ADVANCED USE OF ELECTRONIC HEALTH RECORDS IN PATIENT-CENTERED MEDICAL HOMES

By

Norbert Erik Belz

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Co-Chairperson, Dr. Mary Zimmerman, PhD

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Co-Chairperson, Dr. Jarron Saint Onge, PhD

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Dr. Tami Gurley-Calvez, PhD

_____
Dr. Jean P. Hall, PhD

_____
Dr. Jeffrey P. Searl, PhD

Date Defended: May 14, 2015

The Dissertation Committee for Norbert Erik Belz
certifies that this is the approved version of the following dissertation:

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Co-Chairperson, Dr. Mary Zimmerman, PhD

_____
Co-Chairperson, Dr. Jarron Saint Onge, PhD

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ABSTRACT

Electronic Health Records (EHRs) offer the promise of improved health outcomes through care coordination, in particular for costly and difficult to manage chronic illness. Adoption levels of EHRs in primary care have increased significantly since the recent Meaningful Use policy initiative began incentivizing EHRs in 2011; however, the full benefits of EHRs will only be realized once widespread use of advanced EHR functions is achieved. Patient-Centered Medical Homes (PCMHs) are considered the pinnacle of primary care and are expected to rely heavily on EHRs to coordinate care across settings.

The goals of this dissertation are to describe and discuss overall EHR adoption and use in PCMH practices, including the practices' progress towards meeting advanced criteria for the Meaningful Use policy, and to identify and explain the specific PCMH practice characteristics and contextual factors associated with advanced EHR use. This dissertation utilizes innovative data on PCMHs to create and evaluate an advanced EHR use index and explore the iterative differences distinguishing advanced EHR use from no advanced use in PCMHs. The EHR index is the dependent variable defining the levels of advanced EHR use by the PCMH. Four models of advanced EHR use are created and variations in the models are explored to validate the EHR index and identify the PCMH practice characteristics associated with advanced EHR use at higher levels of the EHR index.

This dissertation indicates higher EHR adoption and use levels for PCMHs compared to other office-based and primary care practices in the current literature. Practice size, type, and location (rural versus non-rural) of the PCMH demonstrate unique associations with advanced EHR use. Contrary to prior studies, this dissertation indicates that larger PCMHs as well as federally-funded centers are less likely to be advanced EHR users and that practice affiliation

(being part of a network) has no association with advanced use; also, smaller and non-rural PCMHs practices that are physician or hospital/system-owned are more likely to be using advanced EHR functions, which is also contrary to previous research.

These findings have significant implications for future policies, practice, and research. As advanced EHR use becomes more widespread, the findings from this study provide future researchers with robust baseline data on PCMHs. The measures of EHR adoption and use levels in this study, as well as the various models tested, provide frameworks for future studies to evaluate and track advanced EHR use in primary care.

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CHAPTER 1

Introduction

Electronic Health Records (EHRs) offer the promise of improved health outcomes through care coordination (Chaudhry et al., 2006), in particular for costly and difficult to manage chronic illness. Over the past several decades, advanced economy countries have been increasing their investment in health information technology, like EHRs, to enhance health systems and to more efficiently manage the health care needs of populations. The United States has lagged significantly behind in this regard (in some cases more than a decade behind); however, recent policy initiatives are attempting major reform of primary care with EHR as a key component (Anderson, Frogner, Johns, & Reinhardt, 2006).

Adoption levels of EHRs in primary care have increased significantly since the recent Meaningful Use policy initiative began incentivizing EHRs in 2011 (Hsiao & Hing, 2012); however, the full benefits of EHRs will only be realized once widespread use of advanced EHR functions is achieved. Advanced features like health information exchange with patients and providers are priorities for Meaningful Use (MU), yet use of these features remain low (Audet, Squires, & Doty, 2014; Furukawa et al., 2014) . Much of the existing literature focuses on adoption (implementation) of isolated systems rather than the true advanced use of EHRs (information exchange) in primary care settings. Furthermore, various definitions of EHR adoption and use in the current literature make deciphering the findings difficult, and often do not clarify that adoption (implementation, or simply purchasing an EHR) does not equate to actual EHR use (McClellan, Casalino, Shortell, & Rittenhouse, 2013). Patient-Centered Medical Homes (PCMHs) are considered the pinnacle of primary care and are expected to rely heavily on EHRs to coordinate care across settings (Adler-Milstein & Cohen, 2013; Bitton, Flier, & Jha,

2012). Very little research exists on EHR use in PCMHs (Richardson, Vest, Green, Kern, & Kaushal, 2015), and even less exists about use of advanced EHR functions. Considering the vast amount of resources being dedicated to EHR adoption, understanding the specific practice characteristics and contextual factors associated with advanced EHR use within practices that are at the forefront of primary care (PCMHs) has important implications for all other practices. Identifying those characteristics associated with the least probability for successful use of EHRs is also an opportunity to expand current policy initiatives to assist struggling practices.

This dissertation seeks to describe and discuss overall EHR adoption and use in PCMH practices compared to other practices and settings nationally (within the current literature) and then identify and explain PCMH practice characteristics and contextual factors associated with advanced EHR use. The goal is to answer the question, what are the practice characteristics and contextual factors that distinguish advanced EHR use from non-advanced use in PCMHs? Considering that the MU policy is the driving force behind national widespread EHR adoption (Hsiao & Hing, 2012), this dissertation will also evaluate PCMHs progress towards meeting the advanced criteria for MU.

The literature describing primary care settings suggests that larger, networked practices that are part of a system are more likely to use EHRs, although findings on rural practices are mixed. Thus, this dissertation expects to find EHR adoption and use is higher for PCMHs than rates established in the literature, and that larger, networked PCMHs would be associated with advanced EHR use, whereas non-networked and rural practices would demonstrate lower probability of advanced EHR use.

Background

In the United States, chronic conditions contribute greatly to health care spending (84% of the annual $2 trillion), cause most of the deaths (70%), and are a significant contributor to activity limitations (10%) (Anderson, 2010; CDC, 2009, 2011; Institute of Medicine, 2012). Approximately half of all adults in the United States have a least one chronic condition (Ward, Schiller, & Goodman, 2014). Multiple chronic conditions affect nearly 75% of the U.S. population age 65 and older (Anderson, 2010), yet this baby-boomer population frequently receives suboptimal care due to lack of communication and coordination (Berry, Rock, Smith Houskamp, Brueggeman, & Tucker, 2013). Chronic disease management is complex and time consuming (Bosworth, Powers, & Oddone, 2010), and typically requires collaboration and continuous coordination among a number of providers frequently in different geographic locations (Anderson, 2010; Kreps & Neuhauser, 2010). Care coordination is typically the responsibility of primary care (Dale, Behkami, Olsen, & Dorr, 2012), the setting in which most care is delivered (Hing & Schappert, 2012). However, the demands on primary care providers can be overwhelming (Dale et al., 2012), especially since the United States is plagued with primary care provider shortages (Hing & Schappert, 2012).

Care coordination and EHR adoption are at the forefront of current U.S. health policy and reform initiatives (Dale et al., 2012; Looman et al., 2012). Numerous efforts are underway to improve and coordinate care (Arons, Miller, Gauthier, Rosenthal, & Hanlon, 2012) and expand the adoption and use[1] of EHRs to facilitate coordinated care (Arons et al., 2012; Walsh et al., 2010). For example, the Affordable Care Act and The Health Information Technology for Economic and Clinical Health (HITECH) Act (part of the American Recovery and Reinvestment

[1] Adoption (implementation, or simply purchasing an EHR) does not equate to actual EHR use (McClellan et al., 2013)

Act of 2009), emphasize the importance and support the ability of EHRs to facilitate care coordination across the system (Looman et al., 2012). These efforts also include primary care delivery innovations, like the patient-centered medical home (PCMH) initiative, which rely heavily on EHRs to coordinate care and engage patients (Adler-Milstein & Cohen, 2013; Bitton et al., 2012). The ultimate goals of these initiatives (PCMHs and EHRs) are to continually improve population health (Arend, Tsang-Quinn, Levine, & Thomas, 2012; Crosson, Ohman-Strickland, Cohen, Clark, & Crabtree, 2012), through coordination of care (Morrissey, 2013), and improve chronic disease management in primary care (Richardson et al., 2015; Stange et al., 2010).

Patient-centered medical homes are at the forefront of the primary care and have become the favored exemplar delivery model. Even though it is not a new concept (Arend et al., 2012), PCMHs are currently being extensively implemented (Kern, Edwards, & Kaushal, 2014). A PCMH is a practice that has moved beyond standard primary care and has undergone extensive transformations to improve care coordination for patients with chronic illness (Richardson et al., 2015; Stange et al., 2010). The core of PCMHs includes access to primary care that is comprehensive, continuous, and coordinated by innovative practice teams focused on continuous quality improvement (Arend et al., 2012).

Primary care practices may receive PCMH designation from the National Committee for Quality Assurance (NCQA), based on their care coordination and patient-centered efforts. This widely adopted model includes three levels, which are 1, 2, or 3 (highest), based on the overall scoring on standards. Practices are scored on six standards: patient-centered access, team-based care, population health management, care management and support, care coordination and care transitions, and performance measurement and quality improvement. These PCMH standards

are also aligned with federal definitions under the MU policy, positioning the practices to qualify for EHR incentive payment (NCQA, 2014). For more information, about PCMH recognition see http://www.ncqa.org/Programs/Recognition/Practices/PatientCenteredMedicalHomePCMH.aspx.

Many leaders believe the United States is at a "tipping point" of harnessing the power of EHRs to transform the health care delivery system (Arons et al., 2012). Proponents argue that adoption of truly interoperable EHRs will improve health care and costs by reducing fragmentation (Buntin, Jain, & Blumenthal, 2010; KaiserEDU.org, 2011) and improving efficiency, safety, and quality (Chaudhry et al., 2006; Hillestad et al., 2005a). EHRs have the potential to be effective communication and coordination tools, but the capabilities of EHRs are underutilized (Morrissey, 2013). The true benefits of improved care coordination will only be realized through increased adoption and meaningful use of EHRs (Balfour et al., 2009). Thus, a better understanding of PCMH (the leaders in primary care practice) EHR use and their characteristics, with the highest as well as lowest probability for advanced EHR use, is needed.

Overview of Electronic Health Records

Health Information Technology (HIT) embodies a series of technologies that exchange health information among providers, patients, researchers, payers, and/or others pertinent entities (Beni, 2011; President's Council of Advisors on Science and Technology, 2010) with the goal of improving health care delivery through care coordination. The most common and important type of HIT is the EHR (Robert Wood Johnson Foundation, 2008), defined as a digital record of all health-related information captured in clinical visits and other important information related to the patient's medical history and condition (President's Council of Advisors on Science and Technology, 2010). The EHR transmits health information beyond a single facility and focuses on the comprehensive health of a patient. The EHR stands in contrast to an electronic medical

record (EMR), which is simply a digital version of the paper clinical chart (Garrett & Seidman, 2011). The EMR typically encompasses a patient's medical and treatment information in one practice or facility.

The terms electronic health record (EHR) and electronic medical record (EMR) have been used synonymously/interchangeably throughout the literature; however, there are distinct and inherent differences. Both EHRs and EMRs capture patient information from clinical visits, but the EMR is more limited (Terry, 2013) and does not allow for the exchange of health information outside of the originating organization. EHRs also embody advanced functional capabilities such as health information exchange and patient engagement through portals and personal health records. These features and the ability of an EHR to exchange and share information are fundamental to achieving recent federal policy initiatives for improving care. The goal of an EHR is that health information moves with the patient from facility to facility (Garrett & Seidman, 2011), transcending a single facility, while being freely and appropriately shared to facilitate clinical decision making and care coordination. Thus, another principal difference is that an EHR has interoperability, the ability of different systems to communicate and exchange information (The National Alliance for Health Information Technology, 2005, 2008). The term "advanced EHR" is used in this dissertation to represent these information exchange and interoperability functions between providers as well as patients.

EHRs have been recognized for their potential to improve quality of care and coordination among providers, patient safety, and efficiency (Chaudhry et al., 2006), with billions of dollars in estimated annual savings (Beni, 2011; Hillestad et al., 2005b). EHRs facilitate consistent documentation of process/clinical outcomes, remind providers of evidence-based guidelines, and track conformity with those guidelines (Walsh et al., 2010). The benefits

of basic EHR use include better documentation of quality reporting, operational efficiency, reduction in the cost of transcription, and even increased revenue through better billing practices (Walsh et al., 2010). Advanced EHR functions, like the ability to exchange health information with other providers and patients, have the promise for improving care coordination and even quality of care (Bitton et al., 2012; Furukawa et al., 2014; Vest & Gamm, 2010). However, barriers to EHR adoption and use include cost, technical challenges, organizational constraints, resistance to change, and interoperability and standardization (Ajami & Arab-Chadegani, 2013), which pose challenges for allowing EHR to exchange health information. Other barriers to EHR adoption include the potential negative impact on clinical encounters (Dorr et al., 2006), frustrations from disruption in workflow, loss of physician autonomy, and overdependence on technology (Menachemi & Collum, 2011).

Three key features of an advanced EHR are crucial for practices to realize the true benefits of care coordination; these include interoperability, health information exchange, and patient engagement through web portals. Interoperability is essential in that a patient's health information must efficiently be transferred from provider to provider (Leventhal, Taliaferro, Wong, Hughes, & Mun, 2012), as "Interoperability is the ability of different information technology systems and software applications to communicate, to exchange data accurately, effectively and consistently, and to use the information that has been changed" (The National Alliance for Health Information Technology, 2005, 2008). Similarly, Health Information Exchange (HIE) is defined as "the sharing of clinical and administrative data electronically across healthcare institutions" (O'Donnell et al., 2011, p. 1019). Benefits of HIE include improvements in quality and safety through better coordination of care, provider access to patient information and decision support, and improved patient-provider communication (Fricton &

Davies, 2008; O'Donnell et al., 2011; Vest & Gamm, 2010). In addition, HIE has the potential to reduce medical errors, improve continuity of care, and reduce costs (Walker et al., 2005). Portals allow patients direct access to basic medical information in the EHR. Health care providers are utilizing web portals to deliver lab reports, test results, and other basic health information. Patient portals also have the potential to bridge different forms of communication (interpersonal and mass communications) and have demonstrated effectiveness for interactive health communications (Kreps & Neuhauser, 2010). Patient portals can engage patient in their care (Otte-Trojel, de Bont, Rundall, & van de Klundert, 2014; Robert Wood Johnson Foundation, 2012).

As previously discussed, the EHR is an important component of many current delivery system innovations, such as the PCMH and its core principle of care coordination (Leventhal et al., 2012). PCMHs rely heavily on EHRs to coordinate care and engage patients (Adler-Milstein & Cohen, 2013; Bitton et al., 2012). EHRs can promote teamwork (information exchange) and engage patients in their care (patient portals), two essential components of PCMHs (Bitton et al., 2012).

National EHR Initiatives and the MU Policy

Current EHR, health reform, and reimbursement policy initiatives are incentivizing providers to adopt interoperable EHRs and deliver collaborative, integrated, and patient-centered care (Looman et al., 2012). The Health Information Technology for Economic and Clinical Health (HITECH) Act (part of the American Recovery and Reinvestment Act of 2009), authorized $20 billion to stimulate EHR adoption and use. Under the Medicare and Medicaid programs, eligible providers and hospitals can receive financial incentive payments for the adoption and meaningful use of certified EHRs. Eligible professionals can receive up to $44,000

or $63,750 through Medicare or Medicaid respectively (CMS.gov, 2013a). Participation in the MU program is voluntary; however, in 2015 the incentives turned into penalties for those failing to join or meet the requirements of MU (CDC, 2012a). The MU program has significantly contributed to the increased and widespread implementation of EHRs (Hsiao & Hing, 2012); however, providers interested in experiencing true benefits of EHRs should focus on care coordination rather than the incentive payment for MU (Morrissey, 2013). Thus expedited research on provider adoption and use of EHRs is needed in the context of the current care coordination and policy reform efforts.

There are three stages for MU, and the penalties for not meeting MU Stage 1 began in January 2015 (Bowman, 2014). An estimated 257,000 Medicare Eligible Professional able to participation in the MU program will receive a 1% reduction to their payments (Bowman, 2014). The MU program has two different sets of criteria for hospitals versus Eligible Professional (EP).[2] Stage 1 of MU focuses on data capture and sharing (initially implementing and adopting an EHR) (HealthIT.gov, nd) and includes 24 measures for EPs and 23 for hospitals. Each has a core set of required objectives (14 for provider and 13 for hospitals), and has 5 of 10 menu objectives (CMS.gov, 2013b). For the menu objectives, EPs select 5 of the 10 MU criteria. For a list of the provider MU measures, see http://www.cms.gov/. Under the MU guidelines for Medicaid, EPs[3] must adopt, implement, or upgrade an EHR; adopt, implement, or upgrade is defined under 42 CFR 495.302:

(a) Acquire, purchase, or secure access to certified EHR technology

[2] Under the CMS Medicare EHR Incentive Program for MU, Eligible Professionals (EP) include doctor of medicine or osteopath, doctor of dental surgery or dental medicine, doctor of podiatry, doctor of optometry, or chiropractor (CMS.gov, 2012).

[3] Under the CMS Medicaid EHR Incentive Program for MU, Eligible Professionals (EP) include Physicians, Nurse practitioners, certified nurse-midwifes, dentist, or physician assistant furnishing services to a Rural Health Clinic or Federally Qualified Health Center (CMS.gov, 2012).

(b) Install or commence utilization of certified EHR technology capable of meeting MU requirements, or

(c) Expand the available functionality of certified EHR technology capable of meeting MU requirements at the practice site, including staffing, maintenance, and training, or upgrade from exiting EHR technology to certified EHR technology per the ONC [Office of the National Coordinator of Health Information Technology] EHR certification criteria.

The final requirements for Stage 2 MU were released on August 23, 2012 and began in 2014. Stage 2 focuses on advanced clinical processes and more rigorous exchange of health information (HealthIT.gov, nd). The proposed rules for Stage 3 were released on March 20, 2015. Stage 3, the final stage of MU, builds on the previous stages' focus on interoperability but expands advanced EHR use and health information exchange to improve health outcomes through care coordination, patient engagement, and patient-centered care. Stage 3 is scheduled to begin in 2017 (CMS, 2015b). For specific information on MU criteria, see Table 1.1.

Table 1.1 Meaningful Use Criteria

Stage 1: MU criteria focus on:	Stage 2: MU criteria focus on:	Stage 3: MU criteria focus on:
Electronically capturing health information in a standardized format	More rigorous health information exchange (HIE)	Improving quality, safety, and efficiency, leading to improved health outcomes
Using that information to track key clinical conditions	Increased requirements for e-prescribing and incorporating lab results	Decision support for national high-priority conditions
Communicating that information for care coordination processes	Electronic transmission of patient care summaries across multiple settings	Patient access to self-management tools
Initiating the reporting of clinical quality measures and public health information	More patient-controlled data	Access to comprehensive patient data through patient-centered HIE
Using information to engage patients and their families in their care		Improving population health

Source: HealthIT.gov. (nd). Policy, Regulation, & Strategy: Meaningful Use. Retrieved July 1, 2013, from http://www.healthit.gov/policy-researchers-implementers/meaningful-use

Two important aspects of the MU policy are electronic health information exchange and patient engagement (Furukawa et al., 2014). Electronic health information exchange is facilitated by interoperable EHRs with interfaces that allow for direct networked connections, or through a third party health information exchange organization. Patient engagement is facilitated by providing patients with access to their health information within an EHR through technology like a patient portal. A patient portal can promote patient self-management and facilitate communication among patients and providers (Arend et al., 2012). Patient portals have been suggested to engage patients in their care (Robert Wood Johnson Foundation, 2012), and thus lower use of the patient portals might be an indication of challenges with patient engagement.

As part of the HITECH Act, and in coordination with the MU policy, the Office for the National Coordinator (ONC) established the Regional Extension Center (REC) program. Across the country, 62 RECs were recognized to "assist primary care providers in the adoption and

meaningful use of electronic health records" (HealthIT.gov, nd). Specifically, RECs were funded to provide technical and operational support to priority primary care providers, with the goal to become self-sustainable (Green et al., 2015). The HITECH act defined priority primary care providers as "individual and small group practices (less than 10 professionals) primarily focused on primary care, public and critical access hospitals, community health and rural health centers and other settings serving predominantly uninsured, under-insured and medically under-served populations" (Office of the National Coordinator for Health Information Technology, 2015). Overall, the RECs have been reasonably effective. According to HealthIT.gov, nearly half of all primary care providers are enrolled in the REC program, and 92% of them are live with an EHR. However, in February 2015 funding for the REC ended (Kansas Foundation for Medical Care, 2015). At this point it is unclear if RECs will continue supporting those priority primary care practices, although many states have created private organizations to continue assisting practices (Kansas Foundation for Medical Care, 2015).

The Health Information Management and Systems Society (HIMSS), a not-for-profit organization dedicated to improving health through information technology, created a national framework for measuring EHR adoption. The HIMSS Ambulatory EMR Adoption Model (A-EMRAM) classifies EHR adoption levels based on seven stages (see Table 1.2). There are two HIMSS models that are used in the United States, the hospital and the ambulatory model. Organizations receive special recognition after attaining all 7 stages of the HIMSS model. Both of the models assume the organizations move through the stages in a sequential pattern. Recognition of a certain stage is accomplished after all lower stages are met. These levels are thought to be additive/ordinal, beginning at Stage 0 and moving up to Stage 7. However, this model has not been extensively evaluated in the literature. Similar to the requirements set forth

in MU, the HIMSS A-EMRAM Model includes requirements for communication, health information exchange, patient engagement, and coordination of care. An important note, however, is that the HIMSS A-EMRAM model includes all ambulatory facilities that participate in their annual survey (HIMSS Analytics, 2014b) and does not separate out primary care physicians or practices. For more information about their model and the stages, see Table 1.2 and the website http://www.himssanalytics.org/emram/AEMRAM.aspx.

Table 1.2 HIMSS A-EMRAM

US Ambulatory EMR Adoption Model SM		
Stage	Cumulative Capabilities	2014 Quarter 2
Stage 7	HIE capable, sharing of data between the EMR and community based EHR, business and clinical intelligence	4.30%
Stage 6	Advanced clinical decision support, proactive care management, structured messaging	5.83%
Stage 5	Personal health record, online tethered patient portal	5.56%
Stage 4	CPOE, Use of structured data for accessibility in EMR and internal and external sharing of data	1.23%
Stage 3	Electronic messaging, computers have replaced the paper chart, clinical documentation and clinical decision support	11.42%
Stage 2	Beginning of a CDR with orders and results, computers may be at point-of-care, access to results from outside facilities	30.74%
Stage 1	Desktop access to clinical information, unstructured data, multiple data sources, intra-office/informal messaging	34.29%
Stage 0	Paper chart based	6.63%
Data from HIMSS Analytics® Database ©2014		N = 26,008
HIE=Health Information Exchange, EHR = Electronic Health Record, EMR=Electronic Medical Record (referred to as EHR in this project), CDR = Clinical Data Repository. CPOE = Computerized Physician Order Entry.		

Reproduce with permission from HIMSS Analytics – source: HIMSS Analytics (2014). *Ambulatory Electronic Medical Record Adoption Model (EMRAM)* [sm]. Retrieved September 18, 2014, from http://www.himssanalytics.org/home/index.aspx**.**

Research Aims

The overall goals of this dissertation are to describe and discuss overall EHR adoption and use in PCMH practices and identify and explain PCMH practice characteristics and contextual factors associated with advanced EHR use. In order to carry out these goals, this dissertation uses innovative data on PCMHs to create and evaluate an advanced EHR use index and explore the iterative differences distinguishing advanced EHR use from no advanced use in PCMHs. The EHR index is the dependent variable for advanced EHR use and broadly includes the EHR's ability to exchange and provide health information to providers and patients. To better inform policymakers concerning current reimbursement initiatives (MU) and delivery system innovations (PCMHs), this study evaluates the specific characteristics and contextual factors associated with advanced EHR use in PCMHs. Understanding the specific characteristics associated with higher as well as lower levels of EHR use can also direct current policy initiatives and provide additional assistance to practices with lower levels of advanced EHR use (Furukawa et al., 2014).

An additional purpose of this dissertation is to describe EHR adoption and use in PCMH practices as compared to other practices and settings nationally. Specifically, this project will describe, categorize, and evaluate current EHR adoption and use levels for PCMHs. The well-known and widely used HIMSS framework is also used to describe EHR adoption. In doing so, this study provides a comprehensive cross-sectional analysis of adoption and use of EHRs in PCMH-designated practices in the United States. The results will provide future researchers with comprehensive baseline data for EHR adoption and use in PCMHs.

This dissertation also describes and evaluates the progress of PCMHs toward meeting the advanced stages of MU. The MU policy is the driving force behind widespread EHR adoption

and is frequently used in the literature to describe EHR use. Understanding PCMH practice EHR adoption levels and progress towards meeting advanced stages of MU may inform policymakers regarding the overall success of the MU policy

The findings of this study have important implications for primary care practice in general. PCMHs are part of an innovative primary care delivery system reform intended to deliver coordinated and patient-centered care and rely extensively on EHRs (Adler-Milstein & Cohen, 2013; Bitton et al., 2012). Findings from this study may indicate the need to modify or expand the current policy initiatives. For example, if PCMHs (a benchmark model for primary care) lag in progress towards advanced EHR use, other primary care and office-based practices are likely experiencing even more significant challenges.

Overview of Subsequent Chapters

Chapter 2 is a review of the literature as it relates to EHRs. The first section provides the findings from earlier research on EHRs that were used to develop the current policy initiative incentivizing EHR adoption (MU). The other sections focus on EHR adoption and use and the practice characteristics associated with EHR use in recent literature since passing the MU of the HITECH Act. This chapter also provides supporting literature for the specific research questions and justification for the overall dissertation project. Chapter 2 concludes with an overview of the main research questions of this dissertation.

Chapter 3 provides the overall study design and methodology utilized in this dissertation. It includes a description of the dataset, the sample, the variables, and justification for the statistical methods used in the study. This chapter further describes the EHR index and introduces the EHR use models.

Chapter 4 presents the results for EHR adoption and use in PCMHs. It begins with a brief overview of the PCMH practices included in the final analyses and provides EHR adoption levels. Chapter 4 also evaluates basic and advanced EHR use in PCMHs in relation to the other national studies, the HIMSS framework, and the MU policy.

Chapter 5 presents the major PCMH characteristics associated with advanced EHR use. The EHR model will be evaluated and further discussed in Chapter 5. Variations in the model will also be explored to validate the index and demonstrate changes in the PCMH characteristics associated with advanced EHR functions at differing levels of use. The types of practices are also further tested and described in the context of the EHR model.

Finally, Chapter 6 provides the discussion and conclusions. This chapter summarizes the major findings and provides plausible explanations for the main effects noted in this study. Implications for policy, practice, future research, and limitations are also presented.

CHAPTER 2

Review of the Literature

Chapter 2 presents an overview of the literature as it relates to EHRs. To provide background for this dissertation, several aspects of the literature must first be explored. The first section of this chapter presents the early literature used to develop the current policy initiatives incentivizing EHR adoption. The next sections focus on EHR functions, as well as adoption and use in the more recent literature since the passing of the MU policy. Next, the literature review explores physician and primary care practice characteristics and other factors associated with EHR adoption and use across various settings and geographic locations. Considering that widespread EHR adoption is now prevalent, this literature review indicates the current need for expedited research concerning actual EHR use within the context of existing health care policy and delivery reform initiatives. Specifically, the literature findings validate this dissertation's purpose, which is to measure advanced EHR use and to identify the practice characteristics of PCMHs associated with advanced EHR use.

The literature is inconsistent and creates confusion in the terminologies for EHR adoption, implementation, basic use, and advanced use. Not only are varying definitions utilized, but in many cases these terms are used interchangeably. This literature review will operationally define these terms as utilized by this study. In this dissertation *adoption* is synonymous with implementation (simply purchasing a system) and does not equate to EHR use; *advanced EHR use* includes the EHR functionalities that exchange health information among provider and patients; and *basic EHR use* refers to all other EHR functionalities not related to information exchange.

This chapter develops, refines, and sets the foundation for the specific dissertation research questions based on the existing research and noting gaps in the current literature. The studies in this current literature review focus on outpatient, ambulatory, office-based physician, and other primary care settings that involve EHR adoption (implementation) and/or use. Studies describing inpatient and other settings were excluded from this review.

Background of EHR Literature

Electronic health records (EHRs) but not Electronic Medical Records (EMRs) have been recognized for their potential to improve quality of care, patient safety, and efficiency (Chaudhry et al., 2006) with billions of dollars in estimated annual savings (Beni, 2011; Hillestad et al., 2005b). Because of the low EHR adoption rates until the more recent passing of MU (Furukawa et al., 2014), the results of earlier studies have been mixed (Walsh et al., 2010), and research has not been able to consistently document significant improvements in quality and clinical outcomes (Holroyd-Leduc, Lorenzetti, Straus, Sykes, & Quan, 2011; Keyhani et al., 2008; Poon et al., 2010; Romano & Stafford, 2011).

In a previous landmark study, Chaudhry et al. (2006) evaluated the effects of HIT on cost, quality, and efficacy. In that extensive review, 257 studies met the inclusion criteria spanning the timeframe 1995-2004. Most of the included studies focused on EHRs and clinical decision support, typically embedded in an EHR and evaluated within an outpatient setting. Nearly one quarter of the studies were from four benchmark institutions. These large integrated delivery systems (benchmark institutions) with multi-functional EHR systems demonstrated consistent improvements in quality and efficiency. Findings from other settings like non-integrated primary care practices, however, remained less clear (Chaudhry et al., 2006).

In a pivotal report from the RAND Corporation, Hillestad et al. (2005) estimated $147 billion in savings by using health information technology (HIT) for prevention and management of chronic disease, with an estimated $81 billion of the potential savings from EHR implementation alone (Hillestad et al., 2005a). However, as adoption of HIT is being encouraged, the providers are expected to pay for systems such as EMRs or EHRs (Terry, 2013). The major barrier for EHR adoption discussed in the study by Chaudhry et al. (2006) was the misalignment of incentives. In particular, financial incentives at that time did not support provider implementation and adoption of HIT. Regardless of the benefits to the systems, the cost of implementing an EMR or EHR had been prohibitive. The Commonwealth Fund study established the average initial cost of an EHR to be $44,000 per provider, with an average cost of $8,500 per year per provider following purchase and implementation (Miller, West, Brown, Sim, & Ganchoff, 2005).

As a result of pivotal studies like Chaudhry et al. (2006), Hillestad et al. (2005), and Miller et al. (2005), policies have been created and are being implemented to incentivize the adoption of EHRs, offset the cost, and address many of the previously stated barriers. The RAND and Commonwealth Fund studies have been used to estimate the cost of implementation and adoption of EHR technology, thus establishing thresholds and guidelines for setting the MU policy incentive payments (Hillestad et al., 2005a; Miller et al., 2005).

Since the landmark study by Chaudhry et al. (2006) suggesting benefits of EHRs in improving quality and efficiency, numerous subsequent studies and articles have contributed to this body of literature. Chaudhry's initial review of the findings indicated improved quality and efficiency through EHR adoption. As indicated currently in the literature, EMRs within isolated, independent practices do not consistently demonstrate favorable trends toward improved

outcomes (Crosson et al., 2012; Crosson et al., 2007; Keyhani et al., 2008; Linder, Ma, Bates, Middleton, & Stafford, 2007; Romano & Stafford, 2011; Walsh et al., 2010; Zhou et al., 2009), whereas mature interoperable EHRs within integrated systems demonstrate improvements in process, clinical outcomes, and quality of care in chronic outpatient disease management (Chaudhry et al., 2006; Reed et al., 2012; Weber, Bloom, Pierdon, & Wood, 2008). However some of the subsequent research concerning various EHR outcomes and quality of care conflict and lack consistency (Kern, Barron, Dhopeshwarkar, Edwards, & Kaushal, 2012). The inconsistent findings in the literature are likely due to the lack of universal and robust EHR use as well as inconsistent measures and definitions for adoption and use of EHR functions. These aspects of EHRs are explored in the following sections of this literature review.

EHR Functionality

EHRs have been recognized for their potential to improve quality of care, patient safety, and efficiency (Chaudhry et al., 2006), but these improvements require consistent provider use of key EHR functions (Simon et al., 2007). The core functions of an EHR were defined by an Institute of Medicine Panel (Robert Wood Johnson Foundation, 2006) and summarized by Zhou et al. (2009) as including "health information and data, result management, order entry and management, and decision support" (p. 458). Zhou et al. (2009) also added the advanced EHR functions of "electronic communication and connectivity" (p. 458).

In the reviewed literature, the terms electronic health record (EHR) and electronic medical record (EMR) have frequently been used synonymously or interchangeably; however, as described in Chapter 1, there are distinct and inherent differences. The primary difference is that an EHR has interoperability (The National Alliance for Health Information Technology, 2008), which an EMR does not have. This ability of an EHR to exchange and share information

with other systems is fundamental to achieving the objectives for MU and the goal for improving care, as well as meeting advanced stages of the HIMSS Ambulatory EMR Adoption Model (HIMSS Analytics, 2014a). Exploring true advanced EHR use is an opportunity for current and future research.

In the current literature, the most common dataset used to explore EHR adoption is the National Ambulatory Medical Care Survey (NAMCS) Electronic Medical Record Supplement. The NAMCS studies utilize the definition "any EHR" to represent a "yes" response to the question: "Does this practice use electronic medical records or electronic health records (not including billing records)?" The definition of a "basic EHR system" has continued to evolve overtime within the NACMS survey, but it generally includes "recording patient history and demographic information, clinical notes, and patient problem lists; viewing laboratory and imaging results; and ordering prescriptions" (p.3). "Recording a list of medications and allergies" was later added to the definition (Hsiao, Hing, & Ashman, 2014, p. 3). Thus, according to the NAMCS studies, "basic EHR system" is in fact an electronic *medical* record, not an electronic *health* record.

In the current literature, fully functional EHR systems typically reference the core or optional menu objectives of MU Stage 1 or 2, depending on when the study was conducted (DesRoches, Audet, Painter, & Donelan, 2013; Hsiao & Hing, 2014; Hsiao et al., 2014; Patel, Jamoom, Hsiao, Furukawa, & Buntin, 2013). As described in Chapter 1, MU Stage 1 objectives emphasize data capture and sharing (initially implementing and adopting an EHR), while Stage 2 focuses on advanced clinical processes and more rigorous exchange of health information (HealthIT.gov, nd). Thus for this dissertation, as stated previously, an advanced EHR includes electronic exchange of health information with other providers and patients.

The growing penetration of EHRs in the United States increases the potential for improved communication, integration, and health information exchange (HIE) between providers and their patients (Ngo-Metzger, Hayes, Yunan, Cygan, & Garfield, 2010). One common theme throughout the literature is the need for EHR systems to exchange health information electronically (interoperability and HIE), and engage patients in their care (Furukawa et al., 2014). Similar to the Chaudhry et al. (2006) finding that only 1% of the systems had interoperable capabilities beyond the benchmark and integrated delivery systems, the ability to exchange information or share data with different facilities remains challenging (Furukawa et al., 2014). HIE and electronic patient access are priorities in Stage 2 of MU, but they were the least adopted functions in a recent study (Audet et al., 2014). MU Stage 3 further emphasizes advanced use of EHRs to promote HIE among providers and patients (eHealth Initiative, 2015). Furthermore, exchanging information outside the organization is often the most challenging aspect of use (DesRoches et al., 2013), especially for rural providers (Furukawa et al., 2014). Furukawa et al. (2014) indicated the overall use of patient engagement technology was low, with only 39% of office-based practices reported having HIE capabilities (use was not indicated). Considering the low rates and the importance of HIE and patient engagement in the current health policy initiatives and their roles in improving health care delivery, there is a need for additional research in these areas of advanced EHR use (Furukawa et al., 2014).

Based on recent findings, it still appears that EMR adoption is far more prevalent than EHR use (Terry, 2013). Thus, the focus should be on adoption of robust EHRs and increasing appropriate use of specific advanced EHR features (Poon et al., 2010). This is an area identified as a significant opportunity for future research.

EHR Implementation, Adoption, and Use

In most of the current literature, studies describe EHR adoption as synonymous with use, even though there are inherent differences. Adoption includes simply implementing any EMR/EHR system and does not translate into use (McClellan et al., 2013). Within the EHR literature, researchers frequently utilize various classifications of "any," "basic," and "advanced" to describe EHR implementation and adoption (DesRoches et al., 2013; Furukawa et al., 2014; Grinspan, Banerjee, Kaushal, & Kern, 2013; Hsiao & Hing, 2014; Hsiao et al., 2014; Patel et al., 2013). Due to conflicting definitions in the literature (DesRoches et al., 2013; Jha et al., 2006), it can be difficult to decipher whether practices are simply implementing an EMR-like system or if they are experiencing true use of all the advanced EHR features, and thus meaningful use of the EHR systems. For purposes of this current literature review, the author's original terminology is cited. However, as previously stated, for this dissertation the term "adoption" means "implementation" (or purchase) of any EHR system, and "use" is classified as "basic" or "advanced." Advanced EHR use includes the exchange of electronic health information with patients and other providers, whereas a basic EHR does not include information exchange capabilities with other providers or patients.

Since the HITECH Act, EHR implementation and adoption have been extensively evaluated, and there is substantial information regarding the implementation and adoption of EHRs in office-based physician practices (Ancker et al., 2013; Audet et al., 2014; Baier et al., 2012; DesRoches et al., 2013; Furukawa et al., 2014; Hsiao & Hing, 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013; Singh, Lichter, Danzo, Taylor, & Rosenthal, 2012). While a number of studies have estimated office-based and primary care physician EHR usage, more accurate EHR adoption rates and use are generally based on national representative

samples (Baier et al., 2012, p. 233), such as the National Ambulatory Medical Care Survey (NAMCS). According to these NAMCS studies, EHR adoption rates (as defined by "use of any type of EHR") have drastically increased for office-based physicians, from 18% in 2001 to 48% in 2009, which was the year that MU incentive payments were authorized by the HITECH Act (Hsiao & Hing, 2014). In earlier studies, it is difficult to decipher adoption rates due to lack of standards for defining adoption (Jha et al., 2006). Since the MU criteria were established in 2010, the increases in EHR implementation have been more substantial, with a 26% annual increase from 2011 to 2012 (Hsiao & Hing, 2012). By 2012, adoption rates for office-based physicians were approximately 75% (defined by the authors as "used any type of EHR system"), whereas 39.6% had a basic system (EMR), less than a quarter (23.5 %) met the criteria for a fully functional system, and only 19.5 % had EHR systems eligible to meet most of the MU Stage 1 criteria (Hsiao et al., 2014). In 2013, 78% of office-based physicians indicated use of "any type of EHR system," 45% reported use of a "basic EHR" systems, and 81% of the physicians intending to participate in the MU EHR incentive program (56 % overall) did not have systems capable to support the MU Stage *2* objectives (Hsiao & Hing, 2014). Certain differences in findings of adoption rates in similar years are related to how "EHR adoption" is defined within studies (DesRoches et al., 2013).

Among office-based physicians, EHR/EMR adoption levels have increased significantly (Hsiao & Hing, 2012). However, according to the HIMSS[4] Analytics US Ambulatory EMR Adoption Model (HIMSS A-EMRAM) only 4.3% of ambulatory facilities are currently meeting full EHR requirements (HIMSS Analytics, 2014a). This is up from less than 1% (.96%) in 2013

[4] Health Information Management and Systems (HIMSS) is a not-for-profit organization dedicated to improving health through information technology. The HIMSS Ambulatory US Ambulatory EMR Adoption Model (A-EMRAM) classifies EHR adoption levels based on seven stages. For more information about their model and the stages, see http://www.himssanalytics.org/emram/AEMRAM.aspx

(HIMSS Analytics, 2013); however, according to the HIMSS A-EMRAM, most ambulatory facilities are between Stages 1-3 (approximately 77% of the reporting facilities) of the 7 possible HIMSS stages (HIMSS Analytics, 2014a). In order for an organization to be classified at a particular stage of HIMSS, all criteria for preceding stages must be met.

Only one study was found that evaluated advanced EHR use in physician office settings. Based on 2009-2013 NAMCS data, Furukawa et al. (2014) found that 39% of physicians in office-based practices indicated having any electronic health information exchange, although just 14% reported actually sharing data with external providers. In this same study, only 24% of the physicians provided patients with online access to their EHR (Furukawa et al., 2014). This is in comparison to the HIMSS A-EMRAM model that indicates only 5.56% of providers at Stage 5 (patient portal or similar technology) and 4.3% at Stage 7 (HIE) (HIMSS Analytics, 2014a).

Most of the literature on EHR research has focused on whether providers purchased and installed systems rather than how and why the EHR systems and capabilities were being used (Holden & Karsh, 2010; Simon et al., 2007). For example, Whitacre (2015) considered practices that have adopted an EMR to be "having installed any system." For many of the other reviewed studies, it was difficult to assess whether sites simply implemented an EMR/EHR or if they experienced meaningful use of a fully functional EHR. Given the goal of current policy initiatives for full EHR adoption and use to improve coordination and quality of care, opportunities exists for research that focuses on use of specific EHR features, including the time of implementation (Crosson et al., 2012). Providers who experience the true benefits of EHR likely focus on care coordination rather than the incentive payments for MU (Morrissey, 2013).

EHRs and Practice Characteristics

Throughout the literature, certain provider characteristics have been associated with variations in EHR adoption levels (Xierali, Phillips, Green, Bazemore, & Puffer, 2013, p. 388). Identifying specific characteristics that are associated with EHR adoption and use have important implications for policy and practice (Furukawa et al., 2014). For example, practice characteristics associated with low adoption and use have been targeted by recent initiatives. Smaller practices were thought to lack capacity for EHR adoption (Xierali et al., 2013) and were the focus of the REC program under MU.

Most of the care in the United States is delivered in primary care settings (Hing & Schappert, 2012). All of the major NAMCS studies also indicate the increased likelihood for adoption in primary care practices (Furukawa et al., 2014; Grinspan et al., 2013; Hsiao et al., 2014; Patel et al., 2013). Practice size, type of practice, and ownership demonstrated the most significant associations (DesRoches et al., 2013; Furukawa et al., 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013). Practice size seems to be the most consistently reported characteristic in the literature. Previous studies strongly indicate that larger practices are more likely to adopt EHRs (Audet et al., 2014; Furukawa et al., 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013; Singh et al., 2012; Xierali et al., 2013) and use advanced EHR functions to exchange information with patients and providers (Furukawa et al., 2014) Most studies consider size to be the number of providers, while others considered the number of offices (Singh et al., 2012).

Current health care delivery reforms contribute to the increases in practice mergers and acquisitions. However, nearly one-third of family physicians still practice in small or solo settings, a trend that is not likely to change, particularly for rural communities (Xierali et al.,

2013). Throughout the literature, ownership is significantly associated with EHR adoption and use. Practices owned by hospitals, medical centers, health plans, or other health care organizations are more likely to adopt and use advanced features like HIE and patient engagement (Furukawa et al., 2014; Hsiao et al., 2014), likely due to the financial resources of these larger, system-owned practices (Furukawa et al., 2014). However, one study did show no significant association between ownership by hospital system or HMO and adoption or use of EHRs (McClellan et al., 2013). Being part of an integrated delivery system or a network has also been associated with higher EHR adoption levels and even meeting MU criteria (Audet et al., 2014; DesRoches et al., 2013). In addition, practices are more likely to exchange information internally with other practices, hospitals, and providers than with those outside of the organization (Furukawa et al., 2014).

Other characteristics associated with EHR adoption focus on practice initiatives. For example, practices involved in quality improvement (QI) programs and those eligible for incentive payments were more likely to adopt EHR functions (Audet et al., 2014; McClellan et al., 2013). Similarly, practices that "have formal arrangements with other practices to share resources" (pg. 355) are significantly more likely to report EHR adoption and use, including the ability for HIE and for providing patients with electronic access (Audet et al., 2014).

Many studies in HIT do not take context into consideration, which can be an important factor in determining actual facilitators and barriers to EHR use (Gagnon et al., 2014; Holden & Karsh, 2010). For example, variables like sociodemographics, EHR experience (time), and stage of use may have a moderating effect on EHR use (Gagnon et al., 2014; Holden & Karsh, 2010). Future studies should consider contextual and moderating variables.

In summary, the factors including practice size (larger), specialty (primary care), and ownership (health system) demonstrated significant and positive associations with physician practices adopting EHRs (Furukawa et al., 2014; Hsiao et al., 2014; Patel et al., 2013). In studies of primary care, characteristics associated with higher levels of EHR adoption include size, integrated delivery system, and formal arrangement with other practices (Audet et al., 2014). Considering the lag in adoption for solo practices and challenges with HIE and patient engagement, delivery system reforms are promising (Audet et al., 2014). This is another opportunity for research.

EHR in Underserved Settings

The findings of EHR adoption rates in underserved settings have been less consistent. Physicians practicing in rural areas have historically indicated lower rates of EHR adoption (Decker, Jamoom, & Sisk, 2012); however, these groups are now demonstrating the highest relative gains (Furukawa et al., 2014). In the NACMS study utilizing 2011 data, adoption of EHRs (any/basic) was not significantly associated with urban or rural status (Patel et al., 2013). A more recent study by Whitacre (2015) using 2012 national data found rural practices actually had higher EHR adoption rates than urban practices. Even prior to the MU incentive payments, no significant differences were found in EHR adoption rates between urban and rural practices (Singh et al., 2012).

When considering more advanced EHR functions, the existing literature reveals limited and varied findings concerning use in the rural setting. In one study, being rural did not have a significant impact on EHR use for patient engagement (Furukawa et al., 2014). Even though care coordination is perceived as the major benefit of HIE in underserved settings (McCullough, Zimmerman, Bell, & Rodriguez, 2014), HIE with external practices was significantly lower in

rural practices and community health centers (Furukawa et al., 2014). In another study, however, large rural and small rural offices were more likely to use a wider range of EHR capabilities than were urban offices (Singh et al., 2012).

A major source of care for underserved and vulnerable populations are community health centers (Frimpong et al., 2013; Miller & West, 2007; Shin & Sharac, 2013). These Federally Quality Health Centers (FQHCs) receive federal funding to provide primary care services to disadvantaged patients in rural and urban areas (Frimpong et al., 2013; Miller & West, 2007; Shin & Sharac, 2013). For populations served by federally-funded settings, EHRs have demonstrated the potential to improve quality of care (Frimpong et al., 2013).

Previous literature has suggested lower EHR adoption rates for federally-funded health centers (Shields et al., 2007). However, more recent studies have indicated substantial adoption growth in these settings (Frimpong et al., 2013; Jones & Furukawa, 2014; Shin & Sharac, 2013) and have even suggested no real difference when compared to other settings (Frimpong et al., 2013; Wittie, Ngo-Metzger, Lebrun-Harris, Shi, & Nair, 2014). Overall EHR adoption rates (implementation of any EHR) among FQHCs have been as high as 90%, with nearly 50% reported having a basic EHR (Jones & Furukawa, 2014). Larger centers have indicated significantly higher EHR adoption rates (Jones & Furukawa, 2014); however, no differences were suggested between rural and urban FQHCs (Jones & Furukawa, 2014; Wittie et al., 2014). FQHCs' ability to meet the MU Stage 1 criteria has also grown substantially from 2010 to 2012 (Jones & Furukawa, 2014), although these federally-funded centers may still require additional assistance (Shin & Sharac, 2013).

Considering the overall weak and inconsistent findings of the EHR literature in underserved settings over the years (Decker et al., 2012; Furukawa et al., 2014; Singh et al.,

2012), current research is needed to understand EHR adoption and use in rural and federally-funded practices (Weinfeld, Davidson, & Mohan, 2012).

EHRs in Patient-Centered Medical Homes

Current EHR and reimbursement policies are incentivizing providers to adopt interoperable EHRs and deliver collaborative and integrated care. Changes in reimbursement policy are encouraging providers to create more coordinated delivery systems. Due to primary care shortcomings, new models of care have been developed (Adler-Milstein & Cohen, 2013). The Patient Centered Medical Home (PCMH) is a primary care delivery model that is being implemented extensively (Kern et al., 2014); this model relies heavily on EHRs to coordinate care and engage patients (Adler-Milstein & Cohen, 2013; Bitton et al., 2012).

Overall, evidence in the literature supporting the ability of PCMHs to improve process of care and clinical outcomes has been limited and mixed (Arend et al., 2012; Jackson et al., 2013; Shi et al., 2015). Based on a report from the Patient-Centered Primary Care Collaborative, studies of PCMHs "continue to demonstrate impressive improvements across a broad range of categories including: cost, utilization, population health, prevention, access to care, and patient satisfaction, while a gap still exists in reporting impact on clinician satisfaction" (Nielsen, Olayiwola, Grundy, & Grumbach, 2015, p. 6). PCMHs have also been suggested to improve the care process (Jackson et al., 2013), and EHRs are noted to facilitate improved quality of care in these settings (Kern et al., 2014).

A primary component of the PCMH is the exchange of health information across settings through the adoption and use of fully functioning EHRs (Leventhal et al., 2012). EHRs can promote teamwork through information exchange and engage patients in their care (patient portals), two essential components of PCMHs (Bitton et al., 2012). However, research in the

literature regarding PCMHs and EHRs is quite limited (Richardson et al., 2015), and prior evidence indicates limitations in the EHR's ability to support coordinated care in PCMHs (Adler-Milstein & Cohen, 2013; Fernandopulle & Patel, 2010; O'Malley, Grossman, Cohen, Kemper, & Pham, 2010). A recent study suggested the need for improvements in EHR interoperability and patient engagement to support coordination in PCMHs (Richardson et al., 2015); however, use of these advanced EHR functions remains low in office-based settings (Furukawa et al., 2014).

Within PCMHs, EHR adoption and use are high compared to non-PCMHs; however, technology supporting patient engagement remains challenging (Adler-Milstein & Cohen, 2013). Seventy-seven percent of PCMHs indicated EHR use as opposed to 41% in non-PCMH in late 2011, up from 55.1% of PCMH and 22.8% in non-PCMH in early 2010 (Adler-Milstein & Cohen, 2013). Furthermore, findings from a separate study indicated that the quality of care delivered in PCMHs significantly improved at a rate greater than occurred in non-PCMHs. The positive effect on the quality of care for PCMHs was independent, and it was likely enabled by the EHR (Kern et al., 2014). Based on the existing literature, expedited research is needed to understand EHR adoption and use levels in PCMHs.

Study Design and Methodological Concerns in the EHR Literature

The extensive use of cross-sectional study designs utilized in these studies assessing EHRs may appear problematic; however, considering the current climate and context of EHR implementation, more rigorous studies, such as randomized control trials or even prospective observational studies, would be extremely difficult if not impossible to administer. Given the present status of EHR adoption under the MU policy, being able to find an appropriate control group or implement any kind of randomization would be nearly impossible in the United States.

In assessing the outcomes from these studies, researchers and policy makers must evaluate the results collectively and place them into the proper context. By focusing only on design limitations and dismissing results due to utilization of less rigorous methodologies, researchers can miss important time-sensitive findings, implications, and trends. Considering recent policy initiatives that are increasing EHR implementation and adoption, expedited research is needed to explore meaningful and advanced use of EHRs.

Another limitation in the design of certain studies included in the literature review was the dataset used. The studies tend to be secondary analyses utilizing only a few distinct data sources, such as the National Ambulatory Medical Care Survey (NAMCS) (Furukawa et al., 2014; Grinspan et al., 2013; Hsiao & Hing, 2014; Hsiao et al., 2014; Patel et al., 2013). Secondary analysis is not a limitation; however, research from other recently collected datasets could provide additional insights for this body of literature.

Summary of the Literature and Opportunities for Future Research

Among office-based physicians, EHR and EMR implementation is increasing (Hsiao & Hing, 2012), and since the MU criteria were established in 2010, these increases have been much more substantial (Hsiao & Hing, 2012). However, reported adoption (implementation) of an EHR system does not necessarily translate into actual use (McClellan et al., 2013). Therefore, it is difficult to assess whether practices simply implemented an EHR or if they experienced true meaningful use of a fully functional EHR, thus reaping the recognized benefits of the system. In the midst of all the momentum to adopt EHRs, many practices still lag behind and may not realize the true benefits of using advanced EHR systems.

As indicated throughout the literature, practice characteristics have important implications for EHR adoption and use. Practice size, type of practice, and ownership

demonstrated the most significant associations (DesRoches et al., 2013; Furukawa et al., 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013). Overall, larger practices (Audet et al., 2014; Furukawa et al., 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013; Singh et al., 2012; Xierali et al., 2013) and practices owned by health care organizations were more likely to adopt and use advanced features like HIE and patient engagement (Furukawa et al., 2014; Hsiao et al., 2014). Other contextual factors and characteristics such as having formal arrangements with other practices and focusing on quality improvement also increased the likelihood for EHR adoption (Audet et al., 2014). However, contextual factors and individual practice characteristics related to implementation may be different from those associated with EHR meaningful use (McClellan et al., 2013). Understanding those characteristics associated with higher as well as lower levels of use provides opportunities to expand current policy initiatives and improve widespread EHR use.

More patient care is delivered by primary care physicians and providers (Hing & Schappert, 2012), yet this cornerstone of health care delivery in the United States is plagued with numerous shortcomings (Adler-Milstein & Cohen, 2013). New primary care models, like the PCMH, are extensively being implemented (Kern et al., 2014) and rely heavily on EHRs to coordinate care and engage patients (Adler-Milstein & Cohen, 2013; Bitton et al., 2012). However, the MU policy was based on studies that found positive outcomes between EHR adoption and quality of care in large integrated delivery systems with fully functional EHRs. As indicated in the literature, isolated, independent practices with EMRs do not consistently demonstrate favorable trends toward improved processes or clinical outcomes (Crosson et al., 2012; Crosson et al., 2007; Keyhani et al., 2008; Linder et al., 2007; Romano & Stafford, 2011; Walsh et al., 2010; Zhou et al., 2009), whereas mature interoperable EHRs within integrated

systems demonstrated improvements in process, clinical outcomes, and quality of care in chronic outpatient disease management (Chaudhry et al., 2006; Reed et al., 2012; Weber et al., 2008). Many primary care providers practice independently, and there is inconsistent information in the literature about their experiences with EHR adoption (Weinfeld et al., 2012). Even less is known about actual EHR use in independent and isolated (non-networked, not integrated, or rural) PCMH practices. Are these providers simply implementing EHRs to earn PCMH designation and receive the MU payments, or are they experiencing actual use of EHRs for the full benefits of coordinated and patient-centered care?

Certain researchers have suggested that simply having or implementing an electronic health (medical) record alone is insufficient to improve quality (Poon et al., 2010; Zhou et al., 2009). Other studies have suggested that use of a sophisticated EHR alone could improve outcomes of care (Cebul, Love, Jain, & Hebert, 2011). However, any improvements in quality and outcomes of care require full adoption and use of advanced EHRs. Again, the inconsistent use of terminology and the functions within EHRs make synthesizing the literature difficult. Researchers must carefully evaluate the EHR definition, functionality, and components included in the various studies. As previously suggested, simply implementing and reporting use does not necessarily translate into actual use of a fully functional EHR. Based on the recent findings, it still appears that EMR implementation is far more prevalent than true EHR use (Terry, 2013), Therefore, the focus should be on adoption of robust EHRs and increasing appropriate use of advanced EHR features (Poon et al., 2010). This also provides significant opportunities for future research.

Considering the current climate of large-scale implementation efforts of MU and in light of recent empirical evidence, earlier claims about EHRs effects on outcomes and quality are

subject to critical review (Black et al., 2011). Furthermore, there has been limited research and input from providers since MU incentive payments began (Weeks, Keeney, Evans, Moore, & Conrad, 2014). Thus, research is first needed to understand the adoption and use levels in the context of current delivery reform initiatives.

While a wide variety of designs have been utilized for EHR adoption, a collective look at the overall themes in the literature provides a valuable perspective. Considering the billions of federal dollars invested to stimulate adoption and MU, EHRs have demonstrated exponential growth over a short amount of time. As previously stated, given the current status of EHR adoption and the political climate, it is nearly impossible to conduct more rigorously designed studies, such as randomized control trials. Expedited research is needed to explore and understand the factors contributing to successful adoption and EHR use.

In summary, the findings in this current literature review suggest that future research must address the following five points. First, considering the importance of advanced EHR use to realize the true benefit, studies should evaluate practice characteristics such as ownership, network affiliation, size, location, and time with an existing EHR associated with *advanced* EHR use. Further understanding those characteristics associated with lower use provide opportunities to expand current policy initiatives and improve wide-spread EHR use. Second, use of fully functional EHRs (not simply adoption/implementation) that meet advanced stages of MU criteria with interoperability must be the focus of future evaluations. Third, EHR and EMRs are inherently different; therefore, researchers must clearly define the functionality and capabilities of the systems studied. Standardized definitions are needed. Fourth, fully-integrated health care systems utilizing interoperable EHRs demonstrate improvements in process, clinical outcomes, and quality of care. This indicates that future research must also include independent

organizations, primary practices, and patient centered medical homes that are functionally integrated through EHRs. Fifth, a variety of research designs and methodologies have been utilized, and if put into context, they can provide valuable perspectives and insights. Because it is difficult to use comparison designs in the midst of reform, study designs allowing for expedited research are needed.

Based on the findings of this literature review, research is needed to explore meaningful use of EHRs and the practice characteristics associated with advanced EHR use within current health care delivery reform initiatives. Therefore, this project will evaluate advanced EHR functionalities (information exchange and patient portals) and use in patient-centered medical homes. In order to identify the specific PCMH practice characteristics that are associated with advanced EHR use, this study will analyze secondary data collected by National Center Quality Assurance (NQCA) and American Academy of Family Physicians National Research Network (AAFP). Based on the current literature review, the research questions and hypotheses generated are presented in the next section.

Research Questions and Hypotheses

Research Question 1: What are the adoption and EHR use levels for PCMH practices in this study, and how do they compare to other primary care settings in the current literature?

Quantifying PCMH adoption and use of EHRs will put these types of PCMH practices into the broader context of existing research on other office-based and primary care practices. As described previously, PCMH practices are required to collaborate and coordinate care across settings to receive their national designation. This type of coordination relies heavily on the use of technology like EHRs to facilitate care. Therefore, adoption and use of EHR in PCMH should

be higher than other primary care settings. It is hypothesized the EHR adoption and use levels for PCMHs will be higher than the national averages of other primary care settings (as defined in the current literature). Specifically, most of the PCMH practices will have a basic EHR system and will be using it routinely. The rates for advanced EHR use will also be higher for PCMHs as compared to national averages of other primary care practices. It is hypothesized that overall EHR use levels will be lower for rural and non-networked practices.

The HIMSS EMR Adoption Model is a framework that is widely used to classify EHR adoption levels for hospitals and ambulatory care settings. Health care organizations participate voluntarily in this program and receive designation for meeting all seven stages. Those practices choosing to submit to the HIMSS framework are more likely to be rapidly pursuing Stage 7 designation; therefore, the overall adoption levels for these groups would be high. It is hypothesized that PCMHs would demonstrate lower levels of adoption according to the HIMSS A-EMRAM scale.

Research Question 2: How well are PCMHs meeting advanced criteria for MU Stage 2?

The true benefits of EHRs will not be realized until health care providers are using advanced information exchange functions nationally. Health care providers are being incentivized to adopt and meaningfully use EHRs. Practices that receive PCMH designation may have a unique advantage because they are expected to utilize EHRs to facilitated well-coordinated and patient-centered care. It is hypothesized that PCMHs will progress through advanced stages of MU at a higher rate than other eligible providers participating in the program.

Based on the data recently collected in a survey by the National Committee for Quality Assurance (NCQA) and the American Academy of Family Physicians (AAFP), this current study evaluates factors such as practice characteristics and priorities in the context of care

coordination. This study also describes and evaluates EHR adoption levels for primary care providers in PCMHs and assesses their progress towards meeting the advanced stages of MU. Specifically, this study identifies the PCMH practice characteristics associated with use of advanced EHRs.

Research Question 3: What PCMH practice characteristics are associated with advanced EHR use as compared to no advanced EHR use?

As indicated throughout the literature, practice characteristics have important implications for EHR adoption and use. Understanding those characteristics associated with lower use provide opportunities to expand current policy initiatives and improve widespread EHR use. It is hypothesized that practice affiliation (networked providers), length of time using an EHR (having an EHR longer), practice size (larger), and increased levels of practice innovation (care coordination and quality improvement initiatives) will demonstrate positive associations with advanced EHR use. It is also hypothesized that rural PCMHs and those practices not part of a network will demonstrate lower use of advanced EHRs. It is further hypothesized there will be no difference based on ownership type. Overall external factors and practice characteristics will demonstrate varied associations with advanced EHR use, thus generating additional research and policy opportunities. Below is a list of the specific hypotheses with a brief rationale for each:

- H3a: Practice size will demonstrate a strong and significant positive association with advanced EHR use. Based on consistent findings in the literature, larger practices will have increased odds of advanced EHR use. Larger practices tend to have more resources to purchase EHRs and more opportunities to connect.

- H3b: Practice affiliation (networked providers) will demonstrate a positive association with advanced EHR use. Practices that are part of network will have more opportunities to connect to other network practices to coordinate care and therefore increase the likelihood for advanced EHR use.
- H3c: Rural providers will demonstrate decreased odds of advanced EHR use. Based on the inconsistencies in the literature and given their unique financial and technological challenges, these rural and isolated practices will be associated with lower levels of advanced EHR use.
- H3d: Practices with increased levels of practice innovation (focus on quality improvement and/or care coordination) will have increased odds of advanced EHR use. EHRs can facilitate care coordination and quality improvement initiatives, thus resulting in higher use levels.
- H3e: Practices with higher priority for meeting the MU criteria and practices with high financial concerns will demonstrate decreased odds of advanced EHR use. It is likely that those practices are pursuing the MU incentive payment primarily for financial reasons and are not experiencing true EHR use for the intended purpose of care coordination.
- H3f: Practices with EHRs for longer periods of time will be positively associated with advanced EHR use. Having an EHR longer will increased the odds of advanced EHR use. These findings would suggest a significant learning curve for EHRs.
- H3g: Even though there are inherent differences in capabilities among PCMH by type of practice (Tirodkar et al., 2014), EHR use will not differ significantly among the types of PCMH ownership. These practices have the same criteria for PCMH

designation; therefore, no differences are expected in advanced EHR use by practice ownership type.

CHAPTER 3

Design and Methodology

This dissertation seeks to identify and explain Patient-Centered Medical Home (PCMH) practice characteristics and contextual factors associated with advanced EHR use. In doing so, this dissertation will also describe and discuss overall EHR adoption and use in PCMH practices compared to other practices and settings nationally. Considering that the MU policy is the driving force behind widespread EHR adoption nationally (Hsiao & Hing, 2012), this dissertation will also evaluate PCMHs progress towards meeting the advanced criteria for MU. To identify the PCMH characteristics and factors associated with advanced EHR use, this study utilizes a secondary data analysis of a national cross-sectional dataset of PCMH practices. This chapter describes the research design, methodology, and analyses used in the current study.

Data and Sample

Dataset. The dataset evaluated in this dissertation is from a National Committee for Quality Assurance (NQCA) and American Academy of Family Physicians National Research Network (AAFP) project that surveyed NCQA designated PCMH practices.[5] Data was collected by email, fax, and mail (Morton et al., 2015). The objective of the original NCQA/AAFP study was to explore the proposed MU requirement for care coordination. The survey was funded by an Agency for Healthcare Quality and Research (AHRQ) grant and was seeking input about the proposed Stage 3 objectives for MU. The NCQA and the AAFP conducted this survey to evaluate providers' perceived value of EHRs to support care coordination (Hudson-Scholle, Morton, & Tinoco, 2013). The survey questions were adapted from previous care coordination

[5] The data contained in this dissertation is used with permission of the National Committee for Quality Assurance ("NCQA"). Any analysis, interpretation, or conclusion based on these data is solely that of the author, and the NCQA specifically disclaims responsibility for any such analysis, interpretation, or conclusions.

and PCMH surveys (Morton et al., 2015). In addition to the questions concerning care coordination and perceived values of EHR functions for the original study, the NCQA/AAFP survey included measures related to MU objectives, the 7 Stages of the HIMSS Ambulatory EMR Adoption Model[sm] (HIMSS Analytics, 2014a), and other advanced EHR functions. The specific practice-level questions relating to EHR adoption and use were adapted from the National Electronic Health Records Survey, which is affiliated with the National Ambulatory Medical Care Survey (NAMCS) (CDC, 2012b; Morton et al., 2015). The NCQA/AAFP survey questions utilized in this dissertation to represent EHR use are provided in Table 3.1.

Sampling. In the original NCQA/AAFP study, purposeful sampling methods were utilized to select the practices that had achieved PCMH recognition from the NCQA. In total, 997 of the 1,636 total practices met the criteria of the NCQA/AAFP study. The PCMHs were stratified by type of practice (ownership), including physician-owned (438), hospital/health system/health plan-owned (284), and Federally Qualified Health Centers and Community Health Centers (federally-funded health centers) (275). For physician-owned and hospital/system-owned PCMHs, one provider who attested to MU was randomly chosen to respond to the survey from each practice. Due to the lower numbers of providers in federally-funded PCMHs attesting to Medicare's MU program (most utilized the Medicaid program), a single provider was randomly selected from the federally-funded practices. As indicated by the sampling procedures, and according to NCQA, most of the practices indicated at least basic EHR adoption. The overall response rate of the NCQH/AAFP study was 35.1%, as 350 of 997 practice questionnaires were returned (Morton et al., 2015).

For this dissertation, PCMHs were further excluded if the type of practice was categorized as "other" (n=4), "non-physician manager in the group" (n=1), or if the practice did

not indicate their practice ownership type (n=7). Only one practice indicated being "HMO-owned," which has implications for EHR adoption according to the literature (Furukawa et al., 2014; Hsiao et al., 2014). A decision was made to exclude this HMO-owned practice from this dissertation. Thus, 13 additional PCMH practices were excluded from this dissertation, for a final sample size of 337 practices out of the 350 completed surveys (33.8%). This is an acceptable and typical response rate for a study design with physicians (Kellerman & Herold, 2001; McFarlane, Olmsted, Murphy, & Hill, 2007; Willis, Smith, & Lee, 2013; Ziegenfuss et al., 2012).

According to the NCQA/AAFP study, there were no overall differences in the response rates by specialty, practice type, or region; however, there were significant differences by the practices level of PCMH designation (29% for Level 1 or 2, compared to 37% for Level 3, the highest PCMH designation from the NCQA) (Hudson-Scholle et al., 2013; Morton et al., 2015). Based on recent studies of physician office-based and primary care practices, it was determined that the PCMH practices in this dissertation demonstrate similarities to other primary care practices by size and ownership but were different regarding geographic location and network/affiliation (DesRoches et al., 2013; Whitacre, 2015; Xierali et al., 2013). There were fewer rural and networked PCMHs in this study. The complete descriptive statistics are provided in Chapter 4.

Missing values and imputations. Missing values can be problematic, particularly in smaller sample size studies. Not addressing missing values can result in a considerable loss of power and may introduce substantial bias (Acock, 2014). The original NCQA dataset on initial assessment appeared to be missing data even though many of the questions had options for "N/A" and "Don't Know." However, many of the questions were actually part of a question set

with numerous response levels. As an example, one question posed: "Does your practice provide patients with clinical summaries at the end of each visit?" The sub-question then asked, "Do your patients log on to a patient portal to your practice EMR/EHR system to view their clinical summary?" A number of practices that answered "No" to the first question also left the sub-question blank. Most of the data missing from this survey was the result of this type question format. For this dissertation, unanswered questions (missing data) were reviewed and assessed for such sub-questions. As appropriate, blank sub-question responses were recoded as "No" if the respondent answered "No" to the lead question. This process eliminated most of the missing values in this current dataset.

Dependent variable: Creating the EHR index for advanced use

The focus of this dissertation is advanced EHR use in PCMHs. Advanced EHR use includes multiple measures relating to the exchange of information between providers as well as patients. Thus, the dependent variable is actual use of advanced EHR functions as a summary construct (advance EHR index). Table 3.2 describes the eight measures specifically related to EHR adoption and use and includes the corresponding questions from the survey.

Most of the prior literature focuses on EHR adoption (implementation levels) (Holden & Karsh, 2010) and use of certain basic EHR functions within the early stages of MU (Ancker et al., 2013; Audet et al., 2014; Baier et al., 2012; DesRoches et al., 2013; Furukawa et al., 2014; Hsiao & Hing, 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013; Singh et al., 2012). The HIMSS national framework includes advanced EHR functions, but it measures adoption on the assumption that practices move step-by-step through all 7 stages. No studies were found that focus solely on advanced EHR use as an index. Considering the numerous advanced EHR functions available and the inconsistent adoption and use of these advanced EHR

functions (Furukawa et al., 2014), using an index has important implications for this study and allows for the combination of multiple measures for advanced EHR use.

The NCQA/AAFP dataset is unique in that it includes questions specifically related to routine use of the specific EHR functions. This provides an opportunity to compare practices that have the EHR capabilities to those that do not, and to compare those that simply have EHRs to those that routinely use the advanced EHR functions. Considering the dissertation's purpose to evaluate actual EHR use in PCMH practices, all of the EHR variables were recoded from their original format of "1 = No; 2 = Yes, not routinely used; 3 = Yes, routinely used" into dichotomous variables indicating routine use ("No" and "Yes, not routinely" were recoded as "No, routine use"). Stated simply, the variables used in the advanced EHR index are an expression of the dichotomous variables such that non routine use is "0" while routine use of the EHR functions are expressed as "1." Table 3.1 provides the detailed list of the EHR-related variables considered for inclusion in the dependent variable, the EHR index.

Table 3.1 Variables Considered for Inclusion in the EHR Index as the Dependent Variable

Variable	Description – Survey Question and response options	Recoded
Computerized Clinical Decision Support (CCDS)	Does your practice have a system that provides reminders for guideline-based interventions or screening tests to clinicians at the point of care? Is there a computerized system for performing this task? **No / Yes, but not routinely used / Yes, used routinely**	Routine Use? Yes/No
Remote EMR/EHR access	Does your practice have a system to allow clinicians providing after-hours coverage to have remote access to the patient's medical record information at the practice for care and advice no matter where the patient or clinician is located? **No / Yes, but not routinely used / Yes, used routinely**	Routine Use? Yes/No
Fax/transmit patient summary via EHR to others (fax-EHR)	Does your practice use the following methods [Fax via EMR/EHR system] to send a comprehensive patient summary to consulting clinicians or facilities? **No / Yes, but not routinely used / Yes, used routinely**	Routine Use? Yes/No
Use EHR interface to send patient summary	Does your practice use the following methods [direct electronic link or interface from your EMR/EHR system to a different EMR/EHR system] to send a comprehensive patient summary to consulting clinicians or facilities? **No / Yes, but not routinely used / Yes, used routinely**	Routine Use? Yes/No
Use HIE to send patient summary	Does your practice use the following methods [Health information exchange] to send a comprehensive patient summary to consulting clinicians or facilities? **No / Yes, but not routinely used / Yes, used routinely**	Routine Use? Yes/No
Use EHR interface to view reports/results	In your practice's EHR system, can you see patients' consultation reports and diagnostic study results (e.g., colonoscopy and diagnostic imaging) that were sent from other clinicians/services? **No / Yes, but not routinely used / Yes, routinely** How does data from other clinicians/services get into the patient's record in the EHR? [Data via interface between outside provider/facility and EHR system] **No / Yes, but not routinely used / Yes, used routinely**	Routine Use? Yes/No
Use HIE to view reports/results	In your practice's EHR system, can you see patients' consultation reports and diagnostic study results (e.g., colonoscopy and diagnostic imaging) that were sent from other clinicians/services? **No / Yes, but not routinely used / Yes, routinely** How does data from other clinicians/services get into the patient's record in the EHR? [Health information exchange] **No / Yes, but not routinely used / Yes, used routinely**	Routine Use? Yes/No
Uses patient portal to view clinical summary	Do your patients log on to a patient portal to your practice EMR/EHR system to view their clinical summary? **No / Yes, but not routinely used / Yes, routinely**	Routine Use? Yes/No

EHR=Electronic Health Record; EMR= Electronic Medical Record; HIE=Health Information Exchange

The eight variables considered for inclusion in the advanced EHR use index (dependent variable) were aligned with and categorized by the seven stages of the HIMSS framework (HIMSS Analytics, 2014a). As presented in Table 3.2, the advanced EHR variables from the NCQA/AAFP survey are associated with the exchange of electronic health information, either

through health information exchange[6] (HIE, and Stage 7), the EHR interface[7] (Stage 4 & 6), or a patient portal (Stage 7). According to the HIMSS model, two of the variables, Computerized Clinical Decision Support (CCDS) and remote EMR access, are associated with a more basic EHR system (Stage 3) and were thus considered for exclusion from the advanced EHR use index (described in more detail below). The fax-EHR variable (fax a comprehensive patient summary via EHR) may be associated with Stages 3 or 4 of HIMSS framework (HIMSS Analytics, 2014a), depending on why it is being used by the practice to send comprehensive patient summary to other practices. Consideration was given to whether the fax-EHR variable should be included in the advanced EHR use index. Providers who have the ability to fax comprehensive patient summaries via their EHR system may indicate higher use of advanced functions because at least all of the data required for a comprehensive patient summary is available in the EHR. Practices may also be faxing the information with the EHR because the recipient is unable to receive structured EHR data. Thus, the fax-EHR variable could indicate a practice's ability to exchange data and the recipient's inability to receive electronic information. The decision was made to consider this fax-EHR variable in the advanced use EHR index and confirm its inclusion with factor analyses.

[6] For Health Information Exchange, practices may send information via a third party or through a secured internet connection, much like email.
[7] The EHR interface is a networked connection in which interoperable EHRs communicate directly.

Table 3.2 Alignment of HIMSS Framework and NCQA/AAFP Variables

Stage	HIMSS Cumulative Capabilities	NCQA/AAFP Variable
Stage 7	**HIE capable**, sharing of data between the EMR and community based EHR, business and clinical intelligence	Combined "HIE Use" (Use HIE/EHR to send patient summary & Use HIE/EHR to view reports/results)
Stage 6	Advanced clinical decision support, **proactive care management, structured messaging**	Use EHR interface to send patient summary
Stage 5	Personal health record, **online tethered patient portal**	Uses patient portal to view clinical summary
Stage 4	Computerized Physician Order Entry (CPOE), **Use of structured data for accessibility in EMR and internal and external sharing of data**	Use EHR interface to view reports/results Fax patient summary via EMR to others
Stage 3	Electronic messaging, **computers have replaced the paper chart**, clinical documentation and **clinical decision support**	Computerized Clinical Decision Support Remote EMR access
Stage 2	Beginning of a CDR with orders and results, computers may be at point-of-care, access to results from outside facilities	No variables
Stage 1	Desktop access to clinical information, unstructured data, multiple data sources, intra-office/informal messaging	No variables
Stage 0	Paper chart based	

*Bolded text above represents the HIMSS capability associated with the dependent variables used in this project. HIE=Health Information Exchange, EHR = Electronic Health Record, EMR=Electronic Medical Record (referred to as EHR in this project), CDR = Clinical Data Repository (clinical database)

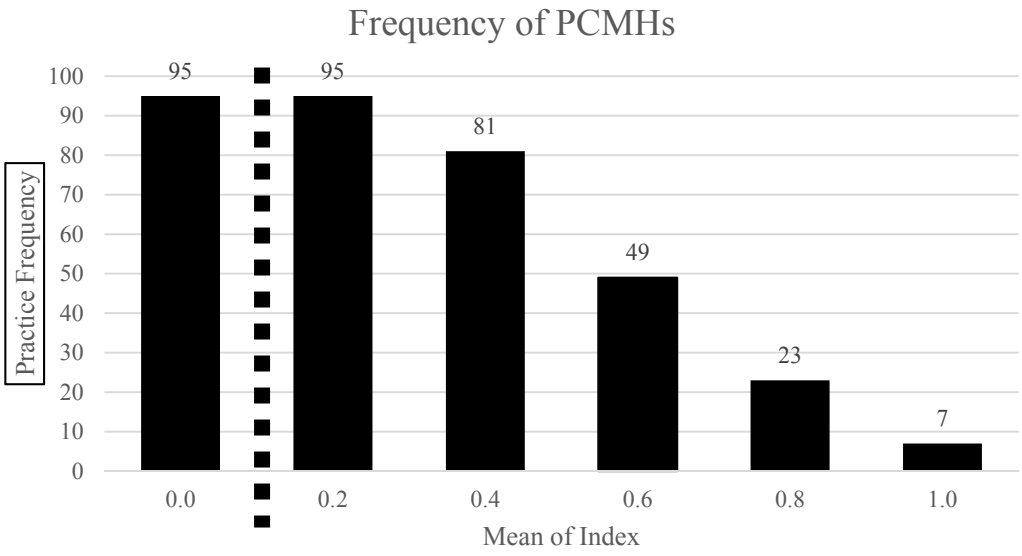
Factor analyses confirmed the eight variables for EHR use as a single factor for the index (1.19 Eigenvalue). Based on the 0.40 threshold for principal component analysis (Acock, 2014), the variables for CCDS and remote access to an EMR were loading on a separate factor. Also, as indicate by the HIMSS framework in Table 3.2, these two variables (CCDS and Remote Access to EMR) are related to more basic, not advanced EHR use, and were removed from the advanced EHR index. Additional factor analyses indicated the possibility for a combined, single HIE variable. Based on the HIMSS framework and confirmed by factor analyses, the variables for using HIE to send patient summaries and review external results and reports with HIE were combined into a single new variable for "HIE Use." The reliability of the remaining variables

was assessed by Cronbach's alpha. A Cronbach's alpha of 0.80 and higher is considered good, while 0.70 is acceptable (Acock, 2014; Cronbach, 1951), although it has been argued that a lower alpha may suffice for earlier stages of research (J. Nunnally, 1978; J. C. Nunnally, Bernstein, & Berge, 1967; Pedhazur & Pedhazure Schmelkin, 1991). The Cronbach's alpha for the remaining variables in this study was 0.55, which is low by these standards. However, removing additional variables would further lower the reliability. Based on the results from the factor analyses, and the alignment with the HIMSS framework, the following variables are included in the advanced EHR use index as the dependent variable: HIE use, EHR interface to send patient summary, patient portal use, EHR interface to view results, and fax patient summary via EHR (fax-EHR).

The advanced EHR use index was initially represented as a continuous dependent variable with values between 0 and 1. The problem with the continuous variable as the EHR index in this dataset is that many of the observations were loading on the low end of the index. As indicated in Figure 3.1, more than 50% of the observations were equal to 0.0 (on a scale of 0.0 – 1.0) on the advanced EHR index. Furthermore, the data violates the assumptions for ordinary least squares (OLS) multiple linear regression (the residuals were not normally distributed, there is a high likelihood for heteroskedasticity, and there is specification error within the model). The primary purpose of this study is to understand and describe the various characteristics and factors of PCMH practices that are associated with advanced EHR use compared to practices with no advanced EHR use. Thus, the advanced EHR index was dichotomized to compare practices using none of the advanced EHR features to those using more or some of the features.

Converting a continuous variable to a dichotomous may result in the loss of variance (Acock, 2014). The challenge is determining precisely what point the cutoff should be to indicate the "1" or "0." Considering the goal of this dissertation is to understand PCMH practice characteristics associated with advanced EHR use as compared to those practices without advanced EHR use, the decision to recode the continuous EHR variable (advance EHR index) into a categorical variable is appropriate. The final model for the advanced EHR use index was coded as 0 = "no advanced use" and 1 = "any advanced use" (see dotted line in Figure 3.1).

Figure 3.1. The EHR Index Threshold



Independent variables

Eleven independent variables are included in the model and represent the PCMH practice characteristics and contextual factors. Table 3.3 provides the full list and measures of independent variables used in this EHR model. The measures for this study include practice characteristics, practice priorities, and practice innovations. The independent variables are further described and evaluated for inclusion in the EHR model noted in the next section of this chapter.

Table 3.3 Independent Variables Measures

Measure	Variable	Measurement
Practice Type	Practice Ownership	physician owned, hospital/system-owned , federally-funded
Practice Size	Number of Clinician (ordinal)	1 clinician, 2-4 clinicians, 5-9 clinicians, and 10 or more clinician
Location	Rural Practice	Yes / No
	Multiple Practice Locations	Yes / No
Practice Affiliation	Practice is part of an IDS/IPO/PHO*	Yes / No
EHR Length of Time	Length of time having an EHR	5 years or less / more than 5 years
Priority	MU Attestation	portion of providers that attested in MU: none / some / all
	MU Highest Priority	MU as the higher priority as compared to care coordination: yes/no
	Financial Concern	Practice has no, moderate, high financial concerns
Practice Innovations	Quality Improvement Categories	Low, moderate, high
	Care Coordination Agreement	Did the practice have any type of care coordination agreement: yes/no

*IDS=Integrated Delivery System; IPA=Independent Practice Association; PHO=Physician Hospital Organization

Practice Characteristics. As indicated by the literature review in Chapter 2, certain practice characteristics have important implications for EHR adoption and use. For example, larger practices that are part of a system or network are more likely to adopt EHRs (Audet et al., 2014; DesRoches et al., 2013; Furukawa et al., 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013; Singh et al., 2012; Xierali et al., 2013), whereas rural practices may be less likely to use information exchange (Furukawa et al., 2014). This dissertation explores the following PCMH characteristics and their association with any advanced EHR use: type of PCMH practice (ownership and low-income), the practice size, the geographic location (rural/ non-rural), practice affiliation/network (being part of an integrated delivery system, independent practice association, or a provider hospital organization), and the length of time the practice has

had an EHR (time since practice EHR adoption). It is hypothesized that practice affiliation (networked providers), length of time using an EHR (having an EHR longer), and practice size (larger) will demonstrate positive associations with advanced EHR use. It is further hypothesized there will be no differences based on ownership type. It is also hypothesized that rural PCMHs and those practices not part of a network will demonstrate lower use of advanced EHRs. As described in Chapter 4 results, certain hypotheses are rejected.

Practice type: Practices were categorized by who owns the practice. Even though the NCQA/AAFP survey included eight separate ownership categories (physicians, non-physician manager, hospital/health system, health plan, military facility, federally qualified health center, community health center, or other government entity), according to the NCQA, there are five main types of PCMHs: large physician-owned practices; small physician-owned practices; practices owned by hospitals, health systems, or health plans; community health center or federally-funded health centers; and military treatment facilities (Tirodkar et al., 2014). Military facilities were previously determined to be different from the other types of PCMHs (Tirodkar et al., 2014). Since no military facilities responded to the survey, this type of practice is not included in the dissertation. Also, the NCQA/AAFP survey included a separate construct for size of practice (described below), so small and large physician-owned practices were categorized together as physician-owned practices. Finally, due to the similarities, federally qualified health centers and community health centers were combined. The three ownership types of PCMHs included in this dissertation are physician-owned practices, hospital/health system-owned, and federally funded health clinic (community/federally-funded health

centers). These three categories of PCMH also represent the major sources of primary care in the United States.

Practice size: PCMHs were asked to report the number of full-time equivalent (FTE) clinicians in the practice as a numeric value. Due to concerns about a nonlinear relationship between practice size and advanced EHR use in the initial data testing, the NCQA's categorical number of providers was utilized for this dissertation. The four categories for number of providers (1 clinician, 2-4 clinicians, 5-9 clinicians, and 10 or more clinicians) is also consistent with previous research and aligns with the primary focus of the federally-funded Regional Extension Centers initiative that provides assistance with EHR adoption for practices with less than 10 providers (Audet et al., 2014; DesRoches et al., 2013; Office of the National Coordinator for Health Information Technology, 2015).

Practice affiliation: The NCQA/AAFP survey asked whether practices were part of an Integrated Delivery System (IDS), Independent Practice Association (IPA), or a Physician Hospital Organization (PHO), as a "Yes" or "No."

Multiple locations: PCMHs were asked about how many locations the group/organization uses for primary care. The four NCQA/AAFP categories (2-5 locations, 6-10 locations, 11-15 locations, >15 locations) were collapsed in to one variable, which indicated that the practice has multiple locations (Yes/No).

Practice location (rural): PCMHs were asked in what type of area the practice is located: "urban, suburban, or rural." For this dissertation, "urban" and "suburban" were combined into a single variable (non-rural). PCMH practices considered rural are coded as "1" and non-rural practices are coded as "0."

Length of time with an EHR: PCMHs were asked how long their practice has been using any EMR/EHR: "<1-2 years, 3-5 years, 6-10 years, 11-15 years, More than 15 years, or Don't know." Nearly 40% of the practices were using EHR for 3-5 years, and another 40% indicated 6-10 years using an EHR. A decision was made the use the NQCA recoded dichotomous variable in which practices with an EHR/EMR for less than five years was coded as "0" and practices with more the five years as "1."

Practice Innovation. Practice innovation refers to the emphasis placed by PCMHs on care coordination and/or quality improvement, both of which are hypothesized to increase EHR adoption levels and improve outcomes of care. In the previous literature, care coordination and quality improvement demonstrated associations with EHR adoption (Audet et al., 2014; McClellan et al., 2013). It is hypothesized that PCMH practices with increased levels of practice innovation (focus on quality improvement and/or care coordination) will have increased odds of advanced EHR use.

Quality improvement (QI): Respondents were asked a series of 17 questions related to the quality improvement strategies, based on the Solberg et al. Change Process Capability Questionnaire (CPCQ) (Solberg, Asche, Margolis, & Whitebird, 2008). The questions assess the practice strategies for implementing PCMH and the culture to support change. The overall index of quality improvement is a composite score for each practice, or the sum of three categories across the questions: "yes used, and worked well" (1 point), "yes used, but did not work well" (0.5 points), and "no, did not use" (0 points). Due to concerns of a nonlinear relationship between QI and advanced EHR use, the variable was recoded into quality improvement categories. Based on the clustering of the data, the

quality improvement score was broken into three ordinal categories: "low," (CPCQ ≤ 8) "moderate," (CPCQ > 8 <12.5) and "high" (≥ 12.5).

Care coordination: Considering the focus of the NCQA/AAFP study to evaluate care coordination activities, the survey has numerous related questions; however, most were care coordination activities reliant on EHRs. One question explored care coordination, independent of the EHR. PCMHs were asked whether they have care coordination agreements in place with other practices: "No", "Yes, 'understood' agreement," or "Yes, written agreement." The three categories were collapsed into a dichotomous variable for having "any care coordination agreements." Practices without any agreement (written or understood) are coded as "0" and practices with any care coordination agreement in place are coded as "1."

Practice Priorities. Practice priorities include MU, care coordination, and the overall financial concern of the practice. These priorities are likely to have a significant impact on EHR use. It is hypothesized that practices with higher priority for meeting the MU criteria and practices with high financial concerns will demonstrate decreased odds of advanced EHR use.

MU priority: The PCMHs reported both their priority levels for implementing MU requirements in the practice and improving care coordination (on a 0 – 10 scale). Considering the intention of this dissertation to understand practices with higher priorities for MU, a dichotomous variable was created to reflect practices with a higher priority for MU as compared to care coordination. Practices with higher priority for MU are coded a "1," whereas other practices were coded as "0."

MU attestation: As part of the dataset provided by the NCQA, the proportion of providers in the practice attesting to Stage 1 MU is included as a categorical variable. The PCMH

practices were classified as "none, some, or all." Practices with all providers attesting to MU are considered to have high priority for MU. However, this variable demonstrated issues across the PCMH practice settings. None of the federally-funded PCMHs had any practices with "all" providers attesting, and physician-owned practices all had at least "some" providers attesting to MU in every practice (no physician-owned practice indicated "none"). This would cause problems with the findings, so the variable was excluded from the initial analyses. The variable was then recoded into a dichotomous variable where "1" represented clinics with "all" providers attesting to MU, and "0" was practices with not all providers attesting (none or some) and was included in the analyses without the federally-funded PCMHs. This issue will be further discussed later.

Financial concerns: PCMHs reported their overall concern about the financial health of the practice as "Not at all concerned," "Moderately concerned," or "Very concerned." These three categories are included in the dissertation analyses with "Not at all concerned" as the reference category.

Methods and Analysis

The main purpose of this dissertation is to identify the PCMH characteristics associated with advanced EHR use. The first step is to describe overall EHR adoption and use in PCMHs and then compare these practices to other national studies in primary care settings. The HIMSS Ambulatory EMR model is also used to compare PCMH practices to a national framework on EHR adoption (HIMSS Analytics, 2014a). Basic descriptive statistics are used (chi-squared analyses) to describe overall adoption and use levels of PCMH and to compare these practices. A comparison of adoption (simply having or implementing as system) versus use of basic EHR systems for PCMHs is included. For advanced function usage, EHR use is measured across PCMH type and location of practice (rural).

MU is the driving force behind EHR adoption in the United States (Hsiao & Hing, 2012). This dissertation seeks to understand how well PCMHs are meeting the advanced criteria for MU. An in-depth description of these PCMH practices' progress towards meeting advanced criteria for MU is included.

A primary goal of this study is to create and then test an index for advanced EHR use and identify PCMH practice characteristics and factors associated with advanced EHR use. The HIMSS framework is used to stratify EHR functions and create the dichotomous advanced EHR index (HIMSS Analytics, 2014a). Practices using any advanced EHR functions are coded "1," and practices not using any of the advanced EHR functions are coded "0."

To measure association between PCMHs characteristics and advanced EHR use, logistic regression analysis is utilized. Specifically, binary multiple logistic regression is used to test and refine the EHR model and to evaluate PCMH practice characteristics associated with the probability of advanced EHR use. Logistic regression is used with a binary dependent variable that has two values, "1" if the result occurred (advanced EHR use) and "0" if the result did not occur (Long & Freese, 2006). This type of regression analysis explores each of the independent variable's effect on the probability that the dependent variable (advanced EHR use) occurs (Long & Freese, 2006). Logistic regression is powerful, and because a single coefficient summarizes the logged odds linear relationship of the PCMH practice characteristics association with advanced EHR use (as odds ratio), the results are more easily interpreted (Acock, 2014; Pampel, 2000). Odds ratios for likelihood of being advanced EHR users are calculated.

The EHR use model was tested for logistic regression assumptions. The model was determined to be properly specified, all the relevant variables were included, and the data fit the model well. A decision was made to use robust standard errors rather than removing any of the

potential influential observations because those responses may provide additional meaning in the final analyses. The EHR model with a dichotomous dependent advanced EHR index variable satisfies all of the assumptions for logistic regression.

In this study, logistic regression is used to evaluate the PCMH practice characteristics associated with advanced EHR use as compared no advanced use. In order to verify the EHR use model, this dissertation will also test variations of the dichotomous dependent variable (the advanced EHR index) and compare the practice characteristics at differing levels on the advanced EHR index as separate models. Since the dichotomous EHR index was created from a continuous variable, testing the models at various levels will ensure the appropriateness of the threshold used to classify and differentiate advanced EHR use from no advanced EHR use. Tests of specificity and sensitivity are used to indicate and compare PCMH practices that were classified as advanced EHR users to those that were classified as non-advanced EHR users.

In this dissertation, five models are proposed and then compared using logistic regression to verify the appropriateness of the threshold for the dichotomous dependent variable (advanced EHR use). Associated characteristics at the more advanced EHR use levels (higher threshold of the EHR index) might be seemingly different from the original model that compares any advanced EHR use to no advanced use. These variations in the models may also provide guidance for future models as advanced EHR use becomes more widespread. These five models will verify the appropriateness of the advanced EHR index:

1. Lowest threshold model: Advanced EHR use compared to no advanced use at the 0.0 threshold of the dichotomous variable for advanced EHR use. This is the initial model described previously and the primary focus of this study.

2. Median threshold model: Advanced EHR user compared to non-advanced user at the median threshold of the dichotomous variable for advanced EHR use. Based on the data, the 0.25 threshold (see Figure 3.3) is the point at which advanced EHR use increases and the volume of practices with "advanced EHR use" begins to decline.
3. Increased threshold model: The cutoff for the data point of the dichotomous EHR index is increased (to 0.50) to evaluate the highest (most advanced) EHR use levels in PCMHs. The increase is based on tests of specificity and sensitivity.
4. Physician-owned and hospital/system-owned model: Due to inherent differences in PCMH, practice characteristics between the federally-funded health care centers and the physician-owned and hospital/system-owned PCMH practices (Tirodkar et al., 2014), and inconsistencies in the models based on type of practice ownership, federally-funded PCMHs are removed from this model. The PCMH practices are evaluated at the initial cutoff (0.0) to identify characteristics of physician-owned and hospital/system-owned PCMH practices associated with any advanced EHR use as compared to practices with no advanced use.
5. Federally-funded clinic model: Due to inherent differences in practice characteristics between PCMH practices (Tirodkar et al., 2014), and inconsistencies in the models based on type of practice ownership, federally-funded PCMHs are evaluated independently in this model. The PCMH practices are evaluated at the initial cutoff (0.0) to identify characteristics of federally-funded PMHCS practices associated with any advanced EHR use as compared to practices with no advanced use.

In Chapter 4, the results and findings from the five models are extensively compared. Unlike in OLS where the R^2 can be used to compare models, the Pseudo-R^2 in logistic regression does not represent explained variance of the model (Pampel, 2000). Furthermore, Pseudo-R^2 provides different measures of fit in different analyses (Long & Freese, 2006), so it is not appropriate for comparing models. As proposed by Raftery (1995), the Bayesian Information Criterion (BIC), which can be used for comparing nested and nonnested models (Long & Freese, 2006; Pampel, 2000; Raftery, 1995), is used for comparing the five EHR models in this study. The differences in BIC represent weak (0-2), positive (2-6), strong (6-10), or very strong (>10) support for the models (Raftery, 1995).

Summary

This chapter describes the EHR index and the parameters surrounding the development of the advanced EHR use model. The EHR use model was tested and refined. In conclusion, based on the initial analyses, the sample is appropriate and the advanced EHR index is a strong and meaningful model for advanced EHR use.

Chapters 4 and 5 provide the detailed results of this dissertation. Chapter 4 describes EHR adoption and use in PCMHs and uses national frameworks to compare PCMHs to other practices. Chapter 5 provides the interpretations of the associations between PCMH adoption and advanced use of EHRs. The EHR model will be evaluated and further discussed in Chapter 5. Variations in the model will also be explored to validate the index and demonstrate changes in the PCMH characteristics associated with advanced EHR use at differing levels of use. The types of practices are also further tested and described in the context of the EHR model.
The specific research questions for this project are restated as follows:

1. What are the overall adoption and EHR use levels for PCMH practices in this study, and how do they compare to the current literature in other primary care settings? Chapter 4 provides detailed results for question 1.
2. How well are PCMHs meeting advanced criteria for MU Stage 2? Chapter 4 provides these detailed results for question 2.
3. What PCMH practice characteristics are associated with advanced EHR use compared to no advanced use? Chapter 5 provides detailed results for question 3.

CHAPTER 4

Results: EHR Adoption and Use in PCMHs

A primary purpose of this dissertation is to create and test an EHR use model to identify PCMH practice characteristics associated with advanced EHR use compared to no advanced use. In order to do so, another primary purpose of this study is to evaluate PCMH adoption and use of advanced EHRs. Advanced EHR functions in this study include the exchange of health information with providers and patients.

This chapter presents the initial findings of the project. It begins with a brief overview of the PCMH practice characteristics included in the final analyses and describes EHR adoption and use in PCMHs. The HIMSS framework (Table 3.2) and the MU objectives are also utilized to further describe EHR use and adoption levels in PCMHs. Based on the existing literature and the preliminary analyses, the practice type (ownership) and location (rural) were determined to be important characteristics (DesRoches et al., 2013; Furukawa et al., 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013) and therefore are used to stratify the results of the analyses.

Descriptive Statistics of Full PCMH Sample

Of the 337 PCMH practice included in the sample, there are 90 federally-funded practices (26.7%), 87 hospital/system-owned practices (25.8%), and 160 physician-owned practices (47.5%). Practices are mainly from the Southeast (20.77%), Midwest (19.3%), Northeast (15.1%), New England (13.7%), and the Mid-Atlantic (11.3%). The majority of the practices (76 %) are designated as level 3 PCMH (the highest NCQA level awarded), indicating advanced PCMH practices. The PCMHs sample includes adult and pediatric primary care specialties, and most practices are classified as both (78.9%).

Table 4.1 describes the major characteristics of the 337 PCMH practices. In this study, most PCMH respondents (85.4%) indicated a moderate to high overall concern for the financial health of their practice, and 75.4% had a care coordination agreement. A similar number of PCMH practices had EHRs for less than five years (45.4%) compared to those with EHRs for more than five years (53.1%). The overall indicated priority level for MU (49.6%) for PCMHs was almost equal to their practice priority for care coordination (50.4%). By September 2013, 25.8% (n = 89) had no providers that attested to MU (mostly federally-funded PCMHs).

Since this is one of the first nationally representative studies on EHR adoption and use in PCMHs, a comparison to other similar studies in physician and primary care practices is important. As noted in a previous study that included primary care providers, the greatest percentage of PCMH practices were physician-owned and had two to four clinicians (DesRoches et al., 2013). For this sample, smaller and solo practices make up a larger portion of the PCMHs, and the percent of rural practices (25.8%) is higher than other recent nationally representative studies of physician practices (Whitacre, 2015; Xierali et al., 2013). Furthermore, the number of practices in this PCMH sample affiliated with or part of a network (41.8%) was lower than noted in a similar study of primary care providers using the nationally representative National Ambulatory Medical Care Survey (NAMCS) data that indicated 65% were part of any physician network or integrated delivery system (DesRoches et al., 2013).

Table 4.1 Characteristics of PCMHs (n=337)

PCMH Characteristic	Total % (n=337)
Practice Type	
Federally-funded (FQHC/CHCs)	26.7% (90)
Hospital/system-owned	25.8% (87)
Physician-owned	47.5% (160)
Practice Size	
1 clinician	17.2% (58)
2-4 clinicians	46.9% (158)
5-9 clinicians	24.0% (81)
10+ clinicians	11.9% (40)
Geographic Location: Rural	25.8% (87)
Affiliated/Networked Practices: Part of an Integrated Delivery System, Independent Practice Association, or Physician Hospital Organization	41.8% (141)
Practice Locations	
Single location	29.7% (100)
Multiple locations	66.7% (225)
Declined to answer	3.56% (12)
Financial Concern for Practice	
No concern	13.6% (46)
Moderate concern	51.3 % (173)
High concern	34.1% (115)
Declined to answer	0.9% (3)
Total Length of Time with an EHR: More than 5 years	53.1% (179)
Quality Improvement Scores	
Low	31.5% (106)
Moderate	34.1 (115)
High	34.4% (116)
Priority: MU higher priority than care coordination	49.6% (167)
Care Coordination : Practice has care coordination agreements	75.4% (254)
Providers in Practice Attesting to MU	
None	25.8% (87)
Some	30.6% (103)
All	43.3% (146)
Declined to answer	0.3% (1)
EHR Vendor	
eClinicalWorks	20.4% (68)
NextGen	14.1% (47)
Epic	13.8% (46)
Allscripts	13.5% (45)
GE/Centricity	7.2% (24)
Other	30.9% (103)

The type of EHR vendor helps to describe the PCMH sample as compared to national reports on EHRs. The brand also has important implications for functional use of EHRs. eClinicalWorks, NextGen, Epic, Allscripts, and GE Healthcare compose the top five EHR vendors for the PCMH practices, which is a similar result to that in the Office of the National Coordinator report. For the PCMHs in this study, these top five EHR vendors account for nearly 70% of the practices as compared to 50% across all participating providers in the ONC report (Office of the National Coordinator for Health Information Technology, 2014a). This has important implications and is an indication that the sample of PCMHs is using similar EHRs as the overall population of eligible providers participating in the MU program. Furthermore, in a recent report by KLAS® Enterprises (an independent vendor research firm), the major EHR vendors were evaluated and compared to each other. The success and depth of EHR interoperability (an advanced EHR function) were reported. Vendors were identified as being simple and successful, sophisticated and successful, simple but less successful, and sophisticated but less successful (Buckley & Tate, 2014). Thus, the EHR vendor could influence a practice's likelihood for information exchange. Based on these findings, including practices with different vendors than the reference population of practices could skew the results of a study, especially considering the focus of advanced EHR use on information exchange and interoperability. This does not seem to be the case with this current study, as the EHR vendors for PCMHs appear similar to other practices nationally.

The Study Sample of Patient-Centered Medical Homes

This section highlights the major characteristics of the 298 PCMH practices used in the final analyses (study sample) that are presented in Chapter 5. Due to missing data for variables, 39 observations (practices) were dropped from the logistic regression analyses. In the next

section, the study sample of 298 is compared to the 337 survey respondents originally included (the full sample) to ensure that the study sample is not different from the original sample of PCMHs. Overall, there were no meaningful differences in PCMH characteristics by the types of practices.

Comparison of the samples. Table 4.2 presents the PCMH characteristics by the type of practice. The details for the full sample are provided in Table 4.1. There were no substantive differences between the full sample (337 practices) and the study sample used in the regression models (298 practices). The variable for practice size (number of providers in practice), which indicated significant differences by practice type in the full sample ($p=0.029$), was not significant in the study sample ($p=0.174$); on further evaluation, no meaningful or relevant differences were identified, based on actual percentages. The only other differences between the samples, none of which revealed statistical significance, were the study sample's higher quality improvement scores for hospital/system-owned practices (2.6% higher), the higher priority for MU for federally-funded PCMHs (3.8% higher), and the lower priority for MU (2.8% lower) for hospital/system-owned practices. These differences are not likely to have an effect on the final analyses.

Characteristics of the PCMHs Practices. As shown in Table 4.2, the types of practice demonstrate strong and differing associations with the PCMH characteristics included in the analyses. Among the sample of PCMH practices used in logistic regression analyses, significant differences are noted for geographic location (rural), affiliations, the number of practice locations, and the length of time having an EHR. Most of the small and solo PCMH practices are physician-owned. These results are typical even though the number of solo practitioners has been declining in the United States due to the changes in delivery systems and increased

integration (Xierali et al., 2013). Physician-owned practices also had the highest percent of EHRs for more than 5 years ($p< 0.001$).

Table 4.2 Study Sample: Characteristics of PCMH by Practice Type (n=298)

Variable	Total (n=298)	Federally-funded (n=76)	Hospital/system-owned (n=71)	Physician – owned (n=151)	*p* Value
Practice Size					0.174
1 clinician	17.4 (52)	10.5% (8)	12.7% (9)	23.2% (35)	
2-4 clinicians	47.3% (141)	46.1% (35)	52.1% (37)	45.7% (69)	
5-9 clinicians	22.8% (68)	26.3% (20)	22.5% (16)	21.2% (32)	
10+ clinicians	12.4% (37)	17.1% (13)	12.7% (9)	9.9% (15)	
Geographic Location					0.008
Rural	25.5% (76)	38.2% (29)	16.9% (12)	23.2% (35)	
Non-rural	74.5% (222)	61.8% (47)	83.1% (59)	76.8% (116)	
Affiliation					0.027
IDS/IPA/PHO	44% (131)	32.9% (25)	54.9% (39)	44.4% (67)	
No IDS/IPA/PHO	56% (167)	67.1 (51)	45.1% (32)	55.6% (84)	
Practice Locations					<0.001
Single Location	32.2% (96)	15.8% (12)	14.1% (10)	49% (74)	
Multiple locations	67.8% (202)	84.2% (64)	85.9 (61)	51% (77)	
Financial Concern					0.096
No concern	13.8% (41)	19.7% (15)	15.5% (11)	9.9% (15)	
Moderate concern	51% (152)	52.6% (40)	54.9% (39)	48.3% (73)	
High concern	35.2% (105)	27.6% (21)	29.6% (21)	41.7% (63)	
Length of Time EHR					0.001
5 year or less	43.3% (129)	57.9% (44)	49.3% (35)	33.1% (50)	
More than 5 years	56.7% (169)	42.1% (32)	50.7% (36)	66.9% (101)	
Quality Improvement Scores					0.060
Low	32.2% (96)	40.8% (31)	36.6% (26)	25.8% (39)	
Moderate	33.6% (100)	31.6% (24)	23.9 %(17)	39.1% (59)	
High	34.2%(102)	27.6% (21)	39.4% (28)	35.1% (53)	
Priority					
MU higher	49.7% (148)	60.5% (46)	40.9% (29)	48.3% (73)	0.052
Care Coordination higher	50.3% (150)	39.5% (30)	59.2% (42)	51.7% (78)	
Care Coordination					
Practice has CC agreements	78.2% (233)	71.1% (54)	84.5% (60)	78.1% (119)	0.138
Practice has no CC agreements	21.8% (65)	29% (22)	15.5% (11)	21.2% (32)	
MU Attestation					P< 0.001
None	25.2% (75)	96.1% (73)	2.8% (2)	0%	
Some	31.2% (93)	3.95% (3)	50.7% (36)	35.8% (54)	
All	43.6% (130)	0%	46.5% (33)	64.24% (97)	

*IDS=Integrated Delivery System; IPA=Independent Practice Association; PHO=Physician Hospital Organization

Physician-owned practices have high quality improvement scores. These practices also have the highest percent of providers attesting to MU as well as the highest financial concern (41.7% of these practices compared to less than 30% for the other types). When compared to

hospital/system-owned PCMHs, the physician-owned PCMHs have higher priority for MU, a higher proportion of providers all attesting to MU, and high financial concerns, which could indicate that these practices are focusing on MU, possibly reflecting interest in the incentive payments for eligible providers. This is consistent with a recent ONC report that found the incentives (and penalties) are the drivers for EHR adoption for physicians (Heisey-Grove & Patel, 2014). This trend could be problematic because health care delivery reform efforts centered on care coordination are likely to be more effective than a focus on the incentive payment. Furthermore, the incentive payment may assist practices to overcome the financial barriers of EHR adoption and implementation (Xierali et al., 2013); however, adoption alone does not ensure use of advanced EHR functions to improve coordination of care (McClellan et al., 2013).

Hospital/system-owned practices have the highest percent of network affiliation, either through an Integrated Delivery System (IDS), Independent Practice Association (IPA), or a Physician Hospital Organization (PHO). These practices also have the highest overall quality improvement scores (39.4%), the highest percent of care coordination agreements (84.5%), and the lowest percent for MU priority (40.9%). These are expected outcomes, as hospital/system-owned practices would rely more on the parent hospital organization for these types of agreements. In addition, the lower score on the MU priority also reflect a higher priority for care coordination, which is consistent with the increased number of care coordination agreements in place for these practices. Due to longer and more rigid and mandated quality reporting requirements for hospitals (as compared to the menu/optional reporting requirements under the Physician Quality Reporting System for physician practices), the increased focus on quality improvement for hospital/system-owned practices is likely a result of the parent organization's

priorities. In turn, the increased requirements for hospitals to focus on quality increases the likelihood their owned practices would share the same emphasis on quality improvement initiatives.

The federally funded PCMHs had a significantly higher percent of rural practices (38.2%) as compared to hospital/system-owned (16.9%) and physician-owned (23.2%) PCMH practices, and the highest percentage of practices with 10 or more clinicians (although not significantly different from the other types of PCMHs). These practices also had the lowest percent of affiliation (32.9%; $p< 0.05$) and the least overall time with an EHR (57.96% with less than 5 years; $p< 0.001$). Interestingly enough, these practices also demonstrated the lowest financial concern and the highest priority for MU (although not statistically significant). As discussed previously and suggested in physician-owned practices, higher financial concerns may be associated with a higher priority of MU. This seemingly conflicting relationship for federally-funded PCMHs could be a reflection of the physician respondent's lack of financial concern for the federally-funded practice and their individual priority for obtaining the MU incentive payments for themselves (the incentive payments for MU are to the eligible providers, not the practice).

In summary, practice characteristics vary significantly by the type of PCMH; thus, differences across practices may be related to the type of PCMH (ownership). In particular, the differences noted for federally-funded as compared to the physician and hospital/system-owned practices is consistent with prior research on their NCQA designation (Tirodkar et al., 2014), and will be important in the final analyses. Considering the results from the descriptive statistics and prior studies (DesRoches et al., 2013; Furukawa et al., 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013), the type of practice and its location (rural) are important indicators and

will be evaluated separately in each of the major analyses. It is also anticipated that contrary to the hypothesized results, the type of PCMH practice will in fact have important and significant implications for advanced EHR use. Further discussion about practice type is included in Chapter 5.

Overall Results

The following section provides the results for the first two research questions and includes a brief overview, discussion, and summary. It begins with the overall PCMH adoption and use that provide the foundation for a primary purpose of this study, which is to identify PCMH characteristics associated with advanced EHR use. As indicated previously, the results are categorized by type of practice (ownership) and location (rural) when feasible.

Research Question 1: What are the overall adoption and EHR use levels for PCMH practices in this study, and how do they compare to other primary care setting in the current literature?

A primary purpose of the project is to evaluate advanced (as well as basic) EHR use. This section will describe basic EHR adoption and use in PCMH practices, followed by the findings of advanced EHR use. As indicated previously and described in Table 4.2, the type of practice (ownership) and location (rural) have important implications for EHR adoption and use.

Basic EHR Adoption and Use

Table 4.3 displays the basic EHR functions for PCMHs and compares these functions across practices with no capabilities to those that have the EHR capabilities and to practices that routinely use the basic EHR capabilities. It was hypothesized that PCMH practices would demonstrate high levels of basic EHR adoption and use as compared with other primary care and office-based practice, and that EHR adoption and use rates would be lower in rural practices. As

indicated by the results, PCMHs demonstrate high basic EHR adoption and use rates; however, contrary to expectations, rural practices have even higher rates for basic EHR adoption ("Has Capabilities") and use ("Routinely Uses Capabilities") as compared to overall PCMHs in this study.

In this study of PCMHs, a basic EHR is defined by three functions: computerized clinical decision support (CCDS), viewing external diagnostic results in the EHR, and having remote access to the EHR. As discussed previously in Chapter 3, two of these variables (CCDS and remote EHR access) loaded similarly in the factor analyses and were excluded from the advanced EHR index and thus classified as basic EHR use. The third variable, viewing external results in the EHR, was used in existing research to classify basic EHR use (Whitacre, 2015). Having "any EHR" is defined in this study as those PCMHs that have capabilities to view external results in their EMR/EHR or having remote access to their EMR/EHR.

The PCMH practices are evaluated in Table 4.3 based on *having* the basic EHR functions (adoption) as compared to *using* the functions (use). This is an important distinction, as adoption does not always translated into EHR use (McClellan et al., 2013). The EHR functions were also stratified by the size of the practice and the practice location (rural), and the data were compared to national research findings.

Table 4.3 Adoption and Basic Use of EHR Functionalities in PCMHs

Basic EHR Use Functionality (n=298)	PCMH No capabilities	PCMH Has capabilities (Adoption)	PCMH Routinely Uses Capabilities (Use)
Computerized Clinical Decision Support	12.8% (38)	86.2% (257)	67.8% (202)
View external diagnostic study results in EMR/EHR	4.7% (14)	95.0% (283)	81.2% (242)
Remote access to EMR/EHR	7.7% (23)	92.0% (274)	81.2% (242)
All Basic EHR functions			
PCMHs (n=298)	0.7% (2)	77.2% (230)	51.0% (152)
Smaller practices: <10 providers (n=261)		75.5% (197)	48.3% (126)
Rural Practices (n=76)		78.9% (60)	56.6% (43)

Based on the percentage of practices with the capabilities to view external diagnostic study results in the EHR/EMR or having remote access to an EMR/EHR as seen in Table 4.3, more than 90% of the PCMH practices in this project have adopted at least "any EHR." This is compared to the Office for the National Coordination for Health IT (ONC-HIT) that reported a national average of 78% within the same timeframe as this dissertation. In addition, nearly 95% of the PCMH practices indicate the ability to view diagnostic results, compared to 77% of office-based physician practices nationwide. Even so, 77.2% of practices in this sample adopted a basic EHR system. This is higher than the national average of 53% for primary care providers but is close to the 78% of physicians practices that have nationally adopted "any EHR" (Office of the National Coordinator for Health Information Technology, 2014b). However, only 51% of the PCMHs report routine use of the basic EHR system. The national percentages for actual routine use are unclear but are thought to be much lower. Computerized clinical decision support is the lowest basic EHR function routinely used in this study of PCMHs. As hypothesized, the PCMHs

indicate higher adoption and use of basic EHRs than other office-based and primary care practices when looked at nationally.

Contrary to the hypothesized results, rural and smaller PCMH practices are comparable to other PCMHs on adoption and use of basic EHRs and slightly higher than all other primary care providers nationwide. The rural PCMH practices demonstrated higher adoption rates (78.9%) and use (56.6%) as compared to the overall PCMH sample (77.2% and 51%). As indicated in Table 4.3, smaller PCMH practices are similar to the overall PCMH sample and just slightly lower for basic EHR adoption and use. This is in comparison to national averages for adoption of basic EHR in which the smaller practices (41%), and rural practices (46%) had lower rates than all other national physician practices (48%) and primary care practices (53%) within a similar timeframe of this dissertation (Office of the National Coordinator for Health Information Technology, 2014b).

Among PCMHs, a very small percentage of practices reported no basic EHR capabilities. Only two practices, one hospital-owned and the other physician-owned, did not have any of the basic EHR functions; both indicated that they were "hybrid" systems. Based on the low number of years that these practices indicate having an EHR (3-5 years), it is likely they are transitioning to full EHR adoption. This could be a result of the purposeful sampling methods used in the survey. The PCMH practices were included if they were progressing towards EHR adoption.

Advanced EHR Use

An important purpose of this study is to describe advanced EHR use in PCMHs. Table 4.4 compares PCMH use of advanced EHR functions across practice type (ownership) and location (rural). It is hypothesized that PCMH practices will demonstrate high levels of advanced EHR use and that advanced EHR use rates will be lower for rural practices. Based on

the results, overall advanced use is relatively high for individual advanced EHR functions, although it varies for rural practices depending on the type of practice (ownership).

As described in Chapter 3, several variables are classified as advanced EHR functions: HIE, EHR interfaces for exchanging health information, patient portals, and faxing comprehensive patient summaries within the EHR to consulting providers (fax-EHR). As hypothesized, most of the PCMH practices (72.2%) indicate using at least some of the advanced EHR features. However, only 43.3% of the practices are using all of basic EHR functions and any of advanced EHR functions, 4.5% are using all of the advanced functions, and only 7.2% are using all of the advanced electronic exchange functions (HIE, EHR interface, and patient portals). The EHR interface is the highest advanced function utilized at 51.3%, and the patient portal and HIE are the lowest with just over 20%.

Contrary to expectations, significant differences are indicated for all advanced EHR use functions across the types of PCMHs. When comparing practice types, federally-funded PCMHs demonstrate significantly lower advanced EHR use across all functions. The lower rate in federally-funded PCMHs is concerning, especially considering the role they serve in caring for patients with increased needs. Physician-owned practices have the highest percent of any advanced use, interface use, and fax-EHR use. Hospital/system-owned practices have the highest percent of HIE (28.2%) and patient portal use (29.6%). In addition to MU guidelines, hospitals are under strict guidelines to reduce readmissions and are penalized when Medicare patients are readmitted within 30 days from discharge (CMS.gov, 2014b). Therefore, it is likely that hospitals might be using HIE to coordinate care with their owned PCMH practices and using the patient portals to engage patients in their care, thus potentially explaining these higher percentage of use in the hospital-owned PCMH settings.

The overall lower use rates of HIE and the patient portal in PCMHs is consistent with the low rates indicated in the literature (Furukawa et al., 2014). According to the ONC-HIT, nationally only 49% of office-based physicians have the capability to exchange information with patients, but 53% have the capability to send electronic orders, an indication of HIE capacities (Office of the National Coordinator for Health Information Technology, 2014b). However, Furukawa et al. (2014) indicated that the overall use of patient engagement technology was low; only 39 percent of office-based practices reported having HIE capabilities, while 14% actually share information with outside providers (Furukawa et al., 2014). In this study, most of the 24.8% PCMH practices that have HIE capabilities are also using this function (24.1%). However, 61.1% of PCMH practices have patient portals, but only 20.8% routinely use them to provide patients with their clinical summaries. These rates are consistent with the 24% of providers nationally that are sharing electronic health information with patients (Furukawa et al., 2014). Low use of the patient portals is an indication that PCMHs are not fully engaging patients. A further discussion is provided in Chapter 6.

Table 4.4 Use of Advance EHR Functions by Type of PCMH and Rural/non-Rural Status

Advanced EHR Use Functions	Overall %(n)				Federally-funded %(n)			Hospital/System-Owned %(n)			Physician-owned %(n)			p value
	Has Capabilities	*Non-Rural (n=222)*	*Rural (n=76)*	**Total (n=298)**	*Non-Rural (n=47)*	*Rural (n=29)*	**Total (n= 76)**	Non-Rural (n=59)	*Rural (n=12)*	**Total (n=71)**	Non-Rural (n=116)	*Rural (n=35)*	**Total (n=151)**	
HIE Use	*24.8 (74)*	*23.9 (53)*	*13.2 (10)*	**21.1 (63)**	*21.3 (10)*	*0*	**13.2 (10)**	32.2 (19)	*8.3 (1)*	**28.2 (20)**	15.9 (24)	*25.7 (9)*	**21.9 (33)**	< 0.05
Interface Use	*58.7 (175)*	*55.4 (123)*	*39.5 (30)*	**51.3 (153)**	*34 (16)*	*34.5 (10)*	**34.2 (26)**	57.6 (34)	*33.3 (4)*	**53.5 (38)**	48.3 (73)	*45.7 (16)*	**58.9 (89)**	0.001
Patient Portal Use	*61.1 (182)*	*23.4 (52)*	*13.2 (10)*	**20.8 (62)**	*4.3 (2)*	*0*	**2.6 (2)**	28.8 (17)	*33.3 (4)*	**29.6 (21)**	21.9 (33)	*17.1 (6)*	**25.8 (39)**	<0.0001
Fax from EHR	*57.7 (172)*	*41 (91)*	*53.9 (41)*	**44.3 (132)**	*23.4 (11)*	*51.7 (15)*	**34.2 (26)**	39 (23)	*41.7 (5)*	**39.4 (28)**	37.7 (57)	*60 (21)*	**51.7 (78)**	<0.05
Any Advanced EHR Use		*76.3 (165)*	*65.8 (50)*	**72.2 (215)**	*51.1 (24)*	*62.2 (18)*	**55.3 (42)**	78 (46)	*50 (6)*	**73.2 (52)**	82.8 (125)	*74.3 (26)*	**80.1 (151)**	<0.0001
All Advanced EHR Function Use		*4.5 (10)*	*3.9 (3)*	**4.36 (13)**	*2.1 (1)*	*0*	**1.3 (1)**	**3.4 (2)**	*8.3 (1)*	**4.2 (3)**	**0**	*5.7 (9)*	**6 (9)**	
All Advanced Electronic Exchange Function Use (HIE, Interface, Portal)		*7.2 (16)*	*3.9 (3)*	**6.4 (19)**	*2.1 (1)*	*0*	**1.3 (1)**	**8.5 (5)**	*8.3 (1)*	**8.5 (6)**	**8.6 (10)**	*5.7 (2)*	**7.9 (12)**	
All Basic EHR Functions (Table 4.3) + Any advanced EHR Use		*42.8 (95)*	*44.7 (34)*	**43.3 (129)**	*27.7 (13)*	*34.5 (10)*	**30.3 (23)**	**44.1 (26)**	*50 (6)*	**45.1 (32)**	**37.1 (56)**	*51.4 (18)*	**49 (74)**	

Rural PCMH Advanced EHR Use

The hypothesis that rural practices would demonstrate lower levels of EHR use is rejected. Across all settings, rural PCMHs demonstrated a slightly higher percentage of practices using all basic functions and "any of the advanced functions." However, as presented in Table 4.4, a lower percentage of rural PCMHs practices overall demonstrate use of advanced EHR functions, with the exception of the fax-EHR variable. Across all types, using the EHR to fax clinical summaries (fax-EHR) is higher for rural practices. For all of the advanced use variables, rural federally-funded PCMHs have a higher percentage of EHR use compared to non-rural federally-funded practices.

Rural physician-owned practices have a higher percentage of HIE use compared to their non-rural counterparts. Rural hospital/system-owned PCMHs have the highest percentage of use for patient portals across all PCMHs. However, EHR interface use is lower in both rural hospital/system and physician-owned PCMH practices. These results suggest varying advanced EHR use by setting and geographic location (rural).

The lower rates for advanced EHR use in the rural groups are further evaluated. A series of chi-squared analyses are conducted with Cramer V's (**ϕ)** to determine strength and direction of potential relationships between rural and the advanced EHR use functions: HIE, EHR interfaces for exchanging health information, patient portals, and faxing comprehensive patient summaries within the EHR to consulting providers (fax-EHR). The EHR interface demonstrates a significant negative association, indicating lower use of this function in rural practices. It is noteworthy that all of the other variables (HIE, patient portals, and fax-EHR) also have a negative association with rural, except for fax-EHR, which had a weak positive association

(p=0.064). This could indicate that rural practices are using the fax-EHR functions to exchange information as opposed to the other advanced EHR exchange functions. This implies that rural practices may lag in advanced EHR use. Rural practices are further evaluated in the analyses in the next chapter, and a brief discussion is included immediately below.

All of the variables for advanced EHR functions are related to sharing and exchanging electronic health information with other providers and patients, with the exception of faxing the clinical summary from the EHR (fax-EHR). Consideration was given to this variable (fax-EHR). As previously described in Chapter 3, the factor analyses and the reliability (alpha) tests supported the inclusion of the fax-EHR variable, even though it does not technically indicate interoperability (electronic exchange of information), which is an important distinction of EHRs from EMRs (The National Alliance for Health Information Technology, 2008). Based on the 44.3% percent of practices using this function and considering the moderate association between the fax-EHR and interface variables ($\varphi = 0.3455$, $p < 0.001$), practices using fax-EHR likely have the capacity to exchange information electronically. It may be that the other practices (not these PCMHs) that are unable to accept the information electronically, therefore requiring the rural PCMHs to fax the health information via the EHR. Thus, faxing from an EHR is an important indicator for PCMHs at this point in time, and it is further discussed in Chapter 6.

PCMH Adoption Levels and the HIMSS Framework

The HIMSS EMR Adoption Model is a framework that is widely used to classify EHR adoption levels for hospitals and ambulatory care settings. Health care organizations participate voluntarily in this program and receive designation for meeting all seven stages. Those practices choosing to submit to the HIMSS framework are more likely to be rapidly pursuing a Stage 7 designation; therefore, the overall adoption levels for these groups should be high. It was

hypothesized that primary care providers in PCMHs would demonstrate lower levels of adoption than other ambulatory centers according to the HIMSS A-EMRAM scale.

Table 4.5 presents the highest HIMSS A-EMRAM stages with the overall adoption rates for ambulatory facilities nationally as compared to the PCMHs in this study. Even though all of the HIMSS metrics were not included in the survey, the corresponding NCQA survey questions and this study's estimations provide an initial and valid comparison at the highest stages. According to HIMSS A-EMRAM in Table 4.5, 6.21% of centers meet all 7 stages of the model. As hypothesized, the PCMH in this study demonstrate lower rates of practices meeting all 7 stages of HIMSS (2.34%), although the adoption levels are comparable. Specifically, patient portal use and EHR interface in PCMHs seem to empirically align closely with Stage 5 and 6 rates for HIMSS. This is an indication that PCMHs are similar to other ambulatory centers on EHR adoption. When comparing the specific adoption and use rates, it is evident that PCMHs practices do not sequentially move through the stages (beginning with stage 1 and ending with stage 7).

Table 4.5 HIMSS A-EMRAM Highest Stages Compared to PCMH Practices

US Ambulatory EMR Adoption Model [SM]				
Stage	Cumulative Capabilities	HMSS 2014 Ambulatory Rates	NCQA Survey Questions	PCMH %
Stage 7	HIE capable, sharing of data between the EMR and community based EHR, business and clinical intelligence	6.21%	HIE use	2.34% (7)
Stage 6	Advanced clinical decision support, proactive care management, structured messaging	7.59%	EHR Interface Use	6.38% (19)
Stage 5	Personal health record, online tethered patient portal	7.30%	Patient Portal use	7.72% (23)
Data from HIMSS Analytics® Database ©2014		N = 30,354		N=298

Reproduce with permission from HIMSS Analytics – source: HIMSS Analytics (2014). *Ambulatory Electronic Medical Record Adoption Model (EMRAM)* [sm]. Retrieved September 18, 2014, from http://www.himssanalytics.org/home/index.aspx.

<u>Research Question 2:</u> How well are PCMHs meeting the advanced criteria for MU Stage 2?

MU objectives have been utilized to describe and evaluate EHR use and adoption levels in physician practices (DesRoches et al., 2013). In the NCQA/AAFP survey, eight questions measure objectives for MU Stage 2 (see appendix for descriptions). The specific measures are included in Table 4.7. The results from this study suggest PCMHs are meeting more of the MU criteria when compared to the national population of eligible professionals. Physician-owned PCMH have the highest percentage of practices viewing lab and test results and for all three measures of providing a summary of care. This includes use of electronic summary of care and EHR interface to send the summary of care; measures1 and 3 are significant. Rural physician-owned practices have similar results, with the exception of a lower percent of patient portals (57% compared to 67% in non-rural) and summary of care measure 3 (EHR interface), which is 17% compared to 25%.

The hospital/system-owned practices have higher percentages of practices meeting the criteria for computerized clinical decision support ($p=0.052$), the ability to provide patient online access to health information (patient portal; $p< 0.001$), and having patients signed up for secure electronic messaging ($p< 0.001$). Again, the rural practices have similar results, although the total number of hospital/health-system practices is low with just 12 practices in this setting, so these results must be interpreted with caution.

The federally-funded PCMHs have a significantly lower percent of practices with patient portals ($p < 0.001$), secure messaging for patients ($p < 0.001$), the ability to view lab/test results in the EHR ($p< 0.05$), and the summary of care requirement 3 (use EHR interface; $p< 0.05$). These practices also experience lower percentages for measure 2 (send electronically), although this is not statistically significant. These findings are consistent with a recent study on Federally

Qualified Health Centers that found overall relatively low adoption of the MU Stage 1 capabilities, and in particular those related to care coordination (Jones & Furukawa, 2014). However, the rural federally-funded PCMH practices in this study have a higher percentage of practices meeting most of these same requirements as compared to the non-rural federally-funded counterparts: 44.8% versus 29.8% for patient portals, 41.4% versus 23.4% for secure messaging for patients, 79.3% versus 63.8% the ability to view lab/test results in the EHR, 86.2% versus 59.6% for measure 2 of the summary of care requirement (send electronically), and 48.3% versus 27.7% for the measure 3 summary of care requirement (use EHR interface). This finding warrants further investigation to understand the increased ability for rural federally-funded health centers to meet the MU stage 2 measures as compared to their non-rural counterparts.

Nationally, 68% of office-based physicians have the capability of providing clinical summaries to patients at each visit, a MU objective for Stage 1 and 2 (Office of the National Coordinator for Health Information Technology, 2014b). For PCMHs in this study, over 80% are providing patient clinical summaries to patients. These results are likely a reflection of the requirements for PCMH designation to coordinate care and their focus on primary care, whereas the national group is representing all office-based physicians. This is explored more in the Chapter 6 discussion.

As of November 2014, less than 2% of the MU eligible professionals met the MU Stage 2 (American Medical Association, 2014). Based on the MU Stage 2 criteria used in this sample, 25.8% of PCMHs are meeting most of the criteria (measure 1 of the summary of care requirements), but only 8.1% are meeting the full requirements (measure 1, 2, and 3 of the summary of care requirements). While this percentage seems low, it is actually higher than

national rates of providers currently focused on meeting MU stage 2. Furthermore, in a recent study, DesRoches et al. (2013) found that only 9.8% of the overall physicians were meeting Stage 1 MU, while primary care providers were at 11.2%.

Of all the measures, the summary care document is the most important for coordinated care, because it is the comprehensive patient information a practice sends to other referring organizations. The physician-owned practices have a much higher percent of clinical summaries being sent across all three measures for this MU objective. The lower rates in hospital-owned and federally-funded PCMHs are concerning, especially considering the role they serve in caring for patients with increased needs. These chronically ill patients would further benefit from better coordinated care in these settings. Additional discussion is provided in Chapter 6.

Table 4.6 PCMH MU Objectives

MU Criteria	Overall %(n)			Federally-funded %(n)			Hospital/System-Owned %(n)			Physician-owned %(n)			p value
	Non-Rural (n=222)	*Rural (n=76)*	**Total (n=298)**	*Non-Rural (n=47)*	*Rural (n=29)*	**Total (n= 76)**	*Non-Rural (n=59)*	*Rural (n=12)*	**Total (n=71)**	*Non-rural (116)*	*Rural (n=35)*	**Total (n=151)**	
Computerized Clinical Decision Support	*66.2 (147)*	*72.4 (55)*	**67.8 (202)**	*63.8 (30)*	*69 (20)*	**65.8 (50)**	*66.1 (39)*	*91.7 (11)*	**70.4 (50)**	*67.2 (78)*	*68.6 (24)*	**67.6 (102)**	**0.052**
Provide patients the ability for online health information (Have patient portal)	*62.6 (139)*	*56.6 (43)*	**61.1 (182)**	*29.8 (14)*	*44.8 (13)*	**35.5 (27)**	*76.6 (44)*	*83.3 (10)*	**76.1 (54)**	*53.6 (81)*	*57.1 (20)*	**66.9 (101)**	**< 0.001**
Provide clinical summaries to patients	*79.7 (177)*	*81.6 (62)*	**80.2 (239)**	*80.9 (38)*	*86.2 (25)*	**82.9 (63)**	*83.1 (49)*	*83.3 (10)*	**83.1 (59)**	*59.6 (90)*	*77.1 (27)*	**77.5 (117)**	**0.822**
Secure electronic messaging (Have)	*60.1 (135)*	*63.2 (48)*	**64.4 (183)**	*23.4 (11)*	*41.4 (12)*	**30.3 (23)**	*76.3 (45)*	*83.3 (10)*	**77.5 (55)**	*52.3 (79)*	*74.3 (26)*	**69.5 (105)**	**< 0.001**
View lab-test results	*81.1 (180)*	*81.6 (62)*	**81.2 (242)**	*63.8 (30)*	*79.3 (23)*	**69.7 (53)**	*81.4 (48)*	*75 (9)*	**80.3 (57)**	*67.5 (102)*	*85.7 (30)*	**87.4 (132)**	**0.016**
Summary of Care (M1): Send summary of care	*65.8 (146)*	*76.3 (58)*	**68.5 (204)**	*59.6 (28)*	*86.2 (25)*	**69.7 (53)**	*57.6 (34)*	*33.3 (4)*	**53.5 (38)**	*72.4 (84)*	*82.9 (29)*	**74.8 (113)**	**0.023**
Summary of Care (M2): Send electronic summary of care	*43.7 (97)*	*48.7 (37)*	**45 (134)**	*27.7 (13)*	*48.3 (14)*	**35.5 (27)**	*44.1 (26)*	*33.3 (4)*	**42.3 (30)**	*38.4 (58)*	*54.3 (19)*	**51 (77)**	**0.076**
Summary of Care (M3): Send electronic summary of care via EHR interface	*22.1 (49)*	*13.2 (10)*	**19.8 (59)**	*10.6 (5)*	*3.4 (1)*	**7.89 (6)**	*20.3 (12)*	*25 (3)*	**21.1 (15)**	*27.6 (32)*	*17.1 (6)*	**25.2 (38)**	**0.012**
Met all above MU criteria	*8.1 (18)*	*7.9 (6)*	**8.1 (24)**	**4.3 (2)**	*0*	**2.6 (2)**	**8.5 (5)**	*8.3 (1)*	**7.04 (6)**	**7.3 (11)**	*14.3 (5)*	**10.6 (16)**	

The MU program has two different sets of criteria for hospitals versus eligible professionals (EP). Some of the differences between the physician-owned and hospital/system-owned practices in this study are likely due to the differences in the criteria between the MU Stage 1 programs for hospitals versus EP. Even though the hospital/system practices would be operating under the MU EP program, they still might be more likely to follow the priorities of their hospital owners. For example, both programs have identical requirements for clinical decisions support, hence the similar percentages in table 4.7. Both programs also require hospitals/EPs to allow patients to view, download, and transmit health information after their visits (CMS.gov, 2014a). However, MU Stage 1 requires EP (not hospitals) to provide clinical summaries to more than 50% of patients after each visit. This criterion might also have increased the likelihood for EPs to provide summary of care records to the referring provider (an optional menu objective for both programs), which is likely reflected in the much higher percentage of summary of care records being sent in physician-owned practices. Although the MU Stage 2 criteria for EPs include the requirement to use secure messaging to communicate with patients, the hospital program does not include this requirement. However, based on the PCMHs responses, hospital/system-owned practices have a higher percentage of patients (77.5%) who have signed up for secure messaging compared to physician-owned practices (69.5%). This is consistent with the finding that hospital/system-owned PCMHs have the highest patient portal adoption (76.1%) and use (28.2%) rates as indicated by Tables 4.4 and 4.6, and it might indicate their increased ability to engage patients.

Another difference in the results across PCMH types might be reflected in the MU program the practice participates in, Medicare or Medicaid. Medicaid MU programs, which are more likely to be federally-funded PCMHs in this study, have less stringent criteria for the initial

incentive payment of Stage 1, requiring only that practices adopt, implement, or upgrade their EHR system, whereas Medicare providers (more likely hospital-owned), are required to meet all of the MU Stage 1 criteria in order to receive the first year's incentive payment (CMS.gov, 2015). Not having the specific MU program for the PCMH practice providers is a limitation of this study. Future studies should indicate the MU program for the practices.

As presented in Table 4.7, rural physician-owned and federally-funded PCMHs have higher percentages of practices meeting many of the MU criteria as compared to their non-rural counterparts. This finding warrants further review and might suggest the success of the Regional Extension Center program that targeted rural practices to improve EHR adoption and provide assistance for meeting MU criteria (Whitacre, 2015).

Summary

Basic and advanced EHR use varies based on the type of practice and location. The results of this study indicate higher overall EHR use for PCMHs (basic and advanced); however, the purposeful sampling methodology used in this study and the different definitions of any, basic, and advanced EHR use in the literature mean that it is difficult to make direct comparisons of PCMHs practices to other national studies. The HIMSS framework provides a national perspective on the overall adoption rates of ambulatory facilities and suggests that PCMHs practices are making better advancements on basic EHR adoption and are almost equivalent to other ambulatory facilities on advanced EHR adoption levels. Overall, practices (PCMHs and nationally) have low adoption rates for all advanced EHR functions. The findings in rural practices warrant further investigation and are discussed in the proceeding chapters.

While the overall rates are very low, PCMHs appear to be meeting the MU Stage 2 objectives at higher rates than other eligible professionals. These differences might have

important ramifications for the success of the MU program, in that additional resources could be needed to assist certain types of practices. Thus, it is important to understand the specific characteristics associated with advanced EHR use. Chapter 5 provides the results for the PCMH characteristics associated with advanced EHR use.

Chapter 5

Results: PCMH Characteristic Association with Advanced EHR Use

A primary purpose of this study is to identify the PCMH characteristics associated with advanced EHR use. Identifying the PCMH characteristics associated with the most and least likelihood for advanced EHR use provides opportunities to expand current policy and assist practices that are struggling. In this chapter, logistic regression analyses are used to identify and explain the PCMH practice characteristics associated with advanced EHR use. As described in Chapter 3, a binary dependent variable for advanced EHR use (EHR index) is coded as 0 = "no advanced use" and 1= "any advanced use." Based on the logistic regression diagnostics, the analyses utilize robust standard errors to answer this important research question:

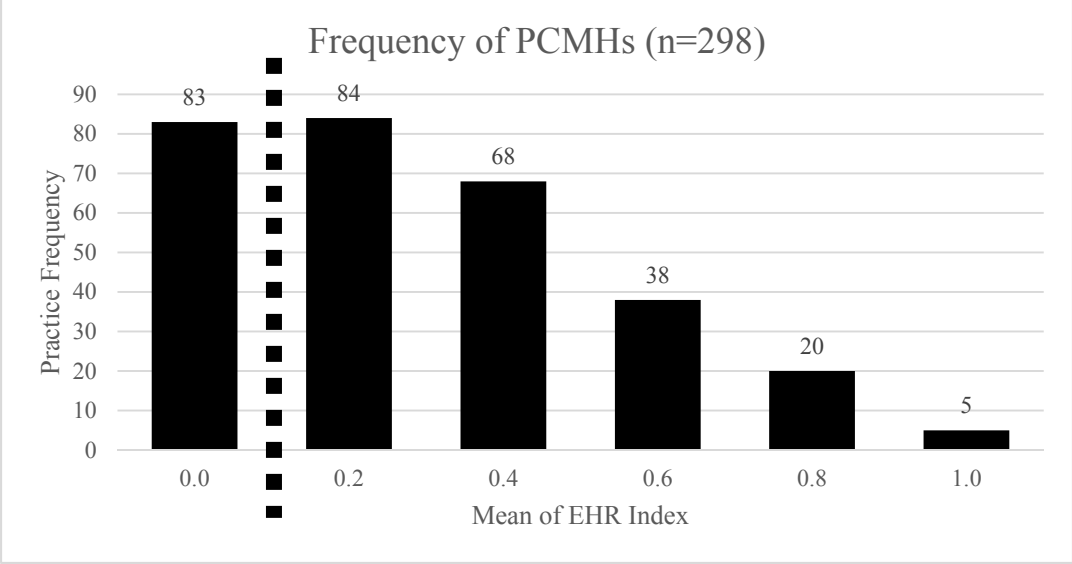
Research Question 3: What are the PCMH characteristics associated with advanced EHR use compared to no advanced use?

Considering the current overall low use of advanced EHR functions throughout the United States, the initial model compares PCMH practices with "no advanced use" to "any advanced use." The current progress of PCMHs towards EHR adoption and use (as described in Chapter 4) also indicates the need to evaluate EHR use at differing levels (low versus high). Variations in the model will also be explored to validate the index and demonstrate changes in the PCMH characteristics associated with advanced EHR use at higher levels of use. Testing the model at various levels also ensures the appropriateness of the threshold for the dichotomous variable (EHR index) ultimately used to differentiate "any advanced EHR use" from "no advanced EHR use." Tests of specificity and sensitivity are used to describe PCMH practices that are correctly identified as advanced EHR users or non-advanced EHR users. As discussed in Chapter 3 Methods, due to the limitations of the Pseudo-$R^{2,}$ the Bayesian Information Criterion

(BIC) is used to compare the models. Logistic regression is utilized to evaluate the practice characteristics associated with advanced EHR use in the four models. A fifth model was suggested in Chapter 3 to evaluate federally-funded PCMHs independently in separate analyses. However, due to the low sample size of these federally-funded practices, logistic regression indicates a non-significant model that is not included in these results. The inability of this study to evaluate federally-funded PCMHs independently indicates an opportunity for future research with a larger sample of these practices.

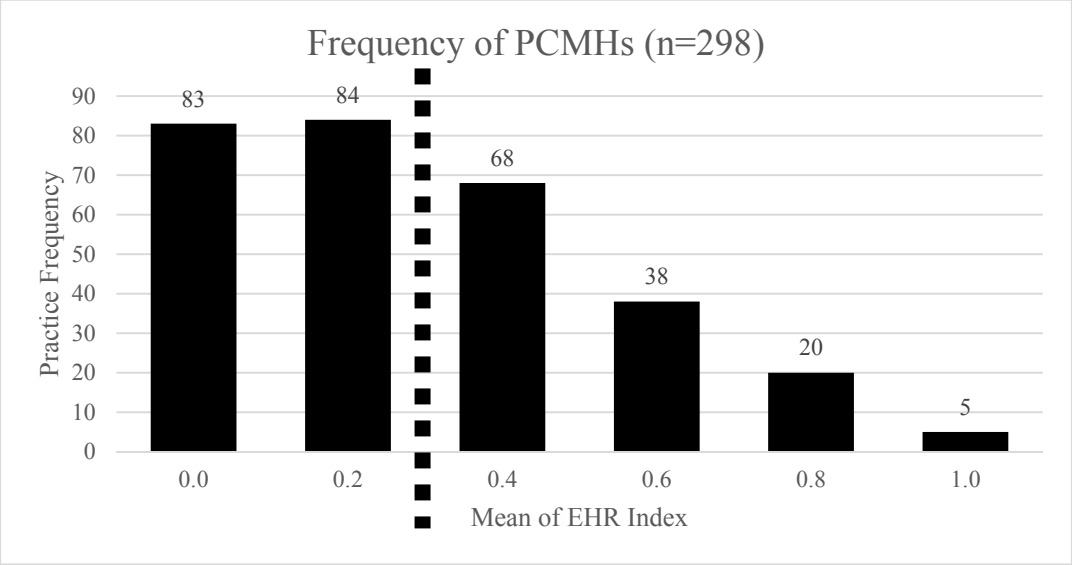
These four models are evaluated in Chapter 5 of this dissertation:

1. Lowest threshold model: "Any advanced EHR use" compared to "no advanced use" at the 0.0 threshold of the dichotomous variable for advanced EHR use (see dotted line cutoff below). This is the original model described previously and a primary focus of this study.

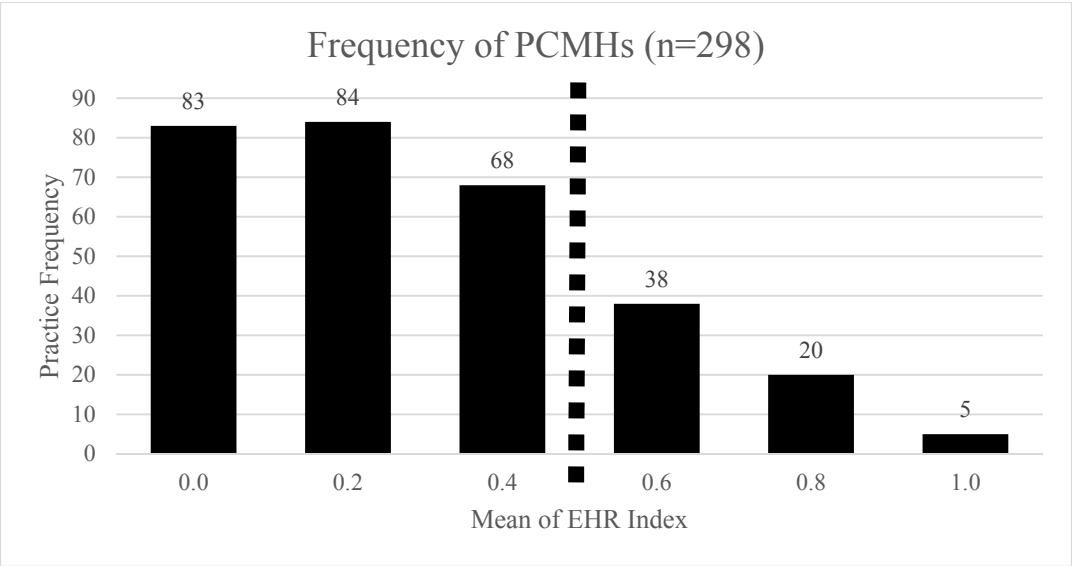


2. Median threshold model: Advanced EHR use compared to non-advanced use at the median threshold of the dichotomous variable for advanced EHR use. Based on the

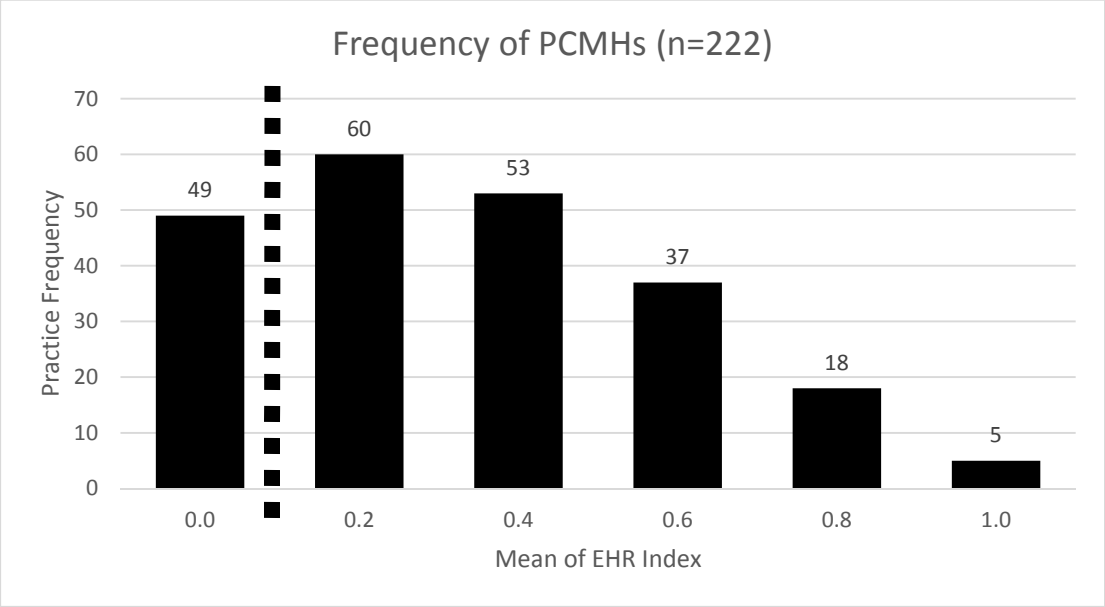
data, the 0.25 threshold (see median dotted line cutoff below) is the point at which advanced EHR use increases and the frequency of practices with "advanced EHR use" begins to decline.



3. Highest threshold model: The cutoff for the data point of the dichotomous EHR index is increased to 0.50 to evaluate the highest (most advanced) EHR use levels in PCMHs (see dotted line cutoff below). The increase is based on tests of specificity and sensitivity.



4. Physician-owned and hospital/system-owned model: Due to inherent differences in PCMH practice characteristics between the federally-funded PCMH practices and the physician-owned and hospital/system-owned PCMH practices as noted in this study and prior research (Tirodkar et al., 2014) and inconsistencies in the models based on type of practice ownership, federally-funded PCMHs are removed from this model. The PCMH practices are evaluated at the initial cutoff (0.0) to identify characteristics of physician-owned and hospital/system-owned PCMH practices associated with "any advanced EHR use," as compared to practices with "no advanced use."



It is hypothesized that practice affiliation (networked providers), length of time using an EHR, practice size, higher quality improvement scores, and having care coordination agreements will demonstrate positive associations with advanced EHR use. It is also hypothesized that rural practices that are not part of a network will demonstrate lower advanced use of EHRs, but the types (ownership) of PCMH would demonstrate no differences, although as indicated in the previous results of this study on EHR use in PCMH (Chapter 4), the type of practice may have implications for the analyses.

Model 1: Lowest Threshold

Model 1 is the original model. Considering the purpose of this dissertation and justified by the current overall low use rates of advanced EHR functions noted in this study (Chapter 4), comparing those practices that are using "any advanced EHR" functions to those that are using "no advanced EHR" functions is appropriate at this time. Model 1 is defined by utilizing the lowest threshold < 0.20 of the Advanced EHR index. In Model 1 no advanced EHR functions = "0" (83 practices) and use of any advanced EHR functions = "1" (215 practices).

Table 5.1 provides the results for the logistic regression analysis for Model 1. The reference categories for variables are also provided in Table 5.1 (and all analyses in this chapter). The odds ratios and significance levels are emphasized in the regression output in bold and indicated in parentheses in the subsequent text. The overall model was significant at Wald Chi-squared= 35.27, df 15, $p < 0.01$. Therefore, the null hypothesis, that all of the coefficients in the logistic regression equation are zero, is rejected. The results suggest that only length of time with an EHR and the practice quality improvement scores are associated with advanced EHR use in Model 1. These two variables demonstrate significant effects on the probability of advanced EHR use and are discussed in more detail.

Table 5.1 Logistic Regression Output - Model 1: No Advanced EHR versus Any Advanced EHR Use (Lowest Threshold)

Variables		Odds Ratio	*p* value	95% Conf. Interval	
Practice Size	*1 clinician*	-	-	-	-
	2 to 4 clinicians	0.986	0.972	0.458	2.125
	5 to 9 clinicians	0.630	0.285	0.271	1.468
	10 or more clinicians	0.455	0.098	0.179	1.156
Ownership	*Federally-funded*	-	-	-	-
	Hospital/System-owned	1.613	0.234	0.733	3.549
	Physician-owned	1.999	0.062	0.966	4.137
Rural		0.732	0.362	0.374	1.432
Affiliated/Networked (IDS, IPA, PHO)**		1.139	0.659	0.640	2.027
Quality Improvement Score	*Low*	-	-	-	-
	Med	**2.187***	**0.028**	**1.086**	**4.402**
	High	2.043	0.052	0.993	4.204
Length of time with EHR		**1.929***	**0.029**	**1.070**	**3.477**
MU as Highest Priority		0.583	0.063	0.330	1.030
Financial Concern	*No concern*	-	-	-	-
	Moderate concern	1.111	0.809	0.472	2.618
	Very concerned	0.952	0.917	0.375	2.415
Any Care Coordination Agreement		1.411	0.348	0.688	2.895
Multiple Practice Locations		0.786	0.474	0.405	1.522
Constant		1.107	0.883	0.286	4.282
N		298			
Log-likelihood		-157.013			
Wald Chi^2		35.270			
p value		0.0022			
Pseudo R^2		0.1093			
BIC		405.179			

*Significant at the $p < 0.05$ levels

**IDS=Integrated Delivery System; IPA=Independent Practice Association; PHO=Physician Hospital Organization

Overall Model 1 suggests that having an EHR for a longer period of time and having higher quality improvement scores increase the likelihood of a PCMH practice utilizing any of the advanced EHR functions. However, many of the hypothesized results were not demonstrated in Model 1. Surprisingly, practice affiliation (networked providers), location (rural), MU priority, financial concern for the practice, and having multiple locations did not contribute to this model. It was predicted that being non-rural and part of a network would demonstrate significant increased likelihood for advanced EHR use, as would having multiple locations. The

rationale is that practices that are part of network and/or have multiple locations would have increased opportunities to connect, whereas rural and isolated practices would not. The expectations did not hold true in this model, evaluating "any advanced EHR use" compared to "no advanced use."

Practices involved in quality improvement (QI) initiatives are suggested to have higher levels of EHR adoption (Audet et al., 2014). As predicted, PCMHs with higher QI scores in this study demonstrate a significant positive association with EHR use (OR 2.10, $p<0.05$). However, the odds ratio of advanced EHR use for practices with a moderate quality improvement score increased significantly (OR 2.19, $p<0.05$) but then lessened at the highest QI levels (OR 2.04, $p=.052$). This exemplifies the variable's nonlinear relationship with advanced EHR use as previously identified in Chapter 3, in that the likelihood of advanced EHR use increases significantly from the low to moderate QI scores but then tapers off at the highest QI scores (the greatest increases are between the low and moderate scores).

As predicted, practices with EHRs for more than five years were over two times as likely to be in the advanced EHR use category as compared to practices with EHRs for five years or less (OR 1.93, $p < 0.05$). These findings suggest that EHRs may require a significant learning curve, and that over time, practices are more likely to become advanced EHR users.

It is noteworthy to mention that physician-owned practices may have an effect on the model (OR 1.99, $p= 0.062$). These findings suggest the possibility of federally-funded PCMHs to have less likelihood for advanced EHR use. Although not a significant finding in this model, variation of the EHR index may provide further insight. Similarly, PCMH practice size (number of clinicians) did not appear to have a statistically significant effect on the overall probability of advanced EHR use; however, the consistently decreasing likelihood of advanced EHR use from

the smallest to larger practices is an interesting finding and will also be further explored in the other models.

Summary

As predicted, the length of time using an EHR and higher quality improvement scores increase the probability for advanced EHR use, although practice size suggests an inverse relationship with advanced EHR use. It was expected that larger practices would be more likely to use advanced EHRs to share information among providers; however, the findings in Model 1 suggest the possibility of an opposite relationship, which is explored later in this study. Practice type also did not have a significant effect on the model as was originally predicted, although it appears the federally-funded PCMHs may be less likely to use advanced EHRs. These findings will be explored in the other models.

Very few of the hypothesized results were demonstrated in Model 1, and findings did not align fully with existing studies. This could be an indication Model 1 is not an appropriate model (mis-specified) for advanced EHR use at this time or that PCMH practices are fundamentally different from other types of practices (nationally) that are evaluated in the literature. It may also be an indication that PCMH practices have differing characteristics associated with advanced EHR use. The test for specificity and sensitivity indicates a need for further refinement of the model at possibly a higher threshold. Overall, 75.5% of the PCMH practices were classified correctly in Model 1. Model 2 below adjusts the cutoff for the dependent variable and explores this effect. A decision was made for Model 2 to move up the threshold to the median index score for the distribution of the data, or the 50% cut-off.

Model 2: Median Threshold (Increase EHR Index)

Model 2 is defined by utilizing the median index score for the distribution of the data, or approximately the 50% cut-off. This median threshold at 0.25 (on a scale of 0 to 1) is based on the breakpoint in the data at which advanced EHR use began to decline. In this model, 131 PCMHs are classified "advanced EHR users" and 167 are "non-advanced EHR users."

Table 5.2 provides the results of the logistic regression analysis for Model 2. The overall model was significant, at Wald Chi-squared= 39.67, df 15, $p < 0.001$, although the higher Bayesian Information Criterion (BIC) statistic shows stronger support for Model 1 (see Chapter 3 for an overview of BIC). Furthermore, only 63.76% of the PCMH practices were classified correctly in Model 2, compared to 75.5% in Model 1. The results still have important implications and suggest that practice size, ownership, EHR length of time, and care coordination are significantly associated with advanced EHR use at the higher threshold. These variables demonstrate significant effect on the probability of advanced EHR use and are discussed in more detail.

Table 5.2 Logistic Regression Output-Model 2: Advanced EHR Use versus Non-Advanced Use (Median Threshold)

Variables		Odds Ratio	*p* value	95% Conf. Interval	
Practice Size	*1 clinician*	-	-	-	-
	2 to 4 clinicians	0.925	0.829	0.458	1.869
	5 to 9 clinicians	0.575	0.177	0.258	1.285
	10 or more clinicians	0.436	0.088	0.168	1.132
Ownership	*Federally-funded*	-	-	-	-
	Hospital/System-owned	**2.540***	**0.015**	**1.201**	**5.375**
	Physician-owned	**2.696***	**0.006**	**1.336**	**5.438**
Rural		0.763	0.382	0.417	1.398
Affiliated/Networked (IDS, IPA, PHO)*		0.917	0.744	0.544	1.544
Quality Improvement Score	*Low*	-	-	-	-
	Med	1.677	0.111	0.888	3.167
	High	1.382	0.328	0.723	2.645
Length of time with EHR		**2.138***	**0.005**	**1.259**	**3.631**
MU as Highest Priority		0.803	0.401	0.481	1.340
Financial Concern	*No concern*	-	-	-	-
	Moderate concern	0.615	0.229	0.279	1.358
	Very concerned	0.642	0.303	0.276	1.492
Any Care Coordination Agreement		**2.193***	**0.026**	**1.096**	**4.388**
Multiple Practice Locations		0.994	0.983	0.552	1.789
Constant		0.230	0.02	0.067	0.789
N		298			
Log-likelihood		-183.050			
Wald Chi^2		39.670			
p value		0.0005			
Pseudo R^2		0.1044			
BIC		457.254			

*Significant at the $p < 0.05$ levels
**IDS=Integrated Delivery System; IPA=Independent Practice Association; PHO=Physician Hospital Organization

Moving the threshold up to the median has several important implications for the EHR use model. While length of time with an EHR maintains significance in Model 2, the quality improvement score was no longer significantly contributing to the model. For Model 2, the type of PCMH practice and having a care coordination agreement significantly contribute to the

model. This is an indication that at higher levels of advanced EHR use, care coordination (over quality improvement) becomes an important factor for advanced EHR use.

At the higher threshold model in this study, the type of practice (ownership) has important implications for advanced EHR use in PCMHs. Model 2 suggests federally-funded practices are less likely to use advanced EHR features. Contrary to hypothesized results, physician-owned and hospital/health system-owned practices were significantly more likely to be advanced EHR users than federally funded health centers (OR 2.70, $p < 0.01$; OR 2.54, $p< 0.05$). The differences between physician-owned and hospital/system-owned practices were not significant, which is an indication of the similarities between these two types of PCMHs.

Federally-funded practices experience different levels of EHR use as noted in the previous chapter of this study and now demonstrate differing associations with advanced EHR use. These results are inconsistent with the literature that indicates federally-funded health centers have similar EHR adoption rates as other practices (Frimpong et al., 2013; Wittie et al., 2014). These findings also suggest inherent differences between federally funded PCMHs and the other types of PCMHs, as noted in a prior study (Tirodkar et al., 2014). It is likely that the federally-funded practice characteristics contribute to these findings and that PCMH designation does not minimize the differences among types of practices, as originally expected. This has important implications for the subsequent analyses and is further evaluated in Model 4 by removing the federally-funded practices.

Care coordination is an important component for PCMHs. The literature has suggested that care coordination is supported by EHR use (Balfour et al., 2009; Looman et al., 2012). In this study, care coordination was assessed by the presence or absence of care coordination agreements with other providers. It was hypothesized that practices focusing on care

coordination would more likely be advanced EHR users. As predicted, practices with any type of care coordination agreement have a 119.3% higher odds of being advanced EHR users (OR 2.193, $p<0.05$). These findings suggest a relationship between EHR advanced use and care coordination at the higher levels of advanced EHR use.

Summary

Similar to Model 1, many of the hypothesized results are not demonstrated in Model 2. Practice affiliation (networked providers), location (rural), MU priority, financial concern for the practice, and having multiple locations did not contribute to this model.

As predicted, the length of time using an EHR and having care coordination agreements in place increase the probability for advanced EHR use in Model 2, although practice size again suggests an inverse relationship with advanced EHR use. In Model 2, practice type also has a significant effect on the model, which is contrary to predictions, in that federally-funded PCMHs were significantly less likely to use advanced EHRs. The question remains regarding associations at the highest levels of advanced EHR use. The test for specificity and sensitivity indicates a need for further refinement of the model at an even higher threshold. Model 3 adjusts the cutoff for the dependent variable and explores the associations of PCMH practice characteristics at the highest level of advanced EHR use.

Model 3: Increased Threshold for the EHR Index (Highest EHR Index)

Model 3 introduces a variation of the dependent EHR index and evaluates the effects of the various PCMH characteristics at the highest level of advance EHR use. To explore the higher end of the advanced EHR index, a decision was made to increase the threshold from 0.25 in Model 1 to 0.50, as suggested by the test for specificity and sensitivity. In this model, 63

PCMH practices were categorized as "advanced EHR users," 235 were classified as "non-advanced users."

Table 5.3 provides the results of the logistic regression analysis for Model 3. Model 3 maintains significance, Wald Chi-squared= 26.63, df 15, $p < 0.05$, and suggest associations of advanced EHR use with practice size, ownership, and length of time with an EHR. The lower BIC statistic shows stronger support for Model 3 over Models 1 and 2 (see Chapter 3 for an overview of BIC). In Model 3, 79.53% of the practices are being correctly classified (the highest thus far).

Table 5.3 Logistic Regression Output – Model 3: Advanced EHR Use versus Non-Advanced Use (Highest Threshold)

Variables		Odds Ratio	*p* value	95% Conf. Interval	
Practice Size	*1 clinician*	-	-	-	-
	2 to 4 clinicians	1.356	0.473	0.590	3.117
	5 to 9 clinicians	0.904	0.84	0.340	2.404
	10 or more clinicians	**0.159***	**0.031**	**0.030**	**0.849**
Ownership	*Federally-funded*	-	-	-	-
	Hospital/System-owned	**8.451***	**0.003**	**2.097**	**34.063**
	Physician-owned	**8.318***	**0.003**	**2.070**	**33.420**
Rural		0.996	0.992	0.478	2.074
Affiliated/Networked (IDS, IPA, PHO)*		1.404	0.289	0.750	2.629
Quality Improvement Score	*Low*	-	-	-	-
	Med	0.718	0.413	0.325	1.586
	High	0.822	0.615	0.383	1.764
Length of time with EHR		**1.981***	**0.044**	**1.020**	**3.850**
MU as Highest Priority		0.822	0.555	0.429	1.576
Financial Concern	*No concern*	-	-	-	-
	Moderate concern	0.510	0.19	0.187	1.397
	Very concerned	0.466	0.153	0.163	1.328
Any Care Coordination Agreement		1.351	0.468	0.599	3.046
Multiple Practice Locations		1.152	0.698	0.564	2.353
Constant		0.042	0	0.008	0.228
N		298			
Log-likelihood		-132.550			
Wald Chi^2		26.630			
p value		0.0319			
Pseudo R^2		0.1377			
BIC		356.255			

*Significant at the $p < 0.05$ levels
**IDS=Integrated Delivery System; IPA=Independent Practice Association; PHO=Physician Hospital Organization

At the highest threshold, a major change in the model was that having any care coordination agreement was no longer significant as it was in Model 2, nor was Quality Improvement as significant as it was in Model 1. Therefore, at higher levels of advanced EHR use, having a care coordination agreement or a quality improvement focus does not increase the practices' likelihood for advanced EHR use, and thus it loses its association. In other words, at the highest threshold for the EHR index, practice innovations do not significantly contribute to advanced EHR use. This is an interesting finding that is contrary to expectations and prior research (Audet et al., 2014). EHR are thought to facilitate care coordination and quality improvement; however, these implications are not present for PCMHs at the highest levels of advanced EHR use. This suggested that practice innovations are only associated with the initial use of advanced EHR functions. Alternatively, the higher levels of advanced EHR indicate practices that are higher achievers and may not need external care coordination agreements or quality improvement initiatives because they are relying on a fully functional advanced EHR system.

In Model 3, the inverse relationship (decreasing trend) for advanced EHR use as practices size increases is more pronounced and significantly contributes to the model. PCMHs with 10 or more providers indicate a significantly lower likelihood of being advanced EHR users (84.1% lower) than practices with one provider (OR 0.16, $p< 0.01$). Thus, smaller PCMHs demonstrate an increased likelihood for advanced EHR use. This is inconsistent with the literature that suggests larger practices are more likely to adopt and use EHRs (Audet et al., 2014; Furukawa et al., 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013; Singh et al., 2012; Xierali et al., 2013). The inverse relationships in PCMHs may be related to their PCMH designation,

which requires all practices to coordinate care. Thus, the smaller practices would need to rely on the EHR capabilities to coordinate external services.

The types of practices indicate similar associations in Model 2 and Model 3. Hospital/system-owned practices (OR 8.45, $p< 0.01$) and physician-owned practices (OR 8.32, $p<0.01$) are significantly more likely to be advanced EHR users compared to federally funded health centers. Similarly, length of time since EHR adoption is consistent across Models 1, 2, and 3. This suggests consistent relationships with these PCMH characteristics (practice type and length of time with an EHR) and advanced EHR use.

Summary

Overall, the highest threshold in Model 3 demonstrates some changes over Model 2. EHR length of time and PCMH type remained significant. The important finding in Model 3 is that as the number of providers in the practice increase, the likelihood for advanced EHR use significantly decreases. The lower BIC statistic shows stronger support for Model 3 over Models 1 and 2 (see Chapter 3 for an overview of BIC).

Across all models, and especially at the higher thresholds, the type of PCMH demonstrates important implications. The findings consistently suggest that federally-funded practices are less likely to be advanced EHR users. Chapter 4 also indicates inherent differences for federally-funded practices and significantly lower levels of EHR adoption and use. Taken together, the type of practice may be masking other relationships in the model. For example, in Model 3, physician-owned and hospital/system-owned practices had more than a 730% increased odds of being advanced EHR users as compared to federally-funded PCMHs. Considering these differences, further analyses are necessary to evaluated physician-owned and hospital-owned PCMHs separately. Model 4 removes federally-funded PCMHs and identifies the practices

characteristics associated with "no advanced use" as compared to "any advanced EHR use" for physician-owned and hospital-owned PCMHs.

Model 4. Physician-owned and Hospital/system-owned Practices

Referencing the findings on the types of practice across the three models and the decreased likelihood of federally-funded practices to be advanced EHR users, Model 4 evaluates physician- and hospital/system-owned PCMHs characteristics associated with advanced EHR use. Federally-funded PCMHs are removed. Model 4 maintains the original threshold of the EHR index (<0.20) to evaluate "no" versus "any" advanced EHR use. A total of 49 PCMHs are classified as "no advanced EHR use" and 173 are classified as "any advanced EHR use." Since the independent variable for whether or not the practice has "all of the providers attesting to meaningful use" was not used in the previous three models due to federally-funded PCMHs having no practices with "all," this variable is now included in the Model 4 analysis of provider-owned and hospital/system owned PCMH practices.

Table 5.4 provides the logistic regression results for Model 4. This model suggests practice size, geographic location (rural), quality improvement, length of time with an EHR, and the proportion of providers attesting to MU significantly contribute to the model. Although the sample used in Model 4 is different from Models 1, 2, and 3 (federally-funded PCMHs are removed), the BIC statistic suggests support for Model 4. In addition, 80.63% of the practices are correctly being classified as "no" versus "any" advanced EHR users in Model 4 (highest overall).

Table 5.4 Logistic Regression Output – Model 4: Physician- and Hospital/System-Owned (Lower Threshold)

Variables		Odds Ratio	*p* value	95% Conf. Interval	
Practice Size	*1 clinician*	-	-	-	-
	2 to 4 clinicians	0.464	0.142	0.166	1.295
	5 to 9 clinicians	**0.120***	**0.001**	**0.035**	**0.412**
	10 or more clinicians	**0.090***	**0.003**	**0.018**	**0.442**
Ownership	*Federally-funded Hospital/System-owned*	-	-	-	-
	Physician-owned	1.739	0.213	0.729	4.149
Rural		**0.318***	**0.005**	**0.143**	**0.711**
Affiliated/Networked (IDS, IPA, PHO)**		1.415	0.333	0.701	2.856
Quality Improvement Score	*Low*	-	-	-	-
	Med	**2.994***	**0.025**	**1.146**	**7.825**
	High	2.291	0.092	0.873	6.009
Length of time with EHR		**2.951***	**0.006**	**1.360**	**6.403**
MU as Highest Priority		0.758	0.456	0.366	1.571
Financial Concern	*No concern*	-	-	-	-
	Moderate concern	1.668	0.454	0.437	6.364
	Very concerned	1.003	0.996	0.262	3.844
Any Care Coordination Agreement		2.301	0.072	0.928	5.706
Multiple Practice Locations		1.225	0.633	0.532	2.822
All Provider Attesting to MU		**0.314***	**0.015**	**0.124**	**0.796**
Constant		2.154	0.441	0.305	15.193
N		222			
Log-likelihood		-98.144			
Wald Chi^2		34.350			
p value		0.0030			
Pseudo R^2		0.1624			
BIC		282.731			

*Significant at the $p < 0.05$ levels
**IDS=Integrated Delivery System; IPA=Independent Practice Association; PHO=Physician Hospital Organization

Overall in Model 4, smaller, innovative PCMH practices with EHR for longer than 5 years were the most likely to be using any advanced EHRs. Practices in rural locations and those with all providers attesting to MU were less likely to be using advanced EHR functions. The EHR length of time, practice size, and QI score are consistent with previous models, although rural is significant in Model 4. It is also important to emphasize the consistent trend across the models for practice size that again suggests that smaller practices are more likely to use

advanced EHRs. As the number of providers increases, the likelihood for advanced EHR use decreases. This is contrary to expectations and prior research (Audet et al., 2014; Furukawa et al., 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013; Singh et al., 2012; Xierali et al., 2013) and suggests two plausible explanations: PCMH designation has an impact for smaller practices and/or the Regional Extension Center focus on EHR use in smaller practices was effective. These findings have important implications and are discussed extensively in Chapter 6.

A noted change in Model 4 is that PCMH practices in rural settings exhibited a 68.2% decreased likelihood of being advanced EHR users (OR: 0.318, $p<0.01$). Thus, rural practices are less likely than non-rural practices to be using advanced EHRs. This has important implications and is consistent with a recent study that found electronic information exchange and patient engagement to be particularly difficult in rural practices (Furukawa et al., 2014). This may also help explain some of the inconsistencies in the literature, and it is discussed in Chapter 6.

Interestingly, practices with all providers attesting to MU are significantly less likely (68.6% less) to be advanced EHR users (OR 0.3142, $p< 0.05$). This may reflect the timing of the data collection for this study being around the time of MU Stage 1 attestation requirements that did not require full use of these advanced EHR functions during the first year. This may also indicate the importance of MU incentive payment for these practices and poses a topic for future research.

At this point in time, and based on advanced EHR use across PCMH types, Model 4 seems to be more relevant. Model 4 evaluates "no" versus "any" advanced EHR use at a time when overall advanced EHR use is relatively low nationwide. This model demonstrates results

that are consistent with the hypotheses and the literature. As advanced EHR use increases nationally, the higher threshold models may become more appropriate

Summary of Overall Findings

As suggested by the analyses in Chapter 4, the overall EHR use for PCMHs is high, and the results from this study indicate that these PCMH practices are using more advanced EHRs and making better progress towards MU than other eligible providers and primary care practices. In Chapter 5 the analyses across the four models for EHR use, certain PCMH characteristics like EHR length of time, practice type, and size of practice demonstrate consistent and substantive effects on the probability for any advanced EHR use, although the individual effects vary based on different levels of the EHR index across the four models. Across all four models, practices with EHRs for longer periods of time are significantly more likely to use advanced EHR functions. This indicates a possible learning curve for EHR use and that advanced EHR use should be facilitated over time.

Practice Type

Contrary to predictions, the type of practice revealed a consistent and substantive effect on the models. Specifically, federally-funded PCMHs are significantly less likely than physician-owned and hospital/system-owned PCMHs to be advanced EHR users, suggesting that additional support for EHR use is needed for these types of practices. The prior literature suggested no differences in EHR adoption for federally-funded practices (Frimpong et al., 2013; Wittie et al., 2014); however, this dissertation finds that actual use of advanced EHRs for these PCMH practices is substantially different. Furthermore, the characteristics associated with advanced EHR use may be different for federally-funded PCMHs. The proposed model with only federally-funded PCMHs was unable to provide results due to low sample size. Model 3 and

4 suggest practice size has strong associations for physician- and hospital/system-owned PCMHs but not the federally-funded PCMHs.

It becomes evident that certain associations are being masked by the type of practice across all of the first three models. For example, at the highest threshold (Model 3), practice type becomes important, in that federally-funded practices were significantly less likely to be advanced EHR users. This indicates that federally-funded PCMHs have a negative relationship with advanced EHR use. Furthermore, as the threshold increases (with the federally-funded PCMHs included model), so does the inverse relationship with practice size. In Model 4, when the federally-funded PCMHs are removed, the inverse relationship is the most pronounced. In other words, the inverse relationship with practice size may not be as prevalent in federally-funded PCMHs.

As discussed previously, these findings and the inability of this dissertation to evaluate federally-funded PCMHs separately due to small sample size presents an opportunity for future research. Federally-funded health centers have an important role in caring for some of the nation's more challenging patients (Frimpong et al., 2013; Miller & West, 2007; Shin & Sharac, 2013). These settings would benefit greatly from use of the advanced EHR capabilities to coordinate care (Bitton et al., 2012; Furukawa et al., 2014; Vest & Gamm, 2010). Federally-funded PCMHs are further discussed in Chapter 6.

Practice Size

The inverse relationship of practice size across all four models is in conflict with the existing research and contrary to the hypothesized results. The literature strongly suggests larger practices adopt and use EHRs (Audet et al., 2014; Furukawa et al., 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013; Singh et al., 2012; Xierali et al., 2013). The research

findings in this study indicate that PCMH designation may have a significant and positive impact on smaller practices and advanced EHR use. This has important policy implications as it suggests that PCMH designation may be associated with advanced EHR use in smaller PCMHs, and it is different from other primary care settings. These findings may also suggest the success of the Regional Extension Centers focus on smaller (although not rural) PCMH practices. This inverse and unique relationship will be further explored in Chapter 6.

Practice Innovations

This study demonstrates the consistent association between practice innovation (care coordination and/or quality improvement) and increased likelihood for advanced EHR use. It is also indicated that quality improvement is important for all PCMHs. At the higher threshold of advanced EHR use, care coordination indicates a significant positive association with advanced EHR use, and at the lower threshold, higher quality improvement scores demonstrates positive associations. Chapter 6 provides the in-depth discussions.

Meaningful Use

The non-significant results for MU priority across all of the models indicates that the MU policy is not the driver of change, but instead other characteristics are. This is surprising considering that prior research has suggested that the MU incentive payment/penalty is the driving force behind adoption (Heisey-Grove & Patel, 2014). However, simply adopting an EHR does not equate with use (McClellan et al., 2013); therefore, the MU incentives may not be the driver for advanced EHR use. It is surprising that Model 4 (without the federally-funded PCMHs) practices with "all providers attesting to MU" are less likely to be advanced EHR users. This could be a reflection of the timing of this study and the priority for MU Stage 1 at this time, or that practices are seeking MU incentive payments rather than the main purpose of EHRs to

coordinate care. These and other unique findings are also explored further in Chapter 6 Discussions.

Summary

This study evaluates EHR use, at an appropriate level ("no" versus "any" advanced use) based on current national trends of EHR use. Considering the findings from this study, PCMHs and likely all other primary care practices still have a considerable way to go before realizing the true benefits of advanced EHR use. Evaluating "no" versus "any" advanced EHR use is an appropriate measure to evaluate advanced EHR use at this time. As expected, the higher threshold models demonstrate differing results and associations. As EHR use progresses nationally, the higher thresholds may become more appropriate. In future studies, it is remains appropriate to first measure the actual rate of EHR use in order to identify the proper threshold for the EHR index.

CHAPTER 6

Discussion and Conclusions

This study describes overall EHR use in PCMHs and their progress towards meeting advanced criteria for MU. This dissertation also identifies the PCMH characteristics and contextual factors associated with advanced EHR use. Previous literature suggests that PCMHs overall would demonstrate higher levels of EHR use than other primary care practices and that that larger, networked PCMHs that are part of a system would demonstrate higher probability for advanced EHR use (Adler-Milstein & Cohen, 2013; Audet et al., 2014; DesRoches et al., 2013; Furukawa et al., 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013; Singh et al., 2012; Xierali et al., 2013). In this dissertation, the original hypotheses suggest that practice affiliation (networked providers), having an EHR for a longer period of time, practice size (larger), and practices focused on care coordination and quality improvement will demonstrate positive associations with advanced EHR use. It is also suggested that rural providers not part of a network will demonstrate lower use of advanced EHRs.

Four EHR models are tested. The model without federally-funded PCMHs is found to be the most relevant at this time. As advanced EHR use increases, the higher threshold models may become more appropriate. The comparison across the models provides substantial insight into advanced EHR use in PCMHs.

As expected, this dissertation finds higher EHR adoption and use levels for PCMHs compared to other office-based and primary care practices. This dissertation also reveals three important relationships regarding PCMHs and EHR use, which are surprising and have significant implications for current policy and practice in primary care (and beyond). Specifically, this study finds that PCMH practice size, type, and location (rural versus non-rural)

demonstrate unique associations with advanced EHR use. Contrary to prior studies and the current hypotheses, this dissertation finds that larger PCMHs as well as federally-funded centers are less likely to be advanced EHR users and that practice affiliation (being part of a network) has no association with advanced use. In addition, this dissertation finds that smaller and non-rural PCMHs practices that are physician or hospital/system-owned are more likely to use advanced EHR functions.

Chapter 6 discusses the major findings and offers plausible explanations for the significant and unique associations revealed in this study. Chapter 6 also describes and explains EHR use in the PCMHs and the practice characteristics and factors associated with advanced EHR use. This chapter provides the background, details, and implications of the study findings relevant to current health policy and beyond.

EHR Use in PCMHs

A fundamental purpose of this dissertation is to describe overall EHR use in PCMHs and to distinguish advanced EHR use from simply having (adopting) basic EHR functions. This study confirms that EHR adoption and use levels are higher for PCMHs than for other primary care practices nationally, a finding consistent with the literature (Adler-Milstein & Cohen, 2013). Given the ability of EHRs to facilitate care coordination (Looman et al., 2012; Morrissey, 2013), these findings are not surprising. PCMHs practices must demonstrate high levels of collaboration and care coordination to receive PCMH designation from the NCQA. They rely on EHRs to facilitate well-coordinated, patient-centered care (Adler-Milstein & Cohen, 2013; Bitton et al., 2012), so it is likely that the higher EHR adoption and use found in PCMHs are attributed to these PCMH designation requirements. Overall it is concerning, however, that even these innovative practices have a considerable way to go before realizing the full benefits of truly

advanced EHR use. Achieving the maximum benefits of EHRs requires all practices and health organizations to become fully integrated and to consistently utilize all of the advanced functions in the EHR, especially electronic information exchange (with patient and providers) and interoperability.

Advanced EHR use in this project is defined to include HIE, EHR interface, patient portal, and fax-EHR (faxing comprehensive clinical summaries from the EHR). All of these functions relate to the fundamental criterion of the EHR to exchange information with other practices and patients and are priorities for the current policy initiatives (HealthIT.gov, nd). As previously discussed in Chapters 3 and 4, the fax-EHR variable was given much consideration for inclusion in the model. The final decision to include this variable provides valuable insight into the overall use of EHRs in PCMHs and is further discussed later in this chapter.

MU Stage 2 incentivizes providers to share information with other practices and patients via the EHR (see Chapter 1). Patient engagement and HIE are two important aspects of MU, and both are necessary to realize the full benefits of EHRs; however, for PCMHs, advanced use of these functions remains surprisingly low. This finding is similar to the findings in prior studies of other practice settings (Furukawa et al., 2014; Hsiao et al., 2014). The relatively low level of EHR use is concerning, especially considering PCMHs are more progressive than other primary care practices. Since the majority of patient care is delivered in primary care settings (Hing & Schappert, 2012) and true benefits of care coordination rely on widespread EHR use (Balfour et al., 2009), monitoring both EHR use and care coordination is crucial. Overall, more needs to be accomplished before the maximum benefits of EHRs are realized in primary care settings. This study documents the need and offers support for a national framework to assess primary care EHR adoption and advanced use.

As more practices move towards PCMH designation and the other delivery reform initiatives, it becomes increasingly important to understand the specific practice characteristics currently associated with achieving advanced EHR use versus no advanced EHR use. This information will help promote the expansion of policy priorities and the development of programs targeted to improve EHR use. This study reveals important findings regarding various PCMH characteristics associated with advanced EHR use, including, practice type, size, and location.

PCMH Characteristics Associated with EHR Use

A primary purpose of this dissertation is to identify those characteristic in PCMHs with any advanced EHR use compared to PCMHs practices with no advanced EHR use. Four EHR use models are tested to verify the appropriateness of the advanced EHR index as a dichotomous variable. The advanced EHR index broadly includes information exchange functions with other practices and patients. As described in Chapter 5, changing the threshold of the advanced EHR index causes various effects on the model, although certain variables such as practice size, ownership type, and EHR length of time remain fairly consistent. The relevant model at this point in time is Model 4, which evaluates physician-owned and hospital/system-owned PCMHs (excluding federally-funded practices) with "no advanced EHR use" compared to PCMHs with "any advanced use." As advanced EHR use becomes more widespread, higher threshold models may well provide better measures for practice progress. The discussion below provides the finding across all four models.

Overall, smaller physician-owned PCMH practices with EHRs in place for more than five years demonstrate the greatest odds of being advanced EHR users. Based on the findings in Model 4 (excluding federally-funded PCMHs), having care coordination agreements and an

increased focus on quality improvement further increased the likelihood of advanced EHR use. However, being rural and having all providers attesting to MU decreased the probability for advanced EHR use. Consistently noted in Models 1-3, federally-funded PCMHs demonstrate significantly lower odds of being advanced EHR users.

Length of Time with an EHR. Across all four models, the length of time with an EHR (greater than five years) is significantly associated with advanced use. This strong relationship of higher EHR use and length of time is consistent with previous findings concerning perceived ease of use and exposure to EHRs (Holden & Karsh, 2010). This suggests a significant learning curve, for as providers gain more experience with EHRs, adoption and use levels are expected to increase. Thus, policymakers may need to consider longer periods of time for the incentives and/or penalties for providers working towards advanced EHR use.

Practice Size. Across all EHR models in this study, the probability of advanced EHR use was lower for larger PCMH practices compared to practices with one provider. This is inconsistent with existing literature, which strongly indicates larger practices tend to be the highest EHR adopters (Audet et al., 2014; DesRoches et al., 2013; Furukawa et al., 2014; Hsiao et al., 2014; McClellan et al., 2013; Patel et al., 2013; Singh et al., 2012; Xierali et al., 2013). One potential explanation for this apparent contradiction is that larger PCMH practices may adopt EHRs but fail to consistently utilize advanced EHR functions; adoption is not synonymous with EHR use (McClellan et al., 2013). Another possible explanation of this finding may be that larger practices utilize alternative internal communication mechanisms for care coordination, such as for email or other messaging platforms. Being in close proximity also provides opportunities for face-to-face dialogues among providers. These behaviors of bypassing the

EHR system could be problematic because important information related to patient care is not documented in the EHR. This is a topic for further research.

This study finds that smaller practices are more likely to utilize advanced EHR functions. Considering the requirements for PCMHs to coordinate patient care, smaller practices would need to formally work with other outside practices to deliver collaborative care, whereas larger practices and those associated with hospitals and health-systems are by affiliation more connected. It is likely that the smaller practices would need to utilize features available within an EHR to connect with other providers and practices for patient referrals and care (requirements for PCMH designation). EHRs are an important component of PCMHs (Bitton et al., 2012; Leventhal et al., 2012). As indicated by this study's finding, EHRs may be even more important for smaller practices to coordinate care and obtain PCMH designation. Therefore, the requirements of care coordination and care transitions for PCMH designation may contribute to this unanticipated finding.

Practice Affiliations. Previous literature suggests that being part of a network or multi-location practice is associated with higher EHR adoption (Audet et al., 2014; DesRoches et al., 2013). The current study finds no association between advanced EHR use and PCMH practice affiliation or having multiple locations. The lack of association was surprising and may be due to this dissertation's focus on evaluating the actual use of advance EHR functions, as opposed to most of the other studies that were simply evaluating adoption of any or basic EHRs. As previously discussed, there is a fundamental difference between adoption of an EHR and advanced EHR use (McClellan et al., 2013). A larger percentage of PCMH practices in this study have adopted EHRs compared to those that are actually utilizing advanced EHR functions.

Being connected with other practices (in a network-like manner) to coordinate care transitions and referrals is part of the requirements for PCMH designation (NCQA, 2014). Thus, regardless of whether a practice is officially networked or affiliated, under the PCMH designation that practice is expected to work with other practices to provide coordinated care. Given the current delivery system reforms, practices are merging and being acquired by larger organizations. As these trends in primary care delivery continue, it is increasingly important to understand the associations of practice ownership and size with EHR use. This is another topic for future research.

Practice Type (Ownership). The type of PCMH (practice ownership) reveals significant associations with advanced EHR use. In particular, federally-funded PCMHs, which include Federally Qualified Health Centers and Community Health Centers, appear very different from physician-owned and hospital/system-owned practices, while physician-owned and hospital/system owned practices appear quite similar. Contrary to what the literature suggests (Frimpong et al., 2013; Wittie et al., 2014), federally-funded PCMHs in this study demonstrate lower basic and advanced EHR use and are significantly less likely to use any of the advanced EHR features related to information exchange and interoperability. As discussed in Chapter 4, these findings are likely due to the inherent differences in the practice characteristics and capabilities of PCMHs (Tirodkar et al., 2014).

Federally-funded practices play an important role in serving disadvantaged populations (Jones & Furukawa, 2014; Miller & West, 2007). These populations are particularly challenging and disproportionally affected by chronic disease (Shields et al., 2007; Shin & Sharac, 2013). The consistent findings across the EHR models in this study that federally-funded PCMHs demonstrate significantly lower odds of being advanced EHR users is concerning, especially

considering the EHR's ability to coordinate care and engage patients (Bitton et al., 2012). These findings are inconsistent with current research and could suggest, in part, a digital divide (Wittie et al., 2014), in that poorer, disadvantaged patients served by federally-funded PCMHs are less likely to have access to technology that supports improved outcomes. It also must be noted that these economically disadvantaged populations may be less likely to use patient portals, leading to the lower advanced EHR use in the federally-funded PCMH practices.

Another potential and interesting explanation for the findings of federally-funded PCMHs is that the current MU policy may be an effective driver for EHR use. Most of the federally-funded PCMHs would likely be applying for the MU incentive under the Medicaid program, which only requires the practice to adopt, implement, or upgrade the EHR for the initial incentive payment. This stands in contrast to the Medicare MU program that requires practices to meet the full MU objectives to receive the incentive payment (CMS.gov, 2015). The assumption for this study would be that these Medicare MU program PCMHs are more likely to be physician-owned and hospital/system-owned practices. The Medicare MU objectives include use of some advanced EHR features, such as providing patient access to electronic health information (CMS, 2015a). Based on these assumptions, the current "carrot and stick" method of Medicare MU appears to be working in certain settings. Additional incentives and penalties should be explored to assist these federally-funded practices to utilize advanced EHR functions for care coordination and catch up with their private sector counterparts (physician-owned and hospital/system-owned PMCHs).

The differences by ownership carry additional implications for the further analyses of PCMHs. For example, when the federally-funded PCMHs are removed from the logistic regression analyses (Model 4), many of the hypothesized associations are demonstrated. An

important finding in Model 4 is that rural physician-owned and rural hospital/system-owned practices are significantly less likely to use advanced EHR functions, even though the rates for EHR adoption and basic use are similar for rural and non-rural PCMH practices (See Chapter 4). These findings in Model 4 without federally-funded PCMHs could also explain some of the inconsistent findings in the literature concerning rural practices and EHR adoption and use (Decker et al., 2012; Whitacre, 2015). Many of the prior studies of rural EHRs evaluated any and/or basic adoption levels of EHRs as opposed to advanced EHR use in these office-based practices (Furukawa et al., 2014; Whitacre, 2015). Advanced EHR use is the focus of the current study and advanced use is lagging in rural PCMH practices (physician-owned and hospital/system-owned). These findings suggest an opportunity for policy expansion in the rural settings.

Advanced EHR Use in Rural Settings

A recent study by Whitacre (2015) suggesting higher adoptions rates in rural settings evaluated whether an EHR was installed, if e-prescribing was used, and if the EHR was used to view lab results. That study was evaluating only very basic EHR systems. Whitacre (2015) and this current study both find rural PCMH practices are similar to non-rural practices in basic EHR adoption. However, as noted in this dissertation, when it comes to actual advanced EHR use, rural practices lag behind. For example, there were no real differences between rural and non-rural practices when evaluating the overall PCMHs adoption model with basic EHR use (see Chapter 4). In fact, in the initial analyses rural practices actually indicated a higher percentage of basic EHR use. However, rural practices demonstrate lower levels of advanced EHR use. At the threshold of Model 4 (“any advanced EHR use” versus “no advanced use”) evaluating physician-owned and hospital/system-owned practices (federally-funded removed), the findings that rural

practices demonstrate significantly decreased odds of being advanced EHR users is concerning. These isolated rural practices would benefit from the EHR's advanced ability to electronically exchange information, connect with other practices (interoperability), and engage patients. EHRs may help isolated practices create network-like relationships with other providers.

Rural practices are by definition geographically isolated, and thus the ability for EHRs to exchange information, communicate with other providers, and effectively engage rural patients, would greatly enhance a rural provider's ability to deliver patient-centered and coordinated care. These systems also allow isolated and independent practices to create network-like relationships with other providers and health care organizations. One of the major challenges for these geographically isolated practices is the availability of high-speed broadband internet (Kansas Department of Commerce, 2013; Missouri Office of Administration Information Technology Services Division, 2014). Services can be too expensive, and in some cases, unavailable (Green et al., 2015). The findings in this study that rural PCMH practices lag in advanced EHR use, but not basic EHR adoption and use, is consistent with this claim. Advanced information exchange functions and interoperability rely on broadband internet. As noted previously, many of the rural PCMH practices are using the fax-EHR function, indicating adoption of an EHR with advanced capabilities but not true advanced use. Recent reports from states with high rural populations found increased costs and lower internet connection speeds in rural areas (Kansas Department of Commerce, 2013; Missouri Office of Administration Information Technology Services Division, 2014). Current federal policy initiatives like MU should be expanded to assist rural practices and patients to gain access to broadband internet, thus increasing the use of advanced EHR functions, especially information exchange and patient portals.

As described previously, findings in this study also suggest that rural practices are using the EHR to fax comprehensive patient summaries to other practices. This is an important point and an indication that the rural PCMH practices have an EHR with all of the capacity and relevant information to create a comprehensive patient summary and that those practices routinely use the EHR to fax other practices these summaries. Noting the high levels of EHR adoption in the rural settings and considering the moderate association between the fax-EHR and interface variables (practices using fax-EHR likely have the capacity to exchange information electronically), the ability to electronically exchange information is likely one-sided for the rural PCMHs and not completely feasible at this time. For example, if a rural PCMH practice having the ability to exchange information electronically intends to send information to another practice that does not have those capabilities, the information cannot be shared electronically via the EHR and must be faxed. Therefore, it may be the other practices that do not have the capability of receiving information electronically, which results in the rural PCMH's inability to fully utilize advanced EHR functions. Stated simply, if a rural specialist cannot accept the rural PCMH's referral and electronic patient summary, then the health information is faxed via the PCMH's EHR. This possibility warrants additional evaluation.

The decreased use of patient portals in the rural setting is also concerning and further suggests a rural-urban digital divide. Rural patient populations have been found to feel more vulnerable and often lack access to health care services (Brundisini et al., 2013). Rural practices and their patients would likely benefit from improved patient engagement, especially considering the distances patient travel for medical care. The patient portal, as previously discussed, is a useful tool that can engage patients by providing results and patient education as well as allowing for direct communication with providers. Patient portal use does require the patient and

the practice to have access to internet, but the use of smart phones and web apps for portals may increase the ability for rural patients to access their information electronically.

Evidence from this dissertation may suggest the positive impact of Regional Extension Centers (RECs) that were funded as part of MU. RECs targeted smaller (<10 providers) and rural practices to provide support and resources for EHR adoption with the goal of meeting MU (Office of the National Coordinator for Health Information Technology, 2015). As suggested in this study, smaller PCMH practices demonstrate increased odds for advanced EHR use, while rural practices experience higher levels of basic EHR adoption and use. RECs also had a focus on practices that provide primary care services to underserved population, like community health centers (Office of the National Coordinator for Health Information Technology, 2015), which demonstrate lower EHR use in this study. Taken together, and considering the consistency with previous studies (Whitacre, 2015), the current findings suggest an overall benefit of RECs. However, REC funding ended in February 2015 (Kansas Foundation for Medical Care, 2015), and many low-resource, rural practices are still in need of assistance (Green et al., 2015). Policy regarding REC should be revisited with consideration to continue the focus on small and rural practices as well as on federally-funded practices. These RECs could be ongoing, open-ended efforts (Green et al., 2015). Many RECs have created strategic partnerships and formed new organizations to assume the expired REC roles; however, the effectiveness of these agencies has yet to be determined, and sustainability remains a major concern (HIMSS, 2015). This is also an opportunity for future research.

Meaningful Use and Policy Implications

Penalties for not meeting MU Stage 1 began in January 2015, and an estimated 257,000 Medicare eligible providers (EPs) will experience a 1% reduction in their payments (Bowman, 2014). DesRoches et al. (2013) found that only 9.8% of all physicians were meeting Stage 1 MU, while 11.2% among primary care providers were meeting Stage 1. The final requirements for Stage 2 MU were released on August 23, 2012 and began in 2014 (HealthIT.gov, nd). As of November 2014, less than 2% of eligible providers met these requirements (American Medical Association, 2014). Based on the MU Stage 2 criteria used in this dissertation, 25.8% of the PCMH practices are meeting most of the criteria, but only 8.1% are meeting the full requirements of Stage 2 MU.

The PCMH practices seem to be progressing better than the overall eligible providers towards meeting Stage 2 of the MU policy. Findings in this study, however, indicate that the MU policy may not be the primary driving factor for advanced EHR use. Across all four of the EHR models, MU priority demonstrated no significant association with advanced EHR use.

The finding that MU attestation actually decreased the likelihood for advanced EHR use for physician-owned and hospital/system-owned practices is perplexing. This is contrary to what was intended by the policy, and it is an indication that many practices may be adopting basic EHRs for the MU incentive payment and not for the true benefits of advanced EHR use. Practices that realize the true benefits of EHRs should have a focus of coordinating care rather than meeting MU for the incentive payments (Morrissey, 2013). Although, at the time of this study, those practices were focused on Stage 1 of MU. The more advanced EHR functionalities are part of MU Stage 2 (see Chapter 1 for more details). As suggested by the findings in this study, PCMHs are progressing better than overall eligible providers, but the rates are still quite

low. Considering the learning curve suggested by the EHR length of time, there is a need to revise the MU guidelines and timelines.

Current payment reform initiatives are incentivizing providers to deliver high-quality and well-coordinated care (Morrissey, 2013). Across the four models, innovative PCMH practices that focus on care coordination and/or quality improvement demonstrate increased likelihoods for advanced EHR use (substantive, not always significant). Based on the findings in this study, it is likely that these PCMH practices are focused on care coordination and quality improvement, as opposed to solely conforming with the MU incentives, thus realizing more of the true benefits of EHRs (Morrissey, 2013). While the practices' stated level for MU priority has no effect on the EHR models, practice initiatives with care coordination and quality improvement seem to demonstrate varied positive associations with advanced EHR use.

Practices involved in QI initiatives are suggested to have higher levels of EHR adoption (Audet et al., 2014). In this study, QI is measured by the Solberg et al. Change Process Capability Questionnaire (CPCQ) (Solberg et al., 2008), which assesses the practice strategies for implementing PCMH and their culture to support change. In Models 1 and 4, which compare PCMH practices that have any advanced EHR use to those with no advanced use, higher quality improvement scores in these models increase the likelihood of advanced EHR use. These findings suggest that the practices with high capacity for quality improvements also demonstrate increased EHR advanced use. Similarly, the practices having care coordination agreements demonstrate increased likelihoods of advanced EHR use. Thus, practice initiatives for PCMH designation are likely to have an effect. As previously discussed, care coordination requires collaboration across practices and can be facilitated by advanced EHR information exchange and interoperability (Bitton et al., 2012). Similar to previous research (Audet et al., 2014; McClellan

et al., 2013), the current results suggest the EHR is a tool that facilitates care coordination and quality improvement for PCMH practices. Taken together, these findings also suggest policy initiatives should focus on the outcomes of care coordination and continuous quality improvement. That is, the MU policy could be expanded to include requirements and incentives for practices to focus on care coordination agreements as well as quality improvement initiatives.

PCMHs have been suggested to improve care (Jackson et al., 2013; Nielsen et al., 2015), and EHRs are noted to facilitate further improved quality of care in these settings (Kern et al., 2014). As implied by the findings in this study as well as in previous research, the EHR is a tool that facilitates well-coordinated and patient-centered care. Since PCMHs rely on advanced EHR functions to coordinate care (Balfour et al., 2009; Looman et al., 2012), the mixed results in previous studies of PCMHs (Arend et al., 2012; Jackson et al., 2013; Shi et al., 2015) are likely due to the current low rates of advanced EHR use. Thus, the focus of policy initiatives to improve care delivery should be on care coordination and advanced EHR use within PCMH designated settings. Exploring opportunities to expand the PCMH designation requirements to all practices may be beneficial.

Limitations

This study has several limitations, including the inability of the study design to assess causality, use of self-reported data, the limitation of the survey measures to reflect EHR criterion, low response rate, necessary use of a dichotomous variable, missing data for important variables, and generalizability. Each of these limitations is explored in more detail below.

Cross-sectional data does not allow for the longitudinal assessment of care (Romano & Stafford, 2011) and may lack the ability to asses causality (Linder et al., 2007). Longitudinal studies with proper controls would provide more suitable data that may allow for causal

inferences to be made about characteristics that predict advanced EHR use. However, as previously stated, there are no suitable controls at this time. Thus, this secondary analysis of cross-sectional data allows for the needed research on current EHR adoption and use to be expedited and to inform policymakers in a timely manner of the PCMH characteristics associated with advanced EHR use. The findings for EHR use are time-sensitive, and outcomes may change rapidly.

Self-reported data and the nature of the secondary analysis utilized in this dissertation pose additional threats to construct validity. Respondents may provide the expected desirable response, or alternatively, may dislike the EHR and provide negative responses (Shadish, Cook, & Campbell, 2002). There are also methodological problems with the subjective measure of self-reported usage, which can be a weak indicator of the objectively measured *actual use* (Straub, Limayem, & Karahanna-Evaristo, 1995). Furthermore, system usage has not demonstrated strong associations with self-reported system usage (Straub et al., 1995). However, within the U.S. health system, only self-reported usage is currently available on a large-scale basis. Furthermore, the dataset utilized in this study provides valuable baseline information on EHR adoption (having a system) and advanced use of the system in PCMHs. As EHR use becomes more prevalent, future studies should be able to evaluate actual use within the EHR systems.

Similar to the limitation stated in Jones and Furukawa (2014), the measures for MU and HIMSS in this study may not reflect whether the PCMHs practices actually met the full criteria (all of the MU/HIMSS measures were not included in the survey, and some of the questions were not exactly worded as MU or HIMSS). Rather, the questions in the NCQA survey served as a proxy for the MU objectives and the HIMSS framework. However, the measures used in this

study expand across MU and HIMSS and incorporate measures of advanced EHR use from the recent literature. The results from this research provide a good baseline for future studies of PCMH practices that may choose to use the exact MU objectives or HIMSS measures, thus allowing for more research opportunities.

Low physician response rates in survey studies has always been problematic (Kellerman & Herold, 2001). However, research has suggested that nonresponse bias among physicians may be of less concern than general public surveys (Kellerman & Herold, 2001), and additional attempts for responses has little effect on findings (Willis et al., 2013). Many studies similarly reported little concern for nonresponse bias among physicians (McFarlane et al., 2007; Ziegenfuss et al., 2012), which is likely due to the homogenous nature of physician "knowledge, training, attitude, and behavior" (pg. 65), as compared to general populations (Kellerman & Herold, 2001). Considering the primary care providers in PCMH settings in this study (very homogenous), the 34.6% response rate should not be problematic. In addition, this response rate is similar to other physician surveys in the United States (Willis et al., 2013; Ziegenfuss et al., 2012). Furthermore, the findings from this study are similar to other studies of primary care practices. Comparing the PMCH to the non-PCMH counterpart by type of practice (ownership) is another opportunity for future research. Once EHR use is widespread, studies of physician practices could also use data directly from the EHR systems, alleviating the response rate issues.

In some cases, converting a continuous variable into a dichotomous variable for use with logistic regression may not be appropriate due to loss of variance (Acock, 2014). However for this project, the goal was to understand PCMH practice characteristics associated with advanced EHR use and those that have no advanced EHR use. Furthermore, this dissertation provides an in-depth rationale (theoretical and practical) as well as statistical justification for inclusion of the

variables in the model (Pedhazur & Pedhazure Schmelkin, 1991). Future researchers utilizing this study are presented with a detailed and justified rationale for easy replication of each model for appropriate comparisons.

The variable measuring practices with high percentages of low income patients was removed from the model (based on the percentage of uninsured and Medicaid patients). This variable may have provided additional information in regards to socioeconomic status. The total values for this variable were provided as a percentage of payer mix but did not add up to 100%, so there were concerns about its accuracy. Furthermore, this variable is based on the responding physician's impression of the payer mix, not the actual amounts. Future studies should collect actual practice income levels based on the percentage of payers to assess socioeconomic factors associated with advanced EHR use.

This study is of a selective group of primary care PCMH practices, thus limiting the generalizability of the results and posing a threat to external validity (Shadish et al., 2002). The PCMH practices were selected based on their progress towards EHR adoption. As the forefront of primary care, the findings for these PCMH practices may be helpful for improving EHR use in other primary care practice settings. Future research of EHR usage should also evaluate individual systems, explore longitudinal actual EHR use as the objective measure, and include various provider types and settings.

Future Research Opportunities

Future research may focus on patient and community outcomes within innovative delivery systems, like the PCMHs, that rely on EHRs to coordinate care. The cross-sectional nature of this study does not allow for causal inferences. Future research could focus on longitudinal data evaluating the causal relationship between provider characteristics, EHRs, care

coordination, quality improvement, and patient (health) outcomes. Based on the higher EHR use levels in PCMHs as compared to other primary care practices, the PCMH settings are appropriate for future outcomes research involving EHRs.

This study provides a comprehensive cross-sectional analysis of adoption and use, including advanced use, of EHRs in PCMH-designated practices in the United States. The results will provide comprehensive baseline data for EHR adoption and use in PCMHs. Future studies could build on the findings to evaluate the ongoing progress of PCMHs and EHR use. As EHR systems become more widely used, researchers may utilize actual EHR use reported in the system itself, thus eliminating the potential issues of self-reported data.

As the health care delivery system in the United States continues to evolve at a rapid pace, understanding the consequence of mergers and acquisitions and their effects on EHR use and health outcomes become increasingly more valuable. Future studies should consider these challenges and opportunities.

EHRs are also suggested to be effective tools for population health management and patient profiling. Once they become widely utilized, the advanced care coordination and quality improvement features in the EHR will provide additional opportunities for future research.

Considering the findings for federally-funded PCMHs and rural practices and their lower probability for advanced EHR use, future research should investigate the implications of a potential digital divide. The interesting finding that the rural federally-funded PCMHs experienced higher levels of EHR use as compared to the non-rural federally funded PCMHs warrants further investigation. Additional and adaptive technologies use may also be particularly beneficial for these disadvantaged and isolated populations.

Evidence from this dissertation may also suggest an impact of RECs that were funded as part of MU. As suggested in this study, REC targeted smaller PCMH practices that demonstrated increased odds for advanced EHR use, and rural practices experience higher levels of basic EHR adoption and use. However, many low-resource, rural practices are still in need of assistance, which indicates that policy regarding REC should be revisited with consideration for ongoing open-ended efforts focusing on small and rural practices as well as federally-funded practices (Green et al., 2015). This is an opportunity for future research.

Implications and Conclusions

The results from this study contribute to the current literature on EHR adoption and advanced use as well as impact policy, practice, and future research. The focus on advance EHR use and the creation of the advanced EHR use index are the primary contributions of this study. Specifically, using the advanced EHR index, this dissertation identifies practices with the least likelihood for successful advanced EHR use and provides suggestions for their improvement. This dissertation also provides implications for current policy initiatives concerning EHR use and the advanced EHR use index for future researchers to utilize.

This study assesses actual reported advanced use of EHRs as compared to simply adopting (having) specific EHR functions. This has important implications and expands the operationalized definitions for advanced EHR use in the literature. Future research must consider both having and using EHRs and explicitly note how each is being measured.

PCMHs represent the pinnacle of primary care and are experiencing higher EHR adoption levels and use compared to other primary care and office-based practices. However, given their stated reliance on EHRs to coordinate care, PCMHs' overall advanced EHR use is not as high as would be expected. Considering the stringent requirement for PCMH designation to

utilize technology like EHRs to coordinate care, the general primary care provider population (non-PCMHs) may continue to lag even further behind in advanced EHR use. Current policy initiatives should address these concerns by aligning MU criteria with PCMH designation requirements for care coordination.

By identifying the characteristics of PCMH practices with the least opportunities for successful EHR adoption and advanced use, the dissertation provides valuable insight for current policy initiatives. For advanced levels of EHR functionality, most of the factors associated with actual use are characteristics of the practice itself: size, ownership, and geographic location (rural). It is surprising that larger PCMHs as well as federally-funded centers are less likely to be advanced EHR users and that practice affiliation (being part of a network) has no association with advanced use. It is clear that EHRs may support smaller and isolated PCMH practices and create network-like relationships with other practices to coordinate care. The inverse and unique relationship found in this study between the number of providers in a PCMH (size) and the association with advanced EHR use further suggests the importance of PCMH designation for these smaller practices.

Overall, federally-funded PCMHs demonstrate significantly lower advanced EHR use across all functions and are significantly less likely than the other types of PCMH to be advanced EHR users. These findings suggest, in part, a digital divide (Wittie et al., 2014), in that poorer, disadvantaged patients served by federally-funded PCMHs are less likely to have access to technology that supports improved outcomes. Federally-funded health centers have an important role in caring for some of the nation's more challenging patients (Frimpong et al., 2013; Miller & West, 2007; Shin & Sharac, 2013) and should benefit from use of the advanced EHR capabilities to coordinate care (Bitton et al., 2012; Furukawa et al., 2014; Vest & Gamm, 2010). Since most

of the federally-funded PCMHs would likely be applying for the MU incentive under the Medicaid program, which only requires the practice to adopt, implement, or upgrade the EHR for the initial incentive payment, additional incentives and penalties should be explored to assist these federally-funded practices to utilize advanced EHRs functions for care coordination and to allow them to catch up with their private sector counterparts (physician-owned and hospital/system-owned PCMHs).

Similarly, rural physician-owned and rural hospital/system-owned practices are significantly less likely to use advanced EHR functions, even though the rates for EHR adoption and basic use are similar for rural and non-rural PCMH practices. These isolated rural practices would benefit from the EHR's advanced ability to electronically exchange information, connect with other practices (interoperability), and engage patients. In addition, EHRs may help isolated practices create network-like relationships with other providers. Many of the rural PCMH practices are using the fax-EHR function, indicating adoption of an EHR with advanced capabilities but not true advanced use. This is likely due in part to the increased network costs and lower internet connection speeds in rural areas. Current policy initiatives like MU should be expanded to assist rural practices to gain access to broadband internet, thus increasing the use of advanced EHR functions, especially information exchange and patient portals.

One of the main components of the MU policy and the PCMH designation is to engage patients. The patient portal is a tool for engaging patients. In addition to being able to provide medical information to patients (such as lab/test results, clinical summaries, and important clinical information), portals can be used to communicate with providers, send appointment reminders, check a patient's adherence to care, provide patient educational material, request follow-up information, and promote opportunities for patient self-management, among other

things (Arend et al., 2012). The overall adoption of patient portals for PCMHs is low. For a patient to find portals useful, all relevant information must be available and easy to use. This can only be accomplished once the medical data has been transformed into understandable patient health information and routinely exchanged electronically. Patients and practices must also have access to robust internet services. Requiring patients to manage multiple portals with differing types of data and without internet access is unrealistic. Thus, the focus first needs to be on access, interoperability, and electronic health information exchange through the EHR to then allow patient portals to be useful.

The MU policy is a driving force behind widespread EHR adoption (Hsiao & Hing, 2012). The PCMH practices seem to be progressing better than the overall eligible providers towards meeting Stage 2 of the MU policy. Findings in this study, however, indicate that the MU policy may not be the primary driving factor for advanced EHR use. Across all four of the EHR models, MU priority demonstrated no significant association with advanced EHR use. Other factors like care coordination and quality improvement initiatives appear to be more influential for advanced EHR use in PCMHs.

EHRs are neither the solution nor the outcome but rather are a tool to help facilitate well-coordinated and collaborative care. Based on the findings in this study, practices should focus on certain outcomes, like care coordination and quality improvement, both of which rely on EHRs as means for attaining these goals. The MU policy could be expanded to include requirements and incentives for practices to focus on care coordination agreements and networks, as well as quality improvement initiatives, beyond the specific adoption of EHR functions.

This study of PCMHs also suggests the initial and potential success of the MU policy. The Medicaid MU program (more likely to be federally-funded PCMHs in this study) has less stringent criteria for the initial incentive payment of Stage 1, requiring only that practices adopt, implement, or upgrade their EHR system, whereas Medicare providers (more likely physician and hospital/system-owned in this study) are required to meet all of the MU Stage 1 criteria in order to receive the first year's incentive payment (CMS.gov, 2015). Albeit an assumption because the actual PCMH practices' MU Program is unknown, the decreased likelihood for federally-funded PCMHs to be advanced EHR users may indicate the initial success of the Medicare MU Program over the Medicaid MU Program. The Medicare MU objectives include use of some advanced EHR features (like providing access to electronic health information to patients) (CMS, 2015a), which are highly adopted in the physician-owned and hospital/system-owned PCMH practices. Thus, the current "carrot and stick" method of Medicare MU appears to be working in certain advanced settings. Additional incentives and penalties should be explored to assist practices like the federally-funded PMCHs to utilize advanced EHRs functions for care coordination and catch up with their private sector counterparts (physician-owned and hospital/system-owned PCMHs).

This study is particularly pertinent regarding the recent MU policy expansion. As previously suggested, MU Stage 2 timelines should be expanded to allow more time for practices to comply with the advanced use criterion. In addition, as this section of the dissertation is being written, the proposed rule for MU Stage 3 is released for comments (March 20, 2015). Based on the proposed rule, EHR optional reporting is to begin in 2017 and becomes mandatory in 2018. Stage 3 of MU builds on the Stage 2 focus on interoperability while it expands the advanced EHR use and health information exchange to improve health outcomes through care

coordination, patient engagement, and patient-centered care. The proposed rule also aligns the MU objectives with other CMS quality improvement and reporting initiatives. Stage 3 maintains certain payment adjustment exceptions for providers that experience the "lack of availability of internet access or barriers to obtain IT infrastructure" (CMS, 2015b). The findings from this dissertation will provide opportunities for specific comments supported by current research, to improve implementation of MU Stage 3. The specific suggestions are as follows for MU Stage 3:

1. Align MU Stage 3 objectives for all providers with the PCMH criteria for care coordination, collaboration, and quality improvement, in addition to the CMS initiatives. As demonstrated in this study, the PCMH criteria result in more advanced EHR use by PCMH as compared to other office-based and primary care practices.
2. Provide financial and technical assistance to rural practices to overcome internet and network barriers, as opposed to providing exceptions. If all practices are not able to exchange information, the true benefits of EHRs may not be realized.
3. Provide practices with resources and training (providers and patient) for patient engagement. Simply requiring practices to use technology such a patient portals and personal health records will not improve the patients' ability to utilize and understand the process or the information. Furthermore, practices have learned to meet the standard without truly engaging patients. Under the MU Stage 2 requirement for patients to log into a patient portal, many practices have patients do this while waiting for a visit. In many instances, that is the extent of their patient engagement. Just logging into the system does not actively engage

patients. Providing useful information, resources, education, and the ability to communicate with providers does truly engage patients.

In summary, this dissertation describes the PCMH practice characteristics and contextual factors associated with advanced EHR use. This study also provides valuable findings concerning overall EHR adoption levels and use in PCMH practices. Recognizing that the MU policy is the driving force behind national widespread EHR adoption (Hsiao & Hing, 2012), this study also evaluates current PCMH progress towards meeting the advanced criteria for MU. These findings have significant implications for future policies, practice, and research. As advanced EHR use becomes more widespread, the findings from this study provide future researchers with robust baseline data and an advanced EHR use index. The measures of EHR adoption and use levels in this study, as well as the various models tested, provide frameworks for future studies to evaluate and track advanced EHR use in primary care.

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Appendix: Meaningful Use (MU) Variables in the NCQA/AAFP Survey

MU Measure	NCQA/AAFP Survey Question
Use **clinical decision support** to improve performance on high-priority conditions	Does your practice routinely use a computerized system that provides reminders for guideline-based interventions or screening tests to clinicians at the point of care?
Provide patients the ability to view online, download and transmit their health information within four business days of the information being available to the EP.	Do your patients log on to a patient portal to your practice EMR/EHR system to view their clinical summary? →"have the ability" = have portal (not use)
Provide clinical summaries for patients for each office visit.	Does your practice routinely provide patients with clinical summaries at the end of each visit?
Incorporate **clinical lab-test results** into Certified EHR Technology as structured data.	In your practice's EHR system, can you see patients' consultation reports and diagnostic study results (e.g., colonoscopy and diagnostic imaging) that were sent from other clinicians/services?
The EP who transitions their patient to another setting of care or provider of care or refers their patient to another provider of care should provide a **summary care record for each transition of care** or referral. Measure 1: • The EP who transitions or refers their patient to another setting of care or provider of care provides a summary of care record for more than 50 percent of transitions of care and referrals. Measure 2: • The EP who transitions or refers their patient to another setting of care or provider of care provides a summary of care record for more than 10 percent of such transitions and referrals either (a) electronically transmitted using CEHRT to a recipient or (b) where the recipient receives the summary of care record via exchange facilitated by an organization that is a NwHIN Exchange participant or in a manner that is consistent with the governance mechanism ONC establishes for the NwHIN. Measure 3: An EP must satisfy one of the following criteria: • Conducts one or more successful electronic exchanges of a summary of care document, as part of which is counted in "measure 2" (for EPs the measure at §495.6(j)(14)(ii)(B) with a recipient who has EHR technology that was developed designed by a different EHR technology developer than the sender's EHR technology certified to 45 CFR 170.314(b)(2). • Conducts one or more successful	Measure 1: When referring patients, does your practice routinely send a comprehensive medical summary of the patient's information to the consulting clinician or facility?] Measure 2: When referring patients, does your practice send an electronic comprehensive medical summary of the patient's information to the consulting clinician or facility? Measure 3: When referring patients, does your practice send an electronic comprehensive medical summary of the patient's information to the consulting clinician or facility via direct EHR electronic link or interface?

tests with the CMS designated test EHR during the EHR reporting period.	
Use **secure electronic messaging** to communicate with patients on relevant health information.	Percent of patients who have signed up for secured messaging (above 5%).