based paradigm can result in care quality issues and physician productivity decreases.

3.2 High Maintenance and Implementation Costs

In the context of adoption failure, it is important to understand the very high costs associated with the implementation and maintenance of EHRs that make it critical for practices to manage as well as possible their EHR transition.

3.2.1 Main Cost Categories Related to EHR Implementation

There are two main cost categories related to EHR implementation: (i) system costs, which consist of software, hardware, implementation, training and maintenance, and (ii) induced costs including the provider's revenue loss from the temporary reduction in productivity. Put simply, EHR adoption costs can also be split between hard and soft costs, some of which consist in one-time upfront expenses while others correspond to long-term ongoing costs:

EHR Adoption Hard Costs

Cost Category	One-Time	Ongoing
Hardware (servers, office infrastructure, connectivity)	Server/desktop purchase, Wi-Fi installation, internet upgrade	Server/office infrastructures maintenance/upgrades, rental fees
Software (EHR/PM and bolt-on application)	License purchase and vendor set-up feed	Annual maintenance or monthly rental
Support (user support, break/fix support, software upgrades)		Monthly support fees, urgent support surcharges, upgrade fees
Services (setup, implementation, custom development)	Database setup, workflow consulting, training, project management, report forms and interface development	Follow-on training, report forms and interface development
Transaction (eligibility verification, eRx)	Setup fees	Per transaction fees and non-participating payer fees

EHR Adoption Soft Costs

Cost Category	One-Time	Ongoing
Physician/staff time (training, application administrative costs, communication)	Process redesign work, training sessions, initial reduced productivity, practice communication meetings	New employee training time, ongoing communication, application/user administrative costs
Revenue loss (reduced patient volume)	Reduced physician productivity during initial implementation	

3.2.2 Cost Estimates of EHR Adoption

Fleming et al. (2011) analyzed 26 primary care practices included in the Health Texas network that had implemented an EHR and collected financial costs related to the system deployment (e.g., hardware capital expenditures and operational expenditures linked to software hosting and licensing and technical support). They also gathered staff estimates of the time spent by the practice implementation teams on the installation of the EHRs and the staff training and used payroll data to compute the non-financial costs of adopting

their EHRs. They also included the fees charged by external consultants for assisting in the implementation process. They applied the same approach to estimate recurring maintenance costs. They found that, for an average practice of five physicians, implementation costs through the two months following EHR launch (including the financial impact of the several hundreds of hours spent by the implementation team and the physicians) and yearly operational maintenance were $162,500 and $85,500 respectively, or $32,500 and $17,000.

This is somewhat consistent with the results of the 2011 MGMA survey that found a median capital cost per physician and a median yearly operating per physician of $30,000 and $13,200 respectively. These numbers seem to indicate that, in some instances, Medicare and Medicaid incentive payments do not counterbalance the costs of implementing and maintaining an EHR. Indeed, in retrospective study conducted at the Cole Eye Institute in Cleveland, Ohio, which implemented an EHR between July 2011 and March 2012, Singh et al. (2015) collected data net revenue, EHR capital and implementation costs and EHR financial incentives received between April 2011 and April 2013. They reported total capital costs of $1,571,864 and personnel implementation costs of 1,514,334 compared to expected cumulative incentive payments of $983,103 over 2012-2016, highlighting the fact that, in this particular study, EHR implementation costs had far offset the financial incentives received for EHR adoption.

3.3 Physician Resistance to EHRs and Main barriers to Acceptance

Given their status as the frontline EHR users and significant influence on other users such as administrative staff and nurses, physicians play a strong role in EHR adoption. However, as discussed above, in spite of the rapid uptake of EHRs, adoption of these products in a way that captures their potential benefits has been limited. This slow adoption rate suggests significant resistance to EHR among physicians.

Several barriers affect physician acceptance of EHRs and encourage non-use of specific EHR functions and reduce the likelihood of safety and quality improvements. Ajami et al.

(2013) conducted a review 27 articles from the existing literature on this issue and found 25 different barriers to acceptance to be mentioned. Main barriers found were time, the absence of computer skills, lack of incentives, technical complexity, poor communication among users and insufficient training and technical support[18].

Main Barriers to Physician Acceptance of EHRs

Barrier	Description
Time	Physicians do not always spend the appropriate time to familiarize themselves with the EHR or participated in training since they are not being compensated for it
Absence of Computer Skills	Vendors often overestimate physicians' computer skills, especially typing skills
Lack of Incentives	Lack of financial incentives for care quality measures improvement and public reporting of these
Technical Complexity	Navigational, options and screens issues associated with EHR use, especially for filling out progress notes
Poor Communication Among Users	Poor written and oral exchange of information, thoughts and opinions through social networks
Insufficient Training	Training limited to less than one day, often before physicians have had sufficient exposure to the new EHR, and in inappropriate settings such as a classroom
Lack of Technical Support	Unavailability of support staff during off hours and holidays

3.4 Differences in Challenges Between Electronic and Paper Based Practices

Some physician practices that already use an EHR sometimes need to replace their legacy system in order to implement an EHR that meets required Meaningful Use criteria. Such transitions involve similar workflow redesign issues than transitions from paper-based charting, sometimes even worse. EHR selection is particularly critical, as the practice must ensure accurate data conversion from the legacy system to the second EHR.

[18] Others include: cost, workflow disruption, security and privacy concern, physical space, interoperability, vendor trust, access to computers, data entry concerns, inadequate data exchange and patient acceptance

However, there is evidence in the literature that electronic-based organizations have different priorities than paper-based practices when installing a new system and even face a few unique challenges. Zandieh et al. (2008) conducted interviews of 23 practice managers and medical directors of an ambulatory care network between January and May 2006, before the launch of an EHR at the network level and coded the transcripts to compare the perceived challenges associated with EHR implementation between the practices who already had an existing EHR and those who were transitioning from paper-based charting. They found that paper-based practices put an emphasis on (i) the presence of a physician champion, (ii) IT support, (iii) a sufficient number of workstations and (iv) workflow redesign. Meanwhile, practices with an existing EHR prioritized (i) ongoing technical support, (ii) public acknowledgement of physician resistance, (iii) improved technical training and (iv) patient privacy protection and felt that workflow redesign and staff IT level did not constitute significant challenges.

Gettinger and Csatari (2012) conducted interviews of key participants in a health system's transition to a new EHR that involved 7,000 unique users and examined internal decision-making reports. They found that, even though the organization had already executed an EHR implementation in the past, end-users still experienced more workload increases than anticipated and, just like in the case of transition from paper charting, partially continued to use the legacy system. The authors also reported that clinical data conversion from one system to another was a major challenge.

Overall, nonetheless, satisfaction with EHR transition is higher in practices that already use an EHR than in practices that convert from paper charting. Zandieh et al. (2012) surveyed practitioners at six ambulatory care practices three months before and after they transitioned from different EHRs to newer systems. They reported that the majority of respondents were satisfied with the new systems and the transition. However, the authors found that, similar to paper-based practices, the new systems did reach medical staff expectations in respect to care quality and efficiency and medication safety.

Chapter 4: Key success factors in EHR adoption

In chapter 3, we showed that the benefits of EHR use documented in the early 2000s were not significant in the most recent implementation projects. Only a fraction of healthcare organizations manages to adopt successfully these systems. In this chapter, we will review existing literature in respect to the critical factors to transition successfully to an EHR.

4.1 Main Works Reviewed

In a recent cross-functional survey, Safdari et al. (2015) asked 340 healthcare workers to assign scores to each of a set of 19 predetermined critical success factors for EHR implementation through multiple choice questions that used a Likert-type 5-scale. A score of 1 corresponds to a very low impact while a score of 5 is associated with a very high impact. These 19 success factors were divided into 4 categories: (i) project management, (ii) organizational, (iii) human and (iv) technical. Each category was then assigned the mean of the success factors it included in order to evaluate their relative impact on implementation success. They found project management to be the most critical factor with a mean of 4.62, followed by technical and human factors with means of 4.35 and 4.22 respectively. Organizational factors were found to be the least critical success factors with a mean of 3.98. They concluded healthcare organizations should put a stronger emphasis on project management and human factors in order to be successful in implementing their EHRs. We will use the authors' 4 categories to structure this chapter.

Standing and Cripps (2013) analyzed two case studies of EHR implementation projects. In each case, they interviewed the organizations' CIOs, administrative and IT staff, clinicians and vendors' employees via open-ended questions. The two researchers analyzed the interview transcripts to identify approach and behavior patterns.

Crosson et al. (2011) performed a comparative multimethod qualitative case study among five e-prescribing ambulatory practices that were considered as "exemplar". Practices were selected based on their electronic prescription volume and the innovation of their processes by a committee of executives that had significant experience in e-prescription adoption projects. The authors underwent 3-day visits of each practice where they both interviewed practice members and observed prescription processes. Field notes and interview transcripts were coded and analyzed to identify common best practices.

Nemeth et al. (2012) implemented electronic Standing Orders (SOs)[19] for immunization, screening and diabetes measures in eight primary care practices that used EHRs and monitored changes in 15 care quality indicators over 21 months. The authors also conducted interviews and performed on-site observations to link performance improvement with interventions in order to identify the best strategies utilized. They reported improvements in at least three measures for all practices and in 14 measures for two practices.

Felt-Lisk et al. (2009) analyzed 32 medical practices that varied significantly in number of physicians. 24 of the practices examined had already implemented an EHR while 8 expected to implement a new EHR or upgrade an existing one in the following year. Two-person research teams conducted on-site interviews of one to two hours at each of these practices on the adaptation of their work processes to the new system, the factors that carried positive and negative effects on EHR adoption and the quality and performance improvements that had been associated with EHR adoption. Prior to the visits, all teams underwent a common training by a task leader and received an interview guide in order to ensure they followed the same protocols. Interview transcripts were subsequently coded to identify best practices.

Deutsch et al. (2010) retrospectively examined project reviews and audits and incident reports of various EHR implementation projects that occurred in England, Canada, Australia, Germany and Denmark. Reports were normalized into cross-country groupings

[19] Authorizes nurses and other ancillary staff to carry-out a medical order without a clinician' approval

to generate critical areas. They concluded that similar success factors existed across countries and that technical factors bore less importance in respect to EHR implementation success than project management, organizational and human factors.

Fenton et al. (2006) examined journal articles and several case studies of EHR implementation projects and reported the essential tools and people skills they identified as bearing a positive impact on EHR implementation.

4.1 Project Management

Safdari et al (2015) include 6 critical factors for EHR adoption in their project management category: (i) the establishment of working groups and user engagement, (ii) the existence of an appropriate team leadership, (iii) appropriate support, (iv) supporting top managers, (v) management stability and (vi) appropriate training. Standing and Cripps (2013) identified (i) significant clinicians training, (ii) the need for an implementation plan, (iii) financial incentives for clinicians, (iv) innovative leadership, (v) the set up of collaborative processes, (vi) strong developers' commitment to the project and (vii) system quality's ongoing evaluation and improvement as important project management success factors.

Crosson et al. (2011) reported the following project management success factors: (i) the identification of an organizational champion, (ii) the identification and training of super users, (iii) the ongoing availability of technical support, (iv) comprehensive on-site training including test runs of the system, (v) the development of protocols and standardized data entry processes, (vi) the mapping of work processes to understand how they will be impacted by the EHR, (vii) planning of work processes redesign and (viii) ongoing monitoring and modification of work processes.

Nemeth et al. (2012) proposed the following success factors: (i) practice policies and protocols, (ii) the presence within the of a technically savvy leader, (iii) the recruitment of staff that supports a team-based work approach, (iv) clear focus of the leadership, (v)

staff education by leadership, (vi) good communication of expectations and (vii) regular staff meetings. Felt-Lisk et al. (2009) identified (i) having a physician advocate, (ii) technical support for implementation, (iii) adequate end-user training, (iv) standardization of staff's use of the EHR's features through incentives or leadership action and (v) setting regular time slots aside for work processes' redesigns based on EHR issues, administrative tasks and patients follow-up as important project management success factors.

Deutsch et al. (2010) included (i) financial incentives for EHR users, (ii) public monitoring of EHR use, (iii) the development of a strong project governance structure, iv) realistic rescheduling, (v) recruitment of highly experienced staff in the core implementation team, (vi) analysis and re-use of previous implementation successes and (vii) the establishment of control mechanisms as important success factors. Fenton et al. (2006) identified the following critical success factors: (i) acknowledgement of workflows and organizational structures, (ii) prioritization of patient care and safety, (iii) leadership commitment, (iv) presence of a physician champion, (v) leadership's ability to deliver a clear vision of the project, (vi) pre and post implementation training, (vii) extensive 24/7 technical support and (viii) post-implementation evaluation of EHR use.

4.2 Technical Factors

Safdari et al (2015) include 3 critical factors for EHR adoption in their technical category: (i) high speed information processing, (ii) security and privacy principles and (iii) ease of use of the EHR. Felt-Lisk et al. (2009) identified solid product structure as an important technical success factor. In particular, they reported (i) the overpowering of alerts, (ii) a high number of clicks required to perform a task, (iii) the lack of a standardized space to insert key data within the chart, (iv) the absence of condition-specific prompts, (v) discrepancies between the advertised and actual system performances and (vi) the impossibility to create patient lists based on a set of criteria as technical factors limiting the use of EHRs. Deutsch et al. (2010) included (i) data protection and (ii) network connection as important success factors. Fenton et al. (2006)

identified the following critical success factors: (i) user computer experience and (ii) technology infrastructure.

4.3 Human Factors

Safdari et al (2015) include 3 critical factors for EHR adoption in their human category: (i) staff's positive attitude, (ii) the employment of medical informatics professional and (iii) physicians' and nurses' involvement in the EHR implementation. Standing and Cripps (2013) identified (i) end-user involvement, (ii) the buy-in of the system by all stakeholders and (iii) a multidisciplinary implementation team as important human success factors. Nemeth et al. (2012) proposed the following success factors: (i) staff collaboration and interaction and (ii) follow-up of orders by clinicians.

Felt-Lisk et al. (2009) identified (i) the presence within the practice of a physician with the necessary skills to customize an EHR, (ii) above average end-user aptitude and (iii) low average physician age as important human success factors. Deutsch et al. (2010) included (i) clinicians' integration into the execution process, (ii) end-user acceptance and (iii) physicians' computer skills as important success factors. Fenton et al. (2006) identified the following critical success factors: (i) end-users' awareness of project status, (ii) end-user involvement in process redesign, (iii) redesign of communication methods, (iv) end-user feedback and (v) staff experience with technology.

4.4 Organizational Factors

Safdari et al (2015) include 4 critical factors for EHR adoption in their organizational category: (i) the prior existence of appropriate hardware and network infrastructure, (ii) the availability of sufficient funds for investment in the implementation, (iii) the alignment of the EHR with the organization's goals and (iv) staff's understanding of EHR's features and benefits. Standing and Cripps (2013) identified (i) clear communication of EHR benefits to users, (ii) funding and (iii) EHR's support of the organization's goals as important organizational success factors. Crosson et al. (2011)

also reported the communication of e-prescription benefits to practice members as a success factor.

Nemeth et al. (2012) proposed the demonstration to clinicians of templates' application and use as an important facilitator. Felt-Lisk et al. (2009) identified (i) being affiliated with or owned by a larger healthcare organization, (ii) sufficient underlying infrastructure and (iii) alignment of EHR functionalities with the practice's needs as important organizational success factors. Deutsch et al. (2010) included (i) communicating about the project progress, (ii) the development of an EHR benefits measurement framework, (iii) post-implementation proof of financial savings in real-time and (iv) timely dedicated funding as important success factors. Fenton et al. (2006) identified the following critical success factors: (i) the need for the EHR to be aligned with the organizational structures of the practice and (ii) good understanding by senior leadership of EHR value.

4.5 Summary of Key Success Factors Found in the Literature

We reviewed the existing literature and excluded redundancies between academic papers to ultimately identify 33 key success factors to EHR implementation.

In respect to project management, we identified 15 key success factors:

1. Technically savvy physician champion able to clearly communicate his project vision
2. Stable care and safety-focused leadership team strongly committed to the project
3. Analysis and re-use of previous implementation successes
4. Development of clear implementation plan and project governance structure
5. Recruitment of highly qualified team-oriented staff for the core implementation team
6. Mapping of work processes and planning and monitoring of workflow redesigns
7. Development of practice protocols and control mechanisms
8. Establishment of working groups, collaborative processes and regular staff meetings
9. Identification and training of super users
10. Pre- and post-implementation comprehensive on-site user training including test runs
11. Standardization of staff's use of the EHR features and data entry processes

12. Extensive technical support
13. Establishment of financial incentives for clinicians based on EHR use
14. Ongoing post-implementation evaluation of EHR impact on care quality
15. Set up of regular time slots aside for resolving EHR issues and performing administrative tasks and patients follow-up

In respect to organizational factors, we identified 7 key success factors:

1. Alignment of EHR functionalities with the organization's goals and practical needs
2. Sufficient underlying hardware and network infrastructure
3. Affiliation with or ownership by a larger healthcare organization
4. Availability of sufficient dedicated funds and timely funding
5. Good understanding and clear communication to users of EHR benefits by leadership
6. Regular communication to staff on the project progress
7. Post-implementation reporting of financial savings to end-users through EHR benefits measurement framework

In respect to human factors, we identified 6 key success factors:

1. Acceptance and buy-in of new EHR system by all stakeholders
2. Integration of end-users into the execution process
3. Multidisciplinary implementation team including medical informatics professional
4. Staff experience with technology and basic computer skills
5. Staff collaboration and interaction including end-user feedback
6. Redesign of communication methods

In respect to technical factors, we identified 5 key success factors:

1. Solid product structure that reflects advertised features
2. High speed information processing
3. Ease of EHR use with minimum number of clicks required to perform a task
4. Some advanced features (e.g., condition-specific prompts, customizable patient lists)
5. Data and privacy protection

Chapter 5: Applying Lessons From ERP Implementation Case Studies

Enterprise Resource Planning tools (ERPs) are suites of integrated modules that allow an organization to manage its supply chain, inventory, product lifecycles and other back office functions. In this final chapter, we will review two case studies of ERP implementation: the introduction of SAP at Rolls-Royce over 1998-2001 and Nestle USA's roll-out of SAP over 1999-2003. We will first briefly summarize the two case studies and identify the key actions that were taken. We will build on these case studies to make the case that ERP and EHR implementation projects bear strong similarities. We propose to leverage and apply best practices and lessons derived from challenges faced by ERP implementation projects in other industries to the healthcare space in order to ultimately develop an original framework to EHR implementation.

5.1 Similarities between EHRs and ERPs

We argue here that EHRs can be partially treated as a subcategory of ERP systems and that, as such, lessons derived from ERP implementation projects can be applied to the issue of EHR implementation. Indeed, many industries have faced in the past similar challenges to those posed by EHR implementation when rolling out their ERPs. Moreover, the recent uptake in EHR adoption by healthcare organizations is similar to the wave of EPR projects of the past 15 years.

Although the deployment of an EHR occurs in a different context than for an ERP, these systems share many architectural similarities. Both systems aim at standardizing work processes, increasing the speed and improving the accuracy of information exchange and data reporting and enabling cross-functional process integration. They are also both integrated suites of software modules dependent on an access in real time to a common database. In the case of EHRs, this database is the patient health information. For both systems, implementation necessitates considerable investments of funds, human capital

and time. Organizations also need to redesign their work processes so as to align them with the best practices of the EHR or ERP software. And, like in the case of ERPs, in order for a healthcare organization to achieve meaningful use, EHR implementation cannot be restricted to a single department and must be completed at an organization-wide scale.

5.2 ERP Implementation Project at Nestle USA

5.2.1 Summary of Case Study

In 1997, Nestle USA announced its plan to implement its BEST (Business Excellence through Systems Technology) ERP project. The project was budgeted at $280 million ($200 million contract with SAP and an additional $80 million in maintenance, consulting and upgrades) and scheduled to run from 1998 to the first quarter of 2003. Five modules were to be implemented: (i) purchasing, (ii) sales and distribution, (iii) accounts receivable, (iv) accounts payable and (v) financials. The goal was to realize scale economies and unify the organization after years of autonomous operation. For instance, Nestle USA used 9 distinct general ledgers before the SAP implementation. Nestle was also paying 29 different prices for procurement of vanilla and each warehouse was using a different reference number for this product.

A team of 10 senior IT professionals and 50 executives was assembled in October 1997 to come up with some best practices while a smaller technical team spent 18 months implementing a uniform data structure across the organization. Employees that the new system was expected to affect were not involved in the implementation design and, as a result, had started to express significant resistance by 1999, even before the rollout. By June 2000, no employee understood the new system and the new work processes they had to adopt and major technical issues had emerged so that Nestle was forced to stop the implementation. In October 2000, the project was reassigned to a team of 19 key business executives who took the decision to abandon the idea of a predetermined project timeline but rather redesign the project based on based on its core business requirements. They

also decided to harvest stronger support from key employees. It took until April 2001 for the team to develop a detailed roadmap for the project to follow. The new position of director of process change was created whose role was to act as a liaison between the team and the functional divisions. The project resumed and the implementation was completed in 2003, as per the initial plan.

5.2.2 Key Actions Taken

This case study contains both pitfalls and successes. During the first part of the implementation, Nestle USA took a number of bad decisions that ended up being highly detrimental to the project, before correcting them in the second part of the project:

Before June 2000	After April 2001
Employees directly affected by ERP were not included in the implementation team	End-users involved in system testing – regular post-implementation surveys conducted to monitor ERP impact on staff directly affected
Overlooked modules integration in an effort to meet unrealistic project timeline	Several installations delayed based on employee feedback to accommodate groups
Employees received little training before go-live and no training thereafter– relied on the help desks and refused to learn new processes	Staff received training early and all along the project
Management underestimated ease of re-engineering business processes to fit ERP	Modeled modules rollout based on process requirements
System buy-in limited to top-level executives	Educated employees directly affected on reasons for process changes to achieve universal buy-out
Left divisional executives out of the project	Ensured support from key divisional heads - Director of process change acting as a liaison

5.3 ERP Implementation Project at Rolls Royce

5.3.1 Summary of Case Study

In 1996, Rolls Royce outsourced the design and maintenance of its IT infrastructure to Electronic Data Services (EDS) in order to focus on its core capabilities. Soon after, the

company began an ERP rollout project. EDS gathered internal specialists and SAP consultants to form the project management team. Moreover, each of Rolls' Operational Business Units (OBUs) appointed an ERP planning team, in charge of training and workflows redesign. The management team conducted an intense study in the first quarter of 1998 to determine the project scope, outline an implementation plan and forecast costs.

During a second phase, a more detailed plan was developed and a prototype of the ERP was developed and installed. The pilot was run at a small scale in the "number 4 shop" facility that had significantly lower material volume flows than the rest of the organization. A series of reviews assessed the integration of the new system and user acceptance. In parallel, the core implementation team also set up two sets of workshops involving 200 and 300 line personnel to promote cooperation and mitigate initiative fatigue. This phase took 6 more months than the initial timeline to allow the pilot to run for a more extended period and resolve difficulties with the prototype.

Finally, full-scale implementation started at the end of 1998 and continued until the second quarter of 2000 when data was transferred from the legacy system to the ERP over 10 weeks. The legacy systems were switched to read-only mode to monitor variances between the two systems.

5.3.2 Key Actions Taken

Project Risk	Action Taken to Mitigate Risk
Low ERP acceptance in areas where acceptance of legacy system is high	Illustration of potential improvements to the whole company
Hardware issues during implementation	Small scale pilot followed by technical review and system testing – timing changes resolve difficulties with the prototype
Hardware issues after implementation	Legacy systems switched to read-only mode to monitor variances between the two systems
Training ends up being very costly	Specialist experts trained by SAP subsequently trained expert users who then conducted training for end-users

Resistance to change	Series of "Business Simulation" workshops involving 300 line personnel to develop a strong relationship between staff and core implementation team User acceptance testing during pilot project
Change not properly understood	Series of "High Level Process" workshops involving 200 line personnel to discuss business processes affected by the project
Incomplete training	User training before go-live period Training through information meetings, demonstrations within workplace and presentations – 10,000 staff trained
Data load issues	Series of "High Level Process" workshops involving 200 line personnel to discuss business processes affected by the project
Difficulty to adapt ERP to specific processes and workflows	Cross-functional workshops to ensure employees understand the need for processes redesign – mapping of existing processes, comparison with ERP requirements and re-mapping

5.4 High-Level Practical Framework for EHR Adoption

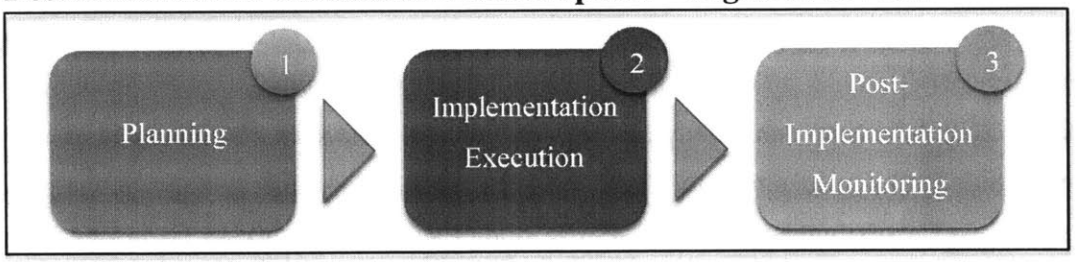
We argued before that ERPs and EHRs bear strong similarities from the perspective of their architectures and the need for organization-wide adoption of these systems. Our review of the Nestle USA and Rolls Royce case studies highlights that, beyond these, ERPs and EHRs are quite similar from an implementation perspective. Indeed, several statements can be derived from them. First, there is a remarkable similarity between the critical success factors highlighted in these case studies and the key success factors for EHR adoption that we found in the existing literature. These factors include the importance of extensive end-user training before and after the new system installation including the involvement of super users, clearly communicating the benefits of the new system to the end-users to ensure their buy-in and its alignment with the organization's strategy.

Moreover, especially in the Nestle USA case study, it appeared key in the end that a successful ERP implementation would require the intervention of a strong project leader who understands each department's needs and has a great ability at working with them.

This is also true of EHR implementation projects where the presence of a physician champion is an important success factor. Finally, as for EHR implementation projects, these case studies raised the issue of continuously having to choose between implementing customizations and workarounds or re-engineering staff work processes all along the implementation process.

Having made the case of ERP implementation projects' relevance to EHR adoption, we will now propose to the reader a new framework for EHR adoption success. In the previous chapter, we briefly discussed Crosson et al. (2011)'s work. In their paper, the authors classify the key success factors they have identified into three categories: planning, implementation and use. We build on this idea and the concept that ERP implementation best practices can bring value to EHR implementation projects. We reviewed ERP frameworks and best practices (Hardcastle and Montgomery, 2015; Hestermann, 2015; Phelan and Hardcastle, 2015) and leveraged our review of EHR critical issues and success factors to develop our dynamic framework.

Best Practices for Successful EHR Adoption – High Level View



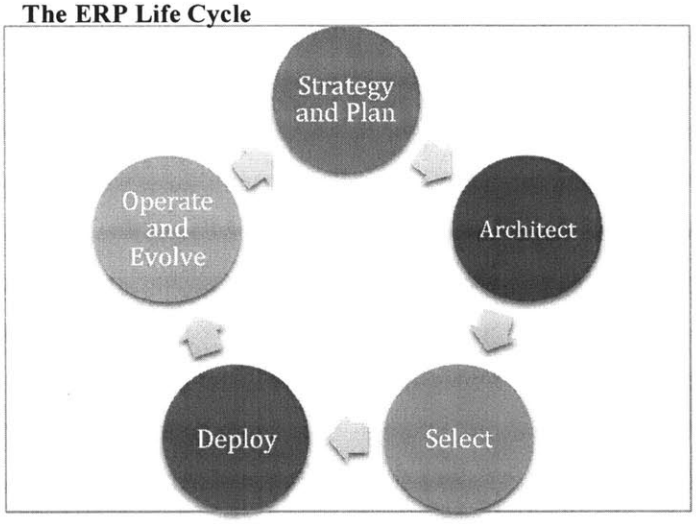
Several key learnings stem from ERP experience highlighted in these best practices:

1. ERP strategies should be designed on the primary basis of an articulated benefits program and a target business model derived from their specific needs. Otherwise, the ERP investment will lead to business dissatisfaction
2. Businesses need to identify their current state and the constraints to reach the desired state. Alignment of the ERP planning framework with the ERP strategy must be cross-checked at all times
3. ERP strategies cannot be translated into an actionable plan unless sufficient end-user ownership is developed

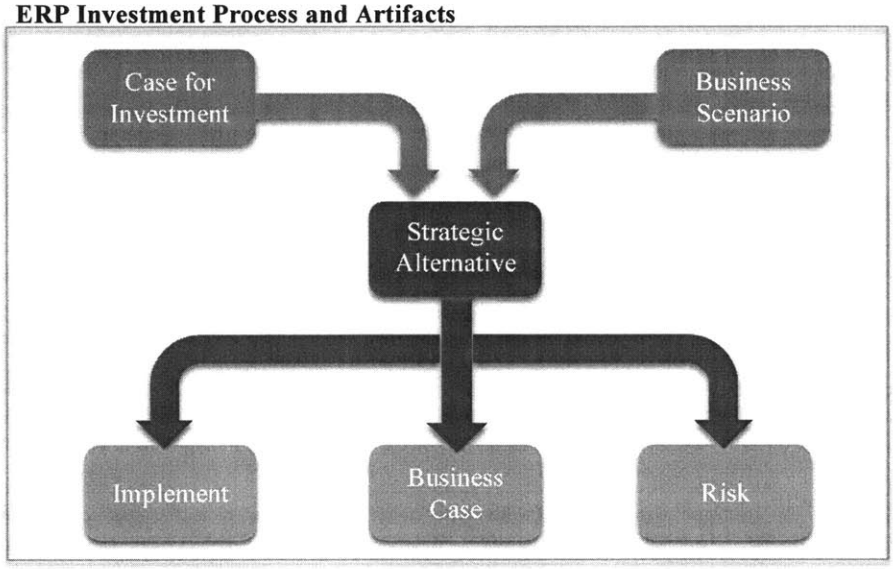
4. Establishing a post-implementation ERP governance model is critical to ensure the ongoing value of the ERP after the go-live period

In addition, we used the two following frameworks to start structuring our approach to EHR implementation[20]:

The ERP Life Cycle



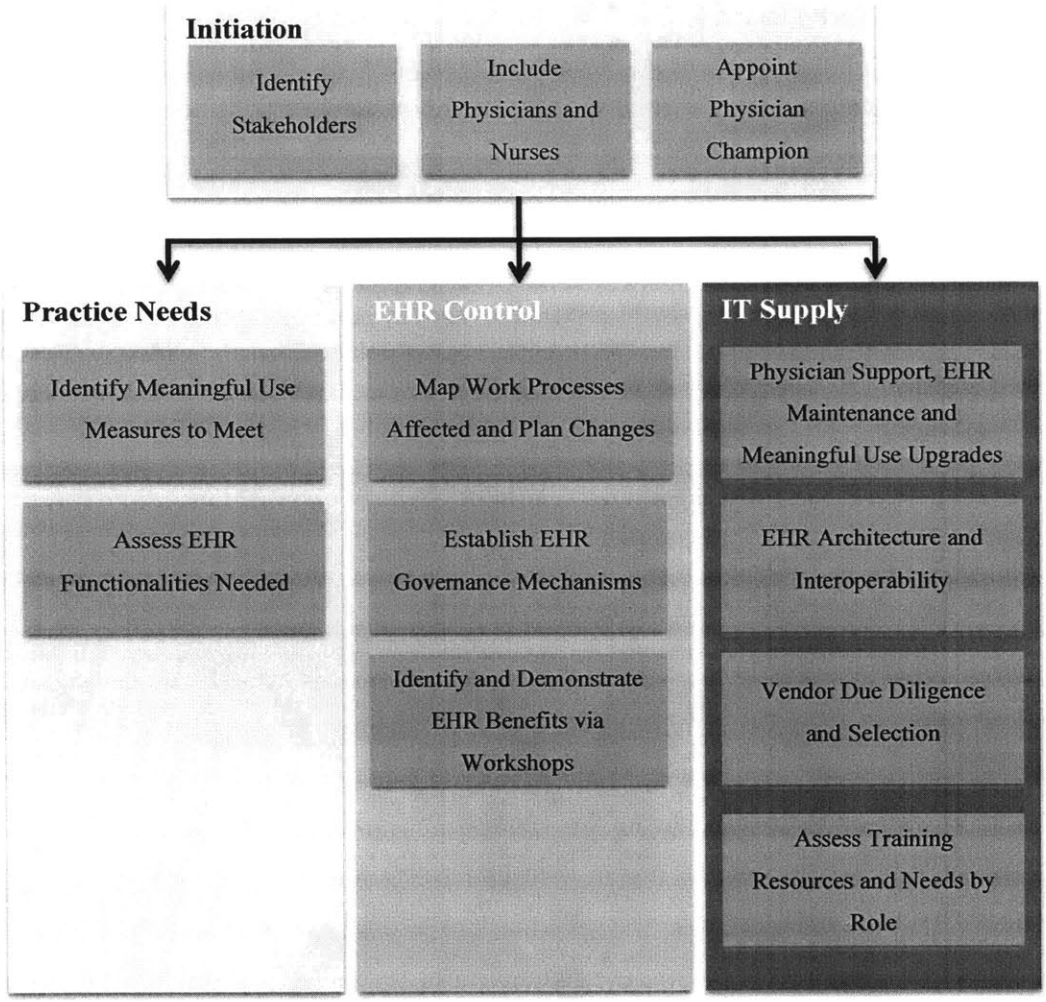
ERP Investment Process and Artifacts



[20] Gartner (2015)

We will now provide the reader with more detailed dynamic frameworks of each of the three highlighted phases.

5.5 Planning for EHR Implementation



5.5.1 Initiation Stage

This short stage consists of three tasks that need to be performed concurrently:

- **Identify Stakeholders:** Identify the stakeholders (e.g., physicians, patients, nurses) who will receive benefits from use of the new EHR. Estimate the project complexity

and establish the governance structure and decision protocols for the development of the roadmap to EHR implementation

- **Include Physicians and Nurses:** Select the team members in charge of creating the implementation plan. Recruit highly qualified executives who support a team-based approach and make sure to include physicians and nurses who must own the strategy since IT staff often lacks understanding of the administrative and medical concerns involved
- **Appoint Physician Champion:** Establish roles within the team. Select a physician advocate and/or administrative within the practice or owner organization to lead the guiding team. It is preferred to choose a physician champion well respected by his peers and with a clear confidence of EHRs' potential for delivering better patient care for this position

5.5.2 Practice Needs

This stage focuses on the importance of the EHR for the healthcare organization and the quality and efficiency outcomes the EHR will achieve:

- **Identify Meaningful Use Measures to Meet:** EHR implementation projects are more successful when they are aligned with the organization's strategy. Clearly identify the specific meaningful use measures that are relevant to the practice
- **Assess EHR Functionalities Needed:** Define the high level EHR capabilities that are in scope and refine them by functional areas. Identify patient health information needs

5.5.3 EHR Control

This stage focuses on EHR implementation guidance and the measurement and communication of EHR benefits. It includes three tasks:

- **Map Work Processes Affected and Plan Changes:** Map the current administrative and doctor-patient interaction practice processes and identify potential issues with the

new EHR. Plan for work process redesigns to effectively incorporate EHR functionalities and requirements

- **Establish EHR Governance Mechanisms:** Choose the core implementation team and determine the groups who will be responsible for the future EHR operation and necessary upgrades to meet more advanced Meaningful Use Stages. Set up a liaison between the implementation team and the medical department heads
- **Identify and Demonstrate EHR Benefits via Workshops:** Identify a small set of care quality and productivity and financial indicators that will be used to measure the project success. Summarize the value added of the new EHR for the practice and set up a series of workshops to discuss work process redesigns with the medical staff, develop a strong relationship between them and the implementation team and clearly communicate about EHR benefits and implementation goals. Ensuring the acceptance of the EHR solution and the understanding of its value added by doctors is critical

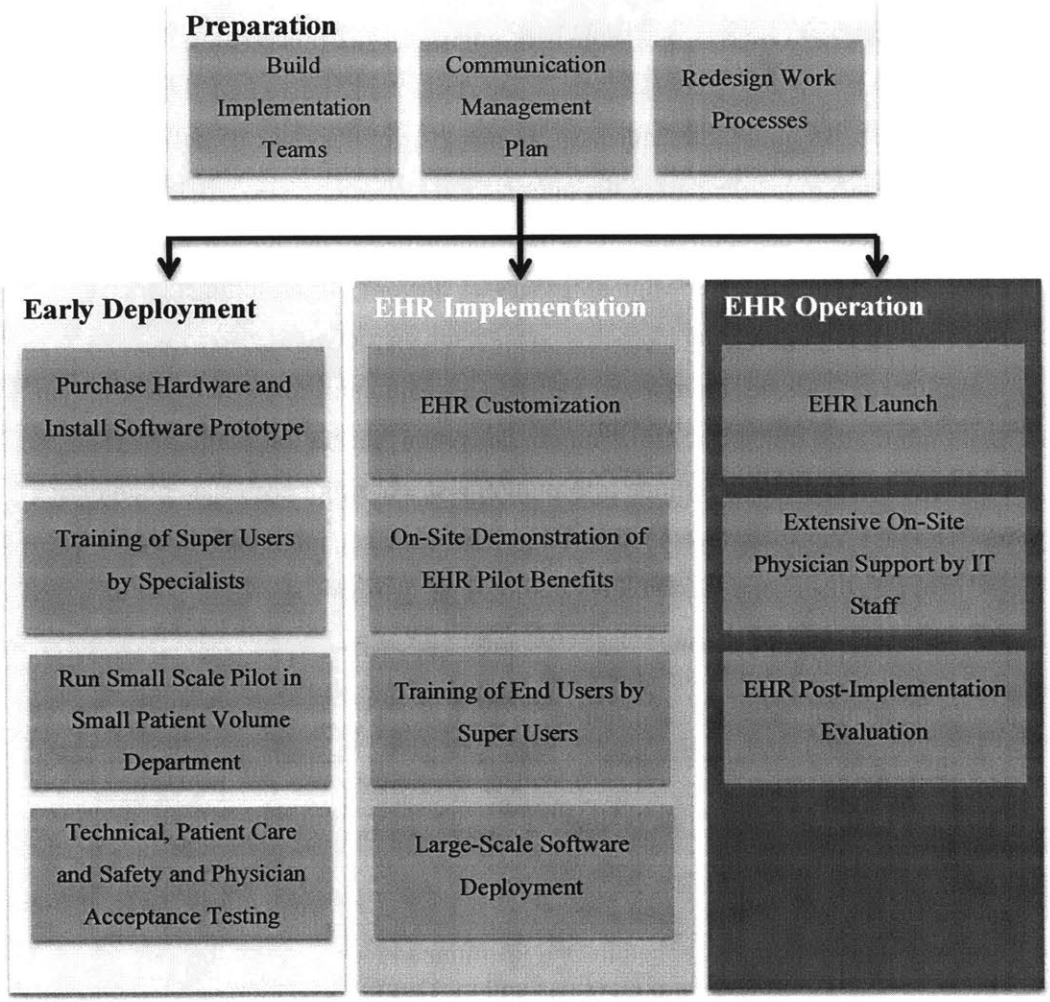
5.5.4 IT Supply

This stage focuses on the services that will be provided by the EHR vendor and includes four tasks:

- **Physician Support, EHR Maintenance and Meaningful Use Upgrades:** Identify which services are needed from the EHR vendor for technical support of physicians, EHR ongoing maintenance and future Meaningful Use upgrades
- **EHR Architecture and Interoperability:** Develop a high-level view of the envisioned EHR architecture and determine the organization's broader Health IT environment to prevent potential interoperability issues
- **Vendor Due Diligence and Selection:** Gather and prioritize most important requirements from prior phases, write RFI, select short-list of vendors, write RFP and run evaluation workshops. Choose EHR solution and negotiate the contract terms
- **Assess Training Resources and Needs by Role:** Assess training needs based on roles, computer skills and common training topics as well as training resources, both vendor-provided and in-house. Write a training plan that describes training requirements for each stakeholder group and how training will be conducted before,

during and after the implementation period. Training design should address points such as training scheduling and duration and the potential use of online training and strategies such as group problem-solving and hands-on activities

5.6 Implementing the EHR



5.6.1 Preparation

This phase involve three tasks. The first two tasks are brief and should be performed before the early deployment. The third task must be performed continuously throughout the implementation execution:

- **Build Implementation Teams:** Select staffs and external resources that will be essential for the implementation and free them from their existing workload
- **Redesign Work Processes:** Continuously re-engineer work processes to fit with the new system based on user feedback. Maximize staff interaction to free clinicians of administrative tasks in order to address other health priorities (e.g., predefine SOs to enable office staff to handle part of the prescription renewal process). Be flexible and delay installations to accommodate workflow redesigns. Do not force a specific timeline. Do not attempt to redesign all processes. Favor EHR customization and workarounds if re-engineering a process appears too disruptive
- **Communication Management Plan:** Develop a Communications Management Plan (CMP) to formalize methods of information collection, generation, formatting, storage and distribution. Determine information restrictions for each stakeholder group. The CMP must be developed by the project manager and reviewed by all project team members and stakeholders before final approval. The CMP should address the following key communication issues:

Key Points Addressed by the CMP

Key Issue	Description
Stakeholder Identification	Description of stakeholders and their information needs
Project Kick-Off Meeting	Information requirements for project kick-off meeting
Team Meetings	Meeting schedule and information requirements for project team meetings and meetings with senior management*
Status Reporting	Reporting policies and information requirements for status reporting on project progress and issues*
Project Schedule	Reporting policies and information requirement for key milestones and activities to be performed throughout the project course

Other Communication Vehicles	Description of other communication canals

Note: Meetings should preferably be held on a weekly basis at least

5.6.2 Early Deployment

This stage consists in four tasks:

- **Purchase Hardware and Install Software Prototype:** Purchase and install the hardware and install the software technical infrastructure. Install the prototype in a medical department that has a low patient volume
- **Training of Super Users by Specialist:** Arrange for vendor staff/specialists to train super users. This task requires a lot of effort and time. Super users must become familiar with EHR use and, most importantly, with the negative consequences incomplete or wrong data entries can have on patient safety and care quality
- **Run Small-Scale Pilot in Small Patient Volume Department:** Run a small pilot of the EHR prototype with the super users and carefully monitor problems
- **Technical, Patient Care and Safety and Physician Acceptance Testing**

5.6.3 EHR Implementation

This stage consists in four tasks:

- **EHR Customization:** Customize EHR based on technical issues raised during the pilot and review of end-user acceptance
- **On-Site Demonstration of EHR Pilot Benefits:** Report quality care indicators and efficiency improvements achieved during the pilot and relay them to all employees through presentations and information meetings. Provide short on-site demonstrations of use of most valuable features. This task is critical for physician acceptance of the new system
- **Training of End Users by Super Users:** Arrange for super users to internally train regular end-users in collaboration with a few consultants. This decreases the overall training costs. Including ample time for training and address inconsistent aptitudes of physicians and office staff through staff education, follow-up by the project leaders

and staff meetings. Demonstrate application and use of templates to clinicians and train them to consistently record the data they sign in in a structured format. Make sure they understand that documents need to be entered as structured data after having been signed in for the computer software to be able to manipulate them conveniently. Also make sure that medical staffs understand that workflow disruptions and productivity losses are expected in the beginning and that they should not draw conclusions on project success too early. Finally, develop and teach new communication behaviors in the exam room in order to enhance patient care experience (e.g., inviting the patient to look at and verify the data on the computer screen, explaining how EHR use improves care quality)

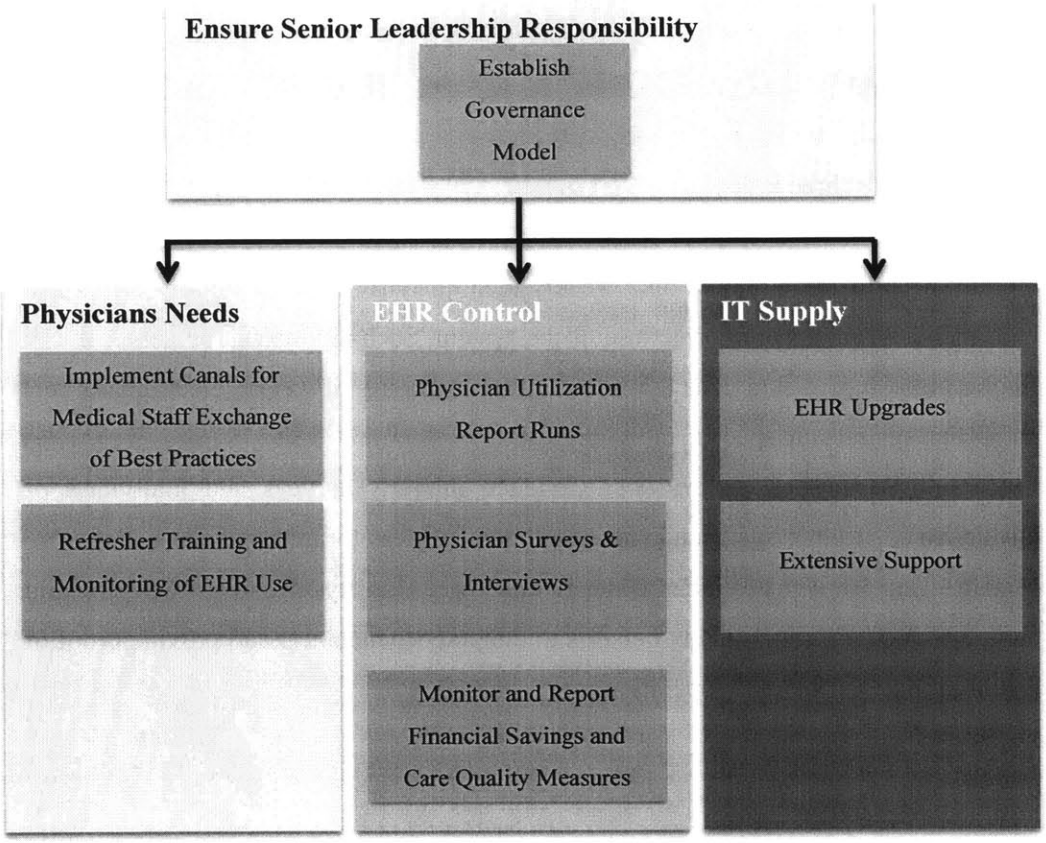
- **Large-Scale Software Deployment:** Install the software organization-wide

5.6.4 EHR Operation

This stage consists in three tasks:

- **EHR Launch:** Switch to the new system
- **Extensive On-Site Physician Support by IT Staff:** Ensure users' access, throughout the transition process and during the 2 to 5 weeks following the go-live period, to extensive technical support. Favor in-person assistance over phone support and, for every 5 clinical staff members, arrange for at least one super-user or expert with both EHR and clinical expertise to be on-site
- **EHR Post-Implementation Evaluation:** One month after the go-live period, conduct a post-implementation evaluation of the EHR. Check that work processes are functioning well and implement the necessary initiatives to address unresolved software issues and training needs

5.7 EHR Use After Implementation



5.7.1 Physician Needs

This stage involves two tasks:

- **Implement Canals for Medical Staff Exchange of Best Practices:** Provide users with some means to communicate tips, best practices and guidance on new EHR functionalities to the rest of the staff, such as through an Internet portal or weekly then monthly "EHR Best Practices meetings"
- **Refresher Training and Monitoring of EHR Use:** Maintain ongoing training after the go-live period to account for software evolution and new recruits and refresh users' knowledge. Focus on standardizing work processes, identifying remaining

training needs and answering questions that have not been covered during initial training. Arrange to have a super user or an in-house trainer monitor staff use of the EHR and address problems in real time

5.7.2 EHR Control

This stage involves three tasks:

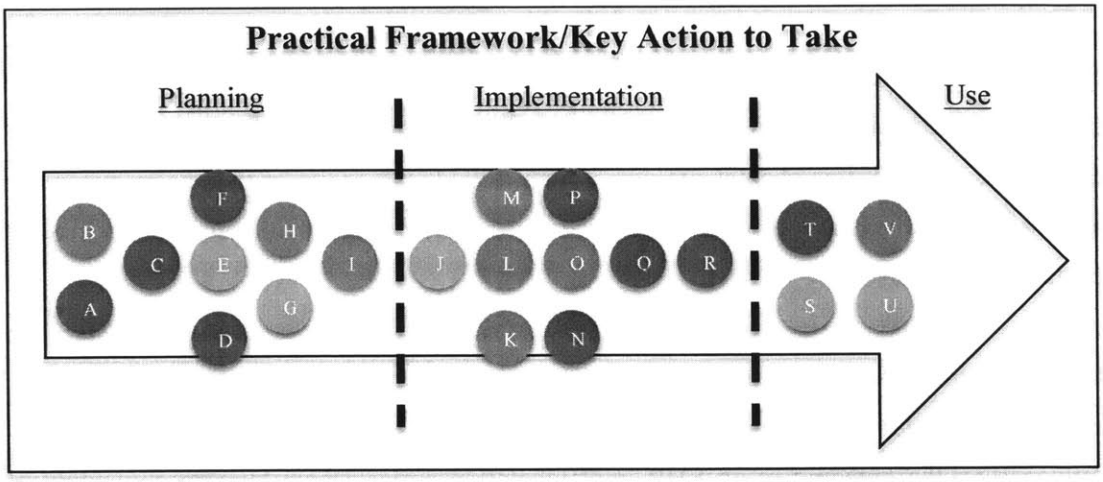
- **Physician Utilization Report Runs:** Monitor staff and physicians by running and monitoring utilization reports on a weekly then quarterly basis to identify errors and inefficiencies and ensure correct use of the system. Such reports can be generated by EHR administrative functions that show creation and use of scripts, electronic orders and progress notes by specific individuals
- **Physician Surveys & Interviews:** Conduct quarterly surveys and interviews of physicians to monitor system adoption and identify areas for improvements
- **Monitor and Report Financial Savings and Care Quality Measures:** Measure and communicate EHR care quality benefits to the practice members and provide proof of actual savings during daily operations

5.7.3 IT Supply

This stage involves two tasks:

- **EHR Upgrades:** Upgrade EHR functionalities based on practice needs and Meaningful Use criteria for more advanced Stages
- **Extensive Support:** Continue providing technical support

5.8 Summary of Recommendations



	Key Action to Take	Criticality
A	Form the development plan team and include physicians and nurses	Very High
B	Select a physician champion to lead the implementation team	High
C	Assess Meaningful Use measures to achieve and needed EHR functionalities	Very High
D	Map work processes and patient-staff interactions affected by new EHR	Very High
E	Choose core implementation team and set up a liaison with department heads	Medium
F	Select quality and efficiency metrics to measure and communicate EHR goals	Very High
G	Identify services required from vendors and predetermine EHR architecture	Medium
H	Conduct vendor due diligence and select EHR solution	High
I	Assess training needs by role (e.g., physician, nurse) and training resources	High
J	Develop the Communication Management Plan	Medium
K	Arrange for specialists and vendor staff to train super users	High
L	Run EHR pilot with super users in small patient volume department	High
M	Conduct technical, patient care and safety and user acceptance testing of pilot	High
N	Redesign work processes and patient interaction behaviors to fit with the new system based on user feedback	Very High
O	Report and relay quality care indicators and efficiency improvements	High
P	Arrange for super users to internally train regular end-users in collaboration with a few consultants	Very High
Q	Launch EHR and ensure users' access to extensive on-site technical support up to 5 weeks after transition process	Very High
R	Conduct post-implementation evaluation of the EHR after one month	Very High
S	Implement canals for medical staff exchange of best practices	Medium
T	Arrange to have one super user/trainer provide refresher training and monitor EHR use	Very High
U	Run physician utilization reports and interviews/surveys	Medium
V	Monitor and Report Financial Savings and Care Quality Measures	High

5.9 Contextual Factors and Limitations

Applying lessons from ERP implementation projects in other industries, we developed a dynamic multi-level framework for a successful EHR implementation. This practical framework integrates some critical success factors into a practice's operational constructs. As such, this chapter provides some of the key learning of this thesis, whose ambition is to study how a medical practice can implement an EHR transition and the challenges it represents.

We close this chapter by remembering the reader that, like any framework, this operational model has its limitations: although critical success factors bear a strong influence on the outcome of an EHR implementation project, many diverse contextual factors also play a critical role. Most generic critical factors should therefore be considered as guidelines whose tailoring to a specific situation often is the real critical factor. Some critical success factors that work in certain settings do not necessarily work in others and vice versa. Contexts vary significantly and require different approaches. Such contextual factors include the project scope, users' and other stakeholders' expectations and level of resistance, junior developers' motivation and the level of resources available to the practice.

Conclusion

The goal of this thesis was to find out how an EHR transition can be successfully implemented. Throughout the thesis, we highlighted that in spite of the numerous benefits of EHR use, implementation projects generate significant operational and financial issues. The degree of challenges encountered and the responses that healthcare organizations give to them vary greatly across them.

In chapter 1, we analyzed the structure of EHRs and the complex and lengthy EHR vendor due diligence and selection process for medical practices. We also described the new legislative landscape brought upon by the HITECH Act, which provides incentive payments to healthcare providers through the Medicare and Medicaid reimbursement systems for using EHRs in a meaningful manner, electronically exchanging health information and submitting clinical quality measures and inflicts financial penalties to those that fail to achieve meaningful use.

In chapter 2, we evidenced the rapid uptake in EHR adoption by hospital and private practices that has occurred in the last decade, fueled by the HITECH Act and the theoretical benefits of EHRs, which include long-term reduction in healthcare costs and improved care quality, patient outcomes and care coordination. We also presented the significant opportunities to apply big data analytics to healthcare through EHR use, especially in respect to knowledge generation.

In chapter 3, we identified the key operational risks that EHRs put on organizations that implement them in respect to patient safety, care quality, physician productivity and access to data and workflow redesign. We also presented the very high upfront expenses and long-term ongoing costs of EHR adoption and the financial threat that adoption failure poses to providers. We then discussed the significant role that physicians play in EHR adoption as frontline users and the effects of the main barriers to physician acceptance of EHRs on EHR adoption rate.

In chapter 4, we reviewed the existing literature on the critical success factors for EHR adoption and identified 15 project management factors, 7 organizational factors, 6 human factors and 5 technical factors, highlighting that project management factors play the most important role in respect to adoption success and that technical factors are the least important contributors.

In chapter 5, we summarized and examined the key action taken in two case studies of ERP implementation: the introduction of SAP at Rolls-Royce over 1998-2001 and Nestle USA's roll-out of SAP over 1999-2003. We observed a remarkable similarity between the critical success factors highlighted in these case studies and the key success factors for EHR adoption that we found in chapter 4 and argued that lessons derived from ERP implementation projects could be applied to the issue of EHR implementation. We reviewed ERP frameworks and best practices and leveraged our review of EHR critical issues and success factors to develop a dynamic multi-level framework of EHR implementation divided into 3 phases: planning, implementing and using the EHR. This framework provides a methodology for dealing with such ambitious programs and integrates key success factors into a medical practice's operational constructs. Nevertheless, like any framework, this operational model has its limitations. In particular, medical practices that implement new EHRs should remember that many diverse contextual factors play a critical role and that this framework should be tailored to their specific situations.

Appendix: Core Meaningful Use Measures For Eligible Professionals[21]

	Objectives and Measures
(1)	Protect electronic protected health information created or maintained by the CEHRT through the implementation of appropriate technical capabilities
(2)	Use clinical decision support to improve performance on high-priority health conditions
(3)	Use computerized provider order entry for medication, laboratory, and radiology orders directly entered by any licensed healthcare professional who can enter orders into the medical record per state, local, and professional guidelines
(4)	Generate and transmit permissible prescriptions electronically (eRx)
(5)	Health Information Exchange -The EP who transitions their patient to another setting of care or provider of care or refers their patient to another provider of care provides a summary care record for each transition of care or referral
(6)	Use clinically relevant information from CEHRT to identify patient-specific education resources and provide those resources to the patient
(7)	The EP who receives a patient from another setting of care or provider of care or believes an encounter is relevant performs medication reconciliation
(8)	Patient electronic access - Provide patients the ability to view online, download, and transmit their health information within 4 business days of the information being available to the EP
(9)	Use secure electronic messaging to communicate with patients on relevant health information
(10)	Public Health Reporting -The EP is in active engagement with a public health agency to submit electronic public health data from CEHRT except where prohibited and in accordance with applicable law and practice

[21] Retrieved from: https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/

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