Exploratory Case-Study of Barriers and Facilitators Associated with the Pilot Implementation of a New Electronic Healthcare Record in the Military

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DISSERTATION

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DISCLAIMER

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position of the U.S. Air Force.

DEDICATION

I dedicate this dissertation to my mother, Roberta Sue Wilson and to my family, Zack, Cora, and Claire.

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KEYWORDS

AHLTA ™- Armed Forces Health Longitudinal Technology Application

Air Force - Arial service branch of the U.S. Armed Forces, initially part of the United States Army, the USAF was formed as a separate branch of the military on 18 September 1947 under the National Security Act of 1947

Army - A branch of a nation's U.S. Armed Forces that conducts military operations on land

Biomedical informatics - Discipline that studies and pursues the effective use of biomedical data, information, and knowledge for problem solving application in healthcare and research to enhance health outcomes

DoD - Department of Defense; an executive branch of the federal government concerned with national security and the U.S. Armed Forces.

Electronic Healthcare Record (EHR) end-user - Clinical (providers, nurses and technician), technical, training and administrative support staff

GENESIS ™- The most current EHR in the used in the Military Health System

HIT - Health Information Technology

HHQ - Higher Head Quarters: In the military, the rank of colonel or general sits in these positions of authority. In the EHR project, this includes members from the Defense Health Agency.

Informatics - Informatics serves to improve the storage, acquisition, and use of information in specific settings to improve health outcomes

Military Health System - An enterprise within the United States Department of Defense that provides health care to active duty and retired U.S. military personnel and their dependents

MTF – Military Treatment Facility; A place where service members, eligible family members, authorized civilians, and retirees receive their medical care

Navy - The branch of a nation's U.S. Armed Forces that conducts military operations at sea

Services - In the context of the Military Health Service; United States Army, Navy, and Air Force

SUMMARY

The Military Health System (MHS) overhauled its previous Electronic Health Records (EHR) system Armed Forces Health Longitudinal Technology Application™ (AHLTA), and trading it in for a new off-the-shelf platform, GENESIS™. The MHS is in need of modernizing its healthcare system to save taxpayer dollars, as most of the defense budget is allotted to the military's most important asset—its people. Additionally, The MHS is striving to improve patient safety and coordination of patient care between the MHS and Veterans Affairs. The MHS is a complex organization that provides medical support for multiple military operations. In 2015, the Department of Defense (DoD) awarded Cerner, Leidos, and Accenture a $4.3 billion EHR contract for a commercialized off-the-shelf system model to be used by more than 146,000 end-users. The MHS recently implemented the new EHR in several Military Treatment Facilities (MTF) on the west coast and will commit to regionally deploy it to all over the globe by 2023. This study looked to explore sociotechnical barriers and facilitators to EHR implementation specifically in the military. A document review served as the data source: implementation plans, evaluation reports, congressional reports, news articles, and relevant peer-reviewed literature. A series of *a-priori* codes were developed, and emergent codes arose out of the thematic analysis process. There were several constructs that emerged from the analysis, placing emphasis on the uniqueness of EHR implementation in the MHS. The constructs of *people*, *communication*, and *hardware and technical factors* were strongly tied to EHR implementation. Additionally, *medical readiness* was identified in the analysis as a unique factor specific to the EHR implementation in the MHS. This research identified four strategic recommendations for the MHS to consider: employ informaticists, parallel EHR implementation, and enhance EHR training. This research also informs an EHR leadership model to guide MHS leaders during

health information technology implementation. Although significant health information technology changes may occur only once every few years, having issues during implementation impacts mission success, overall threatening the vital role that the MHS provides to national security.

I. Chapter 1: Background and problem statement

Informatics is only 20% about technology. -Reed Gardner (Friedman, 2009)

Background

Electronic Health Records and their Impact on Healthcare Systems

The recent and rapid growth of biomedical and health informatics plays an important role in the development of today's healthcare. The American Medical Informatics Association (AMIA), the leading professional and academic organization, defines Biomedical Informatics (BMI) as the "discipline that specializes in researching and evaluating the effective use of biomedical data, information, and knowledge for the purpose of problem solving in healthcare and research to enhance health outcomes" (Kulikowski et al., 2012). BMI maintains several foci in the field: theories and methods, application of technology, and human and social factors (Kulikowski et al., 2012). Originally, the extent of computer involvement in healthcare was thought to be mostly for administrative and budgetary purposes. However, it was not until the advent of *The Computer Based Patient Record* in 1997 by the Institute of Medicine (IOM), that the public became more aware of the fact that electronic healthcare records (EHR) can be instrumental in promoting better clinical decision support and managed care for patients in the United States healthcare system (IOM, 1997).

As researchers in healthcare posited the potential benefits of EHRs for the general community, President George Bush noted the positive use of EHRs in healthcare during his 2004 State of the Union address. Subsequently, President Barack Obama further developed the initiative by signing a legislation that addressed EHR utilization under the Health Information Technology for Economic and Clinical Health Act (HITECH) clause of the American Recovery

and Reinvestment Act of 2009, thereby establishing the first government regulation specific to the field of BMI. The intent behind this initiative was to promote greater healthcare quality, safety, and moreover, the optimal efficiency in healthcare operations (Hoyt & Yoshihashi, 2014). The initiative ensured that EHRs met the specific Meaningful Use (MU) criteria needed for their implementation in Medicare-certified and Medicaid-certified hospitals, with the U.S. government providing a monetary incentive of more than $30 billion towards its adoption in healthcare settings. The focus surrounding the HITECH initiative centered around hospitals and clinics, and furthermore, their ability to enhance safety and quality care through EHR use by meeting the established criteria for Meaningful Use (MU). Clinical decision support, computerized physician or nurse order entry, and health information interchange are great examples of how EHRs are meeting up to MU standards. All in all, HITECH captured the authorization to drive qualified and certified EHRs into hospital settings (Blumenthal, 2010).

Today, EHRs function as a system that manages the clinical data of patients as well as other information regarding administrative support. Despite the fact that there has been more work towards meeting MU standards in general, research shows that approximately 13.6% of a patient's clinical information is not captured during clinical visits even in the recent past (Smith et al., 2005). Types of clinical data typically captured in EHRs are narratives, numerical patient measurements, coded data, textual data, recorded signals, and digital data (i.e., pictures) provided in the form of progress notes or clinical reports. In fact, EHRs collect clinical data through many methods such as writing, typing, speech recognition, scripts, and dictation. Moreover, EHRs serve many purposes in the healthcare setting, specifically by providing the means to facilitate medication reconciliation, promote registry reporting, provide interface with public health services, standardize patient data, in addition to several other functions that can likely improve

the general access as well as the cost efficiency of documentation (Frieden & Mostashari, 2008). The functions of EHRs exist in three categories in order to support hospitals: (i) direct care, (ii) supportive, and (iii) information infrastructure. Thus, EHRs inform many capacities and domains of hospital care, with their roles extending much beyond merely serving in a direct patient care capacity.

Health Information use in the Military Health System

In 2010, Defense Secretary Robert Gates addressed the concern of healthcare costs cutting into the Defense Department's budget during his speech at the Eisenhower Library, stating that the cost could total up to $417 billion a year which amounts to approximately 63% of the Department of Defense (DoD) and Department of Veteran Affairs (VA) budget combined (Shelton, Ondra & Levin et al., 2015; Punaro, 2014). This statistic provides reasoning that healthcare in the military must significantly change to become more efficient, and moreover, that the military must continue its commitment to becoming more fiscally responsible with taxpayer dollars. With the requirements of the wars in Afghanistan, Iraq, and Syria, healthcare costs to support the veterans of these conflicts have consumed approximately 56% of total healthcare expenditures (Bilmes, 2013). Additionally, the Center for American Progress reports military healthcare expenditures grew an overwhelming 300% between 2001 and 2012 (Korb, Rothman, & Hoffman, 2012).

Given the impact of healthcare spending on the defense budget, the high costs directly impact the U.S. national security to an extent (Shelton et al., 2015). Research indicates promise for organizations adopting EHRs in healthcare settings, promoting safer, better quality, and patient-centered healthcare developed by public health surveillance and decision-making services (Chaudhry et al., 2006; Garg et al., 2005; Lorenzi & Riley, 2004, Raghupathi &

Raghupathi, 2014). Ultimately, adopting EHRs will alleviate healthcare costs and increase efficiency, which in turn, can potentially drive the DoD to initiate a new EHR overhaul. Additionally, all three Services can be further integrated for greater standardization in their clinical processes, something never previously seen with Armed Forces Health Longitudinal Technology Application (AHLTA).

Beginning in the early 1960s, the EHR emerged within medical research centers. By the 1980s, the VA utilized VistA, which marked the first appearance of an EHR in the government sector. Overall healthcare organizational leaders began to see the benefits of EHRs in clinical settings (Atherton, 2011). The primary mission of the DoD serves to defend the constitution of the United States, and part of this practice continues to protect information and assets related to military medicine (Gimbel & Conrad, 2009). Currently, the DoD utilizes AHLTA for its "clinical information system that generates, maintains, stores and provides secure electronic medical information for service members and their families" (Defense Health Agency, 2016a). Holistically, AHLTA's purpose lies in medical surveillance, promoting population health, and supporting force health protection efforts for service members (Defense Health Agency, 2016a).

In the early 1990's, the military and IOM identified the importance of a long-term health information exchange system, particularly dealing with a chronic multi-symptom illness referred to as the Gulf War Syndrome (IOM, 2016). Moreover, the DoD progressively determined that collecting, evaluating, and conducting surveillance on military members plays a significant role in protecting the military's most important and expensive asset—its people (Collman, 2009). The findings by the DoD, in turn, motivated the organization to develop a more robust technical information infrastructure in the support of EHRs. Subsequently, the call for a more robust technical infrastructure propelled the development of a number of programs, including the

Medical Data Repository, AHLTA, and Defense Enrollment Eligibility Reporting System and Electronic Surveillance System for Early Notification of Community-Based Epidemics (ESSENCE).

In truth, the DoD has worked for over thirty years to computerize health information, with the ultimate goal of better managing information generated by the Military Health System (MHS). Although the MHS has used his system for over a decade, clinical concerns over the system still remain a vital focus of the organization. Clinical providers report experiencing frequent downtime, slow responsiveness, system limitations, poor synergy between the training process for and actual use of the system, and poor data quality (Graham et al., 2008; Staggers, Jennings, & Lasome, 2010). Building on the MHS guidelines documenting the issues of AHLTA in primary care settings, an additional study involving ambulatory clinics explored human factors among providers. The study revealed AHLTA's limitations during patient encounters, requiring several workarounds to achieve desired patient care. The study also revealed issues in structured documentation efforts such as recording information during patient encounters (Staggers et al., 2010).

Another AHLTA limitation is the lack of visibility of patient information in a deployed location. Medical professionals cannot access patient history at deployed locations: the Middle East, Africa, South America, and other regions around the world. The lack of visibility limits providers' abilities to maintain a comprehensive medical overview of their patients in a deployed area of operation supporting combat contingencies. Subsequently, providers are limited to AHLTA-Theater in a deployed setting, which accepts just-in-time input of health information to AHLTA, but does not allow access to previous patient information (Defense Health Agency, 2016b).

Even though the MHS has achieved success regarding information technology, there is room for improvement (Collman, 2009). Further, information documentation is limited in the MHS and even the VA, which happens to be its primary stakeholder. Both departments have acted in accordance with the patient information exchange policy, and moreover, have begun to merge data since the beginning of 1998 (Jansen & Panangala, 2013). One assessment is that both organizations have the ability to extract active duty service members' data through a one-way transfer with the Federal Health Information Exchange and the Laboratory Data Sharing Interface; however, both organizations desire modernized common health information architecture to facilitate the exchange of data information among the network of stakeholders.

As the MHS adapts to transforming healthcare and the field's use of EHRs, the DoD set a directive to implement an off-the-shelf EHR. A review of available resources revealed that planning has begun to address the lack of flexibility and interoperability within the VA and deployed settings of their current system based on AHLTA. All of the subsequent studies highlighted in this chapter focus on the need for a robust information collection and storage system that promotes the health of service members and their families. The success of this initiative will be determined by whether adaptive leadership and systems thinking can be promoted in order to yield positive health outcomes within our beneficiary population. The aim for the DoD is to lessen disease and non-battle injuries in our deployed population, and furthermore, to maximize efficiency and cost-benefits with the implementation of a new system.

Background of the Military Health System

The MHS remains a complex organization that provides medical support for multiple military operations. Services provided by the MHS focus on combat medicine, healthcare during peacetime, public health activities, medical education, training as well as research and development. Three military services comprise the MHS: (i) Air Force, (ii) Navy (to include the

Marine Corps), and (iii) the Army. Currently, each Service maintains control over medical operations specific to its organization under the direction of the Defense Health Agency (DHA). Importantly, the MHS provides care to 9.6 million beneficiaries including service members, eligible family members, authorized civilians and retirees as of 2016 (Hepner et al., 2016). The military functions with possession of direct and indirect military healthcare components; in 2013, the direct care component of the military consisted of "56 hospitals, 361 ambulatory care clinics, and 249 dental clinics, operating worldwide and employing 60,389 civilians and 86,051 military personnel" (Defense Health Agency, 2014a).

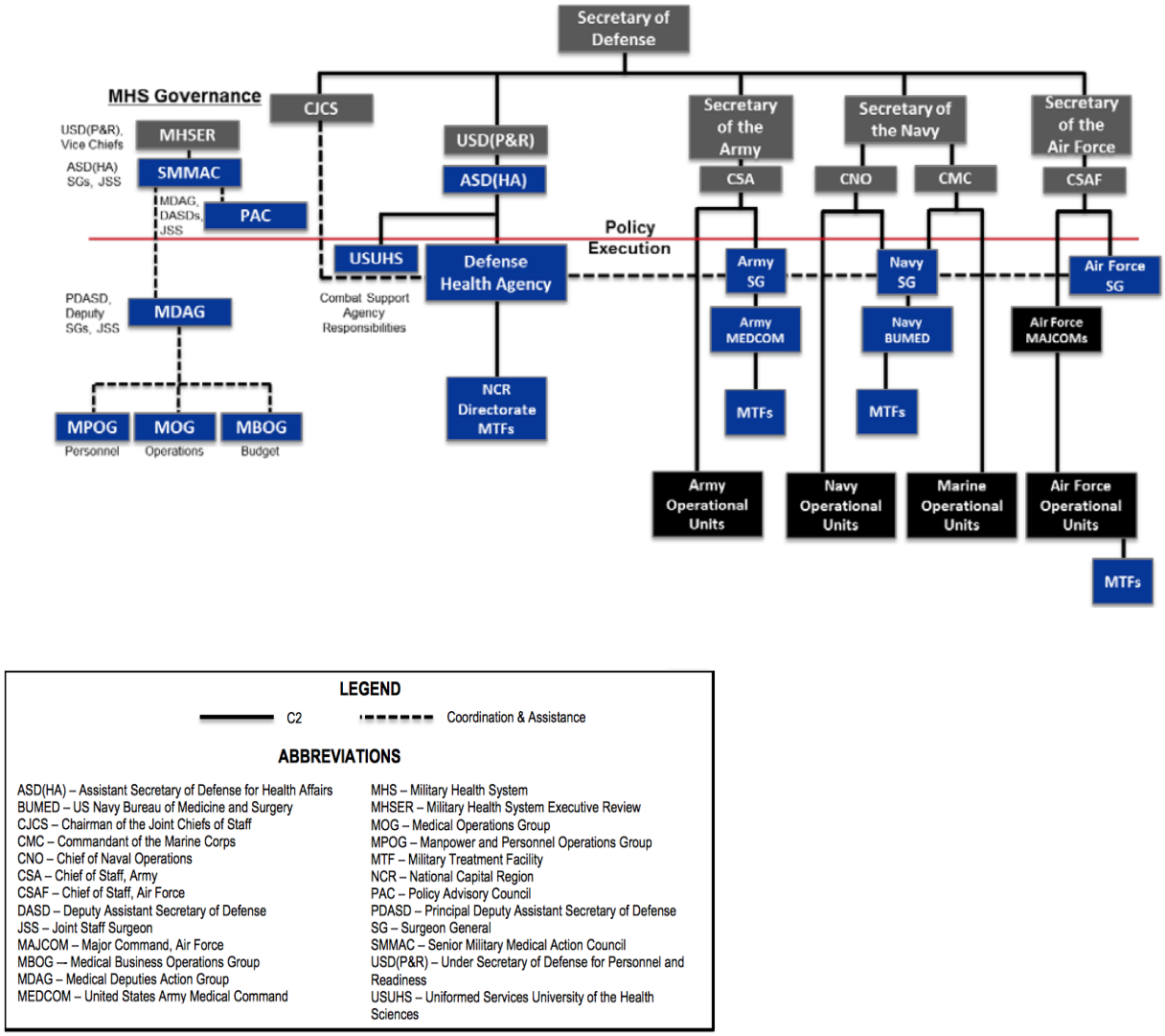
When health services cannot be supported in the MHS, the civilian hospital sector provides comparable services to military members. Notably, funding of the medical services does not occur through traditional insurance reimbursement as often is the case in the civilian sector, but through a congressional authorized budget directing the appropriations of resources and activities. TRICARE serves as the indirect care component including, but not limited to, civilian hospitals and providers operating in regional contracts.

Having faced two wars over the past decade in Afghanistan and in Iraq, the MHS has experienced many challenges throughout the years. Some of the specific challenges include producing a medically ready force, reorganizing governance structure, experiencing budgetary constraints, and lastly, integrating shared health services within an integrated system (Defense Health Agency, 2014b). Similar to many large organizations, the MHS responds to challenges such as shifting demographics, changes to quality of care, and budgetary constraints directed by Congress.

The organizational structure of MHS is hierarchical, as depicted in Figure 1 (Defense Health Agency, 2014b). The Secretary of Defense resides over the MHS, which is further

divided by each of the Services. Each Service operates its own medical system under the direction of a Surgeon General (SG), which is then further divided into operational units and local military treatment facilities (MTF). The focus of the DHA is to provide policy oversight for the SG's Services. The DHA mission integrates combat support agencies and medical services that are an integral part of the Army, Navy and Air Force, with the ultimate objective of providing a medically ready force for the United States military to deploy.

Figure 1. Basic structure of the military health system (Defense Health Agency, 2014b).



LEGEND

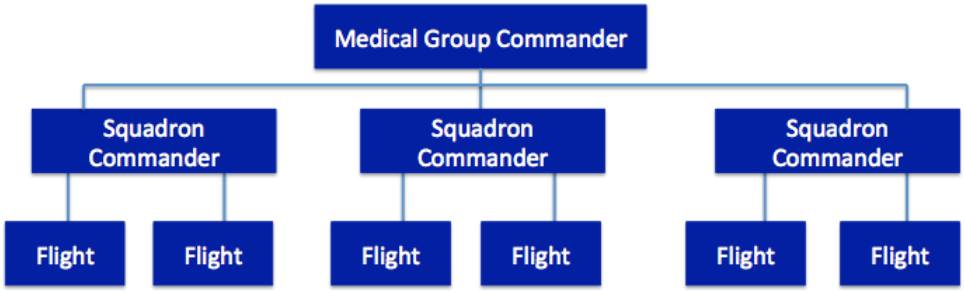
C2 — Coordination & Assistance

ABBREVIATIONS

ASD(HA) – Assistant Secretary of Defense for Health Affairs
BUMED – US Navy Bureau of Medicine and Surgery
CJCS – Chairman of the Joint Chiefs of Staff
CMC – Commandant of the Marine Corps
CNO – Chief of Naval Operations
CSA – Chief of Staff, Army
CSAF – Chief of Staff, Air Force
DASD – Deputy Assistant Secretary of Defense
JSS – Joint Staff Surgeon
MAJCOM – Major Command, Air Force
MBOG — Medical Business Operations Group
MDAG – Medical Deputies Action Group
MEDCOM – United States Army Medical Command
MHS – Military Health System
MHSER – Military Health System Executive Review
MOG – Medical Operations Group
MPOG – Manpower and Personnel Operations Group
MTF – Military Treatment Facility
NCR – National Capital Region
PAC – Policy Advisory Council
PDASD – Principal Deputy Assistant Secretary of Defense
SG – Surgeon General
SMMAC – Senior Military Medical Action Council
USD(P&R) – Under Secretary of Defense for Personnel and Readiness
USUHS – Uniformed Services University of the Health Sciences

In addition to the MHS structure, each MTF contains an organizational structure led by a medical group commander, and further divided by squadron and flight officers (Figure 2).

Figure 2. Basic structure of the military treatment facility



Similar to the civilian hospitals, the MHS is adapting to new standards, policies, and a changing demographic within the healthcare setting. MTFs express concerns over the current EHR, including both patient safety and rigid and inflexible systems (Defense Health Agency, 2014a). Consequently, the focus of the DoD is on implementing a new EHR system by 2023, providing some flexibility in time to surmount these issues, and ultimately, replacing the current rigid information systems: (i) AHLTA, (ii) Composite Health Care System (CHCS), and (iii) Theater Medical Information Program-Joint (TMIP-J). Of note, the DoD's current system is fragmented and lacks systems integration with the Veterans Affairs (VA), its sister-services as well as an important stakeholder within the DoD (Defense Health Agency, 2014a). The military medical service has utilized AHLTA for over ten years.

In 2015, the DoD awarded Cerner, Leidos, and Accenture a $4.3 billion EHR contract for a commercialized off-the-shelf system model to be used by more than 146,000 end-users[1] across 400 DoD MTFs (Defense Health Agency, 2014a). The main objective of this intense overhaul initiative is to institute a modernization system to ensure sustainability, flexibility, and interoperability among the Services as well as to provide improved continuity of care for U.S. service members and their families (Defense Health Agency, 2014a). The main product is an inpatient and outpatient Best of Suite (BoS) EHR system that enables software components to integrate with other common user interfaces, and ultimately, interface with the VA Interagency Program Office and the Defense Medical Information Exchange (DMIX) program. Additionally, the DoD incorporated a third-party business cooperation consultant, Deloitte, to assist with the implementation process.

The key DoD stakeholders involved in the program include the DHA, the Services Active, Reserve and Guard constituents, and the VA. The stakeholders have an invested interest in program implementation, and moreover, play a significant role in program end-user operability. The stakeholders directly play a significant role in planning for implementing the overall transition from the current state to the future state of the new EHR system.

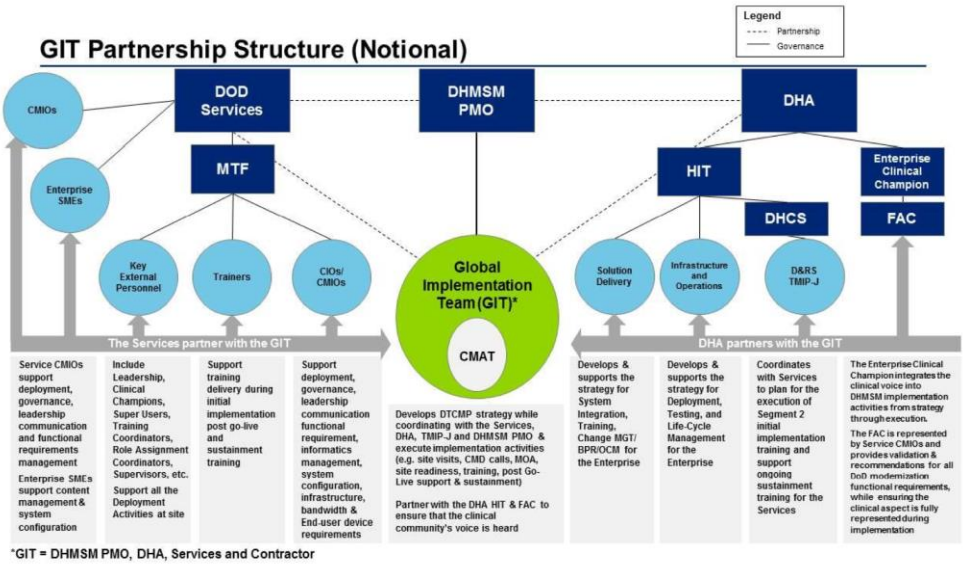
The project is managed by DoD's Healthcare Management System Modernization (DHMSM) Program Management Office (PMO) which works in close collaboration with the Services including DHA, Cerner, Leidos, and Accenture, and they orchestrate the overall implementation efforts. DHMSM PMO leverages the contractors and Services implementation processes and policies in order to promote successful implementation. The DHMSM Global Implementation (GIT) is the central hub for the deployment of the EHR. Responsibilities consist

[1] Clinical, technical, training and administrative support staff

of the development, planning, the execution of deployment, training, change management, and sustainment. Additionally, GIT provides support to end-users just getting started with the EHR. The Change Management Adoption Team (CMAT) is a division of the GIT, designed to meet the needs of the clinical community and to assist in user adoption. Additionally, the CMAT ensures stakeholder alignment and that various implementation needs are fully met.

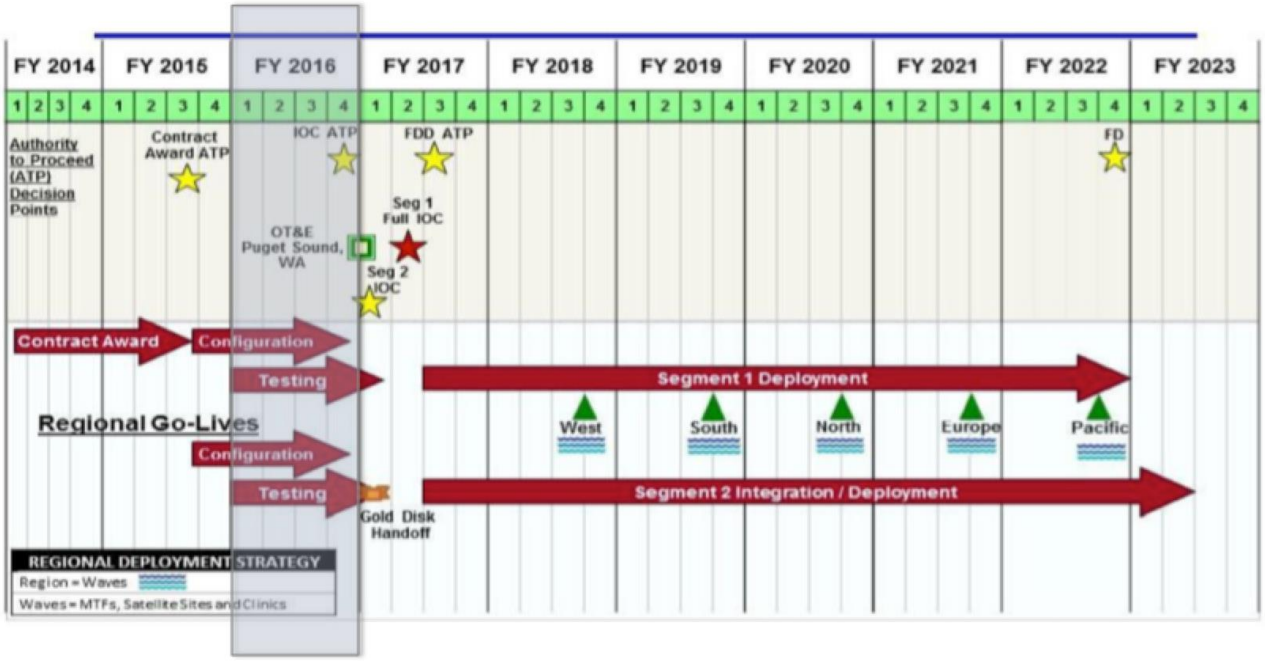
Figure 3 depicts the partnership and governance structure of the Global Implementation Team (GIT) for the new EHR overhaul. The military heavily relies on a hierarchical structure, roles and responsibilities of organizations within the military during implementation. More specifically, the DHA is responsible for defining enterprise workflows and overseeing key components in the implementation process including solution delivery, infrastructure as well as operations. Under the new EHR overhaul, the DHA will have a partnership with the GIT, which will in turn, partner with the DoD Services; and ultimately, the local MTFs. The primary function of the DoD Services is to implement training, communication, and management strategies at the MTF level.

Figure 3. GIT partnership structure (Defense Health Agency, 2014)



For the purpose of this DrPH research, a qualitative case-study, the researcher identified facilitators and barriers of sociotechnical factors existing in EHR implementation in the MHS. This DrPH research will not see the project through to the end or regional deployment to the MTFs; however, it focused on historic and current EHR implementation in the MHS. The focus allowed recommendations to be developed prior to full EHR deployment between 2017-2023. More specifically, 22 MTF sites were assessed during the testing phase; approximately 10 MTF sites are ambulatory clinics and the remaining are in-patient healthcare facilities. All the sites are located in Washington state, encompassing all medical service MTFs: the Army, Air Force, and Navy.

Figure 4. DHMSM PMO's national deployment approach and schedule
Note: The highlighted section of the timeline is the area of focus for this DrPH dissertation proposal (Defense Health Agency, 2014a)



Social and Organizational Considerations in Health Information Technology

Health information technology drives change within organizations, and is identified as a continuous, on-going adoption or process of strategic and structural modifications within an external environment (Lorenzi & Riley, 2004). Health information technology may contribute substantially to an organization's success, in the areas of promoting enhanced patient outcomes and patient safety, high patient satisfaction and long-term cost savings through the collection and dissemination of health information (Bell & Thornton 2011; Duffy, Yui, Molokhia, Walker, & Perkins, 2010; Kern, Barron, Dhopeshwarkar, Edwards, & Kaushal, 2012). Although implementing health information technology is complex with technical solutions not containing the primary solution, making adoption a challenging endeavor for organizations (Lorenzi & Riley, 2004). One of the challenging key factors to this change is the social and organizational characteristic to implementing health information technology. Sometimes noted in the literature are the unintended consequences relating to social and organizational issues, ultimately addressing an end-user's ability to adopt the systems and justifying the importance of this topic to be explored and highly considered during implementation efforts (Holden & Karsh, 2010; Lapointe & Rivard, 2005).

Statement of the Problem

While the DoD oversees approximately 56 hospitals, 361 ambulatory care clinics, and 249 dental clinics operating worldwide and employs over 146,000 personnel, its current EHR system AHLTA often results in delayed patient care because the system is too costly, lacks standard patient care practices, and system integration with the VA and the Services. In an effort to address the delays, the DoD began planning efforts to implement a new system to streamline practice efficiencies, save costs, improve patient care coordination, and secure better patient

outcomes. Although the current planning phase fosters a focus on end-user adoption such as training and technical assistance, this research focuses on the sociotechnical facilitators and barriers that may influence EHR implementation in the MHS, ultimately, to protect national resources and continued military missions.

Research Questions

Many researchers have identified technical barriers to EHR implementation; however, research focusing on the role of sociotechnical barriers and facilitators in MHS EHR implementation has been limited. Part of the EHS implementation process in organizations involves the integration of sociotechnical factors aimed at delineating. The primary goal of this research study will explore the sociotechnical facilitators and barriers that influence EHR implementation in the MHS. Even though this research study will not cover the entire project timeline, this study aimed to provide clear project recommendations prior to the MHS initiating full EHR regional deployment.

This study captured two main objectives: 1) to identify and describe the facilitators and barriers of sociotechnical factors that influences EHR implementation within the MHS guided by the *8 Dimensional Socio-Technical Model* and 2) to provide recommendations to the MHS to assist with EHR implementation. The second objective is vital for the implementation efforts for the remainder of the project that will be carried through 2023.

This study consists of three primary research questions. In order to assist with answering the primary question, the study will also contain embedded sub-questions for question one.

Primary Research Questions:

1. How do sociotechnical factors influence EHR implementation across the military health system?

Sub-Q1: What are the primary sociotechnical facilitators that promote EHR implementation?

Sub-Q2: What are the primary sociotechnical barriers that hinder EHR implementation?

2. How can the lessons learned from initial EHR implementation in the military help inform the process moving forward throughout the military health system?

3. Are civilian responses to barriers to EHR implementation similar to the barriers identified in the military context that would be applicable or helpful in the military context?

Leadership Implications

IOM describes healthcare as rapidly changing, and our healthcare delivery system as falling short in translating new technologies and knowledge into daily practice (IOM, 2001). Furthermore, the IOM report reflects on the need for additional research and development of technology in healthcare, and promotes the examination of the need for leadership. For the DoD, the current health expenditures weighing on the budget is of significant importance, and successful implementation is desired in order to reduce costs and save resources.

Unfortunately, many hospitals fail when implementing EHRs, resulting in great loss of time and money for the organization. As an example, Girard Medical Center in rural Kansas undertook an EHR initiative when purchasing an off-the-shelf EHR; after two years and millions of dollars, the hospital still did not have an EHR integrated within their organization (Schectman, 2012). Why do these projects fail? Understanding the types of challenges related to medical information systems research and development is more important than ever, with a number of developments needed in the discipline of informatics. Examining the facilitators and barriers of sociotechnical factors helps to understand the impact that health information technologies have within and on a prototypical organization.

Theoretically, organizational factors serve as a critical element to organizational change initiatives (Kotter, 2008). In a military context, leadership remains an important component in the Services and often times exist as a topic of focus during professional military training and in

other professional development opportunities. The military internally identifies leadership as needed in the organization to solve problems and create successful organizational change. Leading change may be one of the most challenging aspects of leadership since organizations include people, and their behaviors may be unpredictable as well as resistant to change (Yolitz, 1997). Military leadership, however, often focuses on personal leadership philosophy as opposed to education about the needed skills to manage change (Kelly, 2008).

This research will help support and guide military personnel during a robust organizational change initiative by providing recommendations to move the EHR project forward. Organizational leadership is a process, not instantaneously created through authority positions, and must serve as a key factor when leveraging organizational change. More specifically, a case-study exploring Inova statewide implementation of a health information technology produced several lessons learned as leaders serving as key facilitators during adoption. The leading lesson pointed to the need for an associated champion and decision-maker to guide and drive implementation among end-users. End-users appreciated a thoughtful leader during implementation, making the transition seamless (Feldman, Schooley, & Bhavsar, 2014).

To further support leadership's importance during implementation, Avgar, Litwin, and Pronovost (2012) created a framework displaying leadership involvement during health information technology adoption and explored the relationship of behaviors during several phases. The phases of investment, implementation, and use related to health information technology adoption occurred during several levels of operations (Avgar et al., 2012). Often times, the best leaders for health information change are ones with previous IT experience as they tend to be able to best articulate their vision and obtain the long-term commitment needed during the process of technological implementation (Ingebrigsten et al., 2014). Additionally,

clinical leaders that proactively collaborate with IT professionals often contribute to stronger EHR adoptions (Ingebrigsten et al., 2014).

Chapter Summary

Chapter 1 provides an overview of the military healthcare setting, the importance of health information in the military, and details regarding the DoD's EHR initiative. Additionally, the chapter provides a focus on the justification for the need of leadership when organizational change occurs. This research aims to explore facilitators and barriers of sociotechnical factors to help understand their influence during health information system implementation. Additionally, recommendations were developed to help guide full regional deployment, as this project will carry through 2023. Chapter 2 provides a literature view exploring various concepts of sociotechnical factors that are significant during a health information technology implementation process. The main goal of this project aimed to provide a transparent and comprehensive overview of the current state of the organization, and to fully understand implications of sociotechnical facilitate during EHR implementation.

II. Chapter 2: Theoretical and Conceptual Framework

Literature Review

In today's military, change tends to affect overall mission capabilities of the organization and requires major shifts in service members' mindsets and behaviors (Chinn & Dowdy, 2004). Implementing change within the military sector presents many challenges, and although the military focuses on developing leaders' philosophical principles through robust professional military education and development opportunities, a shortcoming in promoting management skills may contribute to the de-railing of several recent change initiatives in the military (Kelly, 2008).

In 2005, the MHS introduced AHLTA with a total expenditure of $4 billion, budgeted for the upkeep and the overall development of the system (Shelton et al., 2015). Due to backlash of the system from the military healthcare community, the MHS plans to go through significant organizational change implementing a new EHR. Subsequently, planning efforts are already underway for a new EHR to ultimately secure better patient outcomes and enhance patient safety. The effort for the overhaul is discussed in an MHS comprehensive report to the Secretary of Defense. Specifically, the report defines the current information infrastructure in the military as problematic and exhibiting rigid workflows and delaying patient care (Defense Health Agency, 2014b). Additionally, the report notes that three military emergency departments and some ancillary clinics still utilize the archaic method of paper charting. The report calls for a transformation of the system in order to yield better health outcomes, patient safety, improved efficiency, and enhance interoperability between the VA and the MHS, although the report also provides context regarding how the transformation may place the organization at greater risk by the virtue of the fact that the proposed changes are quite significant.

For the purpose of this study, a qualitative design based on a realist approach was utilized in order to identify facilitators and barriers of sociotechnical factors, and to understand the influence of EHR implementation in the MHS. This integrative literature review will bring forward an understanding of concepts and thinking in the context of key sociotechnical components to be considered during the implementation of health information technologies in healthcare settings. Additionally, the review of the literature focuses on systems thinking concepts related to health information technology adoption in healthcare.

Following the review of the literature is the conceptual framework of this study, describing the personal interests of the researcher, complex problem, and theoretical foundations (Ravitch & Riggin, 2012). Most importantly, conceptual frameworks may adopt evidence-based best practices or well-studied theories to guide research endeavors (Bordage, 2009). This conceptual framework ultimately guided the understanding of interrelationships of health information technology and the MHS organization, identifying several sub-factors related to the problem statement and to the future state of the project (Ravitch & Riggin, 2012).

For this research, the conceptual framework is guided by an model within the informatics field, called the *8 Dimensional Socio-Technical Model of Safe & Effective EHR Use*. The model focuses on eight sociotechnical domains of health information technology implementation, and is illustrated in Figure 5. The constructs of the model served as a guide for this chapter, and are defined in Table 1. Further, a measurement table identifies and defines the key constructs to be studied in this DrPH research (Appendix A).

Figure 5. Conceptual model: driving successful EHR implementation (Sittig & Singh, 2015; Sittig & Singh, 2010)

Table I. SUMMARY OF THE DOMAINS *8 Dimensional Socio-Technical Model of Safe & Effective EHR Use* (Sittig & Singh, 2015; Sittig & Singh, 2010)

Factor	Construct	Definition	Focus Areas
Sociotechnical	Hardware & Software Computing Infrastructure	A focus on hardware and software required to run system applications	-Hardware (computer, monitor, keyboard, etc.) -Operating system -Centralized network attached -Software -Uninterruptable power supply
	Human Computer Interface	An interface that enables unrelated entities to interact with the system and includes aspects of the system that users can see, touch, or hear	-Human computer interaction with the interface (touching, hearing, or seeing)
	Clinical Content	Everything on the data-information-knowledge continuum that is stored in the system	-Clinical content information and how that is recorded

	People	Humans (e.g., software developers, system configuration and training personnel, clinicians, and patients) involved in all aspects of the design, development, implementation, or use of the EHR (this research focus on the users of the EHR)	Personnel, clinicians using the EHR on a regular basis -Leadership -EHR Champion
	Workflow and Communication	Two-way communication between people and steps needed to ensure that each patient receives the care s/he needs at the time s/he needs it	-Clinical workflow -Communication between people
	Internal Organizational Policies, Procedures, and Culture	The organization's internal structures, policies, environment, and procedures	-Internal DoD policies & procedures, culture
	External Rules, Regulations, and Pressures	External forces that facilitate or place constraints on the design, development, implementation, use, and evaluation of health information technology in the clinical setting	-HITECH -HIPAA -Any additional external factors
	System Measurement and Monitoring	Measure and monitor the effects of health information technology on a regular basis	-Evaluation -Features and functions are available and ready for use -Measures of system availability include response times and percent uptime of the system & features and functions being used by clinicians

			-Effectiveness of the system on healthcare delivery and patient health -Identify and document unintended consequences that manifest themselves following use of these systems -Assess the quality of care

Rapidly Changing Health Systems

The 2011 report of the IOM highlights that health information technology improves the performance of healthcare professionals, reduces operational and administrative cost, and improves patient safety (IOM, 2011). Although health information technology remains a key component to improve healthcare systems, our healthcare delivery system has fallen somewhat short in translating these new technologies and knowledge into daily practice (IOM, 2001). In light of the rapid changes in healthcare today, managing change is a complex and challenging process, whether it occurs continuously, sporadically, or rarely within an organization (Lorenzi & Riley, 2004; Rashid, 2007). More compelling evidence was in the 2015 Chaos Report generated by the Standish Group in the United Kingdom, as this report estimated that 31.1% of projects were canceled before their scheduled completion date, while 52.7% of projects cost well above their original budget (Standish Group, 2014). Overall, only 16.2% of software projects were successful, delineated by these projects having been completed on time and within budget (Standish Group, 2014). Health information technology implementation research justifies the importance of understanding implementation and properly planning how to implement a new system in hopes to grapple with these problems. There is a robust history of end-user adoption

successes and barriers associated with system deployments (Lorenzi, Novak, Weiss, Gadd, & Unertl, 2008).

Failures in health information technology such as not meeting budget and lack of user adoption greatly contribute to the excessive amounts of organizational change endured by healthcare systems. To a great extent, these levels of change when implementing health information technologies can drive development, reengineering, and even redesign of an entire organization (Lorenzi & Riley, 2004). Health information technology implementation drives and impacts change within four levels of an organization: (i) operational, (ii) strategic, (iii) cultural, and (iv) political. Often times, the change can occur at one or more of these levels, resulting in radical changes to an organization and re-defining relationships both vertically and laterally within a corporation. These broad changes related to EHR implementation put organizations in a delicate situation (Lorenzi & Riley, 2004). Although health information technology implementation may appear to carry a number of risks along with the implementation process, organizations must move forward with these projects based on the evidence that information technology can potentially transform many aspects of the entire organization.

Some organizations have benefitted greatly from the adoption of a new EHR. A RAND Corporation analysis suggested that the national adoption of EHRs could lead to more than $77 to $81 billion in annual savings and reduce healthcare costs up to 20% each year (Hillestad et al., 2005; Walker, Pan, Johnston, & Adler-Milstein, 2005). Much of the savings are attributed to worker productivity gains, optimized billing, reduced medical errors, and more comprehensive data collection. Risk of failing to successfully adopt health information technology places an organization at a greater risk for monetary and other forms of resource loss, and ultimately, could result in significant loss for an organization.

Implementing health information technology has evolved over time, and with the lessons learned, organizations have applied these lessons to their subsequent projects. There are several successful implementation cases to highlight, which provide evidence that when these initiatives are successful, they greatly contribute to the event that an organization is successful in achieving its vision and goals. For instance, Kaiser Permanente (KP) is an organization that successfully implemented one of these examples. KP's organization is similar in scale to the DoD, both in population and nation-wide practices, and is a prime example of successful EHR implementation. In particular, KP set out to transform patient care and services delivered by implementing a new EHR system and a patient health record (PHR).

The leaders of KP developed a vision surrounding their new EHR system, led by their CEO, George Halvorson. Moreover, KP's project managers and leaders drove detailed planning efforts focusing on stakeholder engagement, communication planning with the staff, marketing, and honing in on leadership support. Additionally, the leadership of KP emphasized the need to identify workflows prior to implementation. KP identified several lessons learned, focusing on people and patients first and technology second, while promoting a shared vision (Poorsina, Vilardi, & Eytan, 2011). Additionally, within the organization, there was an emphasis on training as a necessity for its employees and on never underestimating the qualities training has during deployment.

Implementing health information technology pertains to the relationships between the people and technology. Through early engagement of the staff during the early planning stages, training remained a key element to success for KP. Lastly, making a connection with stakeholders was also vital to KP's success (Poorsina, Vilardi, & Eytan, 2011). As a result, all factors emerging during this project greatly influenced their end-user adoption and

implementation of their new system. For the sake of this research, these lessons learned from KP, may provide great insight into successful implementation for such a large organization as the DoD. EHR implementation should consider key sociotechnical factors, which are defined in the literature, to promote successful adoption within an organization.

Sociotechnical Factors Affecting Health Information Technology

Several key sociotechnical factors identified in the literature directly affect successful health information technology adoption. These sociotechnical factors recognize the interaction between people and health information technology. Much of the focus in the literature deals with end-user adoption, the perceptions from the end-users, and how the end-users may view the system to benefit patient care (Holden & Karsh, 2010). Additionally, much of what drives facilitation of implementation is not a stand-alone technical objective, and moreover, not a form of user adoption. Rather than technical factors, the end-users' adoption often directly relates to sociotechnical factors of how the health information technology fits within the organization as well as the technology itself (Lluch, 2011). This section of the literature review will focus on exploring eight specific dimensions adopted from the *8 Dimensional Socio-Technical Model of Safe & Effective EHR Use* described earlier in the chapter. This model proposes that the technology operates within social and organization contexts (Sittig & Singh, 2010; Sittig & Singh, 2015). The model guided the conceptual framework for this research, and the conceptual foundations grounding this study are discussed in Section II of this Chapter. Apart from the *8 Dimensional Socio-Technical Model of Safe & Effective EHR Use*, Ludwick & Doucette (2009) proposed another model that depicts "socio- technical interactions" impacting health information technology project goals and how these factors may influence EHR success (Figure 6). The green color represents barriers or concerns of providers, and the salmon color represents what

policies can be implemented to manage the concerns, with the combination of the two supporting successful EHR implementation.

Figure 6. Insulating and risk factors (Ludwick & Doucette, 2009)

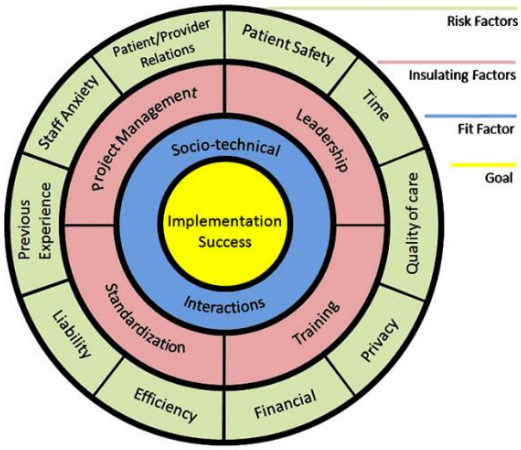


Fig. 1 – Insulating and risk factors.

Even though there are various ways to describe EHR implementation in the literature, the *8 Dimensional Socio-Technical Model of Safe & Effective EHR Use* is the model used for this DrPH research. Currently, there is a gap in the literature focusing on sociotechnical factors investigated specifically in the MHS; therefore, the research is guided with studies and models from the civilian sector. Outlined below is a comprehensive overview of each dimension.

Internal Organizational Policies and Procedures

Organizational structure affects the flow and practice procedures of EHR implementation (Ozcan & Kazley, 2008). Within the organizational structure of the military, a looming challenge for the DoD is the merger of cultures among three Services under one single EHR umbrella to include unifying standardized workflows. In addition to cultural differences among the Services, the MHS has several internal policies and procedures, presenting even more challenges in the

design, development and implementation of the new EHR. In contrast, the military garners additional policies and procedures compared to the civilian sector, such as requiring additional medical requirements for service members solely related to the medical readiness of our forces.

Culture, organizational policies, and procedures can be viewed as a "pattern of assumptions invented, discovered, or developed by a given group as the group learns to cope with external and internal pressures imposed on new members as the correct way to perceive, think, and feel in relation to organizational change" (Starfield, 1992). The military holds unique values, and moreover, exists to contain a formal chain of command modeled after a hierarchal structure. The military is highly regarded as grounded by a long history of traditions and customs representing each Service. The cultural characteristics necessitate this study. Additionally, the culture and complexity of the military hierarchical structure remains unlike any healthcare system in the nation (Ballaro & Washington, 2016).

Further, culture can be defined in several forms of exhibiting clan, market, hierarchy, or adhocracy characteristics. Ballaro and Washington (2016) revealed in their study that the MHS has several characteristics of a clan culture with a number of support systems existing within the organization. In addition, and less similar to the civilian sector, is the stringent and required medical components that service members are subject to such as meeting physical flying standards and receiving human immunodeficiency virus testing every two years. These requirements must remain on the forefront of consideration when integrating the new EHR into the MHS.

External Rules, Regulations, and Pressures

There are a number of external forces that facilitate or create a barrier for EHR implementation, specifically in the design, development and evaluation (Sittig & Singh, 2010;

Sittig & Singh, 2015). Common regulation or rule examples are HITECH, The Joint Commission, and Air Force policy that can impact the flow and design of the system. Lastly, an additional pressure for the MHS is its partnership with the VA. Our current system cannot interface with its EHR, creating a barrier in terms of patient information continuity.

People

User adoption remains a difficult factor for implementation, and is the focus for this research. People in the user adoption context may be defined as software developers, training personnel, patients, and clinicians that are involved in some way of health information technology. When implementing an EHR within an organization, the human factor must be considered during its design, development, and use. People make up a big part of the social system in an organization. Additionally, during implementation, leadership support should flow at all levels of the organization to include the policymakers and management. The support efforts should occur beyond the pilot stage of implementation and carry through the entire project. Some barriers identified pertaining to leadership factors include leaders being too emotionally committed or lacking political skill sets to drive successful implementation (Lorenzi & Riley, 2004).

Since organizations invest millions to even billions of dollars and numerous additional resources for such technology overhauls, possessing an understanding of organizational factors and successful implementation processes will optimize the investment efforts. In particular, Roger's *Diffusion of Innovation Model* helps us to explain why some EHRs are either successful or fail. In the model, five constructs are provided to help explain the acceptance of health information technology among users: (i) relative advantage (benefits from the system), (ii) compatibility, (iii) complexity, (iv) trial ability, and (v) observability of the system (Giebert,

2006). Although this model does not focus on design, development and evaluation, researchers have a better understanding of the factors contributing to user adoption (Giebert, 2006).

Workflow and communication

Workflow design that is aligned with the vision and business practices of the organization promotes successful EHR implementation. Workflow design is organized by tasks: information gathering, information reviewing, documenting information, and lastly recommending treatment. The most significant amount of time spent for an end-user occurs through information gathering during the patient visit—up to 35%. An additional 15% of end-users' time is spent on reviewing information and up to 31% for documenting information (Asan, Chiou, & Montague, 2015; Sykes, Venkatesh, & Rai, 2011). Asan et al. (2015) determined the less technologically-centered physicians spent more time interacting with the patient, indicating that workflows are influenced greatly by physicians' styles of care. Vishwanath, Singh, and Winkelstein (2010) presented one of the first studies to assess how physicians conceptualized EHRs and workflow impacts, and determined that physicians' decisions regarding the usefulness of EHRs were determined at a very early stage when enthusiasm about the new systems was at its peak. This research supports the idea that workflow design serves a critical role, and moreover, is an asset in end-user adoption. Furthermore, sociotechnical factors related to workflows, such as more productivity for the user, can be considered early on during planning stages.

Of course, communication is a continuous theme embedded in the literature, and its importance has been connected with successful EHR adoption in the extant literature. Notably, communication occurs at various levels between vendors, executive leadership, and end-users, which will all be considered in this DrPH research. Although communication may be considered a broad term, specific communication factors have been identified to contribute to EHR

implementation, such as effectively communicating the vision and the expectations regarding productivity from the EHR (Yoon-Flannery et al., 2008). In this case, effective communication does not mean communicating what the technology can do for the organization, but rather how the technology can help the organization attain the strategic vision. Further, communication is at the forefront of leadership, training, and the overall readiness state of an organization. Ultimately, effective communication ensures the readiness of an organization to various situations that may arise and ensures the execution of an organization's vision even during the planning stages, making any issues of communication a vital component to be considered during implementation.

To enhance the uptake of health information technology among end-users, training remains another important facilitator. Overall, training promotes end-user engagement with the system (Lluch, 2011). Training may occur on a one-on-one basis or through prepared training materials, and the process is ultimately designed to promote use and integration into work practices (Flynn, Gregory, Makki, & Gabbay, 2009). Research suggests that providers, nurses and other end-user staff desire training, which ultimately alleviates user frustration during implementation. Additionally, training should be an avenue to address end-user concerns and gaps in the system or business processes (Flynn et al., 2009, MacFarlane, Murphy, & Clerkin, 2006).

System Measurement and Monitoring

Evaluation of the EHR system during implementation allows an opportunity to seek feedback and addresses positive as well as negative outcomes associated with system deployment. The process provides the gateway to understanding the organization, and in a sense, promotes organizational learning. When managers encounter barriers among end-users, the

issues discovered should not be seen as a nuisance, but as a way to enhance organizational learning (Harrison, Koppel, & Bar-Lev, 2007). In fact, research promotes a robust evaluation system encompassing several aspects of implementation, with an on-going evaluation procedure aimed at problem-solving enabling the desired end-state. All in all, evaluation helps project managers in reflecting more closely on implementation and adoption, which could directly influence changes in the overall workflow design and ensure that additional training occurs (Lorenzi, Kouroubali, Detmer, & Bloomrosen, 2009). Ultimately, evaluation will help to identify, orient, and overcome barriers during implementation.

Hardware & Software Computing Infrastructure

Computer hardware refers to the settings under which the provider accesses the computers in the healthcare system. Computer placement and physical access greatly influence end-user adoption. Physical infrastructure barriers may refer to computer layout, overcrowding, and distracting illumination that may affect adoption (Harrison et al., 2007). When the physical infrastructure is not addressed during the planning phases, limited access may occur by the end-user, reducing face-to-face communication between the patient and provider in addition to increasing distractions (Asan et al., 2015).

Human-Computer Interface & Clinical Content

Human computer interface occurs when the hardware and system are both operationalized with the user. Hardware and system-related issues can be a common barrier during implementation, specifically in the areas relating to poor display of information, cognitive overload, navigation issues and workflow design (Clarke et al., 2013). This concern can directly be related to loss of work productivity and ultimately user adoption. Importantly, clinical content remains an important factor in user adoption. This term refers to data-information-knowledge

field that is stored in the system (Sittig & Singh, 2010; Sittig & Singh, 2015). A lack of streamlined clinical content in an EHR could result in improper patient documentation. Further, providers being a part of the development of the clinical content in an EHR can be instrumental in facilitating user adoption, as their participation allows for providers to participate in a meaningful way during the pre-implementation process (Leslie, Heard, Garde, & McNicoll, 2009).

Systematic Thinking for Health Information Systems

Worthley is widely known for introducing the concept of systematic thinking or systems thinking in the context of information system implementation. Worthley defines the methodology as "a way for leaders to anticipate, recognize and address barriers hindering successful implementation" (Worthley, 2000). Indeed, systematic thinking serves as a process to ensure that leaders ask the right questions and receive the best answers during project implementation, and strives to view the project from the beginning to end in order to gain knowledge from the actual experience (Worthley, 2000). The inherent actions of systematic thinking refer to understandings surrounding interrelationships, specifically to understand multiple perspectives and to be fully aware of the boundaries of a situation or even a severe problem within an organization. Thinking systematically allows for the expansion of understanding how the situation is viewed by the organization, reveals underlying relationships and characteristics, and lastly, provides perspectives on the individual attitudes of the situation (Williams & Hummelbrunner, 2010).

Applying systematic thinking concepts recently emerged in the healthcare setting (WHO, 2009). If healthcare frameworks seek only short-term goals, any quick performance improvement can put the organization at risk for failure, and it will not take the organization far

enough to achieve its strategic desires (Senge, 1990). Instead, organizations should focus on fostering aspiration, reflective conversation, and understanding the complexity of the system to solve complex situations such as EHR implementation (Senge, 1990). As more organizations adopt health information technology as a means to improve efficiency and patient safety, implementing these systems endure complex system-related problems, and generally do not follow a straight forward approach (Raza & Standing, 2008). One prominent claim is that not addressing these systemic problems may contribute to the lack of adoption of health information technology (Raza & Standing, 2008).

The approaches to system thinking promotes framing the problem as a pattern of behaviors over time, understanding the context of relationships to the system, operational thinking, and lastly, loop thinking in which the situation is viewed as an on-going process (WHO, 2009). This definition will be used to describe the MHS system for this DrPH research. To date, the MHS planning process has neither outlined nor embraced system-thinking concepts in its development. The development of a successful EHR involves new systematic thinking approaches and leadership applications. Due to the complexities and challenges adopting EHRs, the DoD EHR will need to take more innovative approaches in their implementation in order to be successful. More specifically, the promotion of embracing organizational learning and systems thinking will leave the organization in a stronger state, able to cope with barriers and issues. This DrPH research drew on experiences and perspectives identified during environmental scans, which were used to develop the problem statement.

Conceptual Framework

Conceptual models are instrumental in allowing a researcher to be selective, and under their guidance, a researcher is able to identify the most significant factors to be studied as well as

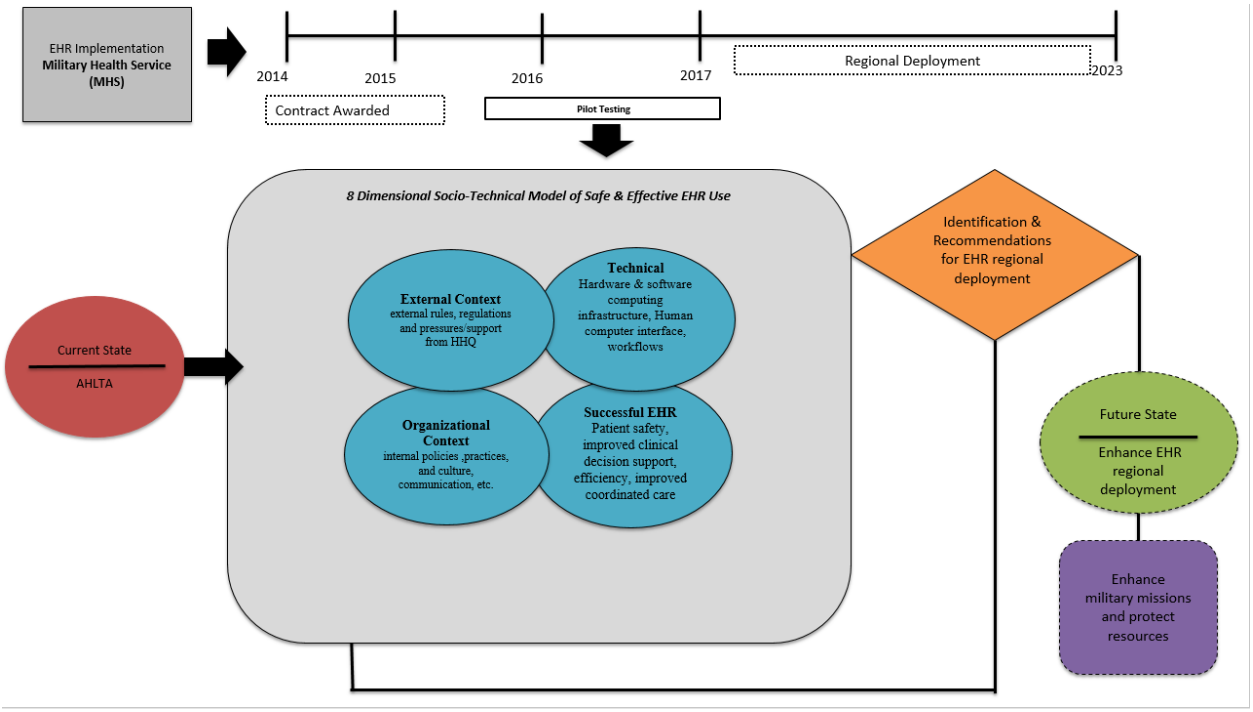
the underlying relationships that are most meaningful (Miles, Huberman, & Saldana, 2014). This research is guided by the *8 Dimensional Socio-Technical Model of Safe & Effective EHR Use* (Figure 7). This model provides a comprehensive approach which addresses several factors associated with EHR implementation, and was a result of a combination of several sociotechnical models such as the *Henriksen's Model* and the *Interactive Socio-Technical Analysis (ISTA) Framework*. A unique tenet of this model deals with the ability to further break down technological components in order to enable researchers to better understand and explore important aspects such as hardware and software as well as their relationship to policies and monitoring processes (Sittig & Singh, 2010; Sittig & Singh, 2015). This model focuses on the design, development, use, implementation, and the evaluation of health information technology (Sittig & Singh, 2010; Sittig & Singh, 2015). The particular model was selected to guide this research due to its well-known application in the field of informatics, rendering its tenets a good fit to explore the unique components of the MHS.

The conceptual model displayed in Figure 7 provides an overview of the qualitative research design proposed for this DrPH research. Although the conceptual framework outlines the MHS timeline for the entire EHR project, the DrPH research solely focused on the pilot-testing phase of implementation prior to full deployment, which is highlighted in the model and supported with a systematic literature review. The model will explore all eight main constructs as demonstrated in Table I: (i) hardware and software computing infrastructure, (ii) human computer interface, (iii) clinical content, (iv) people, (v) workflow and communication, (vi) internal organizational policies, procedures and culture, (vii) external rules, regulations, and pressures, and (viii) system measurement and monitoring. The model will explore the three main constructs' external context, organizational context, and organizational communication.

Methodologically, this DrPH research was guided by qualitative principles in order to provide rich and detailed recommendations to the DoD upon moving forward with this EHR project.

The short-term outcome that will not be evaluated during the research is seeing through the EHR adoption by MHS. The long-term outcomes projected, not observed in this study, were chosen to be the enhanced quality of care/patient outcomes, practice efficiencies, enhanced flexibility and interoperability, and enhanced use of data.

Figure 7. Conceptual Framework



III. Chapter 3: Study Design, Data, and Methods

Research Design and Methodology

As indicated in Chapters 1 and 2, the DoD is investing billions of dollars and resources to implement a new EHR successfully, which is imperative as it spends the majority of the defense and VA budget on medical services for military service members and their families. In order to answer the proposed research questions, this study is framed as a qualitative content analysis exploratory case-study that aims to understand the sociotechnical facilitators and barriers that have influenced EHR implementation within the MHS.

Since this research aims to take an iterative approach to solve a complex problem, it aligns well with a qualitative approach (Stringer, 2014). Qualitative methods are used to uncover "emerging themes, patterns, concepts, insights, and understandings" (Patton, 2002). Qualitative approaches also provide several other advantages in research such as their capacity to improve existing practices and programs, and their tendency to allow greater participatory and collaborative engagement with the participants in the context of the study (Maxwell, 2012). A qualitative research design was appropriate for this research as it promotes reflection from the data collected to better understand the system.

In addition, a case-study is fitting for this research because this is a complex issue and EHR implementation does not occur often in the MHS. Thus, this requires an in-depth analysis of behaviors (Yin, 2013). Case-studies primarily have been used in a social behavior context, but the use of this design in management and business fields is now very common (Parker & Roffey, 1997).

There are several advantages for using a case-study design. Some of the advantages include being able to isolate the phenomenon, allowing for a collective and intrinsic approach,

and lastly, helping to explain real-life complexities within an organization (Zainal, 2007). Additionally, detailed observations captured in the methodology enable researchers to study many different aspects, to examine them in relation to each other, and to view the process within the context of the environment (Gummesson, 1988). The objective is to attain well-supported, thoughtful recommendations emergent from the data, which will, ultimately, be utilized in order to provide recommendations for EHR regional deployment within the MHS.

Content analysis is a systematic overview of text using quantitative or qualitative methods and is concerned with the "aboutness" of the content—identifying themes for example (Ward, 2012). This search for themes aligns well with a qualitative approach. To this end, for this study, a content analysis will be the primary analytical design couched in a qualitative approach. Utilizing a qualitative research approach under a content analysis research design, this study aims to identify the barriers and facilitators that influence EHR implementation in the MHS guided by the *8 Dimensional Socio-Technical Model of Safe & Effective EHR Use*.

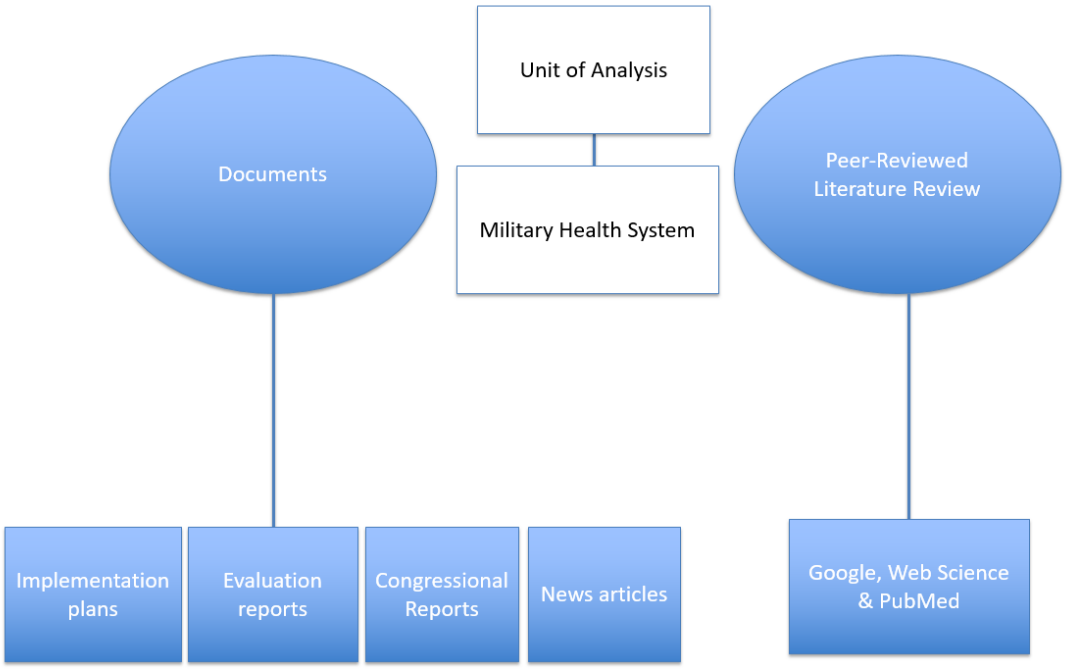
Finally, a goal in qualitative studies is to achieve the triangulation of data, or a method that includes cross-checking multiple data sources to evaluate the convergence in the data. To achieve triangulation in this study, a document review including implementation plans, evaluation reports, congressional reports, and news articles, as well as a literature review of the relevant peer-reviewed literature will be considered as the data sources.

Unit of Analysis

Qualitative analysis takes a systematic, collaborative approach to problem solving. A qualitative research method can be applied during the EHR implementation, and, retrospectively to past EHR implementations. The GENESIS documents were sourced by the DHA, and they relate to the new EHR initiated by the MHS. The data design was drawn from the conceptual

model's key constructs adopted from *8 Dimensional Socio-Technical Model of Safe & Effective EHR Use* (Miles, Huberman, & Saldana, 2014). This qualitative analysis reviews multiple sources of evidence embedded within the literature review and forms of documents, which allow the researcher to address a wide-range of behavioral issues through the examination of the unique history surrounding the issue of the MHS implementing EHRs such as AHLTA and GENESIS (Yin, 2013).

Figure 8. Scheme of the Unit of Analysis: Military Health System



Data Collection Procedures

Three primary questions were examined in this study:

1. How do sociotechnical factors influence EHR implementation across the military health system?

Sub-Q1: What are the primary sociotechnical facilitators that promote EHR implementation?

Sub-Q2: What are the primary sociotechnical barriers that hinder EHR implementation?

2. How can the lessons learned from initial EHR implementation in the military help inform the process moving forward throughout the military health system?

3. Are civilian responses to barriers to EHR implementation similar to the barriers identified in the military context that would be applicable or helpful in the military context?

The questions are characterized in the context of 'what' or 'how' surrounding a phenomenon which allows for a more exploratory study (Yin, 2013). Moreover, the research questions refer to promoting EHR implementation. For purposes of this research, the long-term success factors of the project aim to contribute to reducing costs, granting more flexibility, enhancing patient safety, and improving interoperability with the VA and the reserve/guard constituents. Triangulating the data in this research study remains an important element of this research as the procedure validates and completes the results of the inquiry within this study (Ammenwerth, Iller, & Mansmann, 2003). Triangulation of the data provides an additional layer of rigor for the study.

Peer-Reviewed Literature and Document Review

An extensive peer-reviewed literature review can provide a robust overview of a specific or unique topic to answer these research questions. The literature review represents a comprehensive overview of the unique topic of EHR implementation within the MHS. The MHS remains a unique organization, with a culture different from civilian sector hospitals. Along with the extensive literature review are document reviews of the implementation plans, evaluation report, news articles and congressional reports. The implementation and communication plans guide the military's project and the evaluation report details the status of the pilot-testing phase.

Data Analysis Plan

Document Review

A document review in this study was valuable to help address gaps or lingering questions related to this complex issue that were not addressed in the literature review. Documents were uploaded to ATLAS.Ti 7 © qualitative analysis software program. Code families were created and drawn directly from the *8 Dimensional Socio-Technical Model of Safe & Effective EHR Use* (Appendix B and C). Code families were developed based on related codes identified in the conceptual framework, while allowing for emerging codes from the data to be captured. The research examined the text for themes and patterns.

Literature Review

The researcher conducted an extensive literature review of both peer reviewed literature and news articles found on the internet. The search scope was focused specifically on the EHR implementation in the MHS since it is such a unique organization. Google Scholar, PubMed, and Web Science data searches were conducted in an iterative manner during the months of April. Key search terms are located in Table II. The inclusion criteria set for this study were: 1) articles from peer-reviewed journals and 2) articles had to be related sociotechnical facilitators and barriers. Search terms in described on table II. The peer-reviewed literature discussing civilian medical EHR implementation was excluded from this study. Due to the limited amount of relevant data being available as well as a sample size, the timeframe of the articles was established based on availability, meaning articles were accepted that were over ten years from publication date. Since AHLTA was initiated ten years ago, provides further justification to accept literature over ten years from publication date.

The researcher conducted a scan of the articles in order to determine applicability to the research questions. Additionally, all articles were coded in their entirety. A small number of

studies exist on this unique topic. The researcher evaluated the relevance of retrieved articles against the inclusion criteria. Each article was uploaded to ATLAS.Ti 7 © qualitative analysis software program and codes were applied to all peer-reviewed articles.

Table II. KEY TERMS SEARCHED IN THE LITERATURE

EHR	Unit of Analysis	EHR Systems used in the DoD
Implementation	Military Health System OR Military	GENESIS OR AHLTA OR Health Information Technology

Data analysis. Code families were created and directly drawn from two of the domains comprising the *8 Dimensional Socio-Technical Model of Safe & Effective EHR Use* (Appendix A). They were applied to the entire sections of each article and document. Furthermore, the researcher made self-addressed memos to help guide the final conceptualization needed to answer the research questions.

The researcher created a comparison table. This table compared the findings between the peer-reviewed literature and documents to identify the convergent and divergent factors, and, thus, showing the triangulation of the data. The model listed the code on the y-axis and the data source - documents (news articles, evaluation report, implementation plans, congressional reports) and literature - on the x-axis. If a code was identified in the sample, a placement of "X" was indicated on the table. This shows how the data was triangulated in this research.

Additionally, in the discussion chapter, the research conducted a targeted literature review from civilian EHR implementation (large hospitals) to compare barriers in the context of the military.

A second coder, with experience in qualitative analysis, reviewed three different data sources. The articles will be provided to the second coder along with the a-priori code book. The second coder will code the documents, and the second coder and research will meet to discuss and compare the coding outcomes. The second coder will use the same analysis tool as the researcher, ATLAS.Ti 7©. Reflective journaling will be utilized following the coding and analysis of the document review to help contextually ground the data and enhance validity of the study.

Data Management

Data was managed in the ATLAS.Ti 7© database on the researcher's personal computer. Themes and patterns were recorded on a Microsoft® Excel spreadsheet. No personally identifiable information was used in this study; therefore, no information was formally protected. All documents were approved and released to the researcher by the DHA.

Validity/Reliability

A qualitative study can be evaluated in terms of transferability, dependability, confirmability, and credibility. Transferability refers to evidence supporting the generalization of findings to other contexts and is similar to validity of quantitative studies. Dependability occurs when the research methods can be replicated. Case studies receive criticism as a research tool for their perceived lack of rigor (Zainal, 2007); therefore, the study strategy to maintain transferability and dependability in this research was to promote rich data collection through triangulation of data to validate findings, unlike quantitative studies that leverage statistical interface. The researcher maximized the dependability and credibility of this research by including a second coder to promote consistency in the methodological approach. Additionally,

the researcher had stakeholder checks from key informants to evaluate interpretations and conclusions that emerged from the data. The researcher asked questions such as, “does this represent your experience” or “have I captured the essence of this event?” The researcher met with the stakeholders during the conclusion of big milestones in the data analysis and in the conclusion of the results and discussion analysis. Further, a research journal was maintained by the researcher to track the methodology of the qualitative research, defined in the literature as an audit trail (Merriam & Tisdell, 2016). Journals can be instrumental in describing the approach to data analysis, and moreover, promote the thought of new ideas connected to the data that can help to build an argument. Finally, journals can also promote reflective conclusions.

Confirmability refers to the researcher’s biases, believability of the findings, and trustworthiness of the study and should be taken into account. The confirmability of a research study is strengthened by methodological choices such as the triangulation of data and backing up the support for the results through stakeholder checks. Simplifying complex data also helps to improve credibility in studies.

Study Summary

A qualitative thematic analysis methodology will be used to identify the convergent and divergent themes to answer the research questions. The researcher will code the documents in ATLAS.Ti 7 ©. The following is a list of documents reviewed during this analysis.

- News articles (N=5)
- GENESIS evaluation reports (N=2)
- Implementation plans (N=2)
- Congressional reports (N=4)
- Peer-reviewed literature (N=23)

As noted in Chapter 3, the methodology proposed was the application of *a-priori* codes and emergent codes to all the documents (Appendix C), otherwise known as inductive and deductive coding. The researcher first examined the frequency and co-occurrence to identify themes and categories in the data. The frequency and high co-occurrence of a construct alone does not necessarily mean that the data is critical. Therefore, constructs significant to this DrPH research were identified based on an examination of all the constructs. When codes were too broad in the *a-priori* code book, emergent codes that were seen in the literature to help describe implementation were selected. As mentioned in the previous chapter, this research allows for emergent codes. “Emergent” design in qualitative research is defined as a process that is not predetermined in the methodology, and one that is not finalized (Suter, 2012).

IV. Chapter 4: Results

General Overview

The data collected in this research provide answers to three research questions (see page 13). Research question one was, "how do sociotechnical factors influence electronic healthcare record (EHR) implementation across the military health system?" with two sub questions that address sociotechnical facilitators and barriers that influence EHR implementation. Research question two was, "how can the lessons learned from initial EHR implementation in the military help inform the process moving forward throughout the military health system?" Lastly, research question three was, "are civilian responses to barriers of EHR implementation similar to the barriers identified in the military context that would be applicable or helpful in the military context?"[2] Four assumptions were made prior to data analysis: 1) cybersecurity and internet difficulties will be a barrier for implementation, 2) lack of usability and efficiency will be a concurrent codes, 3) lack of suitable training will remain a common trend in the data, and 4) the system will not be suitable for the Military Health System (MHS). The reasoning for these assumptions is primarily based on the researchers experience with the military EHR system and discussions with senior leadership on the issues. Further, the order of construct is outlined by highest frequency since this was a document review.

Summary of results

Forty-four total codes were applied to the text during analysis. Fourteen *a-priori* codes were identified during the development of the methodology. Thirty emergent codes were incorporated during analysis. The *a-priori* codes were categorized by the external context, organizational context, successful EHR, and technical. These categories were identified and

[2] No data was collected for research question 3, refer to chapter 5

grounded from the *8 Dimensional Socio-Technical Model of Safe & Effective EHR Use* that views EHR implementation as both technical and behavioral. Since the military is a very complicated system to navigate it is easier to categories the technical and behavioral both externally and internally, while leaving the technical factors in its own category. The external context of EHR implementation is defined as activities attributed by higher headquarters that occur outside the Military Treatment Facility (MTF). The organizational context is defined as activities occurring within the organization. Technical factors are defined as procedural components associated with EHR implementation. Lastly, successful EHR is the achievement of the military having better continuity of care and patient safety as a result of a new EHR. The five most frequently occurring codes were *people, interoperability, hardware and software infrastructure, efficiency, and system measuring and monitoring*. Definitions of the codes, as well as all codes that were used for this study, can be found in Appendix C. The 8 dimensional socio-technical model guided the *a priori* codes and since informatics is such an evolving field this research anticipated for several emergent codes. Of the most frequently occurring codes, all but one (*interoperability*) consisted of an emergent code. Table III provides a summary of the results for chapter four.

TABLE III: SUMMARY OF RESULTS*

Construct	Select Document Key Statements That Help to Demonstrate the Code	Document frequency / Number of Mentions	Summary of key statements	Corresponding Research Question(s)
People	*Military leadership is vital to support users during the transition to eHealth operations.* *MTFs will identify key representatives to support this deployment effort.*	109	Only one discussion in the documents placed emphasis on leadership as being a vital component The GENESIS implementation plan identified that people will play a key role in	Facilitator and barrier (RQ1) Lessons learned on collaboration, creating an advisory board, and needing better training from the trainers (RQ2)

			EHR deployment.	
Interoperability	*We must have a Military Health System capable of documenting health care provided to service members throughout their time in the military and be accessible to the Veterans Administration (VA) when they leave military service.*	76	The DoD and VA are working towards a EHR system of interoperability: GENESIS	Facilitator (RQ1)
Hardware and software infrastructure	*Identify network issues vs. GENESIS issues* *Users reported increased lag times when other IOT&E sites went live, suggesting the current system and supporting network configuration will not support the hundreds of additional sites planned for MHS GENESIS.*	64	Several technical issues were identified for both GENESIS and AHLTA that caused mission failure	Barrier (RQ1) Identify network issues prior to implementation (RQ2)
Efficiency	*We can see lab results easier. We can communicate with each other and our nurses a lot easier.*	44	Aspects of GENESIS enables providers to access more health data	Facilitator (RQ1)
System measuring and monitoring	*Defense Health Agency will disseminate communications and updates on initial implementation training to the Services; track all risks, concerns, issues, and other feedback from the sites* *Department leads develop formal process to track issue resolution tickets* *Provide regular updates to staff and leadership on status*	42	Measuring and monitoring were established in the beginning of EHR implementation Process improvement was a focus	Facilitator (RQ1) Develop a formal process to track trouble tickets and ensure leadership has situational awareness. (RQ2)
Workflow	*Pharmacists, in particular, found the system difficult to use. They were working extended hours due to longer prescription order workflows. Pharmacies averaged fill times of 45*	42	Although workflows were designed prior to implementation, it was noted in the documents that some workflows caused	Barrier (RQ1) Improve workflow design and cognitive support to clinicians

	minutes or more for prescriptions that previously averaged 15 to 20 minutes. (GENESIS evaluation report) *EMR improvements to provide better cognitive support to clinicians. (GENESIS evaluation report)*		delays patient care.	(RQ2)
Communication	*The DHA will solicit communications preferences and best practices, and training lessons learned from the MTFs. (EHR implementation plan)*	39	There were several established communication forums from the external and internal organizational environments	Facilitator (RQ1) Continue to improve collaboration
Lack of efficiency	*MHS GENESIS is not operationally effective because it does not demonstrate enough workable functionality to manage and document patient care. (GENESIS evaluation report)*	38	GENESIS is not operationally effective	Barrier (RQ1)
Implementation of policies and procedures	*The MTF Clinical Champion responsibilities will be developed and determined by the Enterprise Clinical Champion (EHR implementation)*	33	The implementation plans outlined several policies and procedures for the implementation of GENESIS	Facilitator (RQ1)
Training	*Inadequate training was perceived to be the reason for quitting by 30 percent of participants. (GENESIS evaluation report)* *MHS GENESIS exhibited usability problems that the training could not overcome. (GENESIS evaluation report)*	32	Usability problems could not be overcome by training Overall GENESIS trainers provided inadequate training	Barrier (RQ1) All department team members should be trained as super users/Improve training and system documentation for both users and adoption coaches. (RQ2)

Lack of Patient Safety	*Users questioned the accuracy of the information exchange between external systems and MHS GENESIS, which could jeopardize patient safety due to inaccurate patient medical data. (GENESIS evaluation report)*	16	GENESIS posed patient safety concerns due to inaccurate information exchange	Barrier (RQ1)
Leadership Characteristics	*Effective leadership involvement is required to align and guide priorities around the changes needed to support an EHR implementation. (EHR implementation plan)*	17	There was limited discussion about leadership involvement in the documents	Facilitator (RQ1)
Medical Readiness	*MHS GENESIS displayed incorrect patient immunization data and immunizations did not populate in the appropriate Medical Readiness System.*	5	Medical readiness was hinder for service members	Barrier (RQ1)
Federal, state, local health regulation	*MHS GENESIS does not support National Provider Identification numbers or National Drug Codes, forcing pharmacists to do manual searches for medications to dispense.*	32	GENESIS is not complying with federal, state, or local health regulations and took risks upon implementation	Barrier (RQ1)

*The constructs listed support answering the research questions and are explained in more detail in chapter four.

There were five data sources utilized for this study: (i) newspaper articles, (ii) EHR implementation plans, (iii) GENESIS evaluation reports, (iv) congressional reports, and (v) peer-reviewed literature. Using multiple sources helps to validate the findings. As shown in Table IV, codes appeared across data sources. Of note, *Hardware & Software Computing Infrastructure, system monitoring and measuring, leadership characteristics, background, interoperability,* and *health data* were identified across all five sources.

Table IV is a comparison table that compared the findings between the peer-reviewed literature and documents to identify the convergent and divergent factors, and, thus, showing the

triangulation of the data. The model listed the code on the y-axis and the data source - documents (news articles, evaluation report, implementation plans, congressional reports) and literature - on the x-axis. If a code was identified in the sample, a placement of "X" was indicated on the table. This shows how the data was triangulated in this research. Five codes (*background, health data, interoperability, system measuring and monitoring*) were identified in all five data sources. Although not codes were seen in each data source; however this provides the research to understand new concepts or lessons learned if the construct was not presented in the literature. Additionally, some constructs had specific mention in the evaluation reports that might be unique in this research. Lastly, some findings were only mentioned in the congressional reports and literature that were not mentioned in the news articles or evaluation reports which gleans to the uniqueness of EHR implementation. An example is that the construct interoperability was only mentioned in the congressional reports and literature. Although not mentioned in the other data sources it still remained an important construct in this research.

Table IV: CONSTRUCT COMPARISON TABLE OF DATA SOURCES

Emergent and *a-priori* Codes					
	Literature Review	**News Articles**	**Congressional Reports**	**DHA Implementation Plans**	**DHA Evaluation Report**
Accuracy					**X**
Background	**X**	**X**	**X**	**X**	**X**
Cost	**X**		**X**		
Culture of data use	**X**				
Deferred Documenters	**X**				**X**
Delay	**X**	**X**			
Health data	**X**	**X**	**X**	**X**	**X**
Healthcare management					**X**

Inadequate training	**X**				**X**
Interoperability	**X**	**X**	**X**	**X**	**X**
Lack of clinical data					
Lack of coordination of care	**X**				**X**
Lack of efficiency	**X**				**X**
Lack of patient safety	**X**	**X**			**X**
Lack of suitability					**X**
Lack of survivability					**X**
Lack of usability	**X**				**X**
Lack of workflow		**X**			**X**
Lack of improved clinical decision support					
Learning health system	**X**	**X**	**X**		**X**
Medical readiness	**X**				**X**
Mental workflow	**X**				
Operational workarounds	**X**				**X**
Organizational readiness				**X**	
Patient privacy	**X**		**X**		**X**
Process improvement	**X**				**X**
Provider productivity	**X**				
Suitability					
Survivability					
User satisfaction	**X**		**X**		**X**
External context					
	Literature Review	**News Articles**	**Congressional Reports**	**DHA Implementation Plans**	**DHA Evaluation Report**

Support and constraints from higher headquarters or consultant partner	**X**	**X**		**X**	**X**
Federal, state, and local healthcare regulations	**X**		**X**		**X**
Internal organizational context					
	Literature Review	**News Articles**	**Congressional Reports**	**DHA Implementation Plans**	**DHA Evaluation Report**
System monitoring and measuring	**X**	**X**	**X**	**X**	**X**
Implementation of policies and practices	**X**			**X**	**X**
Communication	**X**			**X**	**X**
Leadership Characteristics	**X**	**X**	**X**	**X**	**X**
People	**X**			**X**	**X**
Technical					
	Literature Review	**News Articles**	**Congressional Reports**	**DHA Implementation Plans**	**DHA Evaluation Report**
Hardware & Software Computing Infrastructure	**X**	**X**	**X**	**X**	**X**
Computer Interface					**X**
Workflow				**X**	**X**
Successful EHR					
	Literature Review	**News Articles**	**Congressional Reports**	**DHA Implementation Plans**	**DHA Evaluation Report**
Efficiency	**X**	**X**			**X**
Improved coordination of care	**X**			**X**	**X**

Clinical decision support	**X**	**X**			**X**
Patient safety	**X**	**X**		**X**	**X**

Results

Research Question 1:

1. How do sociotechnical factors influence electronic healthcare record (EHR) implementation across the military health system?

The following research question was answered based on these results.

People

The construct of *people* was defined as individuals (e.g., software developers, system configuration and training personnel, clinicians, and patients) involved in all aspects of the design, development, implementation, or use of the EHR. Moreover, *people* was the most grounded construct and was mentioned a total of 109 times in the documents. In addition, the construct of *people* strongly co-occurred with the constructs of *communication* and *training*, as depicted in Table V. These constructs were *a-priori* codes. Then, a closer examination of the content related to those constructs with higher co-occurrences was analyzed. The sociotechnical construct *people* helps to answer research question 1. *People* is identified as a facilitator in EHR implementation in this data.

The excerpt from the implementation plan outlines the need to identify roles and responsibilities for people in order to support the deployment of the EHR.

MTFs will identify key representatives to support this deployment effort. MTF Key Personnel. These personnel will coordinate with the DHMSM PMO and the Services to prepare for deployment of the EHR System at their respective site and identify MTF staff to participate in the training and use of the product. Additionally, IT representatives are requested to ensure

implementation of EHR System is in accordance with local business processes and protocols. (GENESIS evaluation report)

Although not specifically related to EHR implementation, the results outline the need for military leadership to support users during the transition to eHealth operations.

Military leadership is vital to support users during the transition to eHealth operations. (literature)

TABLE V: C-COEFFICIENTS FOR THE CONSTRUCT PEOPLE AND MOST STRONGLY SELECT CO-OCCURRING CONSTRUCTS

People	**r^2**
Communication	**0.12**
Culture of data use	0.01
Efficiency	0.03
Hardware and Software infrastructure	0.06
Health data	0.01
Healthcare management	0.01
Human computer interface	0.02
Implementation of policy and procedures	0.01
Improved coordination of care	0.01
Inadequate training	0.06
Interoperability	0.02
Lack of efficiency	0.03
Lack of patient safety	0.03
Lack of usability	0.04
Lack of workflow	0.02
Leadership characteristics	0.05
Operational workaround	0.04
Process improvement	0.02
Provider usability	0.01
Support and constraints from higher headquarters	**0.07**
System measurement and monitoring	0.06
Training	**0.08**
Usability	0.02
Workflow	0.02

Co-occurrence of constructs: People and Communication (r^2 .12)

Of note, *people* co-occurred with the construct *communication* sixteen times in the documents. *Communication*, in the context of this research, is defined as communication disseminated orally, verbally, or written from the internal organization related to EHR

implementation that has impacted its deployment. Users provided feedback in the MHS GENESIS Initial Operational and Evaluation (IOT&E) Report, which communicated increased lag times and noted the lack of surrounding human and computer interface.

The second major issue noted by the users also focused around technical issues. This construct also co-occurred with *inadequate training* and *operational workarounds*, these constructs are defined in Appendix C. *Inadequate training* and *operational workarounds* are technical, emergent constructs.

Overall the two excerpts noted several issues with the system, mostly technical related.

Users reported increased lag times when other IOT&E sites went live, suggesting the current system and supporting network configuration will not support the hundreds of additional sites planned for MHS GENESIS. (GENESIS evaluation report)

User survey comments from the three IOT&E sites reported similar problems that included undocumented and inconsistent workarounds, excessive system latency, inaccurate patient information, badly assigned user roles, poor user training, uneven assistance from on-site trainers, and lack of visibility of the status of trouble tickets. (GENESIS evaluation report)

Co-occurrence of constructs: People and Training (r^2 .06)

Training also co-occurred with the construct *people*. *Training*, for the purpose of this research, was defined as the action either of teaching a person or a particular EHR skill through computer-based training, lectures, or other one-on-one instructive settings. The constructs *training* and *people* co-occurred eleven times throughout the documents. First, the need for a robust training program was mentioned in all the excerpts, specifically to train super-users. The second mention consisted of additional recommendations to build local military skills, remote expertise using virtual communication tools, and online meetings to share best practices. Of note, in the GENESIS IOT&E report, the users noted the most effective method of training (orally, verbally, written).

The documents only made mention that training needed to improve for the users and adoption coaches. The excerpts state for training to be improved in some way.

Improve training and system documentation for both users and Adoption Coaches. (GENESIS evaluation report)

(1) onsite training to build local military skills; (2) phone, help desk, and e-mail support that provides remote expertise using virtual communication tools; and (3) online meetings to provide additional training to the military eHealth community, provide information on new products, and to share best practice guidance. (literature)

Identify and train sufficient numbers of clinical champions and technical-assistance staff to quickly address implementation issues, assist in development of macros and templates, and reassess performance success. (GENESIS evaluation report)

Co-occurrence of constructs: People and Support and constraints from higher headquarters (r^2 .08)

Support and constraints from higher headquarters is defined as support or constraint factors exhibited by higher headquarters that impact EHR implementation. This construct co-occurred with *people* nine times throughout the documents. The context of *support and constraints from higher headquarters* construct focused on the external environment of the MHS, and how leaders and champions can support the MTFs during implementation. *Support and constraints from higher headquarters* was identified as an external context construct in the original conceptual model (Figure 7). The analysis identified this construct as a facilitator—in particular, in terms of how well higher headquarters provided support during implementation.

Leidos Partnership for Defense Health (LPDH), the system contractor, and the DHMSM PMO established a command center at each MTF as MHS GENESIS went live to monitor and provide support for system users. LPDH provided Adoption Coaches, subject matter experts who offered over-the-shoulder support to users as they worked with MHS GENESIS. Nearly all users received formal training on the system before it went live at their MTF. The training included classroom and computer-assisted training. (GENESIS evaluation report)

Further, the support provided by higher headquarters mentioned the need of more technical support (i.e. trouble tickets, training).

Users from the four IOC sites submitted 14,383 help desk tickets between January and November 2017. The number of help desk tickets became overwhelming for help desk personnel and for site personnel monitoring their status. (GENESIS evaluation report)

The construct involving *support and constraints from higher headquarters* did not include a specific mention of leadership support. The finding is significant because the excerpts focused on technical support versus leadership support.

Interoperability

The emergent construct of *interoperability* was the second most frequent construct. *Interoperability was* mentioned a total of seventy-six times throughout the documents. The construct of *interoperability* is defined as the ability of computer systems or software to exchange and make use of information, and includes the propagation of the information across the federal healthcare system. This construct co-occurred with the *a-priori* constructs *efficiency* and emergent construct *lack of efficiency*, as depicted in Table VI. *Efficiency* was most often mentioned during discussions around the construct *lack of patient safety*, which is defined as hindering patient safety outcomes through EHR adoption. A closer examination occurred with the higher co-occurrences noted in Table VI. The sociotechnical construct of *interoperability* is considered a facilitator in EHR implementation, and moreover, helps to answer research question 1. The DoD and VA will eventually have the same system to capture service members' entire healthcare throughout their career and retirement.

These excerpts identify the need for the MHS and VA to build interoperability between their systems to better document service members' healthcare.

When active duty service members retire, for example, their patient information is transferred to the Department of Veterans Affairs (VA), which then assumes the continuity of care from the point of military separation through the remainder of the service member's life. The DoD has been working with the VA to leverage the benefits of electronic health records through joint information exchange initiatives. (literature)

We must have a Military Health System capable of documenting health care provided to service members throughout their time in the military and be accessible to the Veterans Administration (VA) when they leave military service. (congressional report)

TABLE VI. C-COEFFICIENTS FOR THE CONSTRUCT FOR INTEROPERABILITY AND MOST STRONGLY SELECT CO-OCCURRING

Interoperability	**r^2**
Communication	0.01
Cost	0.01
Efficiency	**0.05**
Hardware and Software infrastructure	0.02
Health data	0.02
Federal, State and other regulation	0.02
Human computer interface	0.01
Implementation of policy and procedures	0.01
Improved coordination of care	0.02
Improved clinical decision support	0.02
Lack of efficiency	**0.04**
Lack of usability	0.01
Learning health system	0.01
Patient Safety	0.02
People	0.02
User satisfaction	0.01
Workflow	0.02

Co-occurrence of constructs: Interoperability and Efficiency (r^2 .05)

The constructs *interoperability* and *efficiency* co-occurred five times throughout the documents. Even though the constructs co-occurred only a total of five times, these constructs helped to answer the research questions and shed light into aspects of the phenomenon of interest. *Efficiency*, in the context of this research, is defined as patient records being readily available, the need to provide more information, and to enhance information sharing within the organization. Discussions centered on a unified EHR that provides a comprehensive overview of the patients' medical information. Specifically, medical information included patient histories,

allergies, and alerts. The second major interoperability issue is that approximately 70 percent of defense and veteran healthcare occur outside the DoD/VA system.

Create unified and detailed EHRs that include patient histories, allergies, alerts, laboratory and radiology results, diagnoses, treatments, and prescribed medications. (literature)

Development of an interoperable longitudinal health record that embraces the patients' voice and control over how his/her medical information is collected, used, and displayed. (literature)

With almost 70% of defense and veteran health care happening outside of the DoD/VA system, the LHR must accept information from the private sector as well as government sources. (literature)

In addition, the discussions in the documents also noted the need for improved EHR documentation for situations when a patient is seen at a civilian hospital. Further, there was mention that inoperable system tends to enhance efficiency, which shows a relationship with the aforementioned constructs.

In addition, the DoD needs a better capability to capture ALL EHR information into a system that will allow meaningful aggregation and query of data, as well as an ability to include data from the VA EHR to permit longitudinal health surveillance for service members for the members time-in-service and post service periods. (literature)

Co-occurrence of constructs: Interoperability and lack of efficiency (r^2 .04)

Interoperability and the emergent construct *lack of efficiency* were identified as barriers during the analysis. The construct *lack of efficiency*, for this research, is defined as patient records not being readily available, provide more information, and enhance information sharing within the organization. *Interoperability* and *lack of efficiency* co-occurred a total of six times throughout the documents. The excerpts below indicate that AHLTA could not meet the needs of proper patient documentation according to the literature, and interoperability did not exist with the VA. There were discussions on information sharing between the VA and DoD. These excerpts also highlight the lack of interoperability between the DoD and VA. Therefore, the lack

of efficiency focuses on information and how the EHR translates medical data. Thus, interoperability can be viewed as one of the barriers.

The excerpts below defined interoperability, and discusses that the AHLTA is not inoperable with the VA's EHR.

Interoperability includes the spread of the information across the federal healthcare system. Many patients are dual eligible beneficiaries for a combination of the VA, DoD, and IHS systems, and therefore, receive portions of their care among different agencies. (EHR Implementation Plan)

Additional work remains to enable the EHR systems to meet the information needs of both the individual medical provider and the military public health. The service members health information maintained in AHLTA stays in the clinical data repository (CDR) and has not until recently been made available for use by the Department of Veterans Affairs (VA) for subsequent health care following discharge from military service. Further, AHLTA does not have a way of capturing civilian health care provided to Reserve and National Guardsmen for deployment-related health issues after they leave active duty. (literature)

Hardware and software infrastructure

In this research, the construct of *hardware and software infrastructure* is defined as the mention of hardware or software required to run system applications, and includes delineation of cyber security. Cyber security was added to the definition after the analysis due to the unique nature of a prototypical military computer's infrastructure. The military operates their EHR on a secure Non-classified Internet Protocol, which has a higher security standard compared to the protocol utilized by most civilian hospitals. In the documents and GENESIS IOT&E report, the GENESIS system was often communicated to have increased lag times and operational incidents. *Hardware and software infrastructure* was mentioned sixty-four times throughout the documents. *Hardware and software infrastructure* most commonly co-occurred with *a-priori* construct *communication* and the emergent constructs of *lack of workflow, lack of efficiency, lack of usability*, and *user satisfaction*, as depicted in Table VII. Even though people and patient

privacy had high c-coefficients (.06), no trends were identified to help answer the research questions. The researcher conducted a closer examination of the content related to those constructs with higher co-occurrences, and noted the results below. As can be seen, the sociotechnical construct *hardware and software infrastructure* was considered a barrier in EHR implementation. Moreover, users reported several technical issues with GENESIS and AHLTA that contributed to overall mission failure. According to the DHA document excerpt, GENESIS network configurations cannot be supported by the MTFs.

Users reported increased lag times when other IOT&E sites went live, suggesting the current system and supporting network configuration will not support the hundreds of additional sites planned for MHS GENESIS. (GENESIS evaluation report)

TABLE VII: C-COEFFICIENTS FOR THE CONSTRUCT HARDWARE AND SOFTWARE AND MOST STRONGLY SELECT CO-OCCURRING

Hardware and Software infrastructure	**r^2**
Communication	**0.06**
Delay	0.03
Inadequate training	0.02
Health data	0.01
Interoperability	0.02
Human computer interface	0.01
Lack of patient safety	0.01
Lack of workflows	**0.04**
Medical Readiness	0.01
Lack of efficiency	**0.05**
Lack of usability	**0.05**
Mental workload	0.01
Operational Workaround	0.01
Patient privacy	0.06
People	0.06
Support and constraint from HHQ	0.02
System measurement and monitoring	0.02
Training	0.02
User satisfaction	**0.04**
Workflow	0.02

Co-occurrence of constructs: Hardware and software infrastructure and communication (r^2 .06)

Hardware and software infrastructure and *communication* co-occurred a total of six times throughout the documents. These excerpts below also co-occurred with the emergent construct *delay,* which for this research, is defined as system interface problems that lead to a delay in patient care. Much of the data related to this construct was taken from exploratory interviews conducted with users during the pilot-testing phase. The GENESIS IOT&E report stated that the users experienced lag times or significant technical related barriers related to using software. Similarly, when the constructs of *delay* and *lack of efficiency* were used in all six excerpts of the documents, so was *hardware and software infrastructure*. The finding emerged as a primary construct for this study. Further, the documents emphasized on the use of workarounds due to these delays and system latencies.

Users reported increased lag times when other IOT&E sites went live, suggesting the current system and supporting network configuration will not support the hundreds of additional sites planned for MHS GENESIS. (GENESIS evaluation report)

Users also noted operational incidents (e.g., system freezes, lockouts, login errors) that caused mission failure or delay. (GENESIS evaluation report)

User survey comments from the three IOT&E sites reported similar problems that included undocumented and inconsistent workarounds, excessive system latency, inaccurate patient information, badly assigned user roles, poor user training, uneven assistance from on-site trainers, and lack of visibility of the status of trouble tickets. Co-occur with inadequate training, operational workaround, people, lack of efficiency, and support and constraint from HHQ. (GENESIS evaluation report)

Co-occurrence of constructs: Hardware and software infrastructure and lack of efficiency (r^2 .05)

Of note, *hardware and software infrastructure* co-occurred with *lack of efficiency* and their co-occurrence was mentioned a total of five times throughout the documents. Like GENESIS, AHLTA experienced issues including: (i) lag times, (ii) large number of steps to

complete the task, and (iii) long execution times. Additionally, due to the lack of infrastructure, this construct co-occurred with *lack of patient safety* and *lack of usability*.

AHLTA: (1) large number of steps to complete a task, (2) long execution time and (3) high percentage of mental operators. (literature)

Even though AHLTA made improvements when providing information in deployed locations, the reviewed documents indicated that efficiency was still lacking.

Although recent improvements have enabled AHLTA to display information from theater patient encounters, not all outpatient encounters are recorded due to unstable electronic communications and high operational risk in some areas. (congressional report)

Co-occurrence of constructs: Hardware and software infrastructure and Lack of usability (r^2 .05)

Of note, in both systems, the construct of *lack of usability* was highlighted in the documents to include the GENESIS IOT&E report. *Lack of usability,* in this study, is defined as a lack of effectiveness, efficiency, and satisfaction with which specific users can achieve a specific set of tasks in a particular environment. Training efforts could not overcome the usability problems identified from users identified in the documents. Of note, the lack of usability was seen to decrease the overall user satisfaction of the EHR systems. In particular, over 50 percent of respondents could not appropriately document patient information in the use of AHLTA.

Orders management in CHCS was never fielded because of its substantial usability issues, such as not using the clinicians' language in the wording of orders. (literature)

Training was insufficient to overcome GENESIS usability problems (literature)

User satisfaction A total of 58.2% responded that "AHLTA itself" prevented completion of encounters with patients in the examination room. Of these, 69.9% cited "the AHLTA screen refresh rate is too slow" to complete the encounter (literature)

Efficiency

The construct *efficiency* was mentioned a total of fifty-four times throughout the documents. Discussions around *Efficiency* often co-occurred with *hardware and software infrastructure,* constructs which has been defined previously. *Efficiency* co-occurred the most often with the *a-priori* construct *hardware and software infrastructure* and the emergent constructs *health data*, *interoperability,* and *lack of usability,* as depicted in Table VIII. A closer examination occurred with the higher co-occurrences. Inadequate training had a high c-coefficient; however, no significant trends were identified during analysis. The sociotechnical construct of *efficiency* was identified as a facilitator, since GENESIS was found to enhance some aspects of accessing health data compared to AHLTA.

This excerpt indicates that some aspects of GENESIS are more efficient compared to AHLTA.

We can see lab results easier. We can communicate with each other and our nurses a lot easier. (news articles on GENESIS)

This excerpt discusses indicates AHLTA enhancing efficiency.

Although AHLTA increases information accessibility and availability of records the overwhelming sentiment was one of frustration. One physician noted, "I can take better care of my patients using paper." (literature)

TABLE VIII: C-COEFFICIENTS FOR THE CONSTRUCT EFFICIENCY AND MOST STRONGLY SELECT CO-OCCURRING

Efficiency	**r^2**
Communication	0.02
Federal, State, Local policies and regulations	0.01
Hardware and Software Infrastructure	**0.04**
Health data	**0.06**
Interoperability	0.02
Human computer interface	0.01
Implementation of policy and procedures	0.01
Improved clinical decision support	0.02
Improved coordination of care	0.03
Inadequate training	**0.05**
Interoperability	**0.04**
Lack of coordination of care	0.02
Lack of patient safety	0.01
Lack of usability	**0.05**
Operational workaround	0.03

Patient safety	0.02
People	0.03
Process improvement	0.02
Provider productivity	0.02
Support and constraints from HHQ	0.03
System measurement and monitoring	0.02
User satisfaction	0.01
Workflow	**0.07**

Co-occurrence of constructs: Efficiency and hardware and software infrastructure (r^2 .04)

This construct co-occurred with *efficiency* five times throughout the documents. Discussions were often related to technical issues such as the typical lag times reported by the systems (AHLTA/GENESIS), with mentions of the lag hindering documentation efforts and accessibility to patients' records. Notably, the new GENESIS system had excessive system latency reported in GENESIS IOT&E report.

User survey comments from the three IOT&E sites reported similar problems that included undocumented and inconsistent workarounds, excessive system latency, inaccurate patient information, badly assigned user roles, poor user training, uneven assistance from on-site trainers, and lack of visibility of the status of trouble tickets. (GENESIS evaluation report)

Similarly, AHLTA's documentation effectiveness was also limited by factors such as slow response time. The information surrounding system latency helps to answer research question 1b as the construct *hardware and software infrastructure* is often known to be a barrier during implementation.

The slow response time of AHLTA was also a contributing factor to not documenting synchronously during the encounter. (literature)

Co-occurrence of constructs: Efficiency and health data (r^2 .06)

Health data is defined as any data related to health conditions, reproductive outcomes, causes of death, and quality of life. The news reports and evaluation report noted that transferring data

between the legacy system and GENESIS appeared to have caused frustration among users, and more importantly, can also directly impact patient safety.

Providers at Fairchild Air Force Base similarly faced frustration when transferring patient health data from the legacy system to MHS GENESIS. (GENESIS evaluation report)

Non-standard data and the failure to adhere to Interface Control Documents (ICDs) hampered information exchange with interfacing systems. (GENESIS evaluation report)

User survey comments from the three IOT&E sites reported similar problems that included undocumented and inconsistent workarounds, excessive system latency, ***inaccurate patient information****, badly assigned user roles, poor user training, uneven assistance from on-site trainers, and lack of visibility of the status of trouble tickets. (GENESIS evaluation report)*

Co-occurrence of constructs: Efficiency and Interoperability (r^2 .04)

Interoperability co-occurred with *efficiency* a total of five times throughout the documents. Even though the co-occurrence does not have a high frequency, the excerpts articulated the important relationship between efficiency and interoperability.

Development of an interoperable longitudinal health record that embraces the patients' voice and control over how his/her medical information is collected, used, and displayed. (literature)

It was reported in the literature that approximately 70 percent of defense and veteran healthcare occurs outside the military health system. There was frustration among the providers who emphasized the inability to capture patient information.

With almost 70% of defense and veteran health care happening outside of the DoD/VA system, the LHR must accept information from the private sec- tor as well as government sources. (literature)

Additionally, the data suggested a need for a better capability to capture all patient information in the systems.

In addition, the DoD needs a better capability to capture ALL EHR information into a system that will allow meaningful aggregation and query of data, as well as an ability to include

data from the VA EHR to permit longitudinal health surveillance for service members for the members time-in-service and post service periods. (literature)

Co-occurrence of constructs: Efficiency and Lack of usability (r^2 .05)

Lack of usability co-occurred with *efficiency* a total of four times throughout the documents. Even though the co-occurrence does not have a high frequency, the excerpts highlight that providers generally did not consider GENESIS to be operationally effective, potentially signifying that the new EHR is not suitable for the MHS to manage and document patient care.

MHS GENESIS is not operationally effective because it does not contain enough functionality to manage and document patient care. (GENESIS evaluation report)

Lack of usability also includes providers and technicians being granted several user roles to complete tasks in the EHR, leading to delays in patient care.

Providers often obtained user roles inappropriate to their jobs because that was the only way they could access all the functionality they needed. This allowed some users access to information and functionality they should not have had access to. (GENESIS evaluation report)

Co-occurrence of constructs: Efficiency and Workflow (r^2 .07)

Workflow is defined as the lack of steps needed to ensure that each patient receives the care they need at the time they need it. Specifically, *workflow* co-occurred with *efficiency* a total of six times throughout the documents. The excerpts showcase the impact workflow can have on patient care and the delivery of healthcare.

Substantial impact on care delivery through care pathways, Health Information Exchange, and benchmarking (what the future holds) (literature)

Additionally, the excerpts also note that there are opportunities within the MHS to improve efficiency in order to reduce system complexity.

Opportunities to improve the efficiency of information delivery and task performance to reduce system complexity. (literature)

System Measuring and Monitoring

The construct *System Measuring and Monitoring* was mentioned a total of forty-two times in the documents. *System measuring and monitoring*, in this research, is defined as the measure and monitoring of the effects of health information technology on a regular basis. In this case, health information could include observations made on a provider's day-to-day tasks. Moreover, *system measuring and monitoring* includes communication to leadership, higher headquarters or to system programmers, and testing. As noted in Table XI, this construct most strongly co-occurred with the *a-priori* construct *people* and the emergent construct *process improvement*. System measuring and monitoring is conducted to help improve processes and identify gaps. Additionally, the metrics are centered on patient and end-user productivity and effectiveness. The higher co-occurrences were examined more closely. A point of data saturation was identified when analyzing the construct *support and constraints from higher headquarters*. The construct *system measuring and monitoring* is a facilitator, which helps to answer research question 1. Plans to measure and monitor the EHR were established prior to implementation. Additionally, recommendations were identified in the documents such as MTFs, developing a formal method to track trouble tickets and ensure that the leadership has awareness.

DHA HIT SDD will disseminate communications and updates on initial implementation training to the Services; track all risks, concerns, issues, and other feedback from the sites; convey that information to the DHMSM PMO; and develop a "Lessons Learned" document to be used in future deployments. (EHR implementation plan)

Additionally, the CMAT will conduct site visits and interview site leadership/staff to gather concerns with the current system and include past EHR deployment lessons learned. The CMAT will solicit communications preferences and best practices, and training lessons learned from the MTFs. The CMAT will compile and analyze this data to create various Stakeholder Analyses. (EHR implementation plan)

The PMO supported a robust series of integrated test events leading to IOT&E and has worked aggressively to address problems discovered during testing, especially those that could affect patient safety. (GENESIS evaluation report)

TABLE IX: C-COEFFICIENTS FOR THE CONSTRUCT SYSTEM MEASURMENT AND MONITORING AND MOST STRONGLY SELECT CO-OCCURRING

System measurement and monitoring	**r^2**
Communication	0.03
Efficiency	0.02
Hardware and Software Infrastructure	0.02
Healthcare management	0.02
Human computer interface	0.02
Implementation of policy and procedures	0.03
Improved coordination of care	0.02
Inadequate training	0.03
Lack of efficiency	0.03
Lack of suitability	0.02
Lack of survivability	0.02
Lack of usability	0.02
Leadership characteristics	0.02
Operational workarounds	0.02
Organizational readiness	0.02
Patient safety	0.03
People	**0.06**
Process improvement	**0.09**
Support and constraints from HHQ	**0.05**
Survivability	0.02
Training	0.01
User satisfaction	0.03

Co-occurrence of constructs: System Measuring and Monitoring and People (r^2 .06)

People co-occurred with *system measuring and monitoring* a total of nine times throughout the documents. These constructs primarily mentioned providing system details to staff and leadership related to GENESIS. All measurements were quantified in the documents, such as the total number of tickets submitted to the helpdesk for assistance (i.e., trouble tickets). Throughout the implementation of GENESIS, there has been system measurement and monitoring either from trouble tickets, users completing tasks, or military operating procedures on the EHR.

During the IOT&E, healthcare providers, technicians, and administrators performed their day-to-day tasks while JITC observed their performance and noted the success or failure of each attempt. Morae video screen capture instrumentation provided information to identify system and user errors. ***The users and JITC prepared IRs to document problems.*** *A Data Authentication Group (DAG), composed of users and testers, convened to formally adjudicate each IR.* ***JITC collected data on interoperability where it was available, and administered user surveys on training, usability, and other suitability areas.*** *(GENESIS evaluation report)*

The test team tested 197 MOPs, which allowed for full evaluation of 17 of the 21 MOEs. Of the 17 MOEs that the testers fully evaluated, 14 (82 percent) were "not satisfied" because users were not able to execute a majority of the functionality and each had at least one high-severity deficiency. The remaining three (18 percent) MOEs were "partially satisfied" because users were able to execute some of the functionality; however, more data is required to fully evaluate the MOE. An additional three MOEs could not be fully evaluated because the functionality exists within the Initial Operational Capability (IOC) sites only at MAMC. *(GENESIS evaluation report)*

Of note in the documents, there were also discussions of monitoring user satisfaction for training. The users did not consider the training adequate for GENESIS (67%).

Users rated the training as poor. Most users (67 percent, 265 of 394) indicated during the IOT&E events that they needed more training. *JITC administered a 15-question training survey – which included one question asking if users felt they needed more training – during both the Go-Live and IOT&E events. (GENESIS evaluation report)*

Co-occurrence of constructs: System Measuring and Monitoring and Process improvement (**r^2 .09)**

Process improvement, for this study, is defined to be the proactive task of identifying, analyzing, and improving upon existing business processes within an organization for optimizations; specifically, the definition includes meeting new quotas or standards of quality. This construct co-occurred with *system measuring and monitoring* a total of five times throughout the documents. Even though the co-occurrence frequency is not as high as other construct co-occurrences, the excerpts from the documents further supported the strong influence that process improvement and system measuring and monitoring can have in a successful EHR

implementation. Further, process improvements are typically implemented to improve patient safety, providing additional benefits to the field of healthcare.

Several processes were tracked formally, such as trouble tickets for the new system GENESIS, with the intent to improve the EHR.

The PMO supported a robust series of integrated test events leading to IOT&E and has worked aggressively to address problems discovered during testing, especially those that could affect patient safety. (GENESIS evaluation report)

Workflow

The emergent construct of *workflow* was mentioned in the documents a total of forty-two times. As noted in Table X, this construct strongly related to the *a-priori* code *efficiency* and the emergent codes *process improvement* and *user satisfaction.* Mentions of these co-occurrences included that user satisfaction with EHR implementation can be increased with EHR speed and efficiency which in-turn relates to workflow.

Prior to implementation, workflows were designed for several processes in GENESIS. The workflows are noted in the excerpt below.

BoS refers to an integrated inpatient and outpatient EHR System with software components that have been designed, integrated, maintained, and deployed with a design architecture that allows for access to and sharing of common data, common user interfaces, common workflows, and common business rules. (EHR implementation plan)

Although workflows were designed prior to implementation, the workflows led to delays in patient care, particularly in pharmacy departments. These delays were primarily due to system difficulty use related to workflows.

Pharmacists, in particular, found the system difficult to use. They were working extended hours due to longer prescription order workflows. Pharmacies averaged fill times of 45 minutes or more for prescriptions that previously averaged 15 to 20 minutes. (GENESIS evaluation report)

Additionally, the documents make mention of the need to provide improved cognitive support to the clinicians.

EMR improvements to provide better cognitive support to clinicians. (GENESIS evaluation report)

TABLE X: C-COEFFICIENTS FOR THE CONSTRUCT WORKFLOW AND MOST STRONGLY SELECT CO-OCCURRING

Workflow	**r^2**
Communication	0.01
Efficiency	**0.07**
Hardware and Software Infrastructure	0.02
Health data	0.03
Human computer interface	0.02
Improved clinical decision support	0.02
Improved coordination of care	0.03
Interoperability	0.02
Lack of efficiency	0.03
Lack of workflow	0.02
Patient safety	0.03
People	0.01
Process Improvement	**0.05**
Provider productivity	0.02
Training	0.01
Usability	0.03
User satisfaction	**0.05**

Co-occurrence of constructs: Workflow, Efficiency, and Process Improvement (r^2 .07 and .05)

Efficiency co-occurred with *workflow* a total of six times throughout the documents and *process improvement* co-occurred with *workflow* a total of three times throughout the documents. Both constructs *workflow* and *efficiency* mention the importance of standardization and using a common language in the EHR to help support the provider in clinical decision-making.

Better cognitive support includes tools and processes to facilitate clinical decisions and thinking about problems in health care (GENESIS evaluation report)

Standardizing a visit template means using a language that can be easily used and understood by all team members. This can decrease redundancy in the office visit. (literature)

These constructs also co-occurred with *process improvement*, specifically mentioning reducing system complexity and improving the overall functionality of the EHR.

The results suggest that there are many opportunities to improve the efficiency of information delivery and task performance to reduce system complexity. (literature)

Co-occurrence of constructs: Workflow and User Satisfaction (r^2 .05)

User satisfaction, in this study, is defined as the combination of ease of use and the degree to which the system supports work and is useful. This construct co-occurred with *workflow* a total of three times throughout the documents. Even though the co-occurrence frequency is not high, workflow clearly relates to users satisfaction particularly in the speed and efficiency of the EHR. One provider noted a positive relationship between the quality of care of method used to document care.

I can take better care of my patients using paper. (literature)

Other frustrations noted were decreasing the quality of care, reduction in patient safety, impeding patient access to care and degrades business processes required to record workflow.

The overwhelming sentiment was one of frustration. One physician noted, "I can take better care of my patients using paper." The chief of the medical staff at the medical center also described frustration related to AHLTA noting it: (1) worsens the quality of care because it is a "bad medical record," (2) places patients and providers at risk due to potential errors, (3) impedes patient access to care, and (4) worsens necessary business processes required to record workload. The collection of complaints concentrates on the usability aspects of AHLTA. (literature)

User satisfaction with EHR implementation correlates with EHR speed and efficiency, but not with accuracy or communication ability. (literature)

Part of user satisfaction mentioned in the excerpts includes thorough workflows and processes. Workflow could also relate to the process in which a patient flows through the EHR system.

The COMPASS workflow uses team documentation, teaches simplified coding algorithms, and uses an advanced generation of alternate input method (AIM) forms to reduce time spent writing notes. It also improves note readability and standardizes documentation

throughout the clinic. The end result is optimal use of all of the skills of clinicians and support staff while reducing the non-value added time of many clinic functions. Although the COMPASS workflow is still in the preliminary phase of rollout, the initial response of providers and support staff has been very positive. (literature)

Communication

The construct of *Communication* was mentioned a total of thirty-nine times in the documents. As noted in Table XI, this construct strongly co-occurred with the *a-priori* construct *hardware and software infrastructure,* and the emergent constructs of *lack of efficiency* and *user satisfaction*. This construct was mentioned in the GENESIS IO&E report, which was an internal communication of the initial operational testing and evaluation of GENESIS. A closer examination then occurred with the higher co-occurrences. Subsequently, the construct of *communication* was identified as a facilitator.

The DHA and MTFs had several avenues for communications and also communicated issues in evaluation reports. The DHA had a communication plan established prior to implementation. The excerpt below is from the communication plan.

The DHA will solicit communications preferences and best practices, and training lessons learned from the MTFs. (EHR implementation plan)

Several recommendations from the documents emerged from evaluation reports to better enhance communication.

Wide-spread collaboration. (GENESIS evaluation report)

Collaborate with other on best practices. (GENESIS evaluation report)

TABLE XI: C-COEFFICIENTS FOR THE CONSTRUCT COMMUNICATION AND MOST STRONGLY SELECT CO-OCCURRING

Communication	**r^2**
Delay	0.02
Efficiency	0.02
Hardware and Software Infrastructure	**0.06**
Improved coordination of care	0.02

Inadequate training	0.03
Interoperability	0.01
Lack of efficiency	**0.04**
Lack of suitability	0.02
Lack of usability	0.03
Learning health system	0.02
Operational workaround	0.02
*People	0.12
Support and constraints from HHQ	0.03
System measurement and monitoring	0.03
Usability	0.02
Workflow	0.01

* *Communication* and *people* co-occurrence is presented on page 45

Co-occurrence of constructs: Communication and Hardware and Software Infrastructure (r^2 .06)

Hardware and software infrastructure construct co-occurred with *communication* a total of six times throughout the documents. These constructs also co-occurred with *delay*, which is defined above. The users heavily communicated regarding the hardware and software issues in the evaluation report of GENESIS. Discussions focused on implementation delay due to technical issues and the significant impact the technical issues had on patient care.

Users reported increased lag times when other IOT&E sites went live, suggesting the current system and supporting network configuration will not support the hundreds of additional sites planned for MHS GENESIS. (GENESIS evaluation report)

User comments accompanying the IRs and user interviews indicate that MHS GENESIS increased patient encounter times to the point that providers were seeing fewer patients per day, despite some providers working overtime. Users also noted operational incidents (e.g., system freezes, lockouts, login errors) that caused mission failure or delay. (GENESIS evaluation report)

Another technical problem involving hardware and software issues was the fact the network could not support EHR operations at the MTF sites.

System outages indicated that the end-to-end system and supporting network did not have sufficient availability to support operations at the four IOT&E MTFs. Users reported increased lag times when other IOT&E sites went live, suggesting the current system and supporting network configuration will not support the hundreds of additional sites planned for MHS GENESIS. (GENESIS evaluation report)

Co-occurrence of constructs: Communication and Lack of efficiency (r^2 .04)

GENESIS showed to decrease access to care with a lack of efficiency. Additionally, it was generally communicated that GENESIS was not effective when documenting patient information.

Some providers reported that they needed to work overtime and were seeing fewer patients per day due to delays caused by defects in MHS GENESIS. (GENESIS evaluation report)

MHS GENESIS is not operationally effective because it does not contain enough functionality to manage and document patient care. (GENESIS evaluation report)

Lack of efficiency

The emergent construct of *lack of efficiency* was mentioned a total of thirty-eight times in the documents. As noted in Table XII, this construct was very strongly related to emergent constructs *inadequate training, operational workarounds, lack of usability*, and the *a-priori* construct *workflow*. Although noted below in the excerpts, GENESIS and AHLTA both exhibited problems, and record keeping remains a key element to EHR success and usability in an MTF. A closer examination then occurred with the higher co-occurrences. A point of saturation in the data for *lack of efficiency* and *hardware and software infrastructure* occurred during analysis. Ultimately, the construct of lack of efficacy was seen as a barrier. The GENESIS evaluation reports concluded that the EHR is not operationally effective according to the below excerpt, which supports research question 1.

MHS GENESIS is not operationally effective because it does not demonstrate enough workable functionality to manage and document patient care. (GENESIS evaluation report)

TABLE XII: C-COEFFICIENTS FOR THE CONSTRUCT LACK OF EFFICIENCY AND MOST STRONGLY SELECT CO-OCCURRING

Lack of efficiency	**r^2**
Communication	**0.04**
Delay	0.02
*Efficiency	0.05

Hardware and software infrastructure	**0.05**
Health data	0.02
Human computer interface	0.04
Implementation of policies and practices	0.01
Inadequate training	**0.11**
Interoperability	0.04
Lack of patient safety	0.02
Operational workaround	**0.12**
Lack of suitability	0.02
Lack of usability	**0.11**
Medical readiness	0.02
Mental workload	0.02
Operational workaround	**0.10**
People	0.03
Provider productivity	0.04
Support and constraints from HHQ	0.02
System measurement and monitoring	0.03
Training	0.03
Workflow	**0.07**

**Lack of efficiency* and *efficiency* constructs can be found on page 67

CHCS II was also plagued with problems. Formal test results revealed that CHCS II was not operationally effective or suitable because of issues with system stability, response delays, the need for a more usable documentation tool, and workflow considerations. In 1999, CHCS II failed user acceptance testing due to these critical usability issues.

This paper identified the following factors related to the performance of AHLTA: (1) large number of steps to complete a task, (2) long execution time and (3) high percentage of mental operators.

Additionally, although headquarters suggest in the news article below that the baseline will improve data sharing and patient safety, discussion in the documents centered on a lack of confidence in the military to fix issues identified in the pilot-testing phase.

It isn't clear how much the military intends to change MHS Genesis in response to complaints about usability and other issues, but it is following through with the next wave of implementations at three bases in California and one in Idaho. Norley said the current version will be improved, and in any case, "the baseline solution allows more data sharing, greater patient safety features, and more cyber security protection than the legacy system it replaces. (news articles related to GENESIS)

Co-occurrence of constructs: lack of efficiency and inadequate training (r^2 .11)

Inadequate training, for this research, is defined as the action of inadequately teaching a person a particular EHR skill through computer-based training, lectures, or one-on-one, in a manner that is not specific to meet the users' needs. This construct co-occurred with lack of efficiency a total of six times throughout the documents. Forty-three percent of users identified GENESIS as offering "less than adequate" training. Of note, in previous excerpts some users stated that a more robust training program could not overcome the usability issues of GENESIS.

Initial AHLTA training to efficiently see patients was rated as "more than adequate" by 32 (6.8%), "adequate" by 235 (50.2%), or "less than adequate" by 201 (43.0%). (literature)

Training was insufficient to overcome usability problems, and a lack of documentation forced users to develop their own operational workarounds. (GENESIS evaluation reports)

Co-occurrence of constructs: Lack of efficiency and Operational workarounds (r^2 .12)

Operational workarounds, in this research, is defined as a temporary 'fix' of perceived workflow hindrances to meet a goal or to achieve it more readily. The hindrances can include violations, deviations, problem solving, improvisations, procedural failures and shortcuts. This construct co-occurred with *lack of efficiency* a total of four times throughout the documents. Providers noted that they used operational workarounds to improve usability and efficiency of the system due to the lack of built-in efficiency. These constructs also co-occurred with the construct *lack of usability*.

Training was insufficient to overcome usability problems, and a lack of documentation forced users to develop their own operational workarounds. (GENESIS evaluation reports)

Issue a with workarounds concerns learning and using multiple systems. AHLTA and CHCS have different methods of interaction, mouse centered and keyboard centered, respectively. (literature)

Co-occurrence of constructs: Lack of efficiency and Lack of usability (r^2 .11)

Lack of usability construct co-occurred with *lack of efficiency* a total of six times throughout the documents. Some providers reported that they needed to work overtime and were

seeing fewer patients per day due to delays caused by the defects in MHS GENESIS. The second major usability issue from both the interviews and observations was the inefficient process of reviewing previous patient encounters to develop the "picture of the patient," known more formally as "situational awareness." Overall AHLTA increased the time it takes to document patient encounters.

This paper identified the following factors related to the performance of AHLTA: (1) large number of steps to complete a task. (literature)

Co-occurrence of constructs: Lack of Efficiency and Workflow (r^2 .10)

Workflow construct co-occurred with *lack of efficiency* a total of five times throughout the documents. It was not surprising in the data that workflow co-occurred with the construct *lack of efficiency*. AHLTA and GENESIS were deemed not operationally effective or suitable during the beginning of implementation. This finding led to a similar pattern in MHS EHR implementation.

MHS GENESIS is not operationally effective because it does not demonstrate enough workable functionality to manage and document patient care. (GENESIS evaluation reports)

CHCS II was also plagued with problems. Formal test results revealed that CHCS II was not operationally effective or suitable because of issues with system stability, response delays, the need for a more usable documentation tool, and workflow considerations. In 1999, CHCS II failed user acceptance testing due to these critical usability issues. (literature)

Implementation of policies and procedures (r^2 .07)

The emergent construct of *implementation of policies and procedures* was mentioned a total of thirty-three times in the documents. The implementation, in this context, refers to policies or practices that may affect EHR implementation. As noted in Table XIII, this construct co-occurred with *a-priori* code *support and constraints from higher headquarters*, which is defined as support or constraint factors exhibited by higher headquarters that impact EHR

implementation. These constructs co-occurred a total of four times throughout the documents. A closer examination then occurred with the higher co-occurrences, leading to the finding that the construct *implementation of policies and procedures* can be considered a facilitator in this research. Prior to implementation the DHA defined several policies and procedures prior to implementation which helps to answer research question one.

These below excerpts refer to the responsibility of people in support roles.

The MTF Clinical Champion responsibilities will be developed and determined by the Enterprise Clinical Champion, FAC and DHMSM PMO. Clinical Champions will meet on a regular basis, the frequency of which will likely depend on implementation activity and proximity to the implementation of the EHR System. Calls and webinars will be used to share developments, such as new functions of the EHR System.

Clinical Champions may perform the following functions:
-Participates in site visits and all related CMD activities
-Assist with identification of Super Users and additional Clinical Champions
-Assist with identification of the site Training Coordinators
-Facilitate the user-to-role mapping assignments and end-user provisioning requirements
-Participate in the development and execution of the DHMSM MOA

TABLE XIII: C-COEFFICIENTS FOR THE CONSTRUCT IMPLEMENTATION OF POLICIES AND PROCEDURES AND MOST STRONGLY SELECT CO-OCCURRING

Implementation of polices and procedures	**r^2**
Efficiency	0.01
Hardware and software infrastructure	0.02
Health data	0.02
Interoperability	0.01
Lack of efficiency	0.01
Patient privacy	0.02
People	0.01
Support and constraint from HHQ	**0.07**
System measuring and monitoring	0.03
Training	0.02

Training

The emergent construct of *training* was mentioned a total of thirty-two times in the documents. As noted in Table XIV, this construct strongly co-occurred with the emergent code *inadequate training* and the *a-priori* code *people*. Although technical, training often co-occurred

with several constructs. Training is considered a primary construct in this DrPH research. A point of saturation in the data was identified when analyzing *lack of usability, operational workaround* and *support and constraints from higher headquarters*. The data saturation made mention to inadequate training. A closer examination then occurred with the higher co-occurrences. The construct *training* was identified as a barrier, with the evaluation being that training for GENESIS was inadequate, leading to insights that helped answer research question 1. Additionally, one recommendation was to include all department members being trained as super users in order to help during implementation. Thus, this finding helps to answer research question 2.

Inadequate training was perceived to be the reason for quitting by 30 percent of participants. (GENESIS evaluation report)

MHS GENESIS exhibited usability problems that the training could not overcome. *If the system is usable, only poorly trained people should have usability problems. However, after accounting for training, usability still significantly predicted workload. (GENESIS evaluation report)*

All department team members should be trained as super users. (GENESIS evaluation report)

TABLE XIV: C-COEFFICIENTS FOR THE CONSTRUCT TRAINING AND MOST STRONGLY SELECT CO-OCCURRING CONSTRCUTS

Training	**r^2**
Hardware and software infrastructure	0.02
Implementation and policies and procedures	0.02
Inadequate training	**0.12**
Lack of efficiency	0.03
Lack of usability	0.06
Learning health system	0.02
Operational workaround	0.05
People	**0.08**
Process improvement	0.02
Support and constraints from HHQ	0.07
System measurement and monitoring	0.01
Usability	0.02
Workflow	0.01

Co-occurrence of constructs: Training and Inadequate training (r^2 .12)

Inadequate training construct co-occurred with *training* a total of six times throughout the documents. In particular, training was a very noteworthy construct, and even though technical, the construct remains an essential component in EHR implementation since it is the first time that a user interacts with the EHR. The GENESIS IO&E report captured interviews that stated poor user training was executed, and assistance from on-site trainers was inconsistent. Most noteworthy in the data was that GENESIS could not overcome usability issues with training alone.

Poor user training

Uneven assistance from on-site trainers

MHS GENESIS exhibited usability problems that the training could not overcome. If the system is usable, only poorly trained people should have usability problems. However, after accounting for training, usability still significantly predicted workload.

Co-occurrence of constructs: Training and People (r^2 .08)

People construct co-occurred with *training* a total of eleven times throughout the documents. Training, by definition, placed much emphasis on people interaction. In the data, people related to training the users. Further, the GENESIS IO&E report recommended improving training not only for users, but also for adoption coaches. Upon reflection, training was characterized as either active sessions involving interactions between trainees such as hands-on learning or passive techniques such as listening or reading. This construct is defined as oneself or someone else demonstrating potential to lead, coordinate, and serve as a leader in EHR implementation.

All department team members should be trained as super users (GENESIS evaluation report)

Improve training and system documentation for both users and Adoption Coaches. (GENESIS evaluation report)

Work with users to document, reduce, and standardize operational workarounds. (GENESIS evaluation report)

Online meetings to provide additional training to the military eHealth community, provide information on new products, and to share best practice guidance. (literature)

Identify and train sufficient numbers of clinical champions and technical-assistance staff to quickly address implementation issues, assist in development of macros and templates, and reassess performance success. (GENESIS evaluation report)

Interestingly, in the below excerpt there was mention of resistance to change, which co-occurred with *leadership characteristics*.

Learning curves involved with implementation of new technology, as well as possible resistance from employees, can pose a challenge for managers who are balancing many competing demands. (literature)

Lack of Patient Safety

Even though the construct *lack of patient safety* was only mentioned a total of sixteen times throughout the documents, the below excerpts were significant due to the implications they had on a patient's safety. A *lack of patient safety*, for this research, is defined as hindering patient safety outcomes through EHR adoption. The EHR had reports of inaccurate prescription submissions, in addition to mentions of serious concern regarding putting patient's lives at risk.

*"I was out there," said Murray at the April 26 hearing. "**I heard issues about inaccurate prescription submissions,** misdirected patient referrals, long waits to resolve problems in the program that were identified by the clinicians, and some practitioners reported that they couldn't even open the program in a timely manner."(congressional report)*

*Worse, I've received reports that staff have received inadequate training on the system and fear they may have to take training out of their own operating budget to pay for that training," continued Murray. "As you can imagine, this has had a significant morale impact on the practitioners in my state—**not to mention serious concern about putting patient's lives at risk."** (congressional report)*

Additionally, there were concerns over the actual accuracy of information and exchange between external and GENESIS which is a patient safety issue.

Users questioned the accuracy of the information exchange between external systems and MHS GENESIS, which could jeopardize patient safety due to inaccurate patient medical data. (GENESIS evaluation report)

Additionally, workaround occurs when the system is not usable to the user, and sometimes workarounds in the system may be detrimental. Notably, the risk involves users bypassing patient safety protections inherently build in the system.

When the number of alerts becomes excessive from the perspective of the user of the health information system, the user may create a workaround to compensate for the excessive alerts. On one hand, workarounds can be assistive tools for healthcare practitioners, such as a flow diagram of how to maneuver through different areas of the health information technology user interface. On the other hand, workarounds may be detrimental—even dangerous—if they are methods of disabling or bypassing patient safety protections built into health information technology system. (GENESIS evaluation report)

Leadership Characteristics

Even though the construct *leadership characteristics* was only mentioned a total of seventeen times throughout the documents, the excerpts were significant due to the implications they had on the overall implementation of an EHR. *Leadership characteristics*, for this research, is defined as oneself or someone else demonstrating potential to lead, coordinate, and be in charge of the EHR implementation. The excerpt below highlights the need to align and guide priorities around the changes needed to support an EHR implementation. Additionally, leaders help to set the tone or climate when implementation first is initiated. Conclusively, the construct *leadership characteristics* is considered a facilitator and helps to answer research question 1. However, it is noteworthy that leadership was rarely mentioned in the documents.

Effective leadership involvement is required to align and guide priorities around the changes needed to support an EHR implementation. *This is significant as the leaders will set the tone within their Segment 1 or Segment 2 environments, serve as advocates for the program,*

support engagement of required resources, and provide messaging to be disseminated to their workforces. Leadership involvement must span the lifecycle of the EHR implementation, from acquisition, to configuration, to Go-Live. (EHR Implementation plan)

Additionally, another barrier of leadership is the short tenure of MTF commanders and the overall complex organization of the MHS. A commander's short tenure (two years) is not conducive to the lengthy process of EHR implementation.

Others noted that the MHS faces challenges that are not amenable to AHLTA-related "fixes." Examples included the short tenure of MTF commanders and the complex organization of the MHS, which comprises three healthcare systems, one for each military service. (literature)

Lastly, this previous excerpt highlights the how military leadership is vital to support users during EHR transition.

Military leadership is vital to support users during the transition to eHealth operations. (literature)

Medical Readiness

The construct *medical readiness* is something unique to MHS when compared to civilian hospitals. *Medical readiness*, in this research, was defined as an organization that enables a medically ready force and prepares personnel and equipment to deliver world-class expeditionary health care across a full range of military operations. This construct was only mentioned a total of five times in the documents. Some data in GENESIS particularly immunization records was incorrect in patient's record, hindering the medical readiness of the unit and posing a major patient safety issue. The construct *medical readiness* was considered a barrier in this research. Most notability, due to the EHR, medical readiness was hampered for service members in particular. Medical readiness is the distinguishing factor between the military health system and civilian sector. Therefore, the finding helps to answer research 1.

Military Medical Readiness. Several IRs written against the Immunization MOE pertained to ICD and standards conformance. MHS GENESIS displayed incorrect patient immunization data and immunizations did not populate in the appropriate Medical Readiness System.

Additionally, due to the unique operating environment of the military, some outpatient encounters do not get recorded.

Although recent improvements have enabled AHLTA to display information from theater patient encounters, not all outpatient encounters are recorded due to unstable electronic communications and high operational risk in some areas.

Federal, state, and local healthcare regulations

Even though the construct *federal, state, and local healthcare regulations* was only mentioned a total of thirty-two times in the documents, the construct remains a barrier during implementation when the EHR cannot meet federal regulations. This construct is defined as regulations, laws, or legislation such as HIPAA or HITECH that could impact EHR implementation. Certainly, legal limitations can pose a challenge for an organization when deciding to integrate a new system. The construct also poses patient safety concerns. Specifically, the excerpts in the documents identified in GENESIS often referred to the lack of radiology and imaging that failed to confirm to standards. The construct *federal, state, and local healthcare regulations* is consider a barrier for this research since GENESIS could not support specific national provider identification numbers or other national standards. The finding helps to answer research question 1.

MHS GENESIS does not support National Provider Identification numbers or National Drug Codes, forcing pharmacists to do manual searches for medications to dispense. (GENESIS evaluation report)

Radiology and Imaging. Messages relating to Radiology interfaces did not conform to standards and ICDs. (GENESIS evaluation report)

Research Question 2:

2. How can the lessons learned from initial EHR implementation in the military help inform the process moving forward throughout the military health system?

The following research question was answered based on these results. This research question helped to identify lessons learned or recommendations gleamed from the data sources. Lessons learned from this research helped inform the recommendations discussed in chapter five.

People

This excerpt places emphasis on the importance of collaboration and draws out recommendations on shared knowledge, lessons learned, and challenges. Not only should the military collaborate with its internal stakeholders, but should look outward and connect with external stakeholders.

The MHS is collaborating with public and private organizations, in an effort to contribute to the success of the health care community at large, through shared knowledge, lessons learned, and challenges overcome along the way. (literature)

The below three excerpts identify recommendations specific for EHR implementation. The recommendations to further support EHR implementation include working closing with the Cerner team when they are on site, and communicating with civilian stakeholders. The mention of collaboration was mentioned a couple f times in the evaluation documents.

Be available to the Leidos and Cerner team when they are onsite (GENESIS evaluation report)

Map out tracking board/room arrangements Incorporate information updates into staff meetings regularly/loop in civilian hospitals. (GENESIS evaluation report)

Cerner has created an advisory group to offer insights and recommendations in support of the company's efforts to modernize the federal agency's EHR system. (GENESIS evaluation report)

Moreover, several users discussed recommendations to mitigate issues with the system as seen in the below excerpt, such as actively being engaged in regular communication with stakeholders and leadership.

Regular communications with all stakeholders about mediation strategy, interoperability rates, patient safety issues, resources, QA findings, etc. Management needs to continuously nurture the commitment to collaboration between all the players. (GENESIS evaluation report)

Meet with other departments regarding current processes (GENESIS evaluation report)

Hardware and software infrastructure

The documents discussed some recommendations aimed at ensuring that all hardware and software infrastructure and network are configured for GENESIS. As noted above *hardware and software infrastructure* was categorized as a barrier. Therefore an overarching theme of fixing big-scale network issues were recommended it fix.

Identify any equipment that interfaces with any clinical systems (ultrasound machines, iSTAT, rapid infusers, Pyxis, etc.) (GENESIS evaluation report)

Identify network issues vs. GENESIS issues. (GENESIS evaluation report)

System Measuring and Monitoring

DoD has so far resolved about 1,000 of a total of 7,000 trouble tickets submitted by clinicians to report problems with the MHS GENESIS EHR system.

Department leads develop formal process to track issue resolution tickets

Provide details and screen shots with ticket submission

Provide regular updates to staff and leadership on status (GENESIS evaluation report)

Workflow

Workflow was identified as a barrier in this EHR implementation. However, some recommendations that included better cognitive support for providers were highlighted in the evaluation reports. Additionally, standardizing template with a universal language was recommended.

Better cognitive support includes tools and processes to facilitate clinical decisions and thinking about problems in health care (GENESIS evaluation report)

Standardizing a visit template means using a language that can be easily used and understood by all team members. This can decrease redundancy in the office visit. (literature)

Training

There were several mentions of lessons learned and recommendations in the below excerpts that involved training. As mentioned above training was a barrier in this EHR implementation. Mention of improved training and expanding the scope of personnel trained was an important recommendation.

All department team members should be trained as super users (GENESIS evaluation report)

Improve training and system documentation for both users and Adoption Coaches. (GENESIS evaluation report)

Work with users to document, reduce, and standardize operational workarounds. (GENESIS evaluation report)

Online meetings to provide additional training to the military eHealth community, provide information on new products, and to share best practice guidance. (literature)

Identify and train sufficient numbers of clinical champions and technical-assistance staff to quickly address implementation issues, assist in development of macros and templates, and reassess performance success. (GENESIS evaluation report)

Summary

In summary, the studying findings confirmed several sociotechnical facilitators and barriers associated with EHR implementation in the MHS. Additionally, the data identified several lessons learned. Most notably, the study also revealed construct *leadership characteristics* was rarely mentioned in the documents. Lastly, *medical readiness* was identified as a unique construct to the MHS. A further discussion is provided in Chapter 5.

V. Chapter 5: Discussion

General Overview

As detailed in previous chapters, the MHS is overhauling its previous EHR system AHLTA and trading it in for a new off-the-shelf platform GENESIS. The MHS is in need of modernizing its healthcare system to save taxpayer dollars, as most of the defense budget is allotted to the military's most important asset—its people. At its roots, the MHS is a complex organization that provides medical support for multiple military operations. In 2015, the DoD awarded Cerner, Leidos, and Accenture a $4.3 billion EHR contract for a commercialized off-the-shelf system model to be used by more than 146,000 end-users. The MHS recently implemented the new EHR in several MTFs on the West Coast, and the organization plans to regionally deploy the system to all west coast MTFs by 2019.

As a whole, the MHS is striving to improve overall patient safety and coordination of patient care. This study aimed to explore sociotechnical barriers and facilitators to EHR implementation, specifically in the military. Additionally, this study aimed to identify key recommendations and draw out comparisons to the civilian sector. The findings described in chapter four highlight that EHR implementation is not solely about the technical factors, but also about the integration of external and internal organizational factors.

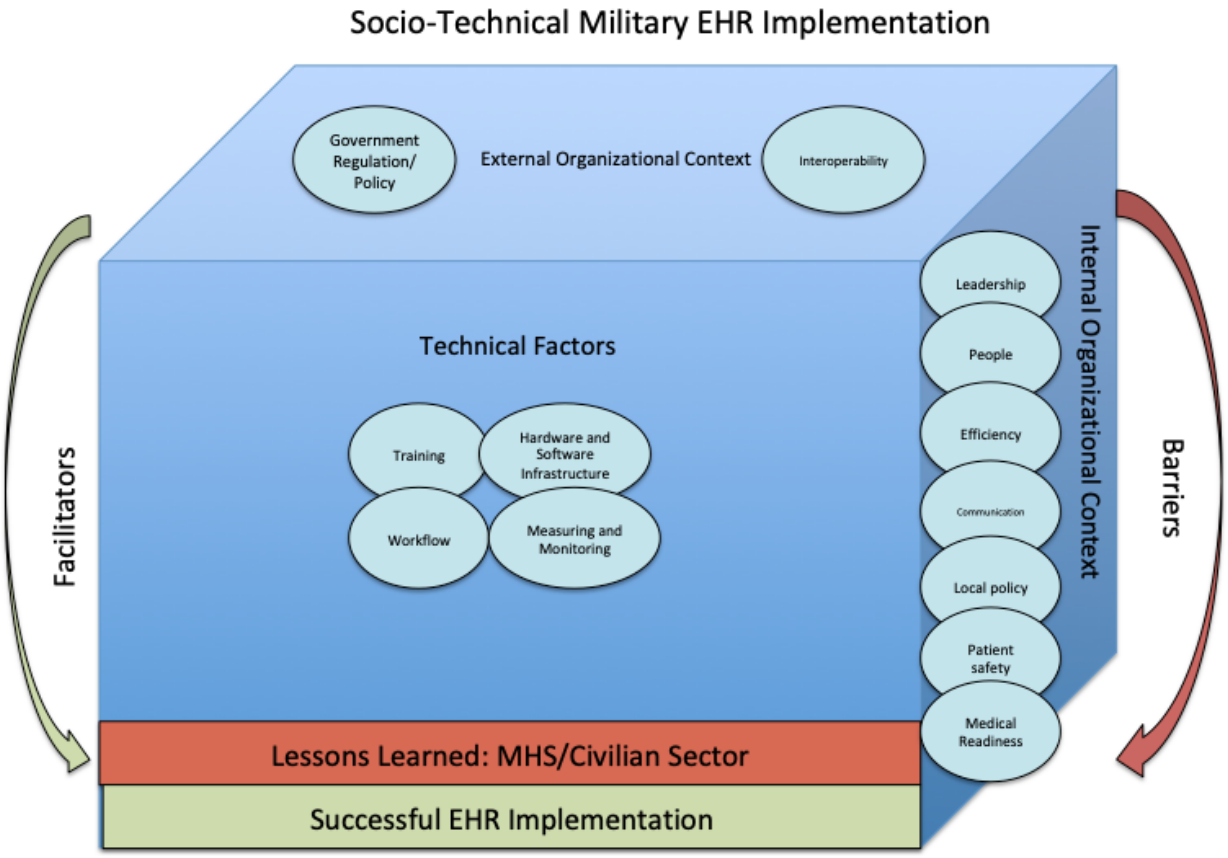
Conclusions and Recommendations for Change

A total of thirty-six documents were analyzed in this qualitative study. The documents were triangulated through the use of multiple types of documents. Analyses took into account sources including newspaper articles, EHR implementation plans, GENESIS evaluation reports,

congressional reports, and peer-reviewed literature. Although an *a-priori* codebook was developed prior to the analysis, the documents yielded a vast amount of very rich data from which several constructs emerged. Therefore, the use of emergent codes was essential to this data analysis. Forty-four total codes were applied to the text during analysis; specifically, 14 *a-priori codes* and 30 emergent codes. Although *a-priori* codes allowed for some structure to be applied to the coding and analysis, the themes and patterns that emerged from the analysis would not have been as meaningful without the application of emergent codes.

A revised conceptual framework was developed as a visual representation of the findings from this DrPH research (Figure 9). This model will be used to help guide the discussion of findings and conclusions for this chapter.

Figure 9. Revised Conceptual Framework: Military EHR Implementation



People

The *a-priori* construct of *people* was a commonly mentioned construct in this DrPH research. During discussions related to EHR implementation, *people* remained a central theme due to the high code frequency in the documents. The construct of *people* seen in Figure 9 shows how it is integrated into external context, technical, and internal organizational factors involved with EHR implementation. People encompass the makeup of an EHR from the end-user, leaders, and champions. People play a dual role in the internal organization as a customer and in the external organization as a stakeholder, interacting with the technical aspects of the system in the process. Therefore, several sociotechnical factors such as communication, leadership

characteristics, and system measuring and monitoring all influence and impact people within the organization.

Implications for the Military Health Service

GENESIS provides service to over 146,000 end-users in the MHS. That being said, people interact with the EHR constantly, and there is an important connection between people and the other constructs mentioned in this research. Of particular importance, the AFMS has a unique job titled Independent Medical Technician (IDMT) which is not considered a doctor, physician assistant, or nurse practitioner, but these unique military providers still have the ability to prescribe medication. Thus, an off-the-shelf product like GENESIS does not have a specific roles built for IDMT's. Some providers had to access several roles in order to use the system effectively and to see all appropriate patient information, which causes delay and is a potential patient safety issue. Even though super-users and champions were identified during implementation, Informatics professionals trained in this field were not resourced. The truth is that the Services continue to have a lack of representation of professional expertise in informatics, which in part, will hinder the overall implementation of the system. The civilian sector also sees the worth of its people in the organization, and identifies with the connection people have with communication, training, and other constructs associated with EHR implementation.

Implications for Civilian Hospitals

Any civilian or military healthcare system consists of a team of people. People have a significant impact on the success or failure of an EHR implementation. Compared to this analysis, communication among providers, nurses, and technicians, or people, is also critical to implementation success. One such study by Gross et al. (2016) outlines an oncology clinic that

recently implemented a new EHR. Prior to implementation, the healthcare facility showed a lack of coordination of care for some of its patients. The point of failure was attributed to underlying human and system failures. Specifically, the clinic identified several implementation barriers related to the team of end-users, communication, and training.

The oncology study advised healthcare facilities to conduct a thorough walkthrough between old and new communication mechanisms prior to implementation, including: (i) mitigation of gaps in the communication functionality, (ii) more strong training for all the staff (iii) better consideration given to the pace of organization change for the individuals, and (iv) the development of models of collaboration between EHR users and vendors and develop team-based care (Gross et al., 2016). This study highlights the importance of connection between people, and critical factors including communication and training during EHR implementation. These factors serve as a vital component to successful EHR implementation, but at the same time, they can serve as a barrier if not properly addressed prior to implementation.

Interoperability

The *a-priori* construct *interoperability* was a critical factor for both the VA and DoD. Previous to GENESIS, the old systems did not talk to each other (AHLTA and VistA). According to the data, interoperability was imperative for both the VA and DoD in order to enhance efficiency and patient safety. Both systems exhibited a lack of health integration once service members retired from the military. However, the implementation of GENESIS can help resolve this important issue by integrating both agencies.

Implications for the Military Health Service

The analysis indicated that there were numerous discussions surrounding the need for the DoD and the VA to work under a unified EHR. Moreover, the results indicated the the need of an efficient and inoperable system between the DoD and VA. Therefore, the importance of the construct of *interoperability* was mentioned several years earlier when only AHLTA was being used by the MHS. According to the literature, these discussions date back up to ten years. Although the VA has not adopted GENESIS yet, there is an expectation from the leadership that patient coordination and efficiency will be enhanced when service members retire from the military and transition to the VA. The VA is a national organization that employs over 370,000 personnel, and over nine million veterans receive care from the VA. As indicated in the analysis, enhancing interoperability between the VA and DoD is needed to enhance overall patient safety and efficiency.

Implications for Civilian Hospitals

Similar to the VA and MHS, the civilian sector is also faced with challenges in regards to interoperability. The lack of ability for systems to be inoperable is typically due to varying requirements posed by the diverse health informatics standards. As a pioneer in a sense, Italy has explored this difficult problem by working towards a national EHR architecture. Although more work needs to be done, Italy is moving forward with standardizing their EHR architecture and enhancing interoperability to improve patient care and reduce costs (Ciampi, Esposito, Guarasci, & De Pietro, 2016). The United States is not on a national health system, as is actually the case for regions such as Europe; therefore, several additional challenges will likely arise due to this discrepancy.

In the U.S., non-interoperable EHRs are hindering health information exchange. Moreover, vendors are imposing additional costs for these health systems to exchange

information to become more operable by design (Vest & Kash, 2016). Therefore, the health infrastructure of the United States civilian sector also faces challenges of interoperability. For the MHS and VA it is imperative to be on the same system since service members receive primary care through the DoD. The civilian sector looks at such solutions as software to provide health data interoperability.

Hardware and Software Infrastructure

The *a-priori* construct *hardware and software infrastructure* is categorized as a technical factor in this research study. As such, this construct proved to be very important during implementation. Technical factors are considered a barrier due to their association with additional delay in implementation and even patient care. Not surprisingly, whenever an EHR has technical problems, the system will tend to not be utilized well and efficiency will not adhere to normal standards. As mentioned above, it was communicated that the Air Force system had to merge onto a new network. This situation caused several delays in implementation that were related to technical and software infrastructure.

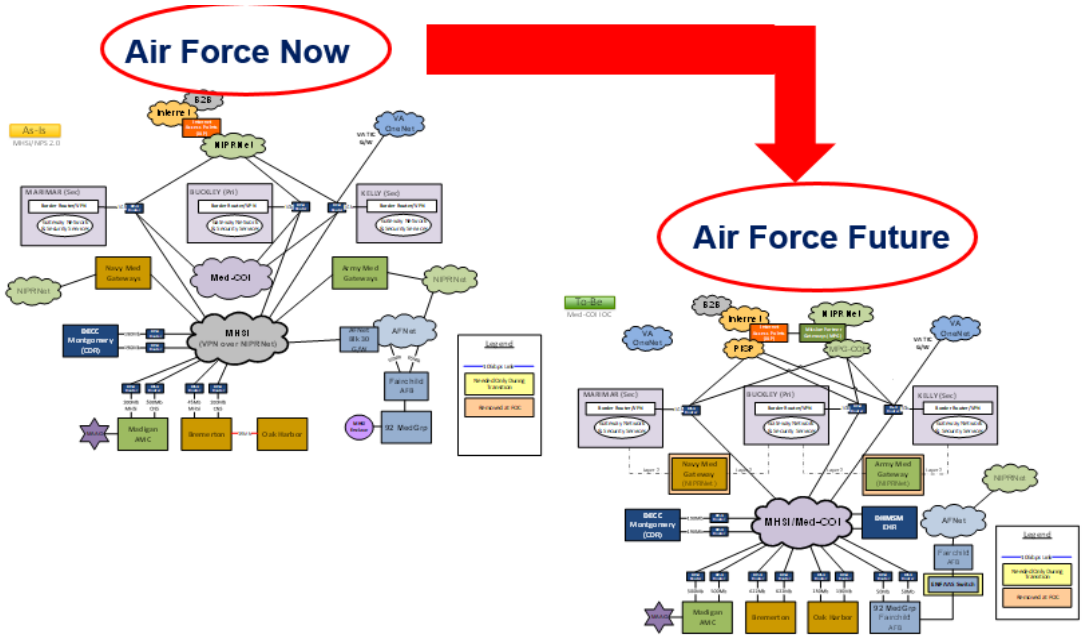
Implications for the Military Health Service

The military operates their EHR on a secure Non-classified Internet Protocol, which has a higher security standard compared to most civilian hospitals. Due to this unique situation, the EHR, much like AHLTA, experiences lag times, system freezes, and operational incidents. This is the first time that the Services are using an off-the-shelf EHR. In the past, AHLTA was specifically designed for the military. The data analysis results showed that this system could not be supported by the current network configuration, and that the outlook for it supporting several other MTFs in the future did not look promising. Therefore, several hardware and software

infrastructure issues were identified. The technical issues not only impacted patient care, but also affected overall user satisfaction of the system. Not surprisingly, like GENESIS, the system AHLTA also had a number of technical issues. Therefore, the external and internal context remains an important element of EHR implementation, but as equally, so does technical factors as outlined in Figure 9. The truth is that these factors all intersect, and all elements should be considered during implementation.

Documents placed emphasis on coordinating with the Cerner team prior to the go-live date to ensure the network was fully capable to handle the EHR. Prior to implementation, the AFMS was on the same network as the US Air Force. The intent for GENESIS was to centralize the network into one--including all the Services. Thus, due to this change in infrastructure, the AFMS implemented GENESIS without having the supportive hardware infrastructure (resources and expertise) to manage local networks (Figure 10). The analysis indicated that the infrastructure issue as generating huge delays during implementation. Therefore, it is important to highlight that prior to implementation, MTFs should conduct a readiness assessment to ensure that all resources and expertise are available to handle a new robust EHR.

Figure 10. AFMS old and new network infrastructure



The evaluation report from GENESIS concluded that both improved training and system documentation for both users and adoption coaches were needed. The finding seemed related to the documentation noting that Cerner and other support agencies were unable to correct and support an overwhelming number of trouble tickets. Overall, the infrastructure of the system posed several challenges.

Implications for Civilian Hospitals

Sociotechnical factors are people-focused (socio) and technical-focused. Both of the concepts must be studied together, not in isolation, as they are not considered to be mutually exclusive. As numerous healthcare facilities have implemented EHRs across the globe and identified technical barriers relating to hardware and infrastructure, the military sector is also taking suit. Of particular note, the unavailability of technology, funding, and lack of technical and computer skills of personnel are the main contributors of technical issues in the civilian sector (Gesulga, Berjame, Moquiala, & Galindo, 2017); however, in the case of the military, the main technical barrier was due to the network the EHR was operating on. The military had the

funding, but experienced barriers with the network and lack of resources to support network-operating issues related to the EHR. Thus, a readiness assessment is highly encouraged in order to determine limiting factors prior to implementation (Gesulga et al., 2017).

Efficiency and lack of efficiency

Both constructs, *Efficiency* and *lack of efficiency*, were categorized as an internal organizational factor according to Figure 9 of the revised conceptual framework. The efficiency of an EHR system, if not designed properly, could hinder the integrity of health data and may have an effect on patient safety and user satisfaction. In turn, as demonstrated in the analysis, a lack of efficiency can lead to mental exhaustion among users and initiate workarounds that may not be safe practices.

Implications for the Military Health Service

Particularly for the MHS, the analysis identified for both AHLTA and GENESIS that hardware and software infrastructure difficulties led to workarounds and overall lack of documentation during an encounter. In addition, transferring legacy health data from one EHR to another is vital for healthcare professionals, as they can evaluate a patient and to make important health recommendations. Seventy-percent (see page 56) of defense health care happens outside of the DoD/VA healthcare system; therefore, mechanisms need to be in place for these systems to receive healthcare data that occurred outside the MHS. In 2015, AHLTA set up a system called HAIMS that would allow for patient healthcare data received from the civilian sector. Although AHLTA had this ability, the system was subject to several errors; for example, incorrect information being uploaded in the wrong medical record. Such errors can also occur in GENESIS. Discussions around the construct of *efficiency* and *lack of efficiency* centered on

GENESIS being identified by end-users as not being operationally effective since the system did not contain enough functionality to manage and document patient information. Coincidentally, the analysis also identified AHLTA as not operationally effective during its initial stages of implementation. Overall, an EHR system needs to effectively document and receive health data. This is very dependent of the system being usable by the end-user, and being supported by hardware and software infrastructure.

Implications for Civilian Hospitals

The civilian sector concludes that implementing a new EHR will decrease efficiency, but once issues are resolved baseline will eventually return (Frazee, Carnes, Munoz Maldonado, Bittenbinder, & Papaconstantinou, 2015). Often times, if the EHR lacks efficiency, workarounds tend to occur. Currently, there is a gap in the literature that explores the unintended consequences of a lack of efficiency and production of operational workarounds. One study by Blijleven (2017), in particular, focused on operational workarounds and their negative impact on the healthcare setting. In particular, workarounds can promote unsafe practices, and in the end, be less efficient and not solve the root issues caused by the EHR to force workarounds. Literature suggests that some workarounds can be resolved with training, redefining organizational policies and practices, and lastly, by conducting a redesign for technical issues (Blijleven, Koelemeijer, Wetzels, & Jaspers, 2017). Therefore, the lack of EHR efficiencies is not just a problem for the military.

System measuring and monitoring

System measuring and monitoring is designed to help improve processes and identify gaps related to EHR implementation—measurement is essential to optimize healthcare. As noted

in Figure 9, system measuring and monitoring is categorized as a technical factor in EHR implementation. Although system measuring and monitoring is a technical aspect in EHR implementation, these quantitative values help inform leadership regarding the effectiveness and reliability of the EHR. Typical measurements include structure, process, outcome, patient experience, and cost.

Implications to the Military Healthcare System

During the pilot-testing phase of GENESIS, trouble tickets were tracked extensively. In the limited number of pilot testing-sites, an overwhelming 7,000 tickets were submitted to the help desks. Consequently, the IT support desks had issues resolving trouble tickets in a timely manner. Moreover, system measuring monitoring gave indications of the barriers to EHR implementation. Additionally, the DHA observed the performance of providers and technicians during the pilot-testing phase and documented their performance. User surveys on training and usability were also measured. Lastly, the DHA measured the quantitative data such as wait times in the pharmacy. System measuring and monitoring is considered a facilitator and a lesson learned from the MHS. The Air Force measured several factors during the pilot testing phase such as wait times, patient safety mishaps, and other important metrics, which helped to inform what the barriers and facilitators were in successfully implementing EHR. Although there were several barriers with the GENESIS EHR implementation, these issues were identified quickly and resolved due to the robust data collection that occurred in the EHR. This informs hospitals to ensure that monitoring and measuring remain a key element during implementation.

Implications to the Civilian Healthcare System

The literature identifies key system measuring and monitoring indicators of an EHR system: evaluation, features, and functions being available and ready for use, measures of system availability including response times and percent uptime of the system, and functions being used by clinicians, effectiveness of the system on healthcare delivery and patient health, identifying and documenting unintended consequences that manifest themselves following the use of these systems, and assessing the quality of care. Further, despite all the information collected, one article suggests that improved data sharing across the healthcare system is still needed. Currently, fragmentation of data occurs across healthcare systems because data collection has a soiled infrastructure (NRC, 2009). Therefore, even when robust EHR data collection occurs in civilian and military healthcare systems, the data collection system remains soiled and fragmented. The literature reveals the need to continue to promote data sharing and standardization. As the MHS and VA healthcare systems become more interoperable, lessons learned on data sharing will remain important for the success of their healthcare integration.

Workflow

The construct of *workflow* was categorized as an internal organizational factor according to Figure 9 of the revised conceptual framework. As evident in the data, workflow is an essential element ensuring functionality of clinical activities. Importantly, workflow impacts user satisfaction, speed, patient safety, and efficiency of clinical care.

Implications to the Military Healthcare System

Although the DHA invested several resources to produce workflows, the construct *workflow* emerged as a barrier to implementation. The DHA built an extensive workflow architecture including providers and technicians from all sister-services. Several issues emerged with the workflows: pharmacists worked extended hours due to longer prescriptions order

workflows which would delay patient care. Additionally, some of the workflows were so complicated in GENESIS that workarounds had to be used to bypass processes in the system. In the end, the use of operational workarounds could significantly impact patient safety. Overall, the GENESIS evaluation report indicated the need for better cognitive support for providers. Although no recommendations emerged in these data, civilian hospitals can provide recommendations to access workflow issues in an EHR.

Implications to the Civilian Healthcare System

As identified above, workflows remain essential to the success of implementing an EHR. Feblowitz et al. (2015) conducted a study that outlined the negative impact on patient efficiency in an emergency room after transitioning from paper documentation to electronic documentation. The increased demand of documentation required in the EHR had a negative impact on patient care. Increased time spent on EHR documentation is a critical barrier to providing quality healthcare. An increase of a few minutes per patient visit due to a change in the workflow may seem like it would not have an impact or inconsequential outcomes, but a result of unintended consequences may occur; however, a patient's wait time faces the most impact on the healthcare system. A study conducted by Vahdal et al. (2018) explored workflows in a dermatology office, and provided several recommendations to improve workflow documentation. Overall, the researchers recommended reducing the in-room documentation workflows and, specifically, nurses were asked to complete input of the patient intake sheet information (medication reconciliation, allergy, smoking status, etc.) in the EHR and queue up medication refills outside the patient room at their nursing station (Vahdal et al., 2018). Providers were asked to minimize any computer work in the rooms by providing patients with a customized report printout of the most recent visit notes and laboratory values in a paper chart prior to entering the room; finally,

scribes were hired for the practice since they were able to help with real-time documentation. In conclusion these practices reduce EHR documentation during the patient visit, and the reduction better explains the patient history to the provider.

Communication

As depicted in Figure 9, *communication* intersects with the external context, internal organizational context, and technical factors. According to the data, the EHR is not operationally effective for the MHS. This same statement was also identified with AHLTA and mentioned in the literature. The study by Pirnejad (2008) stated that errors in healthcare intra-organizational communication can contribute to an increase in medical errors, potentially resulting in morbidity or mortality. Communication error was even found to be the leading cause of death in a study conducted in Australia (Behrens, 2019). Therefore, communication remains an essential element to any organization implementing a new EHR. Not only should good communication occur between the external organization such as the DHA and MTFs, but solid communication also needs to happen intra-agency. During the analysis, the need for continued communication across the various organizational levels of the MHS (headquarters, end-users, and Cerner) was identified. Given the complexity of this project, it was no surprise that collaboration and sharing lessons learned between agencies emerged as a core theme and recommendation. Several recommendations, explored later in this chapter, emerged in these data that mainly focused on enhancing communication across interagency. Further, recommendations to create an advisory group to facilitate lessons learned were identified. Regular communication was an overarching theme. This includes connecting with stakeholders and other Cerner users at staff meetings. Recommendations from the pilot-testing MTF sites focused on how to utilize expertise in the field and lessons learned from other Cerner initial operating capability sites, including civilian

healthcare facilities. In addition to sharing lessons learned, having open communication with people in various departments remains critical, and must include updates in staff meetings and to incorporate the EHR in everyday meetings.

Implications to the Military Healthcare System

The DHA must communicate effectively to the MTFs during EHR implementation. Several communication methods have occurred in the MHS to include: (i) written reports, (ii) memorandums, and (iii) verbal communication. All these methods play a key role in the deployment of a new EHR. Communication can be a broad term, but for this DrPH research, communication was defined specifically as communication disseminated orally, verbally, or written from the internal organization related to EHR implementation that has impacted its deployment. Interestingly, it was communicated in the data that both AHLTA and GENESIS were operationally ineffective. Communication is such an important element that, often times, patient safety can even be hindered as an effect of communication breakdown. Therefore, communication was categorized as a facilitator. In order to uphold transparency in the implementation process, the DHA produced several forums to communicate the vision and overall status of GENESIS. Recommendations did arise to continue to increase collaboration in the services and the VA.

Implications to the Civilian Healthcare System

Much like the military, communication is also an essential element of EHR implementation. In the civilian literature, communication is defined as occurring between the organization, healthcare professionals, and patients. An EHR that incorporates clinical decision support (CDS) to healthcare staff enhances healthcare within the facility. Such examples of CDSs are alerts, reminders for guidelines, and order sets. One study promotes the need for cross

team communication to help enhance patient care (Bush et al., 2018). Another study found that EHRs could sometimes inhibit information sharing and frequently impede intra-care team communication. It was identified in a hospital setting that when providers interface with the EHR, attention often remains more focused on the screen than on the actual team in the room. When an EHR is used in the room, verbal and visual sharing of patient information among care team members is a rare occurrence (Assis-Hassid, 2019). Therefore, EHR design teams and hospitals should consider workflows that do not inhibit team communication sharing. Communication needs to occur in various levels within an organization when implementing an her, and in a sustaining way. An EHR must not inhibit cross team communication, and leaders should explore extensive communication methods to identify barriers in the EHR.

Implementation and policy and procedures

The organization's internal structures, policies, environment, and procedures play an impact on the success of EHR implementation. Shifting an entire organizations business policies and healthcare policies can be challenging. As noted in Figure 9, this construct intersects with the internal and external context and technical factors. The construct serves as a facilitator in the EHR implementation, leaving several implications for the MHS to consider.

Implications to the Military Healthcare System

The implementation and communication plans outlined several policies and procedures for the implementation of GENESIS. Integrating new business processes and workflows between three unique services (Navy, Army, and Air Force) can be the most challenging. All the Services have their own standard of care and organizational culture that had to be unified with a joint EHR system. With this in mind, the system design posed several challenges during

implementation such as defining unique user roles and workflow processes.

Implications to the Civilian Healthcare System

Like the MHS, the civilian sectors also deals with process change. Similar to any change, recommendations are centered on early planning and early engagement with end-users and stakeholders. The literature shows a gap from transitioning from one EHR to another (Whalen et al., 2018). One study, in particular, explored an organization that had an issue implementing a new EHR across eleven institutions with varying patient populations and levels of care (Whalen et al., 2018). As a result of this transition, the number of pediatric medication safety reports increased, although harmful events did not increase. As a result of the increase of safety reports, the organization strived to standardize practices across the EHR in order to better promote the outcomes for the system. The organization established a network pediatric committee to discuss and prioritize pediatric enhancements for the EHR. This committee standardized dosing guidance and addresses issues such as standardized concentrations, common pump platform, and shared policies and procedures (Whalen et al., 2018). Overall, the study placed emphasis on policy and procedures and attained success with considerations that were effectively communicated and standardized.

Training

As depicted in Figure 9, *training* is categorized as a technical factor. Training is considered a barrier for the EHR implementation. The literature firmly supports the vital need for training and, thus, contributes to the success of the EHR. In particular, an open dialogue needs to occur between the trainer and trainee. It is recommended for training to maintain these key points: technical content, administrative content, clinical content, and system operational content

(Garcia-Dia, 2019). Additionally, the method for training must be considered for the trainee. Assessing the computer skills of the trainee is very important in order to modify the training, and to this end, the IT department should work with the vendor to customize the training for the organization.

Implications to the Military Healthcare System

Findings from this study indicate that the training for the EHR users was poor for GENESIS. Additionally, it was suggested that the training could not overcome the usability problems of GENESIS. Therefore, training was an important construct for this research, and was considered a barrier. Although training was poor, several recommendations emerged such as all department leads should be trained as super-users, and this also includes training a sufficient number of clinical champions to quickly address implementation issues. Overall, the training provided by the vendor was inadequate to meet the needs of the MHS.

Implications to the Civilian Healthcare System

The end-users overall determine the quality and effectiveness of the EHR training. In one particular study of physicians, it was determined that these providers wanted more realistic training scenarios and wanted more time for training prior to the go-live date of the EHR (Pirtle, 2019). The civilian sector has demonstrated the importance of EHR training during implementation.

Patient safety

Findings from this study illustrate the implications of EHRs for patient safety. Poorly integrated EHRs could pose a danger for patient safety and decrease the overall quality of care. Besides enhancing interoperability between the DoD and VA, another main driving force for the

MHS to adopt a new EHR is to improve patient safety across the enterprise. As depicted in Figure 9, patient safety is categorized in the internal organizational context.

Implications to the Military Healthcare System

Although the MHS is working towards enhancing patient safety within its organization, some barriers exist with GENESIS. Specifically, the EHR was identified to be hindering patient safety. To highlight, the data suggested that inaccurate prescription submissions were of main concern with the new system. Further, concerns around accuracy of information remained an issue for GENESIS. Lastly, workarounds were common due to issues seen within the system; overall, these promote patient safety concerns resulting in bypassing patient safety protections inherently built into the system. Therefore, workflows must be simple and easy for providers to prevent workarounds that, in turn, may hinder patient safety.

Implications to the Civilian Healthcare System

The civilian sector is as much concerned with patient safety as the military is. There are several domains in which health information technology can improve patient safety, although patient risk is classified high during EHR implementation. Campione et al. (2018) found that during health information technology implementation, patient errors increase compared to health information technology that is fully implemented. A recommendation promoted in the civilian literature is the notion for patients to have access to view their medical record which would enhance patient safety (Albutt et al., 2018). Other recommendations are to have streamline workflows to reduce the number of workarounds and reduce the mental load from providers. Much of the technical aspects in EHRs directly relate to patient safety. For example, if providers continue to conduct workarounds in the EHR, the practice could lead to more patient safety errors. Additionally, if a provider has a large mental workload, the workload can lead to fatigue

that directly ties in with patient safety. In order for an EHR to execute better patient safety, patients must be involved with their own care, and workflows and technical aspects must be simple and streamline.

Leadership characteristics

Findings displayed the important relationship between EHRs and leadership. Leaders help to create the climate during EHR implementation. Change is hard, and it is noted during EHR implementation that providers are disturbed from their day-to-day routines, not to mention that implementation brings with it various challenges. Thus, resistance to change can occur among healthcare providers, and the resistance may have a negative impact n the organization (Heath & Porter, 2019).

Implications to the Military Healthcare System

To plan for EHR implementation, effective leadership strategies require the alignment of priorities that are needed to support the EHR system. Ultimately, the leader will set the tone and serve as the advocate for the EHR transition. Although the military promotes studying leadership in hopes to instill it within their officers, one limiting factor identified in the literature is the fact that MTF commanders only take command for two years. The limited tenure could be a limiting factor when EHR transition can take several months to years to normalize within the organization. Besides the short tour of most commanders, leaders do need to promote a culture of improvement and growth in technology.

Implications to the Civilian Healthcare System

Studies have demonstrated that a lack of physician buy-in can be a major barrier to the development and sustainability of EHR implementation. Thus, physicians play a central role during the implementation of a new EHR. Identifying a physician leader can help promote the

change and overcome resistance (Heath & Porter, 2019). EHR implementation exposes the vulnerabilities within an organizations culture and leadership. Not only does EHR implementation require intensive planning, but it also requires strong leadership to carry it through. Leaders must ask themselves three key questions: 1) what is the organizational culture, 2) what is the organizational readiness, and 3) what are the desire outcomes for the stakeholders (Delisle et al., 2019). Therefore, the civilian sector recognizes the need for leadership during EHR implementation, and acknowledges that leadership occurs at many levels (headquarters, physicians, and EHR champions).

Medical readiness

Compared to the civilian sector, the construct of *medical readiness* is a conceptualization that is unique to the military. Medical readiness looks to support a medically ready force, and furthermore, prepares service members to deliver outstanding expeditionary health care across a full range of military operations in several geographic locations. With the war in Afghanistan and recent conflicts with the Islamic State of Iraq and Syria in Iraq and Syria, medical readiness still remains a critical element for military personnel to carry out combat operations in austere locations where medical resources are extremely limited. Although not a frequently mentioned construct, *medical readiness* remains an important element of implementation due to its military implications. As it relates to EHR implementation, this construct was categorized as a barrier.

Implications to the Military Healthcare System

Surprisingly, the implementation plans focused on patient safety and inoperability, but did not make much mention of medical readiness. The GENESIS evaluation report did capture important medical readiness elements such as immunizations. The military services operate with independent medical readiness systems such as the Army's Medical Protection System, the

Navy's Medical Readiness Reporting System, and the Air Force's Aeromedical Service Information System. These systems typically work independently from the EHR, but some information can be fed into the system. A usable EHR is still needed to accomplish and capture medical readiness tasks. When GENESIS initiated during the pilot-testing phase, barriers arose to providing care for the soldier to meet certain medical readiness requirements. For example, the Air Force's public health technicians often order a human immunodeficiency virus test for airmen every two years. The new system, GENESIS, only allowed for providers to complete this function. Therefore, causing the public health technician to have another role in the system would mean that the test needs to account for further delays in patient care.

One of the MHS' focuses should have been broader than patient safety and interoperability, specifically in terms of including medical readiness. This unique aspect to the MHS was often not addressed enough. The MHS must ensure they are preparing a medically ready force to the commandant commanders.

Federal, State, and local health regulations

The medical system is littered with health regulations from the federal, state, and local levels. With the new uptake of EHRs, regulations and standard of care still needs to be met. Some examples of these regulations are HIPAA and Healthcare Effectiveness Data and Information Set (HEDIS). In this particular research, the construct *federal, state, and local health regulation* is considered a barrier. Referring to Figure 9, this construct is categorized in the external context. Regulations can come from an external environment to be implemented to an internal organization.

Implications to the Military Healthcare System

Most noteworthy in the data, GENESIS was not meeting certain health regulation standards. Findings illustrated how GENESIS is not supporting the National Provider Identification numbers or National Drug Codes. Without this function, pharmacists are forced to look up drug codes, which would lead to further delays in patient care. In addition, analysis indicated that the messages relating to radiology interfaces do not conform to standards and ICDs. Lastly, HEDIS measures were not captured during the pilot-testing phase of implementation, which was a risk to the organization.

Implications to the Civilian Healthcare System

Similar to the military sector, civilian hospitals also experience barriers with regulations and EHRs. One of the barriers, in particular, is in complying with HIPAA regulations. The HIPAA law strives to protect patient information. In order to protect information, EHRs must be set up with encryption capabilities and other security measures to remain compliant to this federal regulation. Regulations have also been noted as barriers or burdens in healthcare, such as the requirement of excess signature requirements. For instance, Smith et al. (2018) recommended that the changes in the federal regulations should support the evolution of health information technology. Documentation burden has become an issue with the emergence of EHRs, and these burdens relate directly to delays in patient care (Smith et al., 2018).

Recommendations for Change

This DrPH research contains several valuable implications for EHR implementation in the MHS, and other organizations can adopt these recommendations in their own organizational context. Although at a glance, some of these recommendations may seem to be a technical fix; as Friedman (2009) indicates, informatics is only 20 percent about technology. The recommendations involve supporting people and the organization, which is the basis of

sociotechnical factors. Therefore, some of these recommendations might incur cost, such as the training or hiring informaticists to provide EHR support to the organization. The MHS needs to reconsider the alignment of its resources to better support an emerging IT future.

Recommendation # 1- Informaticists

A finding emerged from this research regarding the need for more informaticists[3] to be trained or hired in the MHS. The constructs *people*, *communication*, *interoperability*, *efficiency*, *medical readiness,* and *hardware and software infrastructure* supports the need for a more robust presence knowledge of informatics in the MHS, and this would align better with the civilian sector. As noted in the documents GENESIS experienced several barriers during implementation balancing an off-the-shelf product with the needs of a unique medical system.

When President Barack Obama took the initiative by signing legislation that addressed EHR use under the American Recovery and Reinvestment Act of 2009, Health Information Technology for Economic and Clinical Health (HITECH) marked the first government regulation in the field of BMI. The implementation of government regulations and the military leveraging EHRs in their healthcare system for the past ten years justifies the need for informaticists to better integrate EHRs in the MHS and promote overall health outcomes for the beneficiary U.S. population.

Currently, the Air Force does not support informatics fellowships or have specific job placements in the MHS. There are several informatics fellowships to which the Air Force can look to foster partnerships that enhance the professional development of their officers. One fellowship, in particular, is the Centers of Disease Control and Prevention's (CDC) public health

[3] the science of processing data for storage and retrieval; information science.

informatics fellowship. This two-year fellowship provides applied public health informatics training to fellows to apply computer science and information technology to public health problems. The Air Force currently has a partnership with the CDC for the Epidemic Intelligence Service Fellowship.

Other clinical informatics fellowships exist throughout the country. The MHS needs to leverage its civilian counterparts in informatics and engage in collaborative trainings with various universities. The collaboration will further enhance the military's competency to handle a complex EHR operating in a complex environment. Enhancing communication and collaboration was identified analyzing the construct *communication*. Further, the MHS operates in a hierarchal organizational structure, and important information was noted not to flow down to applicable front line staff and middle managers. Having informaticists on staff would help break those communication and implementation barriers. A limiting factor for this recommendation is funding amongst the services. If the MHS is willing to spend $4.3 billion on EHR, it must also be willing to invest the needed professional development that should be aligned with the new system. This implementation will enhance efficiency, medical readiness, and communication across the MTF as well as preserve the integrity of the EHR.

Recommendation # 2- Phased Approach to EHR implementation

How an organization decides to implement its new EHR will have significant effects on the organization's overall success. This recommendation emerged due to the issues with the hardware and software infrastructure of the EHR. During the pilot-testing EHR phase at Fairchild AFB, the leadership decided on a big bang approach for implementation versus a phased approach. The big bang approach replaces the old system with the new system at a single

point-in-time, while a phased approach modules replace the old systems in a planned, gradual sequence. While all approaches have pros and cons, a phased approach is typically more successful in larger organizations versus a big bang approach. The success is a result of a phased approach that allows for larger organizations to meet the various needs of each sub-organization.

Although the big bang approach has the advantage of speed, it hindered the MHS to fully identify the significant barriers and gaps, forcing the clinics to implement workarounds and opened up risk. Can the military afford risk, which can sometimes be inherent in the big bang approach? Although the phased approach may take longer and cost more, the approach can be safer and allows for the system to better adapt to the various organizations. Considering that the entire MHS operates in three soiled organizations that include 146,000 end-users across 400 DoD MTFs, a phased approach would better identify the cultural and technical gaps during implementation. The MHS could have adopted a phased approach during the pilot-testing phase, but then have considered the big bang during regional deployment. The advantages of a phased approach include a reduced risk of change management. Additionally, considering that the MHS bought an off-the-shelf product from a company that was not too familiar with the unique aspects of the MHS, a phased approach would be a more appropriate option to identify limiting factors. Additionally, the organization would have to assume less risk, while preserving the medical readiness of their service members.

Recommendation # 3- Enhance Training

Training was identified as a barrier in this research. Even though new users received training, the regimen was insufficient to meet their needs, as noted in the data. Most notably, there were too many inconsistencies among trainers and materials mostly due to the constant

configuration changes. Training is not simply a form of conveying information to the end-user; specifically, it is recommended that the needs of the organization, strategic goals, competency level, and learning styles of trainees be considered. Training should also occur pre and post implementation, and must be on a continued cycle. Training can have a positive effect on a provider's willingness to use the EHR. Additionally, effective training increases overall user satisfaction.

Research indicates that user training is often not treated as essential to the implementation process; but rather more of an afterthought (Pantaleoni et. al., 2015). It is recommend to: 1) set a training timeline that extends beyond the go-live date, 2) assess training needs and users skill levels, 3) establish a training team that includes all stakeholders, 4) use real time and hands on training, 5) choose the right curriculum, and 6) create a EHR training checklist (Green, 2018). Researchers at Kaiser Permanente, Mid-Atlantic States (KPMAS) recommend including common support questions and answers, recently added EHR improvements, and survey data from expert users. Further, content is important to EHR training. McAlearney et al. (2016) captured the best practices that the MHS should consider for their training program: emphasizing the positive impact and vision of an EHR, training that contains both observation and hands-on EHR activities, imbed clinical champions and positive role-models, building on past computer experiences, as well as consider social and cultural sensitivity. Further, leaders must value training, and the organization must consider individualized computer skills assessments, offer blended learning opportunities as well as ensure that the training staff is knowledgeable. The training should be consistent and standardized across the MHS, but it should tailor the training for cultural diversity and different

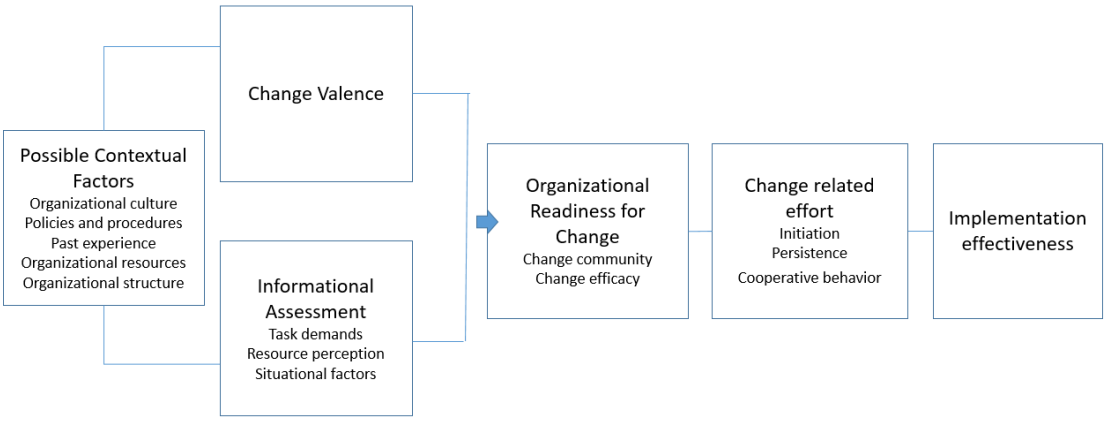
mission sets within each MTF. Improving training efforts would help to enhance efficiency and overall usability of the system, in addition to better preserve patient safety.

Recommendation #4- Leadership Framework

With any organizational change, there are strategic readiness implications. The outcome of unintended consequences experienced in organizational change can present a seemingly simple process a very difficult one. This research informs the model that acknowledges the need to consider friction and unintended consequences and to draw in two other models *Weiner's Organizational Change Readiness Model* and the *8 Dimensional Socio-Technical Model of Safe & Effective EHR Use* (promoting concepts of organizational change readiness factors (culture, resources, etc.) at the organizational level and actions for leaders to consider during change.

The MHS should be guided by Weiner's Organizational Change Readiness Model to help assess their organizations ability to change both at the macro and micro-level. Weiner includes the concept of change valence, which explains the values that individuals' perceive in the commitment of change (i.e. efficiency, various leadership support). Another concept in the model is change efficacy that draws on social cognitive theory. Lastly, contextual factors such as organizational culture, climate, resources, and policies and procedures play an important role in change, and are highlighted in this framework. Overall the model supports a shared approach to change readiness that values the commitment of the individual and belief in their ability to change.

Figure 11. Weiner's Organizational Change Readiness Model

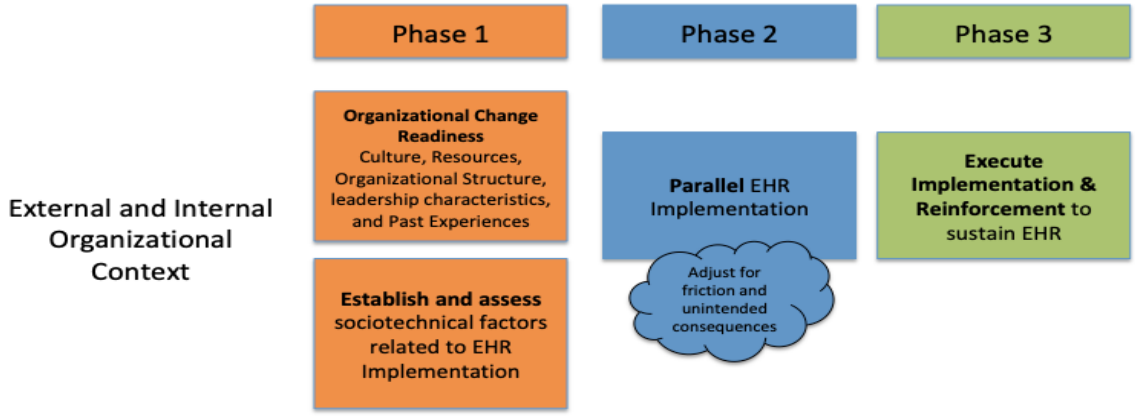


The AFMS should consider these phases of operational change during EHR implementation. The recent changes within the MHS, specifically the Air Force, present important challenges. Considering budget constraints and limited resources, the AFMS focuses on patient safety and efficiency for its 2.6 million patients. Although significant change may occur only once every few years, having issues during implementation impacts mission success, ultimately threatening the vital role that the AFMS provides to national security.

Therefore, this research informs an EHR leadership model to guide MTF leaders during health information technology implementation. The model is broken up into three phases: (i) phase 1, organizational change readiness and sociotechnical factors assessment, (ii) parallel implementation, and (iii) execution and sustainment. Leaders must consider resources and have the awareness that friction and unintended consequences will result during implementation. Therefore, a parallel approach of EHR implementation was emphasized in this model to showcase the benefits that are offered by a parallel approach. Lastly, leaders must consider

sustainment considerations to the new technology. Figure 11 depicts the Air Force Medical Service Health Information Technology Leadership Model.

Figure 12. Depiction of the Air Force Medical Service Health Information Technology Leadership Framework



B. Leadership Implications for Public Health and the Military Health System

Findings from this research have several implications for the public health career field and the MHS. The data indicate that leadership is needed across several levels of the organization including physicians, and that the leadership team can easily make or break the EHR implementation process. Most notably, an off-the-shelf system was implemented across three unique organizations that have their own unique organizational culture. The cultural diversity poses a challenge not only in a technical manner, but leading people through a new change that will cause inherent disruption within the organization.

The MHS inherited a challenge implementing an off-the-shelf EHR across three different services, all of which operate in a unique environment. Vego (2013) defines military culture as the sum of intellectual, professional, and traditional values possessed by an officer corps. Due to

the military's hierarchical structure and the tendency towards resistance to change, the military is not conducive to finding solutions to a new challenge. Therefore, embracing creativity in the military is hindered. The need for creativity and innovation is needed in the military and should be embraced by leaders.

C. Generalizability

Finding from this research were seen from the lens of EHR implementation in the military. However, since large organizations will continue to adopt and phase out old EHRs, this research is relevant for civilian hospitals and future military health information technology implementation. This research only reviewed documents; therefore, the limited type of sources considered could limit the generalizability substantially due to limiting potential data to answer the research questions. The military chose an off-the-shelf EHR to replace their internally developed EHR AHLTA. The choice provides important insight about how to fully adopt an off-the-shelf product that can meet such a large, unique culture such as the MHS. As more and more civilian hospitals adopt EHRs and as this technology advances the importance of research and understanding sociotechnical factors related to implementation, the findings will remain an important factor to consider for years to come.

D. Strengths and Limitations

This research is the first of its kind studying GENESIS in the DoD. Overall research on EHR implementation in the military is limited. A strength of this research was the use of qualitative analysis employing emergent coding. Although *a-priori* codes were identified prior to the analysis, the use of emergent codes allowed for more rich data to emerge and helped to identify potential gaps in the literature or frameworks.

There were several limitations in this study. Due to Air Force regulations, semi-structured interviews were not approved for use in this study. It is unknown whether the addition of interviews would have helped to validate or negate the findings of this research. Secondly, there was limited literature on EHR implementation in the military overall, reducing the variability of the results. Lastly, because of the qualitative research design and the use of emergent codes, a potential threat was that the data were subject to researcher bias. To address this issue, chapter 4 results are supported with excerpts from the data to provide evidence for researcher statements.

E. Next Steps

Presentation: Future plans for this DrPH work is to provide the DHA a presentation of the findings and recommendations. The DHA will be implementing regional deployment in the next coming months, and, therefore, timely communication of these results will be critical to the success of the implementation. The presentation has currently been scheduled January 2020.

Publications: It is possible that organizations beyond the MHS will want to know the results of this DrPH research. The publication will focus on the findings and recommendations outlined in this research. It is anticipated that this publication will be submitted to either *Air University Press* or *Military Medicine*. These publications will promote awareness of federal medicine and its implications on airpower and leadership.

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EDUCATION

University of Illinois at Chicago, School of Public Health, Chicago, Illinois
DrPH: Leadership, anticipated May 2020

Air University, Maxwell AFB, Alabama
Master of Military Operations in Arts and Science, 2019

University of Illinois at Chicago, School of Public Health, Chicago, Illinois
Graduate Certification, Informatics, 2013

The Ohio State University, School of Public Health, Columbus, Ohio
Master of Public Health, 2009

Kent State University, University Kent, Ohio
B.S., Biology, 2006

MILITARY EDUCATION

Black Belt Course, Maxwell AFB, 2017

Food and Water Risk Assessments, Fort Sam-Houston, 2017

Air Command and Staff College, correspondence, Maxwell AFB, 2016

Public Health Emergency Couse, Fort Sam-Houston, 2016

Advanced Incident Command Systems, Command and General Staff (FEMA), Fort Sam-Houston, 2016

Intermediate Incident Command System for Expanding Incidents (FEMA), Fort Sam-Houston, 2016

Green Belt Course, RAF Lakenheath, 2015

Squadron Officer School, in-residence/correspondence, Maxwell AFB, 2012

Basic Military Public Health, Brookes AFB, 2010

Commissioned Officer Training School, Maxwell AFB, 2009

TEACHING EXPERIENCE

Air University, Air Command and Staff College Montgomery, AL

Leadership, 2019

American Culture, 2019

Psychology in Leadership, 2020

INTERNSHIP

International Public Health Internship: tropical medicine, food safety, and other public health topics, Uganda, Africa, 2008

PROFESSIONAL EXPERIENCE

U.S. Air Force Montgomery, AL 06/19 – Present
Director of operations, Air Command and Staff College

- Oversees daily operations of Air Command and Staff College, supervises 250 majors/international officers from 12 different countries
- Serves as a instructor in the Leadership Department, instructs on ethics, leadership, psychological leadership and American culture

U.S. Air Force Montgomery, AL 07/18 – 05/19
Air Command and Staff College Student

- The ACSC resident curriculum is a rigorous 10-month graduate-level program taught through intensive small group seminars and engaging lectures. Courses cover topics that include the profession of arms, leadership and ethics, joint operations, airpower, and the international security environment
- Conducted independent research on "Implementation of Base Operational Medicine Cell"

U.S. Air Force Okinawa, JP 10/15 – 06/18
Public Health Flight Commander

- Provide programmatic oversight in epidemiology, occupational health, deployment medicine, emergency preparedness, food safety, and food defense, direct budgetary allocation decisions, and provide supervision and leadership to a team of 29 employees
- Process Improvement Council Chair, provide oversight on all process improvement events
- Public Health liaison with host nation Japan, US Navy, US Marines and US Army Services

U.S. Air Force England, UK 10/12– 09/15

Chief, Public Health Operations

- Provide programmatic oversight in epidemiology, occupational health, deployment medicine, emergency preparedness, food safety, and food defense, direct budgetary allocation decisions, and provide supervision and leadership to a team of 33 employees
- Air Force Public Health liaison to National Health Service and East of England Public Health and Emergency Response
- Deployed to Niger as the director of preventative medicine; authored first military occupational health report. Enhanced social partnership and capacity building through coordinating visits to local hospitals and increased host nation community ties
- Public Health led for two NATO military exercises; integrated with 9 countries and trained 2.6K personnel
- Joint Commission Project Officer

U.S. Air Force Las Vegas, NV 10/11-09/12

Chief, Commanders Action Group

- Coordinated political engagement with elected Federal, State and local government officials in a career broadening assignment

U.S. Air Force Las Vegas, NV 06/09-09/11

Officer in Charge, Force Health Management

- Provide programmatic oversight in epidemiology, occupational health, deployment medicine, food safety, and food defense and provide supervision to a team of 30 employees

AWARDS

- Health Professional Scholarship Program, United States Air Force, April 2008
- Squadron Company Grade Officer of the Year, 2010, Nellis AFB
- Squadron Company Grade Officer of the Quarter Jan-Mar 2010, Nellis AFB
- Squadron Company Grade Officer of the Quarter Oct-Dec 2011, Nellis AFB
- Surgeon General Real Professional Award, 2010 & 2011, Nellis AFB
- Air Combat Command Biomedical Specialist, Company Grade Officer of the Year, 2011, Nellis AFB
- Group Wing Staff Agency Company Grade Officer of the Quarter Jan-Mar 2012, Nellis AFB
- Medical Group Company Grade Officer of the Year, 2011, Nellis AFB
- Medical Group Company Grade Officer of the Quarter Apr-Jun 2013, RAF Lakenheath
- United States Air Force European Biomedical Specialist Cat II, Company Grade Officer of the Year, 2012, RAF Lakenheath
- Squadron Company Grade Officer of the Quarter Oct-Dec 2013, RAF Lakenheath
- True Ambassador Award, United States Embassy, 2012, RAF Lakenheath
- Medical Group Company Grade Officer of the Year 2013, RAF Lakenheath
- Medical Group Company Grade Officer of the Quarter Apr-June 2014, RAF Lakenheath
- Medical Group Company Grade Officer of the Quarter Jan-Mar 2015, RAF Lakenheath
- Pacific Air Force Nomination for Chief of Staff Excellence in Team Award, 2016, Kadena AB
- AMSUS Force Health Protection Award, 2016, Kadena AB

PROFESSIONAL ORGANIZATIONS

- American Public Health Association
- American Association of Informatics
- Daughters of American Revolution

PROFESSIONAL PRESENTATIONS

- Lessons Learned from Delayed Tuberculosis Diagnosis and its Subsequent Active Tuberculosis Case Response at a Child and Youth Center on Kadena Air Base, Asia Pacific Military Health Exchange, 2017
- Lessons Learned from Active Tuberculosis Case on Kadena AB and Bare Base Public Health Considerations TAOS, 2016
- Prevalence of methicillin resistant staphylococci (MRS+) in pigs and farm workers, SAFER PORK, 2009

OTHER SKILLS

Certification: Green Belt
SPSS, SAS, Epi Info

APPENDIX A

Measurement Table

Measurement Table			
Main Question 1: 1. How do sociotechnical factors influence EHR implementation across the military health system?			
Sub-Q1: What are the primary sociotechnical facilitators that promote EHR implementation? Sub-Q2: What are the primary sociotechnical barriers that hinder EHR implementation?			
Constructs	**Factors**	**Measures/Analysis**	**Data Sources**
• **Organizational Context** –Military Health System policies and practices that affect all aspects of HIT management and healthcare. To include how leadership implements policy and if it is represents HHQ policies and workflows • **External Context-** External forces that facilitate or place constraints on the implementation and use, of HIT in the clinical setting • **Technical-** Technical operations related to the use of the EHR • **Successful EHR -** An EHR that is useful during patient care and that is efficient for the end-user	• **External Context** • Support and constraints from higher headquarters or consultant partner • Federal, state, and local healthcare regulations • Communication from higher headquarters • Emergent Codes • **Organizational Context** • Implementation of policies and practices • Communication • Leadership Characteristics • People • Emergent codes • **Technical** • Hardware & Software Computing Infrastructure • Computer Interface • Clinical Content • Workflow • Emergent codes • **Successful EHR** • Efficiency during patient encounters • Improved coordination of care • Improved clinical decision support • Enhanced patient safety • Emergent codes	• Qualitative Measures with *a-priori coding* via ATLAS.ti • Extraction of key terms and phrases ○ Collation into matrices and coded ○ Examine for key themes and patterns ○ Summary interpretations based on patterns of the codes, major and supportive themes, and extract key terms/phrases	• Extensive literature review using key terms • Document reviews

Main Question 2: How can the lessons learned from initial EHR implementation in the military help inform the process moving forward throughout the military health system?

Constructs	Factors	Measures/Analysis	Data Sources
• **Organizational Context** –Military Health System policies and practices that affect all aspects of HIT management and healthcare. To include how leadership implements policy and if it is represents HHQ policies and workflows • **External Context-** External forces that facilitate or place constraints on the implementation and use, of HIT in the clinical setting • **Technical-** Technical operations related to the use of the EHR • **Successful EHR -** An EHR that is useful during patient care and that is efficient for the end-user	• **External Context** • Support and constraints from higher headquarters or consultant partner • Federal, state, and local healthcare regulations • Communication from higher headquarters • Emergent Codes • **Organizational Context** • Implementation of policies and practices • Communication • Leadership Characteristics • People • Emergent codes • **Technical** • Hardware & Software Computing Infrastructure • Computer Interface • Clinical Content • Workflow • Emergent codes • **Successful EHR** • Efficiency during patient encounters • Improved coordination of care • Improved clinical decision support • Enhanced patient safety Emergent codes	• Qualitative Measures with *a-priori* coding via ATLAS.ti • Extraction of key terms and phrases ○ Collation into matrices and coded ○ Examine for key themes and patterns ○ Summary interpretations based on patterns of the codes, major and supportive themes, and extract key terms/phrases ○ Develop a comparison table to identify sociotechnical factors in each data source (news articles, DHA docs, congressional reports, and literature)	• Extensive literature review using key terms • Document reviews

Main Question 3: Are civilian responses to barriers to EHR implementation similar to the barriers identified in the military context that would be applicable or helpful in the military context?

Constructs	Factors	Measures/Analysis	Data Sources
• **Organizational Context** –Military Health System policies and	• **External Context** • Support and constraints from	• Scanning/reading a targeted literature search on civilian peer-reviewed EHR	• Extensive literature review using key terms

practices that affect all aspects of HIT management and healthcare. To include how leadership implements policy and if it is represents HHQ policies and workflows • **External Context-** External forces that facilitate or place constraints on the implementation and use, of HIT in the clinical setting • **Technical-** Technical operations related to the use of the EHR • **Successful EHR -** An EHR that is useful during patient care and that is efficient for the end-user	higher headquarters or consultant partner • Federal, state, and local healthcare regulations • Communication from higher headquarters • Emergent Codes • **Organizational Context** • Implementation of policies and practices • Communication • Leadership Characteristics • People • Emergent codes • **Technical** • Hardware & Software Computing Infrastructure • Computer Interface • Clinical Content • Workflow • Emergent codes • **Successful EHR** • Efficiency during patient encounters • Improved coordination of care • Improved clinical decision support • Enhanced patient safety Emergent codes	implementation, identify barriers of EHR implementation • Identify how they were addressed in the system and if it was successful • Draw out recommendations that can be helpful in the military context • Develop a comparison table of civilian EHR barriers and military EHR implementation barriers	

APPENDIX B

A-priori Codebook

A-priori Coding Outline for Sociotechnical Barriers and Facilitators

CODES	DEFINITIONS
SOCIOTECHNICAL FACTORS Primary codes and Sub-codes: • **External Context** • Support and constraints from higher headquarters or consultant partner • Federal, state, and local healthcare regulations • Communication from higher headquarters • Emergent Codes • Cost • Interoperability • Survivability • **Organizational Context** • Implementation of policies and practices • Communication • Leadership Characteristics • People • Emergent codes • Delay • Culture of data use • Health data • Healthcare management • Lack of clinical data • Learning health system	The sociotechnical factors relates to codes adopted from the 8 *Dimensional Socio-Technical Model* of Safe & Effective EHR Use. The sub-codes further define each code category. **Organizational Context –**Military Health System policies and practices that affect all aspects of HIT management and healthcare. To include how leadership implements policy and if it is represents HHQ policies and workflows **External Context-** External forces that facilitate or place constraints on the implementation and use, of HIT in the clinical setting **Technical-** Technical operations related to the use of the EHR **Successful EHR -**An EHR that is useful during patient care and that is efficient for the end-user. improved coordination of care, clinical decision support, and decreased medication errors Emergent codes are included to allow open discovery and aligns with a qualitative approach in research

• Medical readiness • Mental workload • Organizational readiness • Process improvement • Provider productivity • Usability • User satisfaction • **Technical** • Hardware & Software Computing Infrastructure • Computer Interface • Clinical Content • Workflow • Emergent codes • Accuracy • Inadequate training • Operational workarounds • Patient privacy • **Successful EHR** • Efficiency during patient encounters • Improved coordination of care • Improved clinical decision support • Enhanced patient safety • Emergent codes • **Barriers (Emergent)** • Lack of clinical data • Lack of coordination of care • Lack of efficiency • Lack of patient safety • Lack of suitability • Lack of survivability • Lack of usability • Lack of workflow • Lack of improved clinical decision support	

APPENDIX C

Codes, Defined, and Relevant Family

Accuracy

Comment:

Defined as the completeness of a healthcare record

Background

Comment:

Defined as any background information of the EHR or AFMS.

Communication

Families (2): Internal Organizational Context

Comment:

Defined as communication disseminated orally, verbally, or written from the internal organization related to EHR implementation that has impacted its deployment.

Cost

Comment:

Defined as costs associated with the EHR, can include savings or other expenditures.

Culture of data use

Comment:

Defined as a strong data culture results when an organization believes in continuous improvement and regularly puts that belief into practice.

Delay

Comment:

Defined as system interface problems that leads to a delay in the EHR implementation.

Efficiency

Families (4): Successful EHR

Comment:

Defined as patient records being readily available, the need to provide more information, and to enhance information sharing within the organization.

Federal, state, and local healthcare regulations

Families (1): External Context

Comment:

Defined as regulations or laws or legislation such as HIPAA or HITECH that could impact EHR implementation.

Hardware & Software Computing Infrastructure

Families (3): Technical

Comment:

Defined as mention of hardware or software required to run system applications, includes mention of cyber security.

Health data

Comment:

Defined as any data related to health conditions, reproductive outcomes, causes of death,and quality of life

---

Healthcare management

Comment:

Defined as a profession that provides leadership and direction to organizations that deliver personal health service

---

Human Computer Interface

Families (3): Technical

Comment:

Defined as interfaces that enables unrelated entities to interact with the system and includes aspects of the system that users can see, touch, or hear.

Implementation of policies and practices

Families (1): External Context

Comment:

Defined as policies or practices that may affect EHR implementation.

Improved clinical decision support

Families (4): Successful EHR

Comment:

Defined as an application that helps healthcare providers make clinical decisions.

Improved coordination of care

Families (4): Successful EHR

Comment:

Defined as better availability of patient information.

Inadequate training

Comment:

Defined as the action either of teaching a person, a particular EHR skill through computer based training, lectures, or one-on-one, which is not adequate to meet the users' needs

---

Interoperability

Comment:

Defined as the ability of computer systems or software to exchange and make use of information, includes spread of the information across the federal healthcare system.

Lack of clinical data

Comment:

Defined as collected during the course of ongoing patient care or as part of a formal clinical trial program and mention of this function within the EHR

Lack of coordination of care

Comment:

Defined as a lack of availability of patient information.

Lack of efficiency

Comment:

Defined as patient records NOT being readily available, provide more information, and enhance information sharing within the organization.

Lack of patient safety

Comment:

Defined as hindering patient safety outcomes through EHR adoption.

Lack of suitability

Comment:

Defined as the lack of an appropriate EHR for the MHS

Lack of survivability

Comment:

Defined as the lack of potential for a EHR to function for a long time within a medical organization

---

Lack of usability

Comment:

Defined as a lack of effectiveness, efficiency and satisfaction with which specific users can achieve a specific set of tasks in a particular environment

---

Lack of workflow

Comment:

Defined as the lack of steps needed to ensure that each patient receives the care they need at the time they need it. Often times a workflow design is defined in the EHR system.

Lack of improved clinical decision support

Comment:

Defined as a lack of application that helps healthcare providers make clinical decisions.

Leadership Characteristics

Families (2): Organizational Context

Comment:

Defined as one self or someone else demonstrating potential to lead, coordinate, be in charge of the EHR implementation.

Learning health systems

Comment:

Defined as a system in which could be a department that tracks its patient's outcomes or EHR lessons learned in order to learn and improve its practice.

Medical readiness

Comment:

Defined as enables a medically ready force and prepares personnel and equipment to deliver world-class expeditionary health care across a full range of military operations.

Mental workload

Comment:

Defined as the portion of operator information processing capacity or resources that is actually required to meet system demands.

Operational workarounds

Comment:

Defined as a temporarily ‘fix’ perceived workflow hindrances to meet a goal or to achieve it more readily, includes violations, deviations, problem solving, improvisations, procedural failures and shortcuts

---

Organizational Readiness

Comment:

Defined as the ability to initiate and respond to organizational change in ways that create advantage, minimize risk, and sustain performance.

Patient privacy

Comment:

Defined as practice of maintaining the security and confidentiality of patient records.

Patient Safety

Families (4): Successful EHR

Comment:

Defined as improving patient safety outcomes through EHR adoption.

People

Families (2): Organizational Context

Comment:

Defined as humans (e.g., software developers, system configuration and training personnel, clinicians, and patients) involved in all aspects of the design, development, implementation, or use of the EHR.

Process improvement

Comment:

Defined as proactive task of identifying, analyzing, and improving upon existing business processes within an organization for optimizations. Also includes meeting new quotas or standards of quality.

Provider productivity

Comment:

Defined as rate at which providers see patients.

Suitability

Comment:

Defined as an appropriate EHR for the MHS

Support and constraints from higher headquarters or consultant

Families (1): External Context

Comment:

Defined as support or constraint factors exhibited by higher headquarters that impact EHR implementation.

Survivability

Comment:

Defined as the potential for an EHR to function for a long time within a medical organization

---

System Measurement and Monitoring

Families (2): Organizational Context

Comment:

Defined as the measure and monitoring of the effects of health information technology on a regular basis. This could be communicated to higher headquarters or system programmers; also includes mention of testing.

Training

Families (3): Technical

Comment:

Defined as the action of teaching a person a particular EHR skill either through computer based training, lectures, or one-on-one

---

Usability

Comment:

Defined as effectiveness, efficiency and satisfaction with which specific users can achieve a specific set of tasks in a particular environment

---

User satisfaction

Comment:

Defined as the combination of ease of use and the degree to which the system supports work and is useful.

Workflow

Families (3): Technical

Comment:

Defined as the steps needed to ensure that each patient receives the care they need at the time they need it. Often times a workflow design is defined in the EHR system.

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