ELECTRONIC MEDICAL RECORD ADOPTION IN OKLAHOMA: RURAL – URBAN DIFFERENCES AND THE ROLE OF BROADBAND AVAILABILTY

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Abstract: Electronic medical records (EMRs) are an important part of the healthcare industry, providing legible and organized patient information along with the potential to reduce healthcare costs and improve health outcomes. However, physicians are still hesitant to adopt. As of 2011, the national EMR adoption rate was only 54 percent – exactly the rate seen in Oklahoma. This study specifically focuses on EMR adoption in Oklahoma. The purpose is to determine the characteristics that influence EMR adoption over time, how those vary across rural/urban locations, and explore the role of broadband availability. Broadband is required for EMR systems to interact with each other, which is an important part of the national “Meaningful Use” criteria. Logistic regressions were run with data from 2800 unique physician offices and the National Broadband Map to accomplish these goals. The data was meshed together to determine the number of broadband providers and average upload/download speeds available to each physician office. This is one of the first studies to explicitly look at the relationship between EMR adoption and broadband availability. The Federal Communications Commission created a pilot program, the Healthcare Connect Fund (HCCF), in late 2012 to expand broadband to healthcare providers – especially those in rural areas. Oklahoma also has a Regional Extension Center (REC) which assists physicians in the EMR adoption process. This research will provide evidence from Oklahoma related to the premise of the HCCF – that certain levels of broadband are needed for effective healthcare; and also provide policy suggestions to increase EMR adoption for Oklahoma’s REC. The results demonstrate that the determinants of adoption do vary between rural and urban practices. However, the results also indicate there is no statistical relationship between EMR adoption and broadband availability. Therefore, targeted policies may be important for increasing EMR adoption, but focusing on broadband availability is likely misguided.

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CHAPTER I

INTRODUCTION

Electronic Medical Records (EMRs) are computer-based health records for patients located in a single database (healthIT.gov). EMRs became a popular topic in the healthcare industry during the late 1990s, as experts recognized their potential to transform the healthcare industry. EMRs are meant to replace paper-based records by creating legible and organized patient information (Boonstra and Broekhuis 2010). The rationale behind the switch to EMRs includes the potential to reduce healthcare costs and improve health outcomes (Whitacre et al. 2009). Although many physicians are still hesitant to adopt EMRs, the national EMR adoption rates for physicians have increased significantly over time. Between 2001 and 2011 EMR adoption rates increased from 18 percent (Burt and Sisk 2005) to 54 percent (Jamoom et al. 2012) - exactly the rate seen across Oklahoma physicians in 2011.

An important piece of EMR adoption relates to interoperability among healthcare entities. EMRs are being used across healthcare infrastructure: hospitals, pharmacies, home health, etc. Interoperable EMRs allow for easier communication between providers caring for the same patient, such as primary care physicians and specialists, along with providing access to pharmacists regarding refill histories (Ayers et al. 2009;

Bates et al. 2003). Ayers et al. (2009) notes this interdependence in the healthcare industry creates a "network effect" among physicians. Researchers define the concept of a network effect as a positive impact on other users' perception of (in this case) EMRs, and may therefore lead others to become EMR users.

Adoption by individual physicians is also important since these visits often lead to additional healthcare encounters. Interoperability will allow healthcare providers access to longitudinal patient records, which is crucial for the long-term goal of improving health outcomes (Brailer 2005). The push for interoperability among EMR systems is currently in progress. Interoperability must be demonstrated by physicians in order to meet one threshold for "Meaningful Use" of an EMR system.[1] While interoperability research is underway, the main focus is still on the lack of physician adoption.

The majority of research on EMR adoption focuses on the influence of physician and practice characteristics on the likelihood of adopting an EMR system, including physician age, specialty, location, etc. An additional factor that may be of importance is the presence of a high-speed broadband connection, which is the foundation for an interoperable EMR system (FCC 2010). In particular, high-speed connections are required for EMR systems to share data with one another. However, a gap exists in the literature regarding the influence of broadband availability on EMR adoption.

A strong broadband connection is important for physician offices due to the increasing demand for electronic data collection and exchange (FCC 2010). Rural areas typically lag behind urban areas in broadband availability (FCC 2010; Whitacre 2010).

[1] "Meaningful Use" is a set of criteria related to incorporating EMRs into a healthcare setting. These criteria are defined by the Centers for Medicare & Medicaid Services (CMS).

Broadband access varies greatly across Oklahoma, with only 8.6 percent of metropolitan county residents lacking access, compared to over 40 percent in the most rural counties (Whitacre et al. 2013). However, the link between broadband availability and EMR adoption in Oklahoma is currently unknown. For example, does the availability of more broadband providers, or higher download speeds, impact the likelihood of a physician adopting an EMR? This question has yet to be explored.

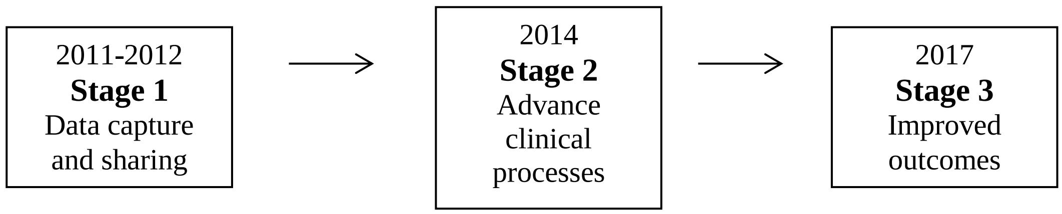
Other questions yet to be explored are the influence of nurse practitioners or physician assistants at a site and association with a hospital on EMR adoption. The presence of nurse practitioners and physician assistants are common in primary care facilities (Bates et al. 2003). King et al. (2013) notes that roughly one-quarter of ambulatory healthcare sites in the United States had a nurse practitioner or physician assistant present during 2011. While many researchers note the influence of hospital ownership on EMR adoption (Jamoom et al. 2012; Decker et al. 2012; Burt and Sisk 2005), few have explored the influence of hospital association. Practices associated with a hospital are only in collaboration, rather than the hospital having ownership of the practice. King et al. (2013) reported 12 percent of U.S. ambulatory healthcare sites were affiliated with a hospital as of 2011.

Several researchers discuss the influence of physician and practice characteristics on the adoption of EMRs. The most influential physician characteristics include age and specialty, while the most influential practice characteristics generally include location, size and ownership. Younger physicians and primary care specialist had higher adoption rates during 2001 – 2011 (Burt and Sisk 2005; Decker et al. 2012). Burt and Sisk's (2005) evaluation of data from 2001 – 2003 determined that EMR adoption rates were greater in Metropolitan Statistical Areas (MSA). However, a more recent study from Decker et al. (2012) found that adoption rates were greater outside MSAs. Thus, the impact of geography on EMR adoption is still somewhat undetermined. Larger practices and those owned by organizations had higher adoption rates compared to their counterparts (Burt and Sisk 2005; Decker et al. 2012).

Regardless of the factors that influence EMR adoption, the federal government is strongly encouraging physicians to adopt. The Obama Administration provided incentive funding for EMRs through the 2009 American Recovery and Reinvestment Act (ARRA) to encourage adoption (Whitacre et al. 2010). Healthcare facilities may receive funding from Medicare or Medicaid if the physician demonstrates "Meaningful Use" of EMRs (CMS 2013). The incentive funding is offered separately by Medicare and Medicaid to individual physicians rather than per practice site (Whitacre et al. 2010; CMS 2013). The incentive payments can be significant (up to $44,000 under Medicare and $63,750 under Medicaid). This is more than the costs of most current EMR systems designed for office use; however, these payments are spread over several years. Further, if physicians do not demonstrate "meaningful use" by 2015, they will experience payment reductions for Medicare reimbursements. However, many physicians have not yet adopted EMRs. Out of the 46% of Oklahoma physicians who had not adopted as of 2011, 43% were aware of the incentive programs available.

"Meaningful Use" is defined by the Centers for Medicare and Medicaid Services (CMS) Incentive Programs as a set of standards to improve healthcare in the United States (HealthIT.gov 2013). CMS has broken meaningful use criteria into three stages.

Figure 1. Meaningful Use Stages



Source: www.healthIT.gov

Stage 1 ended in 2012, and focused on data capture and sharing. Stage 1 also began engaging patients in their healthcare by providing an electronic copy of their health information- including lab results, medication lists, allergies, discharge summary, and procedures (CMS 2013). Meaningful use is currently in Stage 2, which deals with measuring advanced clinical processes. A more in depth focus of Stage 2 is on "more rigorous health information exchange, increased requirements for e-prescribing and incorporating lab results, electronic transmission of patient care summaries across multiple settings and more patient-controlled data" (HealthIT.gov 2013). Stage 2 also introduces patient portals which gives patients electronic access to their health information (CMS 2013). This expectation of electronic transmission of data is of particular interest to the current study since it requires a broadband connection. Stage 3 is expected to begin in 2017 to measure the improved outcomes of EMR use in the United States. Roughly three-quarters of physicians with EMR systems in 2011 reported they meet the criteria for "meaningful use" and almost one-half of those without an EMR system plan to use/purchase one within the next year (Jamoom et al. 2012).

There are two distinct incentive programs: one for Medicare, and one for Medicaid (Whitacre et al. 2010; CMS 2013). Eligible professionals qualifying for both incentive programs must choose which one to participate in (CMS 2013). Most physicians are eligible for the incentive programs; however, nurse practitioners and physician assistants are only eligible for the Medicaid incentive program. Eligible physician assistants are those practicing in a Federally Qualified Health Center or Rural Health Clinic lead by a physician assistant (Whitacre et al. 2010; CMS 2013).

The Medicare EMR Incentive Program for eligible professionals began in 2011 and continues for five consecutive years. The last year to enroll is 2014 and the adopters must demonstrate meaningful use each year of participation. Eligible professionals not demonstrating meaningful use will be subject to a 1% payment reduction, which increases each year to a maximum of 5%, beginning in 2015 (CMS 2013). Additionally, physicians participating in the Medicare program may also qualify for incentive payments if practicing in a Health Professional Shortage Area (HPSA). Physicians in a HPSA may receive a 10% increase to their annual EMR incentive payments (CMS 2013).

The Medicaid EMR Incentive Program is offered by participating states, continuing through 2021. Eligible professionals must meet a minimum Medicaid patient threshold of 30 percent (Whitacre et al. 2010). The last year to enroll is 2016 and participation years do not have to be consecutive. However, participating eligible professionals must demonstrate meaningful use. Medicaid eligible professionals will not be subject to a payment reduction unless the physician also treats Medicare patients. Therefore the payment reduction will be included in the Medicare reimbursement beginning in 2015 (CMS 2013). The payment reduction only applies to those not demonstrating Meaningful Use.

The Centers for Medicare and Medicaid Services has recognized the need for EMR standardization. Interoperability is meant to provide standardization in EMRs through vocabulary, structure, data transport, security and services (HealthIT.gov 2013). Interoperability is a requirement in Stage 2 of Meaningful Use. Brailer (2005) describes interoperability as an essential part of the future health care system. The United States healthcare system allows patients to visit multiple caregivers based on patient preference. However, patient records lack in integration- potentially creating errors, duplicated records, and minimal coordination. Interoperability will allow providers a "longitudinal medical record with full information about each patient" (Brailer 2005). The Office of the National Coordinator for Health Information Technology's (ONC) Office of Science and Technology (OST) is currently working to ensure a rapid development of standardization in EMRs. It is important to determine whether or not a link exists between EMR adoption and broadband availability because broadband is required for interoperability.

The literature review in the following chapter will provide detail on the physician and practice characteristics that researchers have determined will influence the adoption of EMRs. However, the literature lacks in focusing on characteristics most important to rural locations and the role broadband availability plays in EMR adoption.

The Federal Communications Commission's National Broadband Map came out in 2010, providing new insight and low level detail into where broadband is/is not available across the country. Several researchers focus on broadband availability in rural/urban locations but not specifically on the impact broadband availability has on health IT infrastructure. Items such as number of providers and available upload/download speeds could play a role in EMR adoption, particularly as physicians recognize the push towards interoperability that will dominate future EMR use.

This research aims to determine the factors that influence EMR adoption by physicians in Oklahoma. While previous research has uncovered physician and practice characteristics that influence adoption, not much attention has been paid to differences that might exist between rural and urban practices. In particular, no research has been explicitly focused on the role that varying levels of broadband infrastructure might play on EMR adoption. This study will mesh data from over 12,000 Oklahoma physicians during 2009-2011 with broadband availability data based on the location of each office. The study will focus on rural-urban differences in EMR adoption (including assessing changes over time) and will also explore the role of broadband availability. Thus, the specific objectives of this study are to:

i. Document the difference in adoption rates between rural and urban physicians, including among specific specialties / practice sites, over the 2009-2011 time periods.

ii. Determine the physician and practice characteristics that influence EMR adoption.

iii. Compare the characteristics that affect EMR adoption in rural and urban locations and whether these have changed over time, and determine if a network effect is present in Oklahoma.

iv. Determine whether or not a link exists between broadband availability and EMR adoption.

CHAPTER II

REVIEW OF LITERATURE

EMR research began in the late 1990s focusing on the adoption of computer systems in physician offices. The early research consisted of studies on the financial benefits of using EMRs and the perceived notion of improvement in patient care. The literature has changed little over time; however, EMR adoption has seen significant increases since the early 2000s. Research continues to evaluate physician's concerns about the high startup costs and improved patient care. Current research also evaluates physician and practice characteristics to determine those most likely to influence EMR adoption. More recent research focuses on interoperability, which provides standardization among EMR systems and is required for many of the hypothesized improvements in patient care to materialize.

Sullivan and Mitchell (1995) provided one of the earliest studies on this topic when they looked at the importance of desktop computers in primary care offices during 1984-1994. Their research consisted of a review of worldwide published literature over primary care physicians using desktop computers. Sullivan and Mitchell's objective was to measure the effects on patient consultation, clinical performance and patient care outcomes rather than the advantages for administration or research. Patients present a variety of undifferentiated problems to primary care physicians and the computer should easily store and generate the medical data (Sullivan and Mitchell 1995). Sullivan and Mitchell found that consultations involving a computer were longer and took away from "social" interaction with the patient. However, this may be offset by increased clinical performance (preventive care, reminders of recommended screening procedures, and increased efficiency and accuracy in prescribing medication) by the physician (Sullivan and Mitchell 1995; Makoul et al. 2001). Regardless of the notable difference in clinical performance, no change was found regarding outcomes of patient care. Sullivan and Mitchell claim patient care is the most important aspect and further research should be conducted on the effects using a computer has on the outcome of a patient's visit. Jamoom et al. (2012) determined roughly three-quarters of physicians in 2011 reported their EMR system had resulted in improved patient care outcomes.

Makoul et al. (2001) conducted a similar and more recent study of Sullivan and Mitchell's (1995) research, determining the communication patterns between physicians and patients in primary care offices with EMRs and those without EMRs. An observational study was conducted with three physicians who used an EMR system (EMR physicians) and three that did not have an EMR system (control physicians). Each physician saw 34 patients for the study period, totaling 204 observations. The main areas being assessed were a content analysis of communication tasks during the visits and a qualitative analysis on the physician's use of EMRs or paper charts (Makoul et al. 2001). The results concluded physicians using EMRs checked and clarified patient information more often than the control physicians, possibly due to the availability of a structured format for recording data. No significant difference was found between EMR physician visits and the control physician visits in terms of average time. The only difference was that during initial visits, EMR physicians took 37.5 percent longer than their counterparts (Makoul et al. 2001).

While many EMR studies focus on the physician side of EMR adoption, some researchers note the importance of a patient's perspective of an EMR system. Patients have a range of concerns regarding the use of a computer in the consultation; including reduced privacy and security, and loss of a physician's 'personal touch' (Ridsdale and Hudd 1994; Dolan 2012). However, researchers note that EMRs are improving efficiency and quality of care, along with continually increasing privacy and security of EMR systems (Bates et al. 2003; Olson et al. 1998; Pediatrics 1999). Unlike paper records, EMRs take note of anyone who views or prints a record from the database. However, regardless of their resistance, patients are still showing an overall confidence in EMR systems (Dolan 2012) and the physician EMR adoption rate continues to increase.

As EMRs became more popular in the healthcare industry, adoption rates began to slowly grow. Miller and Sim's (2004) research explains several reasons for the slow EMR adoption in the United States. The top reasons include high initial financial costs, slow and uncertain financial payoffs, and high initial physician time costs (Miller and Sim 2004). Miller and Sim (2004) reported the initial costs for an EMR system ranged from $16,000 to $36,000 per physician. During the initial period after implementation, physicians spent more time per patient for a period of months or even years, resulting in longer workdays, fewer patients seen, or both (Miller and Sim 2004). Underlying obstacles include challenges with technology, electronic data exchange, complementary changes and support, and the lack of financial incentives (Miller and Sim 2004).

However, Miller and Sim's (2004) research also documents numerous benefits of EMR adoption: easier viewing and organizing capabilities, documentation and care management, prescription and test ordering, messaging, analysis and reporting, and billing.

One interesting, but hard to measure aspect related to the adoption of EMR systems is the physician's attitude towards EMRs. Miller and Sim (2004) argue that physicians with a positive attitude towards EMRs were a gateway for those physicians less excited about the new implementation. Similarly, an analysis conducted by Wang et al. (2003) argues that the healthcare staff's (not necessarily the physician's) attitude could result in positive or negative effects from EMRs. Wang et al.'s (2003) study determined that when optimistic assumptions about the EMR system were used, the net financial benefits were significantly greater than when pessimistic assumptions were used. Wang et al. (2003) states that implementing an EMR system can yield positive returns on investment to health care organizations.

Another measure of physicians encouraging others to adopt an EMR is through the "network effect" mentioned in Chapter 1. The network effect is common in the healthcare industry due to interdependence among healthcare facilities, such as generalists, specialists and pharmacists (Ayers et al. 2009). Ayers et al. (2009) surveyed Florida physicians in 2005 on whether or not they had adopted an EMR system and if not, did they plan to adopt in the future. An overall network effect between physicians in the same county regarding EMR adoption was found among the surveyed physicians. More specifically, as specialists' adoption rates increased so did the adoption intentions of generalists in that same county, but not vice versa. However, as expected, there was no network effect among the generalist population or specialists in the same field of practice. This outcome was expected since physicians generally do not interact as much with other physicians in their respective field of medicine. While Ayers et al.'s (2009) study yielded some noteworthy results; the financial portion of adopting an EMR is still a concern for many physicians and practices (Miller and Sim 2004; Bates et al. 2003).

Medicare and Medicaid's Incentive Programs relieve a portion of the financial burden of EMR adoption. In the early 2000s EMR system's initial costs for a physician's office ranged from $16,000 to $36,000 per physician (Miller and Sim 2004). Eligible professionals that achieve "Meaningful Use" can receive up to $44,000 over five consecutive years from Medicare, and Medicaid offers up to $63,750 over six non-consecutive years (CMS 2013).

Many studies on EMRs have focused on both physician and practice characteristics that influence adoption. The Centers for Disease Control and Prevention's National Center for Health Statistics collect annual data on health care in the United States. Jamoom et al. (2012) analyzed the influence of physician age, practice size, physician specialty, and ownership influences on the adoption of EMRs. The results suggested that physicians under the age of 50, those in health maintenance organizations, and primary care specialists were more likely to adopt EMRs. Notably, EMR adoption rates also increased as the practice size increased (Jamoom et al. 2012).

Jamoom et al.'s (2012) results reinforce the findings of previous researchers. Burt and Sisk (2005) combined and evaluated two different surveys, the National Ambulatory Medical Care Survey (NAMCS) and the National Center for Health Statistics (NCHS), to determine percentages of physicians and practices using EMR systems. The physician and practice characteristics measured included age, specialty, gender, and practice size, scope of services, ownership, and location, along with whether or not EMRs were used. Burt and Sisk (2005) used a logistic regression to determine the association between using EMR systems or not (dependent variable) and the physician and practice characteristics (independent variables).

During the study period (2001-2003) adoption rates for physicians in office-based practices using EMRs was 17.6 percent. Practices with more physicians were more likely to use EMRs. EMR adoption rates increased each time another physician was added to the practice (suggesting that practice size is highly influential). The organizational structure of a practice was also found to be important. Health Maintenance Organizations (HMOs) were also more likely to use EMRs than practices owned by physicians. HMOs had a 52.7 percent EMR adoption rate while physician owned practices only had 15.6 percent. Burt and Sisk reported 87.8 percent of physicians in their study were located in MSAs in which 17.5 percent had adopted EMRs compared to 15.5 percent EMR adoption in non-MSAs. However, the difference was not statistically significant. The overall outcome of the study was that large physician practices and HMOs were more likely to use EMR systems.

Decker et al. (2012) conducted a more recent study of Burt and Sisk's findings on the use of EMRs. Decker et al. (2012) followed EMR adoption percentages in office-based practices from 2002-2011 using the NAMCS data. The change in use of EMRs from 2002 to 2011 was summarized and then used as a dependent variable (i.e. 1=change occurred). The changes were then regressed (using logit models) against physician and practice characteristics. Decker et al. (2012) found a significant change in the number of physicians using EMR systems, a 38 percent increase from 2002 to 2011. The increase in use of EMRs was greater for primary care practices, younger physicians, large physician practices, practices owned by organizations, and physicians outside of MSAs.

The biggest difference in Burt and Sisk's (2005) and Decker et al.'s (2012) results was the shift in adoption for physicians located in MSAs and those outside MSAs. During 2002 EMR adoption inside MSAs was 19.2 percent and outside MSAs was 13.3 percent. The percentages significantly increased to 53.4 percent inside MSAs and 60.5 percent outside MSAs in 2011. As adoption rates continue upward the gaps between physician and practice characteristics grow larger. However, the gap between MSA/non-MSAs remains relatively close.

Several researchers have evaluated adoption rates between rural and urban areas. Singh et al. (2012) evaluated the adoption of EMRs in rural and urban areas through a national survey. The study consisted of physician practices with one or more primary care physician. The locations were broken up into urban, large rural, small rural and isolated based on Rural-Urban Commuting Area (RUCA) classification codes. A random sample of physician offices was derived from a sample frame created by American Medical Information. The sample frame included offices from each of the four RUCA codes. Thus, three-quarters of the physician offices were located in rural areas. Singh et al. (2012) found no significant relationship between rural locations and computer use, Internet activity and EMR adoption. Singh et al.'s (2012) findings were in agreement with two other national studies. DesRoches et al.'s (2008) and Xierali et al.'s (2013) studies did not report a significant relation between rural/urban location and EMR adoption. While rural areas do lag behind urban in terms of EMR adoption, the difference is not statistically significant (Xierali et al. 2013). None of these studies (Singh et al. 2012, DesRoches et al. 2008, Xierali et al. 2013) explicitly modeled whether or not characteristics that impacted adoption in rural areas were the same as those in urban ones.

There has not been as much research related to broadband availability and physician practices. Singh et al.'s (2012) national study of randomly selected physician offices found that 85 percent of physician offices had broadband internet access, and 86 percent reported computer use for office functions. However, nine percent were completely without Internet connections in urban and large rural areas, six percent in small rural, and seven percent in isolated areas. Approximately one percent of small physician offices across the nation face a broadband connectivity gap and seven percent of those physician offices are located in rural areas (FCC 2010).

The broadband connectivity gap between rural and urban areas is commonly referred to as the "digital divide" (Mills and Whitacre 2003; Bell et al. 2003; Whitacre and Mills 2007). Bell et al. (2003) assessed the possibility of a digital divide among physician offices in Orange County, California. The data consisted of 307 surveyed offices in high-minority, low-income neighborhoods and lower-minority, higher-income areas. The purpose of the study was to determine if a gap existed in broadband availability between the geographic locations. Bell et al. (2003) found that Internet access was equal among physician offices in the different neighborhoods and interests/concerns regarding EMR systems were consistent across Orange County. Overall, the study suggests that physician offices "provide a bridge across the digital divide" and further research should be done to determine if the results are true for other areas of the United States (Bell et al. 2003). Notably, however, this research is over 10 years old and is not representative of the current status of EMR requirements or broadband availability.

EMR systems come with a wide range of computerized capabilities including note taking, prescribing and viewing lab results. Physicians can choose to utilize only a basic EMR system or a system with a wide range of capabilities. Beginning with 2007 data, Decker et al. (2012) analyzed EMR systems with basic computerized capabilities. The basic functions include the ability to record information on patient demographics, compile problem lists, document medications, store clinical notes, view laboratory and imaging results, and execute computerized prescription ordering (Decker et al. 2012). The change during 2007-2011 in adoption of EMR systems with basic computerized capabilities was greater for primary care practices. EMR adoption was 41 percent by 2011, compared to non-primary care practices at 32 percent by 2011. Basic functions were also more common in organization-owned practices. Even with the significant increases in adoption of EMRs, some physicians and practices are still reluctant to utilize EMR systems (Burt and Sisk 2005; Decker et al. 2012).

The previous studies primarily focus on primary care practices; however, EMR adoption is also important in hospitals. Jha et al. (2009) measured EMR adoption rates in hospitals across the United States during 2008. All acute care general medical and surgical member hospitals were surveyed. The questions revolved around the use of EMRs in the given hospital and were divided into three definitions: comprehensive, basic with physicians' and nurses' notes, and basic without physician and nursing notes

(Jha et al. 2009). The results determined that 1.5 percent of hospitals had a comprehensive EMR system, 7.6 percent had a basic system including notes, and 10.9 percent had a basic system without notes. However, many hospitals stated that their lab reports, radiologic images, medication lists, and decision-support functions are available in electronic format (Jha et al. 2009).

A more recent study on EMR adoption in United States hospitals takes place during the wave of "Meaningful Use" regulations. DesRoches et al. (2013) conducted a follow up on Jha et al.'s (2009) study of EMR adoption in United States hospitals. In 2012, 44.0 percent of hospitals had at least a basic EMR system and 16.7 percent had comprehensive systems (DesRoches et al. 2013). In regards to the Meaningful Use regulations, 42.2 percent of U.S. hospitals meet all the core criteria for Stage 1 and 5.1 percent meet all the criteria for Stage 2. Penalties will begin in 2015 for those physicians who are not yet "meaningfully using" EMR systems (CMS 2013).

DesRoches et al. (2013) also note that rural hospitals continue to lag behind their urban counterparts in adopting at least a basic EMR system. In 2012, 23.1 percent of rural hospitals had at least a basic EMR system compared to 28.8 percent in urban hospitals (DesRoches et al. 2013). However, during 2010-2012 rural hospitals experienced a larger percent change in EMR adoption than urban hospitals (DesRoches et al. 2013). DesRoches et al. (2013) suggest that in order to minimize the gap between rural and urban hospitals, policy makers must assist in completing nationwide health IT infrastructure.

In order to achieve nationwide health IT infrastructure, broadband must be available for physician offices. A "first-of-its-kind map" became available in 2010 providing locations of broadband availability at the census block level of detail. The 2010 National Broadband Map provides data by state at the metro, micro and noncore levels. Whitacre et al. (2013) summarize this data and show that broadband availability varies greatly across states. As noted in chapter 1, factors such as number of providers and available upload/download speed could be important to EMR adoption.

The Federal Communications Commission's (FCC) Rural Health Care Program is currently implementing a nationwide program focused on improving health IT infrastructure. The Healthcare Connect Fund (HCCF) was created on December 12, 2012 to expand broadband to eligible healthcare providers. Those eligible include public or not-for-profit hospitals, rural health clinics, community health centers, post-secondary educational institutions/teaching hospitals/medical schools, or a consortium of these. Non-rural healthcare providers may qualify if they belong to an association with more than 50 percent rural healthcare provider sites. The HCCF was built off results gathered from 50 pilot programs which tested the role of broadband in improving quality and reducing costs associated to healthcare in rural locations. The goal of the HCCF is to increase broadband for healthcare providers, deploy broadband healthcare networks, and maximize cost-effectiveness of the healthcare program (FCC 2013). Eligible healthcare providers can receive a 65 percent discount on eligible expenses which include broadband equipment and services. Those belonging to an association can also receive a discount on healthcare provider-constructed and owned network facilities. Funding began January 1, 2014 (July 1, 2013 for those participating in the pilot program). The HCCF program is capped at $150 million annually for upfront payments.

Despite this pilot program, no existing study explicitly models the role of broadband availability on the EMR adoption decision. The following chapter details the data and methodology used to accomplish this objective, as well as the other objectives laid out in the initial chapter.

CHAPTER III

DATA AND METHODOLOGY

The primary objective of this study is to identify characteristics that impact EMR adoption in Oklahoma. The specific objectives are to determine which physician and practice characteristics affect the adoption decision, how these may change across rural and urban locations, and whether broadband availability impacts EMR adoption. This chapter lays out the data and methodology that will be used to accomplish each objective.

3.1 Data

Two data sources are used for this research. SK&A surveys provide the physician and practice level data for Oklahoma physicians during 2009-2011. This data includes questions relating to EMR adoption. The National Broadband Map provides data related to broadband, including the number of providers and upload/download speeds available to each physician.

3.1.1 EMR Data

Most of the physician and practice level data for this study comes from SK&A, a private company specializing in health-related data. SK&A's database information is collected from company and corporate directories, state licensing information, trade publications, and many other directories made available to the public. Supplemental information such as ownership, organization size, practice specialty, and affiliations is gathered by SK&A research associates through telephone surveys. Each database constructed by SK&A is continuously telephone-verified and audited by BPA Worldwide (SK&A, A Cegedim Company 2014).

The data obtained for this research includes information on roughly 12,000 physicians across Oklahoma's 77 counties. Because many of these physicians work in practices with other doctors, approximately 2,800 unique physician offices are included in the dataset. The survey information includes physician names, addresses, location, physician age, specialty, ownership, practice size, EMR adoption, and types of EMR applications used. Location is recorded at the street address level, and can be aggregated to many different measures of rurality. This research will use rural/urban as location classifications rather than smaller categories of metropolitan/micropolitan/non-core. The reason for a broader classification of location is due to this being one of the first times research has focused on the rural/urban differences and role of broadband availability on EMR adoption.

For this research rural will be defined as non-metropolitan. Non-metropolitan is defined at the county level. Non-metro counties do not contain a Metropolitan Statistical Area (MSA) and are not economically linked to an MSA. An MSA contains at least one urbanized area with a population greater than 50,000. The physician level data from 2009-2011 is useful in observing changes in EMR adoption rates across Oklahoma and over time.

The existing literature suggests that a number of physician and practice characteristics could have an influence on the adoption of EMRs. These are shown in Tables 1 (physician characteristics) and 2 (practice characteristics) below, along with the percentage of Oklahoma physicians/practices in each category during 2009-2011. The SK&A data were collected at the physician level. Therefore, in order to properly calculate the practice level statistics found in Table 2, co-practicing physicians were merged together to form a data set resulting in roughly 2,800 practice sites.

The characteristics for physicians known to impact EMR adoption include age and specialty (Burt and Sisk 2005; Decker et al. 2012; Jamoom et al. 2012). The characteristics for practices that have been shown to impact EMR adoption include practice type, number of physicians and location of practice (Burt and Sisk 2005; Decker et al. 2012; Singh et al. 2012). These characteristics are summarized for the current dataset in Tables 1 and 2.

The physician specialties and practice types listed are the top five specialties in Oklahoma as identified in the survey for 2011. However, not everyone listed in the dataset reports a specialty due to many being office managers, directors, receptionist, etc. Table 2 does provide the number of physicians practicing at a given site, along with the patient volume at each site. As seen in Table 2, over half of Oklahoma practice sites are single physician practices and the majority of those sites have relatively low patient volume. Medicare and Medicaid represent the percentage of Oklahoma practice sites accepting the respective insurance payments. Hospital Association and Ownership represent the percentage of practice sites associated with or owned by a hospital. Those practices associated with a hospital are only in collaboration; therefore the hospital has no control over the practice's decisions.

Table 1. Descriptive Statistics (Percentage) – Oklahoma Physician-Level Data

Characteristics	*2009*	*2010*	*2011*
Age			
Under 50 years	3.7	17.6	18.3
50 years and over	4.0	21.5	22.2
Unknown	92.3	60.9	59.5
Specialty			
Family Practitioner	10.4	11.7	13.3
Internist	3.6	4.0	4.5
Orthopedic Surgeon	2.2	2.3	2.9
Pediatrician	2.5	2.8	2.9
Obstetrician/Gynecologists	2.4	2.6	2.8
Other	78.8	76.6	73.6
Doctor of Osteopathy (D.O.)	8.4	9.0	9.4
Location			
Rural	28.4	28.0	27.1
Urban	71.6	72.0	72.9
Observations	11,745	11,889	12,341

Source: SK&A, A Cegedim Company.

Table 2. Descriptive Statistics (Percentage) – Oklahoma Practice-Level Data

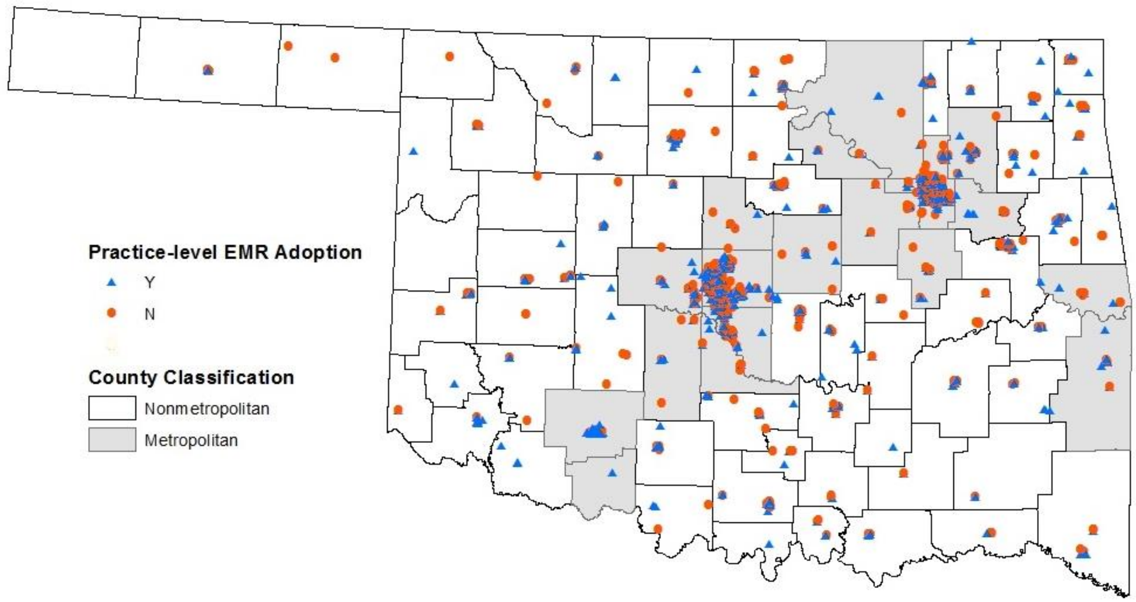
Characteristic	*2009*	*2010*	*2011*
Type of Practice			
Family Practice	21.9	22.3	20.7
Multi-Specialty	10.1	9.0	10.4
Internal Medicine	7.2	7.4	7.4
Psychiatric	5.3	5.7	6.2
Obstetrics/Gynecology	5.2	5.1	5.3
Other	50.3	50.5	50.0
Number of Physicians			
1	57.0	58.6	58.9
2-3	25.4	24.0	24.2
4+	17.6	16.6	15.9
Patient Volume			
0-50	81.3	81.0	79.0
51-100	14.3	14.1	15.4
100+	4.4	4.9	5.7
Location			
Rural	68.5	69.0	69.8
Urban	31.5	31.0	30.2
Medicare	70.1	79.1	80.5
Medicaid	58.6	68.8	70.5
Hospital Association	8.9	9.1	11.1
Hospital Ownership	11.7	9.5	7.8
Observations	2,426	2,579	2,811

Source: SK&A, A Cegedim Company.

Throughout this research more emphasis will be placed on the practice level data (Table 2) with the argument that if a practice has adopted an EMR, then all physicians at that location will be using the EMR. The data suggests that of the physician practices that have adopted an EMR, 98 percent of physicians in that practice are using the available EMR. The physician level data lacked entries in age, specialty, etc. and also included many individuals without a medical degree or not practicing medicine (office managers, directors, receptionists). Thus, the practice level data is much more complete.

Figure 2 represents the location of Oklahoma practices during 2011. Urban (metropolitan) counties are shaded on the map. The triangles represent practices that have adopted and the circles represent those that have not adopted an EMR. As expected, many practices are located in the urban areas of Oklahoma in what looks like an even mix of adopters and non-adopters. However, the northwestern portion of the state appears to have more practices that have not adopted an EMR.

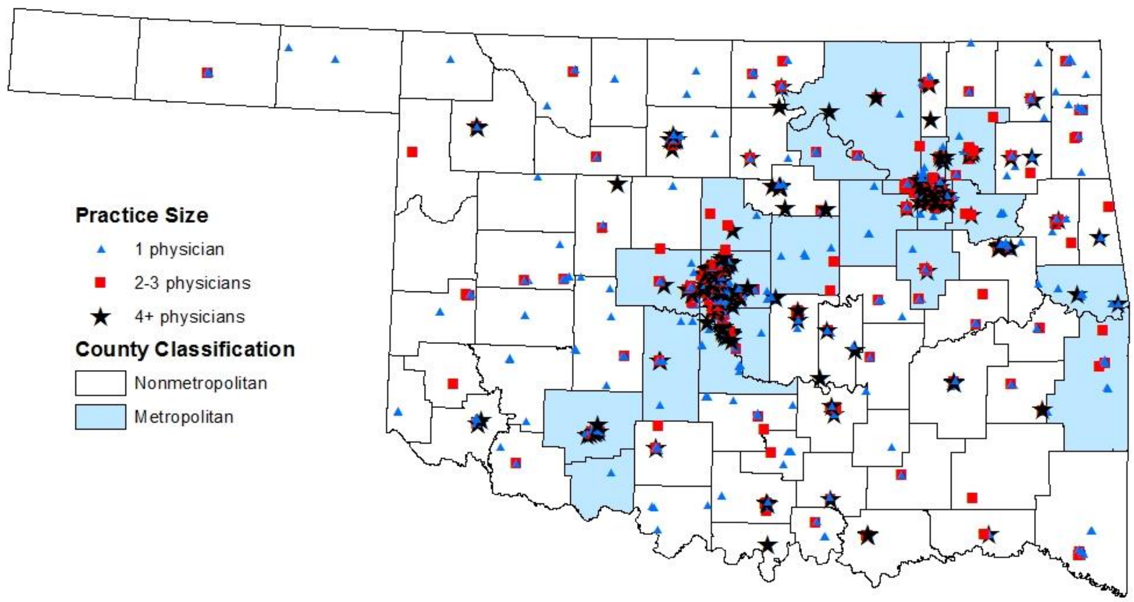
Figure 2. Location of Oklahoma Practices by Electronic Medical Record Adoption.



Source: SK&A, A Cegedim Company.

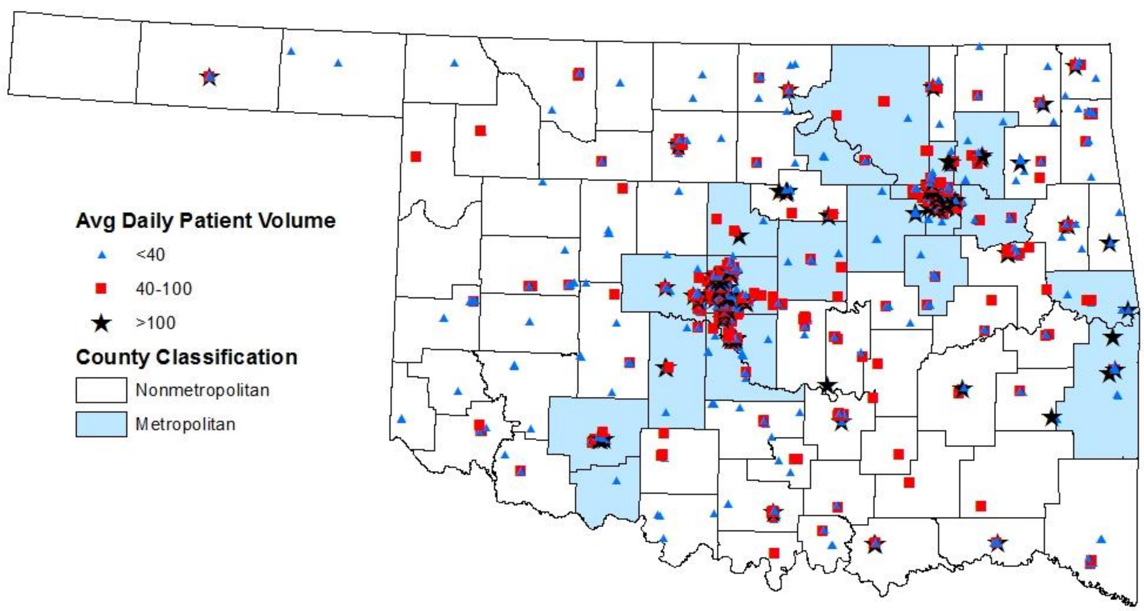
Figure 3, 4, and 5 display the Oklahoma practices by practice size, average daily patient volume, and whether or not the practice is associated with a hospital. In each figure the urban (metropolitan) counties are shaded. In Figure 3 (practice size) solo physician offices are represented by triangles, practices with two-three physicians by a square, and practices with four or more physicians are indicated by a star. In Figure 4 (average daily patient volume) practices seeing less than an average of 40 patients a day are represented by a triangle, practices seeing between 40-100 by a square, and practices seeing on average over 100 patients a day are indicated by a star. In Figure 5 (hospital association) practices associated with a hospital are represented by a star.

Figure 3. Location of Oklahoma Practices by Practice Size.



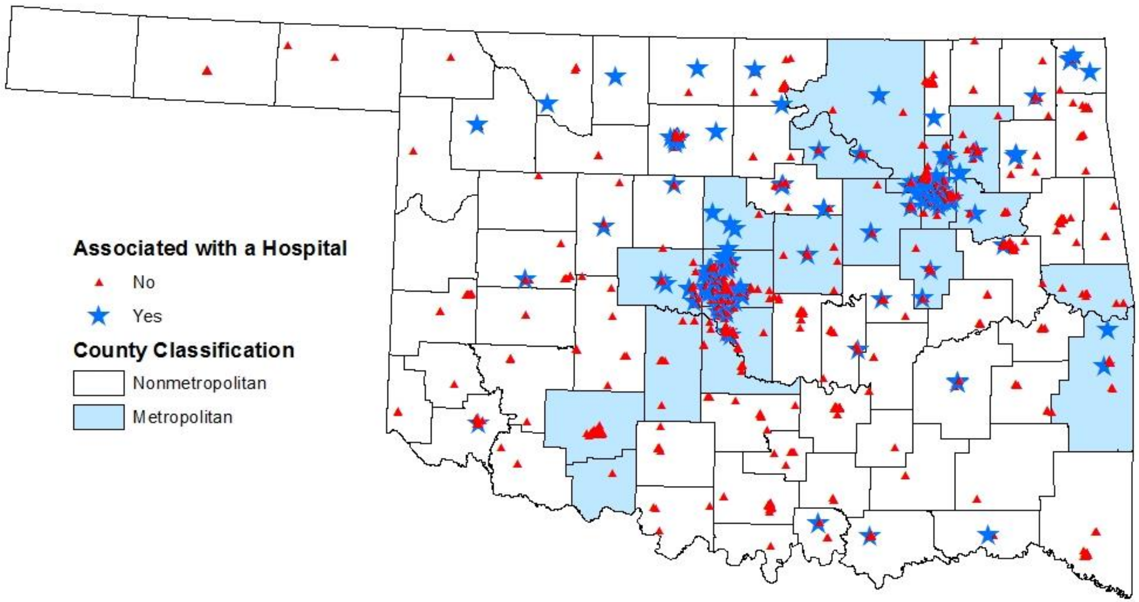
Source: SK&A, A Cegedim Company.

Figure 4. Location of Oklahoma Practices by Average Daily Patient Volume.



Source: SK&A, A Cegedim Company.

Figure 5. Location of Oklahoma Practices by Hospital Association.



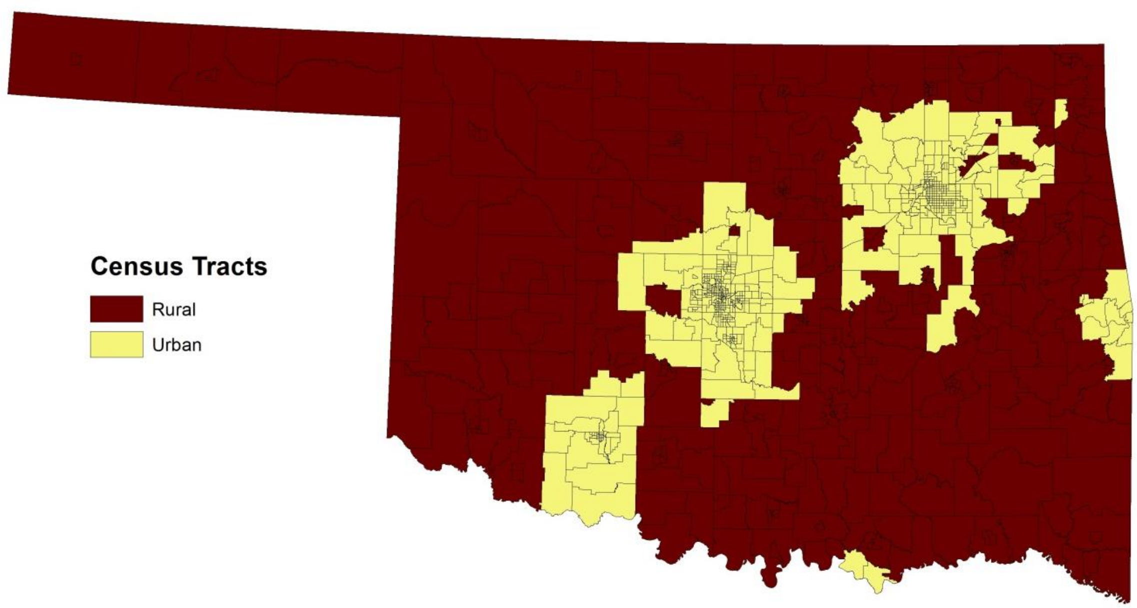
Source: SK&A, A Cegedim Company.

3.1.2 Broadband Data

The National Broadband Map was created and is maintained by the National Telecommunications and Information Administration, in collaboration with the Federal Communications Commission. The map became available in 2010, providing a detailed listing of broadband availability and capability across the United States by census block. The National Broadband Map includes data on the number of providers in a location and the average upload/download speed. For the purpose of this study, the broadband data was aggregated to the census tract level in the hopes of increasing the amount of variation in the data.

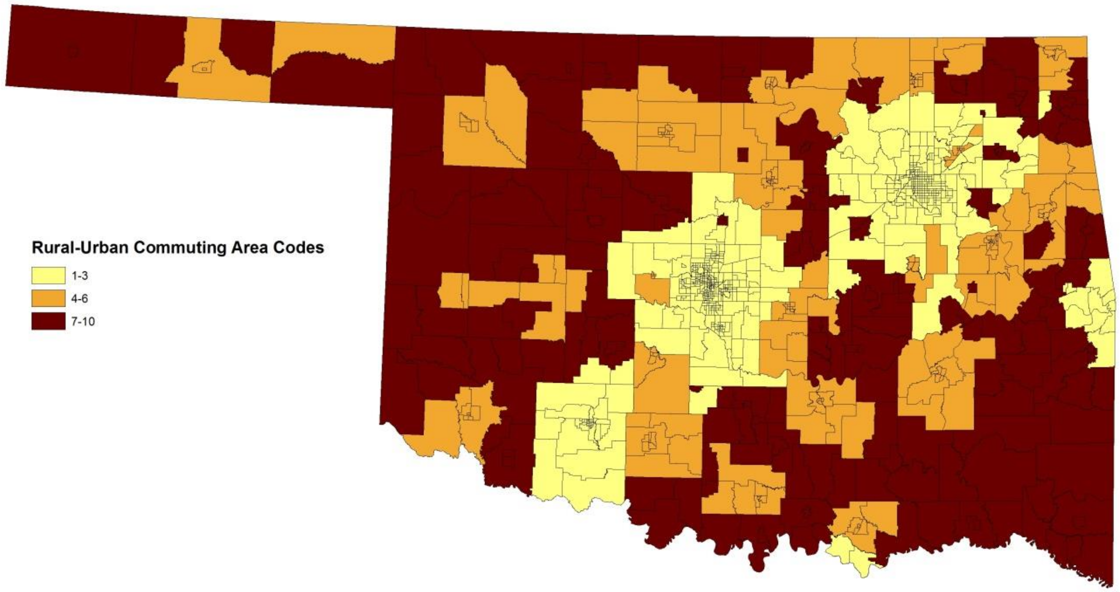
Figure 6 presents the rural and urban census tracts based on the Rural-Urban Commuting Area Codes (RUCAs). The RUCAs define each census tract by measures of population density, urbanization, and daily commuting. A number from 1-10 is assigned based on the size and direction of the primary commuting flows, where 1 is the most urban and 10 is the most rural (USDA ERS 2013). Figure 7 presents the census tracts broken out into three categories of RUCA with 1-3 being urban and 7-10 being the most rural. Figures 8-10 represent the number of providers, average maximum upload speed, and average maximum download speed per Oklahoma Census Tract in 2011. Note that Figure 9 (upload speed) and Figure 10 (download speed) are exactly the same, which could suggest a problem with the data or that providers are very consistent with their speed offerings. Interestingly, the locations with the most providers tend to be more rural (or at least suburban) while higher average maximum upload/download speeds tend to be located in urban locations.

Figure 6. Rural-Urban Census Tracts.



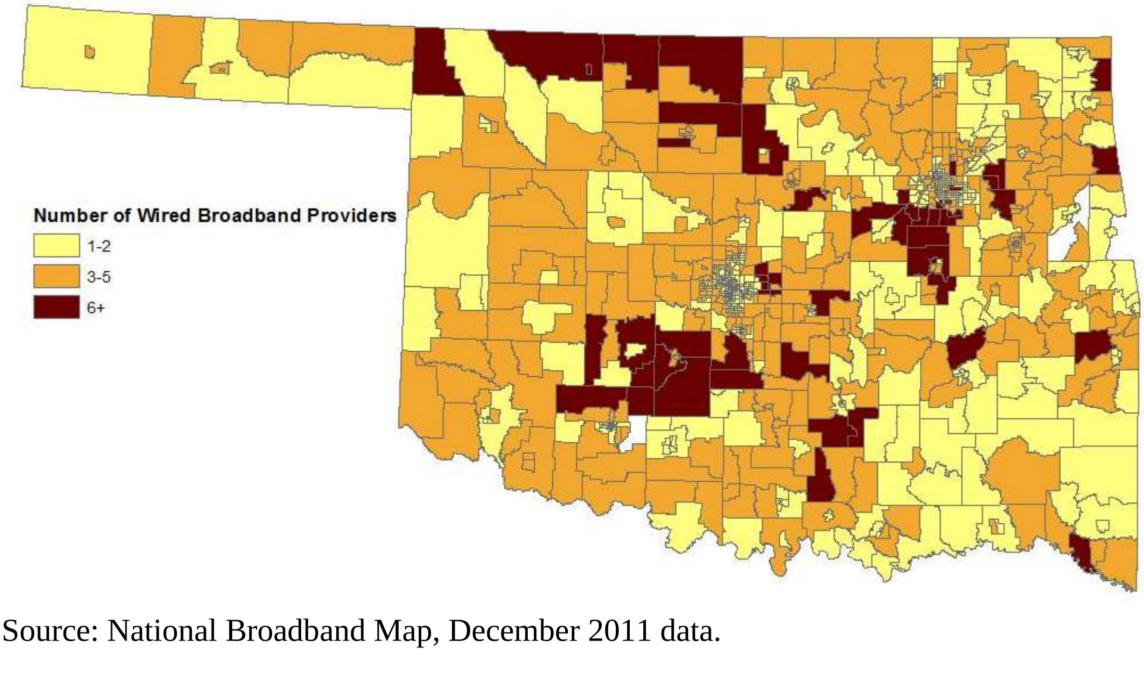
Source: United States Department of Agriculture Economic Research Service.

Figure 7: Rural-Urban Commuting Area Codes.



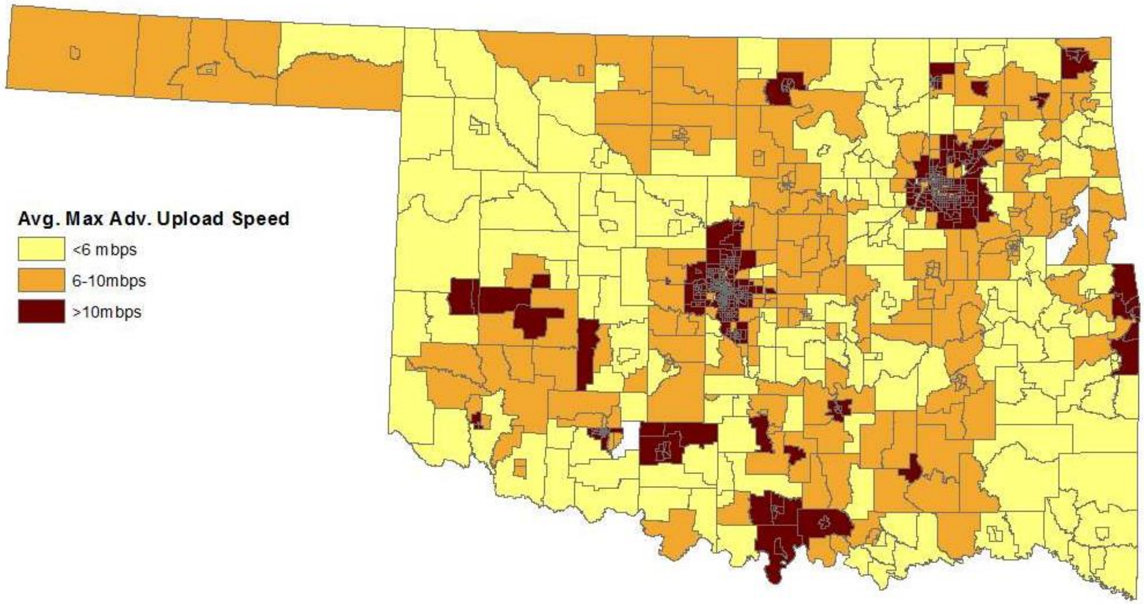
Source: United States Department of Agriculture Economic Research Service.

Figure 8. Number of Broadband Providers per Oklahoma Census Tract, 2011.



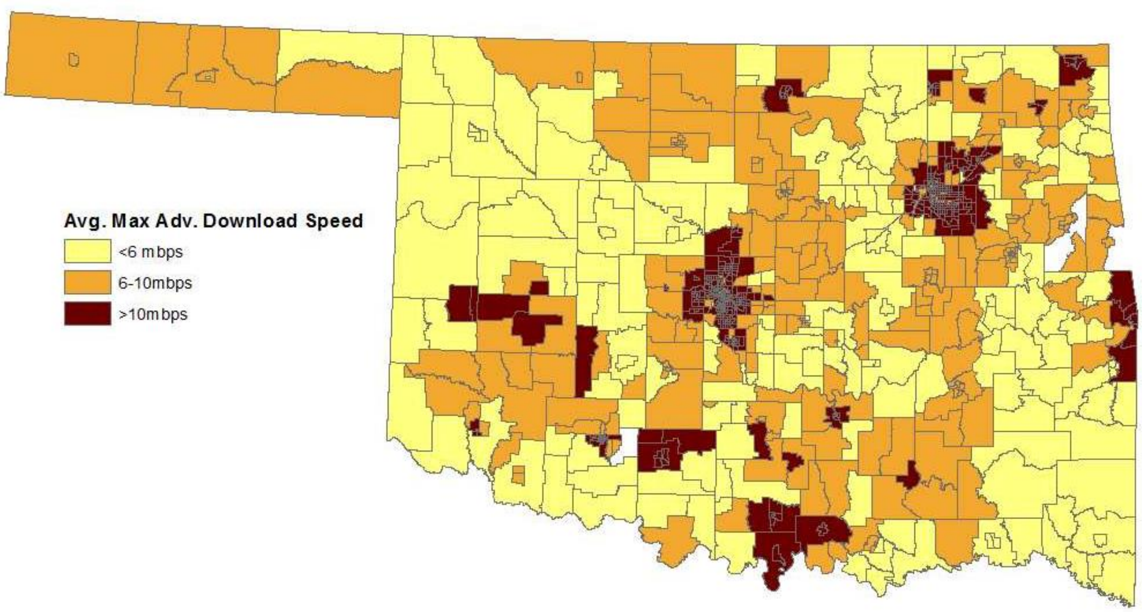
Source: National Broadband Map, December 2011 data.

Figure 9. Average Maximum Upload Speed by Oklahoma Census Tract, 2011.



Source: National Broadband Map, December 2011 data.

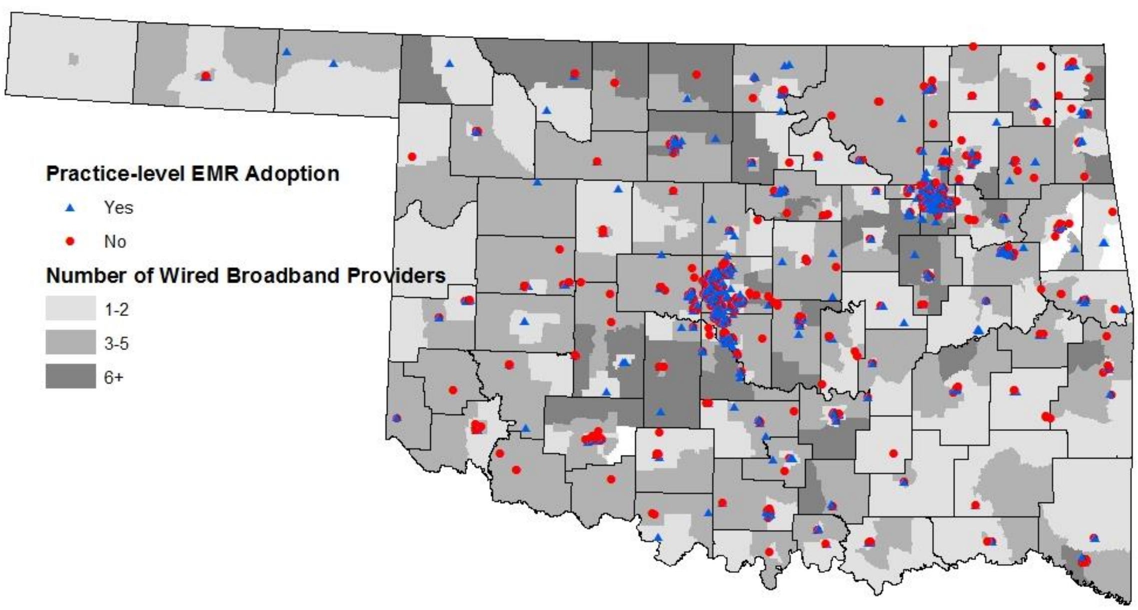
Figure 10. Average Maximum Download Speed by Oklahoma Census Tract, 2011.



Source: National Broadband Map, December 2011 data.

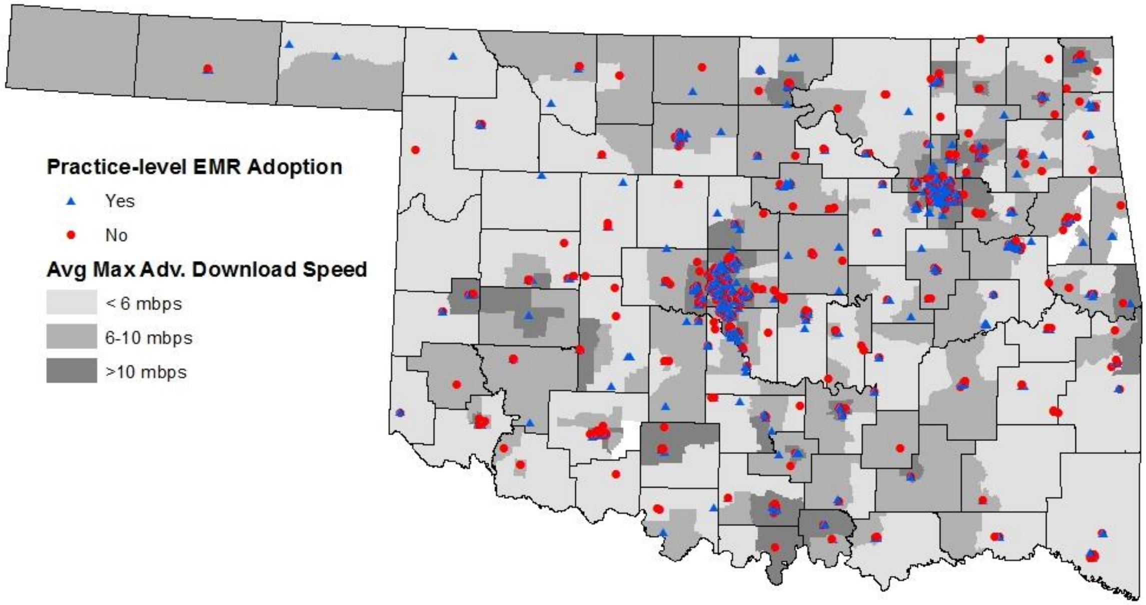
The 2011 version of the SK&A data set will be meshed with information available from the National Broadband Map. Merging the two data sets will allow for matching the specific addresses of Oklahoma physician offices with the levels of broadband (such as the number of providers or upload/download speeds) available to them. Figures 11 and 12 display the location of practices by the number of broadband providers and average upload/download speeds, respectively, along with EMR adoption. In both figures practices that have adopted an EMR are represented by triangles. The number of broadband providers / average speed is represented by shaded areas, with the darkest areas having six or more providers / fastest speeds. Physicians clustered in the most urban areas have access to a low number of providers but the fastest average upload/download speeds.

Figure 11. Location of Oklahoma Practices by EMR Adoption and Number of Broadband Providers



Source: SK&A, A Cegedim Company and National Broadband Map, December 2011.

Figure 12. Location of Oklahoma Practices by EMR Adoption and Average Upload/Download Speed



Source: SK&A, A Cegedim Company and National Broadband Map, December 2011.

Table 3 displays the average number of providers and average upload/download speeds available to practices in Oklahoma during 2011. The table also includes the minimum and maximum availability per rural/urban location. There is no statistical difference between the numbers of providers per practice location. The average upload and download speeds available to Oklahoma practices are exactly the same, which is also seen in figures 9 and 10 (maps displaying upload and download speeds by census tract). The differences in speeds are statistically significant across rural and urban locations.

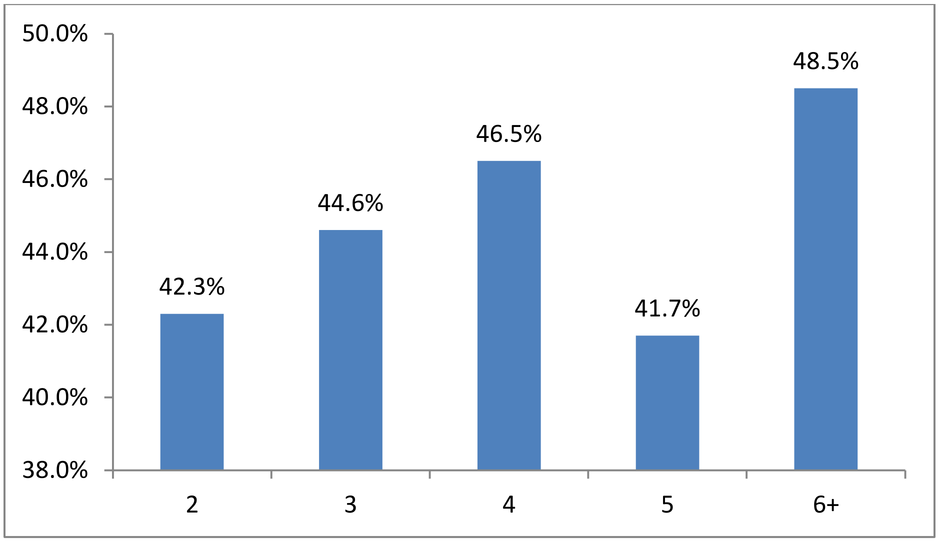
Table 3. Broadband Availability and Capability for Oklahoma Practices, 2011.

	Rural	*Urban*
Average Number of Providers	2.73	2.67
Min	0	1
Max	8	14
Average Upload Speed	6.99	7.63***
Min	0	4.5
Max	9	9
Average Download Speed	6.99	7.63***
Min	0	4.5
Max	9	9
Observations	2744	

Source: National Broadband Map, December 2011.
Note: Speeds are categorical; 7 represents speeds of 10-25 mbps, while 8 is 25-50 mbps.

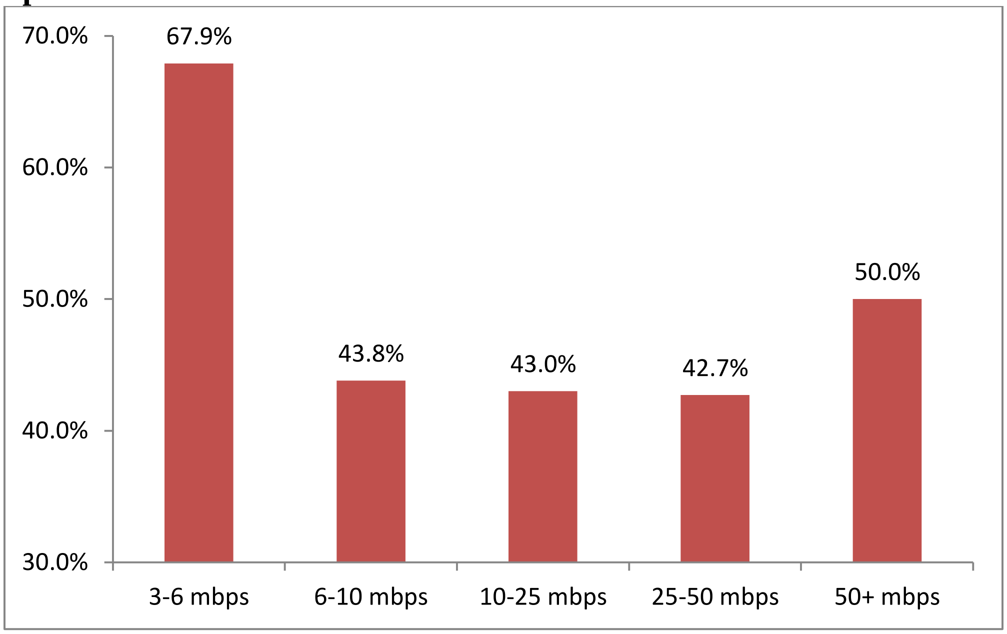
Figures 13 and 14 display the EMR adoption rate by the number of broadband providers and average upload/download speeds available per census tract, respectively. Higher adoption rates are present in areas with the highest number of providers but also in areas with the slowest upload/download speeds. There does not appear to be a relationship between EMR adoption rates and broadband availability. The next section details a logistic regression model that will allow for a more formal test of the influence of broadband on EMR adoption.

Figure 13. Electronic Medical Record Adoption by Number of Broadband Providers.



Source: SK&A, A Cegedim Company and National Broadband Map, December 2011.

Figure 14. Electronic Medical Record Adoption by Average Upload/Download Speed.



Source: SK&A, A Cegedim Company and National Broadband Map, December 2011.

3.2 Methodology

As noted in Chapter I, the primary objective of this study is to determine the factors that influence EMR adoption in Oklahoma. More specifically, this research will aim to determine these four specific objectives.

> [1]: Document the difference in adoption rates between rural and urban physicians, including among specific specialties / practice sites, over the 2009-2011 time periods.

The differences in EMR adoption rates between rural and urban physicians/practices are a summary of statistics calculated from the SK&A data set. Specialty-specific differences will also be documented. By documenting adoption rates and running t-tests for the differences across rural and urban areas, significant differences across these areas can be identified.

> [2]: Determine the physician and practice characteristics that influence EMR adoption.

A logistic regression model is used to determine which characteristics are most influential on EMR adoption. The dependent variable (EMR adoption) of the logistic regression is binary in which the two values are "yes" and "no", determining whether or not the practice site adopted an EMR system. The models noted below will be run using the practice level data, based on the argument that if a practice has adopted an EMR then all physicians at that practice site will be using the EMR. The independent variables include those suggested by the existing literature as well as original contributions, most notably the levels of broadband availability. Model #1 will determine the practice characteristics that influence adoption.

Model #1

$y_i* = \beta_0 + \beta_1$*Practice Specialty* + β_2*Number of Physicians* + β_3*Patient Volume* + β_4*Medicare* + β_5*Medicaid* + β_6*Association* + β_7*Ownership* + β_8*DO* + β_9*NP/PA at Practice* + β_{10}*Only a NP/PA at Practice* + β_{11}*County Adoption Rate* + β_{12}*Urban* + ε_i

$y_i = 1$ if $y_i^* \geq 0$

$y_i = 0$ if $y_i^* < 0$

Where y_i^* is an unobserved measure of the relative costs/benefit associated with EMR adoption and y_i is the actual observation of EMR adoption. Thus, $y_i = 1$ (EMR adoption) is observed if the benefits of adopting outweigh the costs, and $y_i = 0$ otherwise. β_0 is the intercept term and $\beta_{1\text{-}12}$ are the coefficients of the characteristics corresponding parameters. Doctor of Osteopathy (DO), Nurse Practitioner (NP), and Physician Assistant (PA) are represented in the model as to whether or not one is present at the practice site. The county EMR adoption rate (which essentially models the "network effect") was defined at the practice-level by removing the current practice observation in an effort to deal with potential endogeneity. Most other variables (practice specialty, number of physicians, Medicare, Medicaid, association, ownership, D.O., NP/PA at practice, only a NP/PA at practice, and location) will be modeled via a number of dummy variables. For example, 'practice specialty' will include four dummy variables (for multi-specialty, internal medicine, psychiatric, and obstetrics/gynecology) as shown in Tables 2. Similarly, number of physicians will include dummy variables for one and 2-3 physicians in the practice and will be interpreted relative to the default of four or more physicians. Because this is a logistic regression, the actual formula for determining the probability of EMR adoption is

$Prob(y_i = 1) = \frac{e^{x\beta}}{1+e^{x\beta}}$ where $x\beta$ is the right-hand side of Model #1.

> [3]: Compare the characteristics that affect EMR adoption in rural and urban locations and whether these have changed over time, and determine if a network effect is present in Oklahoma.

The logistic regression model is also run on subsets of the data to compare determinants across geographies. Model #1 will also be run interacting a ‘rural’ term with each practice characteristic for 2009-2011. This will allow for documentation of which characteristics impact rural and urban EMR adoption rates differently. For example, association with a hospital could have a measurable effect on EMR adoption in urban practices but not rural practices, or vice versa.

> [4]: Determine whether or not a link exists between broadband availability and EMR adoption.

In order to determine whether or not a link exists between broadband availability and EMR adoption Model #1 will be modified to include variables accounting for broadband. These broadband variables will include the number of providers available and the average upload/download speeds available to the practice.

Model #2

$y_i* = \beta_0 + \beta_1$*Practice Specialty* + β_2*Number of Physicians* + β_3*Patient Volume* + β_4*Medicare* + β_5*Medicaid* + β_6*Association* + β_7*Ownership* + β_8*DO* + β_9*NP/PA at Practice* + β_{10}*Only a NP/PA at Practice* + β_{11}*County Adoption Rate* + β_{12}*Urban* + β_{13}*Number of Broadband Providers* + β_{14}*Average Broadband Upload/Download Speed* + ε_i

$y_i = 1$ if $y_i* \geq 0$

$y_i = 0$ if $y_i* < 0$

This model is primarily interested in whether or not $\beta_{13} = 0$ and $\beta_{14} = 0$, or whether different levels of broadband availability impact a physician's EMR adoption decision.

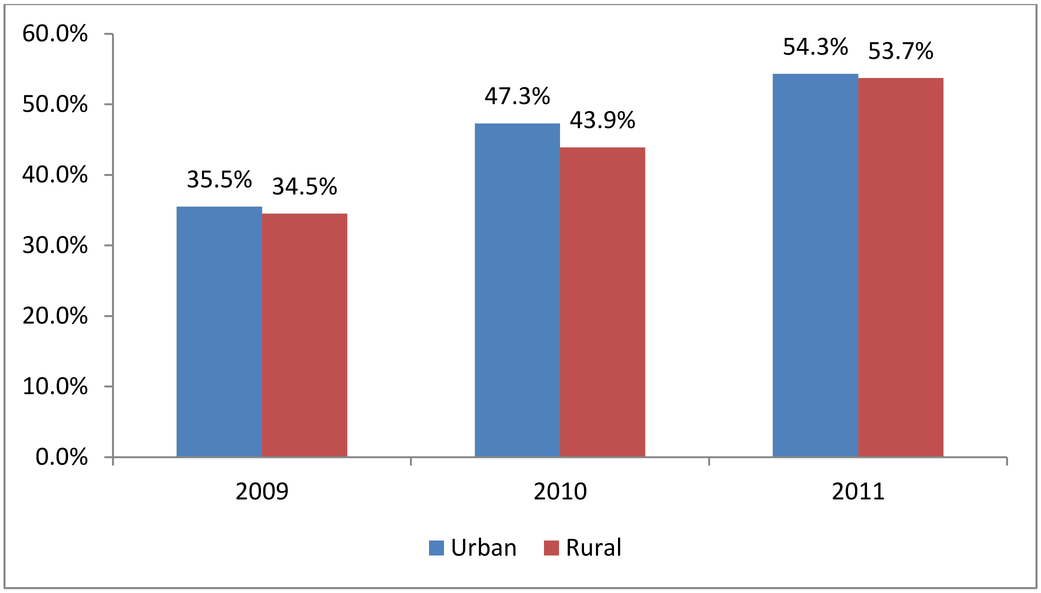
CHAPTER IV

RESULTS

As noted throughout this research, EMR adoption rates have increased over time. However, these rates could vary over rural and urban locations and by lower level categories such as specialty. The primary objective of this study was to identify the characteristics that impact EMR adoption in Oklahoma. This chapter will report the findings of each objective.

The first specific objective was to document the difference in EMR adoption rates between rural and urban physicians, including among specific specialties / practice sites, over the 2009-2011 time periods. Figure 15 demonstrates the change in physician EMR adoption rates across rural and urban locations. Aggregate physician-level EMR adoption rates increased from 35 percent in 2009 to 54 percent in 2011. The difference between rural and urban physician EMR adoption rates remained relatively small during the three year study period, with adoption being greater in urban areas each year. However, the difference was only statistically significant for 2010.

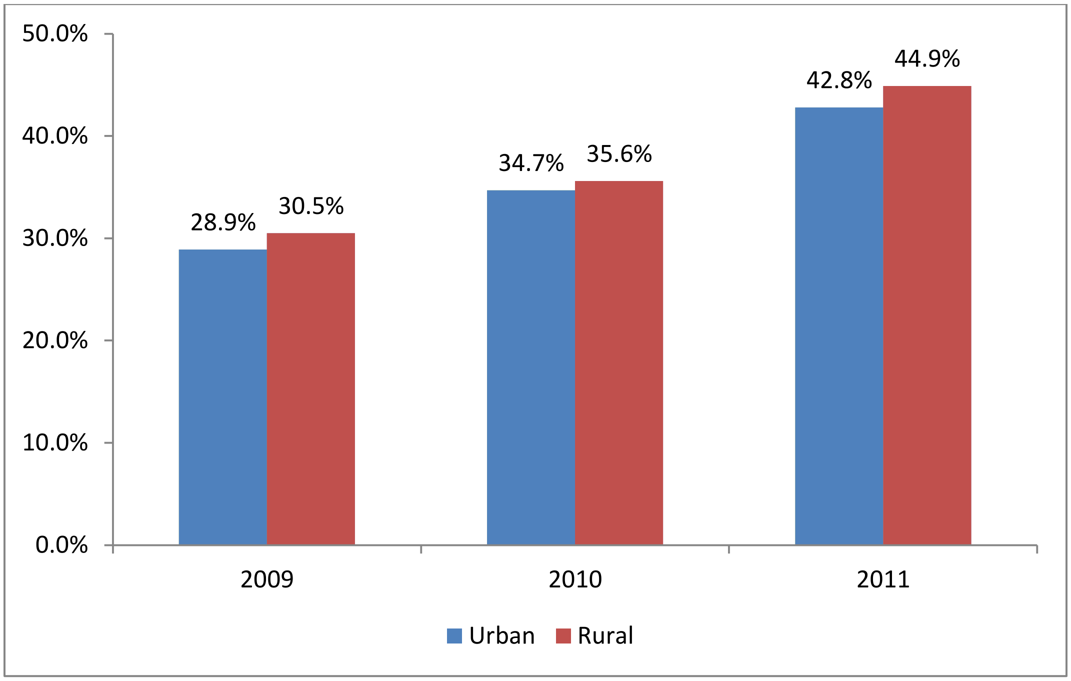
Figure 15. Electronic Medical Record Adoption by Physicians in Urban/Rural Counties in Oklahoma.



Source: SK&A, A Cegedim Company.

Figure 16 demonstrates the change in practice site EMR adoption rates across rural and urban counties during 2009-2011. Contrary to Figure 15's display of higher adoption rates among physicians in urban counties, Figure 16 reveals higher adoption rates among practices in rural counties each year. In 2009, 30.5 percent of Oklahoma rural practices had adopted EMRs and by 2011 adoption had increased to 44.9 percent in rural counties, compared to rates of 28.9 percent and 42.8 percent in urban practices over this period. However, the differences are not statistically significant. The counterintuitive differences between Figures 15 and 16 can partially be explained by the fact that more rural physicians have solo practices, and are in fact more likely to adopt EMRs in those solo practices.

Figure 16. Electronic Medical Record Adoption by Practices in Urban/Rural Counties in Oklahoma.

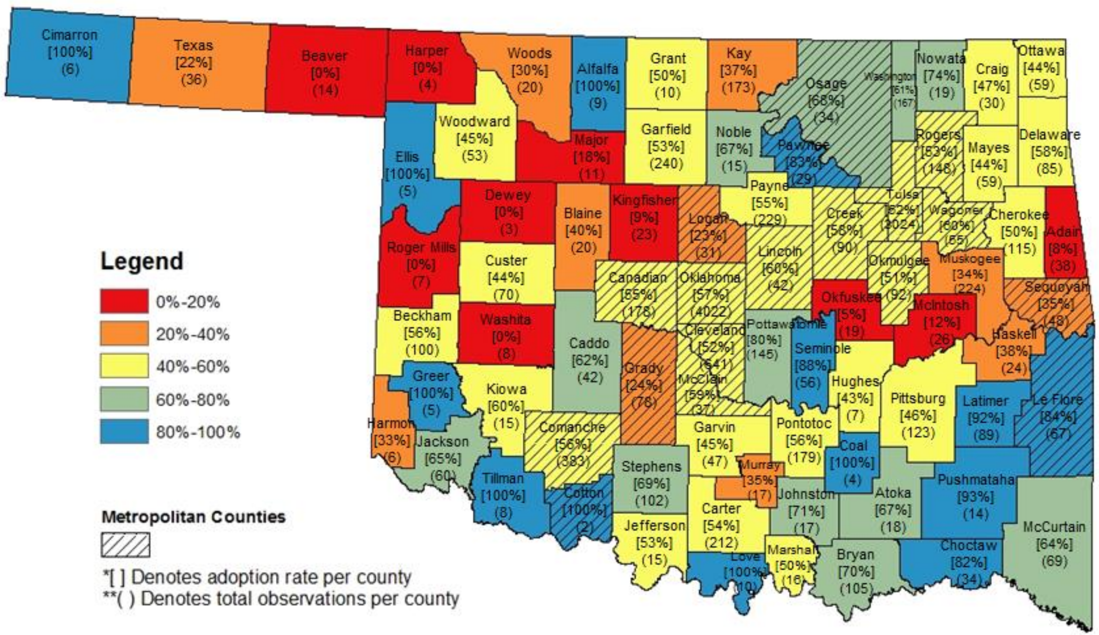


Source: SK&A, A Cegedim Company.

Figure 17 displays the significant variation in physician EMR adoption rates per county. Metropolitan counties are symbolized by diagonal lines though the county and the total number of observations (regardless of EMR adoption) are represented in parentheses underneath the county name. Impressively, several non-metro counties have 100 percent adoption from physicians within their borders, while others have 0 percent adoption. The wide range of adoption rates in non-metro counties could be significantly impacted by the small number of observations in each county. The majority of Oklahoma counties (both metro and non-metro) have adoption rates between 40 percent and 60 percent. The adoption rates of local physicians will be important for nearby hospitals, pharmacies, and other healthcare providers as the interoperability requirements for EMRs come into effect. The interoperability requirements are part of Meaningful

Use's Stage 2 and will officially begin in 2014. Once enrolled in Stage 2 a physician will have two consecutive years to complete the requirements.

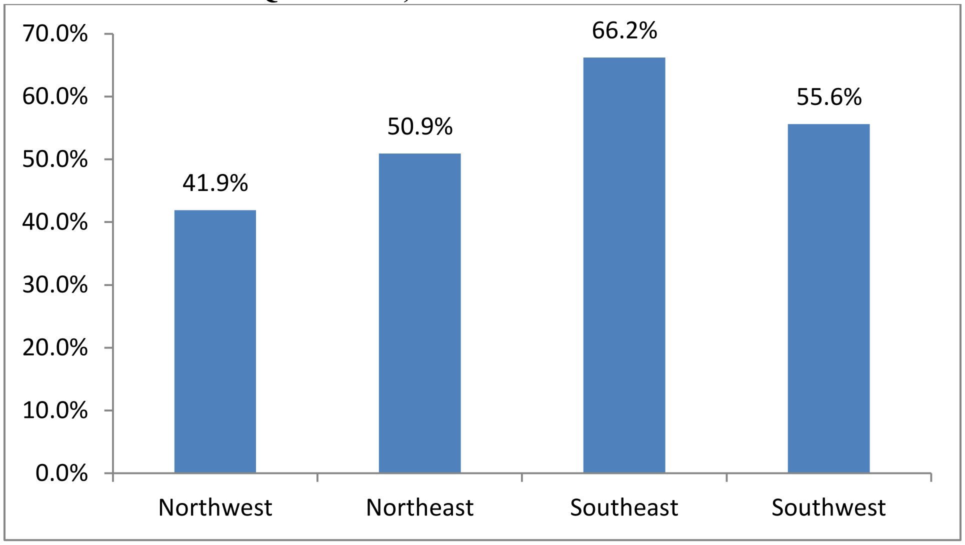
Figure 17. Physician Electronic Medical Record Adoption Rates by County, 2011.



Source: SK&A Data specific to Oklahoma, 2009-2011.

Figures 15 and 17 suggest that while the physician EMR adoption rate differences are not large across urban and rural counties, geographic location can influence EMR adoption rates. Note, for example, lower adoption rates are seen in many northwest counties displayed in Figure 17. The aggregate physician EMR adoption rates in the four quadrants are notably different, as seen below in Figure 18.

Figure 18. Aggregate Physician Electronic Medical Record Adoption Rates for Oklahoma's Four Quadrants, 2011.



Source: SK&A Data specific to Oklahoma.

The physician and practice EMR adoption rates for lower level categories in rural and urban locations can be found below in Table 4 and 5. Table 5 was constructed using the practice level data. Adoption rates for physicians (Table 4) appear to increase over time with urban areas typically having higher rates than their rural counterparts. However, the opposite is true for practice site adoption rates (Table 5). This counterintuitive finding was similar to that found in Figures 15 and 16. Oklahoma practices typically have lower adoption rates in urban areas with significant differences in psychiatric practices, practices with only one physician and those with a lower patient volume. However, practices owned or associated with a hospital had significantly higher adoption rates in urban areas. These categories with statistically significant differences are displayed in Figure 19 for 2011.

Table 4. Rural - Urban EMR Adoption Rates for Oklahoma Physicians

	2009		*2010*		*2011*	
Characteristic	*Rural*	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*
Overall	34.5	35.5	43.9	47.3***	53.7	54.3
Age						
Under 50 years	36.8	43.5	51.2	55.8**	58.6	63.3**
50 years and over	29.7	23.6*	38.6	48.3***	46.5	52.7***
Unknown	34.7	35.7	43.9	44.1	54.8	51.7***
Specialty						
Family Practitioner	40.3	43.4	46.5	55.7***	55.7	61.9***
Internist	29.4	42.4***	41.1	53.0***	47.6	55.3*
Orthopedic Surgeon	38.8	56.8	47.5	59.5**	43.3	68.0***
Pediatrician	26.8	38.1**	63.4	53.2**	67.5	59.6*
Obstetrician/Gynecologists	33.9	28.2	36.1	42.1	48.1	46.2
Other	33.9	33.9	42.9	45.5**	53.6	52.6
Doctor of Osteopathy	30.2	33.6	43.7	52.2***	53.5	56.9

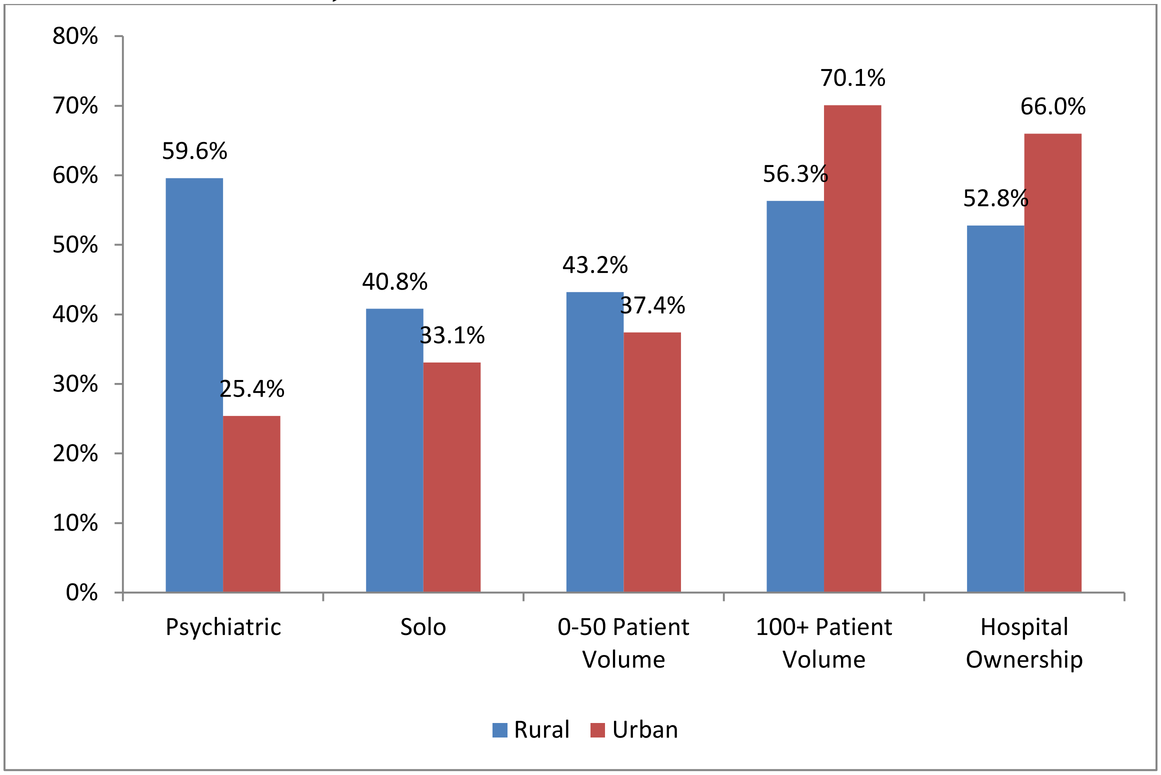
Note: *, **, *** indicate statistically significant differences between rural and urban rates at the p = 0.1, p = 0.05, and p = 0.01 levels, respectively.

Table 5. Rural - Urban EMR Adoption Rates for Oklahoma Practices

	2009		*2010*		*2011*	
Characteristic	*Rural*	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*
Overall	30.5	28.9	35.6	34.7	44.9	42.8
Type of Practice						
Family Practice	32.4	31.7	37.3	36.7	49.6	46.5
Multi-Specialty	41.6	45.0	56.2	59.1	55.2	60.2
Internal Medicine	26.3	21.4	25.8	25.8	36.8	33.8
Psychiatric	34.2	17.6**	47.5	21.7***	59.6	25.4***
Obstetrics/Gynecology	32.4*	19.4*	29.7	30.5	43.6	32.4
Other	26.5	28.0	30.8	33.0	38.9	42.7
Number of Physicians						
1	27.8	21.8***	31.2	23.3***	40.8	33.1***
2-3	31.7	32.8	40.3	39.6	47.8	48.3
4+	44.7	42.0	58.6	61.3	70.1	65.0
Patient Volume						
0-50	29.7	25.6**	34.3	29.4***	43.2	37.4***
51-100	34.0	39.8	40.0	51.7**	52.1	58.5
100+	37.0	48.8	50.0	65.6*	56.3	70.1*
Medicare (=1)	34.1	34.0	36.3	36.2	45.0	45.3
Medicaid (=1)	35.0	34.6	37.6	36.9	47.1	45.8
Hospital Association (=1)	34.5	48.7**	53.4	68.9**	53.7	58.2
Hospital Ownership (=1)	28.7	38.9**	44.4	56.1**	52.8	66.0**

Note: *, **, *** indicate statistically significant differences between rural and urban rates at the p = 0.1, p = 0.05, and p = 0.01 levels, respectively.

Figure 19. Significant Differences in EMR Adoption Rates among Rural/Urban Practice Characteristics, 2011.



Source: SK&A, A Cegedim Company.

These findings for the first objective suggest that the similar aggregate rural-urban rates mask significant differences for specific categories, which is a finding that has not been documented before.

The second specific objective was to determine practice characteristics that influence EMR adoption. The logistic regression, Model #1, noted in chapter 3 determined those characteristics that significantly impact adoption and the results are reported below in Table 6 with parameters and corresponding standard errors for each study period. Correlation coefficients suggest that there are no problems with multicollinearity in the variables used, as the largest value obtained was 0.53 for patient volume and number of physicians.

Table 6. Logistic Regression Results: Electronic Medical Record Adoption in Oklahoma Practices

	2009		2010		2011	
Variables	Coefficient	Standard Errors	Coefficient	Standard Errors	Coefficient	Standard Errors
Practice Specialty						
Family Practice	0.2034	0.1258	0.0872	0.1168	0.1586	0.1128
Multi-Specialty	0.2493	0.1611	0.2655	0.1653	0.0356	0.1491
Internal Medicine	-0.1850	0.1988	-0.2613	0.1865	-0.2027	0.1642
Psychiatric	-0.2940	0.2294	-0.1683	0.2021	-0.2415	0.1759
Obstetrics/Gynecology	-0.3880*	0.2277	-0.2580	0.2105	-0.4083**	0.1897
Number of Physicians						
1	-0.4983***	0.1635	-0.7903***	0.1515	-0.7257***	0.1455
2-3	-0.2964**	0.1462	-0.3827***	0.1392	-0.4056***	0.1352
Patient Volume	0.0015	0.0012	0.0044***	0.0012	0.0042***	0.0012
Medicare	0.6528***	0.1377	0.1299	0.1344	0.1465	0.1248
Medicaid	0.2509**	0.1223	0.1026	0.1186	0.2199**	0.1089
Hospital Association	0.5888***	0.1596	0.9106***	0.1591	0.2632*	0.1352
Hospital Ownership	-0.0162	0.1451	0.2608*	0.1509	0.3717**	0.1601
Doctor of Osteopathy	-0.1794	0.1106	0.0768	0.1024	0.1347	0.0966
NP / PA at site	0.3866***	0.1406	0.3641***	0.1399	0.3306**	0.1401
NP/PA only	0.2426	0.1629	0.4797***	0.1506	0.3111**	0.1390
County Adoption Rate	0.3134	0.5177	0.1393	0.4699	-0.2823	0.4427
Urban	0.0039	0.1042	-0.1152	0.0984	-0.1000	0.0971
Broadband						
Number of Providers					-0.0207	0.0341
Upload/Download Speed					-0.0457	0.0590
Intercept	-1.4515***	0.2654	-0.6502**	0.2650	0.2383	0.5458
Log-likelihood	-1387.0733		-1528.7144		-1768.7266	
Pseudo R2	0.0557		0.0834		0.0570	
Observations	2425		2577		2743	
Percent Correctly Predicted						
Adoption	11.1%		29.8%		39.2%	
No Adoption	96.6%		90.9%		82.0%	

Note: *, **, *** indicate statistically significant differences at the p = 0.1, p = 0.05, and p = 0.01 levels, respectively.

In 2009 the only practice type to significantly influence EMR adoption was obstetrics/gynecology with this particular specialty being less likely to adopt an EMR. Other characteristics that reduced the likelihood of EMR adoption included smaller practices, relative to those employing four or more physicians. Accepting Medicare, Medicaid, being associated with a hospital, and employing a nurse practitioner or physician assistant were all practice characteristics that had a positive influence on EMR adoption.

Several changes take place in 2010, possibly due to the Centers for Medicare and Medicaid Services (CMS) EMR Incentive Program taking effect, allowing practices that demonstrate Meaningful Use to be reimbursed for their EMR purchase. Medicare and Medicaid are no longer significant influencers of EMR adoption. Those characteristics that continued to positively influence EMR adoption include hospital association and practices employing a nurse practitioner or physician assistant. Beginning in 2010, EMR adoption was also positively influenced by patient volume, hospital ownership, and practices only employing a nurse practitioner or physician assistant. Smaller physician practices continued to have a negative influence on EMR adoption.

In 2011, obstetrics/gynecology practices again had a negative influence on EMR adoption, along with smaller physician practices. Patient volume, hospital association, hospital ownership, practices employing a nurse practitioner or physician assistant and those practices with only a nurse practitioner or physician assistant present had a positive influence on EMR adoption. As seen during 2009, Medicaid has a positive influence on EMR adoption during 2011. The primary interest in the 2011 data was the broadband variables for number of broadband providers and average upload/download speed.

Those characteristics found to be significant across each time period include being a small practice (relative to practices with four or more physicians), being associated with a hospital, and employing a nurse practitioner or physician assistant. EMR adoption was also influenced by patient volume, Medicare, Medicaid, ownership, and practices only employing a nurse practitioner or physician assistant. However, these characteristics were not consistent across the time periods. Also noted, the 2011 model correctly predicted EMR adoption 39.2 percent of the time for practices that did adopt, increasing from 11.1 percent in 2009. It also correctly predicted over 80 percent of those practices that did not adopt in 2011, decreasing from 96.6 percent in 2009. It should also be noted that the R^2 for each of the models is relatively low. The next set of results will determine whether these same characteristics are still significant across rural and urban locations.

The third specific objective was to compare the characteristics that affect EMR adoption in rural and urban locations and whether they have changed over time. Parameter estimates for the logistic regression of EMR adoption in Oklahoma practices are listed below in Table 7. Each time period has an urban column presenting the parameters and corresponding standard errors. The rural column in each time period represents the estimated *shifts* in parameters for rural Oklahoma practices relative to urban practice estimates. The results are discussed in the order displayed in Table 7.

In 2009 the likelihood of a practice adopting an EMR was negatively related to psychiatric and obstetrics/gynecology practices in urban areas. However, psychiatric and obstetrics/gynecology practices located in rural areas demonstrate significantly different results, as the shift is positively related to EMR adoption. This reinforces the finding that rural psychiatric practices have higher adoption rates than their urban counterparts (Table 5). Those urban practices with only one physician present (relative to the default of four or more physicians at a practice) were also less likely to adopt as the parameter demonstrates a negative relationship to EMR adoption. The relationship with only one physician at rural area practices did not show a significant shift. Urban practices accepting Medicare, associating with a hospital, and employing a nurse practitioner or physician assistant each demonstrate a higher likelihood of adopting an EMR. Rural practices did not show a significant shift for any of these variables.

Interestingly, as several researchers have noted a network effect in regards to EMR adoption, there only appears to be a network effect present for rural practices in Oklahoma during 2009. The county adoption rate did not have a significant impact on EMR adoption for urban practices. However, the shift between rural and urban county adoption rates was significant; meaning county adoption rates in rural areas were positively associated with EMR adoption. This suggests that the network effects were particularly important for rural practices towards the beginning of the period of analysis.

Table 7. Logistic Regression Results: Rural-Urban Electronic Medical Record Adoption in Oklahoma Practices

	2009				2010				2011			
Variables	Urban		Rural		Urban		Rural		Urban		Rural	
	Coefficient	Standard Errors	Coefficient	Standard Errors	Coefficient	Standard Errors	Coefficient	Standard Errors	Coefficient	Standard Errors	Coefficient	Standard Errors
Practice Specialty												
Family Practice	0.1331	0.1621	0.2858	0.2649	0.0173	0.1520	0.2405	0.2433	0.0460	0.1431	0.4039*	0.2392
Multi-Specialty	0.2260	0.1914	0.1946	0.3674	0.2049	0.1997	0.4299	0.3687	0.0375	0.1749	0.0597	0.3488
Internal Medicine	-0.2805	0.2499	0.3555	0.4209	-0.2576	0.2309	0.0739	0.3991	-0.2835	0.2021	0.3372	0.3507
Psychiatric	-0.5863**	0.2958	1.0344**	0.4856	-0.5477**	0.2604	1.2509***	0.4364	-0.7189***	0.2245	1.5769***	0.3952
Obstetrics/Gynecology	-0.6646**	0.2833	0.8958*	0.4893	-0.3197	0.2543	0.2428	0.4638	-0.6403***	0.2288	0.7832*	0.4219
Number of Physicians												
1	-0.3782**	0.1906	-0.3738	0.3960	-0.7466***	0.1765	0.0236	0.3677	-0.6706***	0.1634	-0.2880	0.3939
2-3	-0.1395	0.1701	-0.4852	0.3513	-0.3223**	0.1625	-0.0068	0.3361	-0.3086**	0.1528	-0.4077	0.3591
Patient Volume	0.0020	0.0014	-0.0021	0.0029	0.0051***	0.0014	-0.0027	0.0028	0.0048***	0.0014	-0.0031	0.0031
Medicare	0.6797***	0.1560	-0.1405	0.3453	0.1859	0.1543	-0.2572	0.3282	0.2804**	0.1424	-0.6498**	0.3105
Medicaid	0.1727	0.1383	0.3836	0.3091	-0.0144	0.1357	0.5293*	0.2955	0.1067	0.1244	0.5971**	0.2731
Hospital Association	0.7323***	0.1935	-0.5928	0.3616	1.0571***	0.1941	-0.5549	0.3526	0.3197**	0.1558	-0.2787	0.3238
Hospital Ownership	0.1088	0.1778	-0.3654	0.3192	0.2893	0.1917	-0.1087	0.3161	0.4727**	0.1998	-0.2861	0.3412
Doctor of Osteopathy	-0.0809	0.1355	-0.2518	0.2388	0.1727	0.1266	-0.2049	0.2197	0.1967*	0.1176	-0.1719	0.2105
NP / PA at site	0.5171***	0.1657	-0.3730	0.3264	0.6108***	0.1658	-0.7951**	0.3239	0.3708**	0.1633	-0.1677	0.3314
NP/PA only	0.2519	0.2209	-0.0556	0.3316	0.3899*	0.2025	0.1797	0.3079	0.3738**	0.1816	-0.1553	0.2872
County Adoption Rate	-2.0520	1.2880	2.9157**	1.4165	0.1126	1.0324	0.0601	1.1581	-0.9880	1.0819	0.8574	1.1875
Broadband												
Number of Providers									-0.0394	0.0440	0.0418	0.0738
Upload/Download Speed									-0.0576	0.0862	0.0214	0.1198
Intercept	-0.8996**	0.4197	-0.5734	0.6210	-0.8246**	0.4063	0.0050	0.6016	0.4914	0.9112	-0.1857	1.2188
Log-likelihood	-1375.27				-1513.6568				-1715.5578			
Pseudo R2	0.0637				0.0925				0.0661			
Observations	2425				2577				2743			
Percent Correctly Predicted												
Adoption	13.9%				30.2%				41.4%			
No Adoption	96.4%				90.7%				81.4%			

Note: *, **, *** indicate statistically significant differences at the p = 0.1, p = 0.05, and p = 0.01 levels, respectively.
Rural coefficients represent shifts on urban coefficients.

During 2010, psychiatric practices in urban areas remain less likely to adopt an EMR system and the rural shift remains positively associated to EMR adoption. However, obstetrics/gynecology practices are no longer significant in urban or rural locations. Urban practices with one-three physicians present are less likely to adopt an EMR system, compared to 2009 where only urban practices with one physician present were significantly less likely to adopt an EMR. Hospital association and practices with a nurse practitioner or physician assistant at the site remained likely to adopt an EMR system; however a significant, but negative, shift is now seen in rural areas among practices that have a nurse practitioner or physician assistant. Medicare is no longer significant in urban locations; however, practices accepting Medicaid in rural areas were more likely to adopt an EMR system. Patient volume and practices with only a nurse practitioner or physician assistant at the site demonstrate a higher likelihood of adopting an EMR beginning in 2010. These results may reflect the initial period of the CMS EMR Incentive Program, which allowed practices demonstrating Meaningful Use to be reimbursed for their EMR purchase.

The significance of the characteristics continues to increase in 2011. Many variables remained the same as 2010, such as psychiatric practices and smaller practice sizes in which these urban practices were less likely to adopt an EMR system. The shift to rural psychiatric practices remained positive. For the first time, rural family practices also have a higher likelihood of adopting an EMR (similar to rural psychiatric practices). As seen in 2009, the 2011 urban practices specializing in obstetrics/gynecology were less likely to adopt an EMR but again, the rural shift was positively related to EMR adoption. Urban practices' patient volume, Medicare, hospital association, and practices with a nurse practitioner or physician assistant present remained increasingly likely to adopt an EMR system. However, rural practices accepting Medicare show a negative shift related to EMR adoption. This may suggest that the CMS Incentive Program was not as effective for the Medicare portion, as opposed to the Medicaid- at least in rural areas. Rural practices that accept Medicaid demonstrate a likelihood of adoption by a positive shift in parameters, which is also seen in 2010. Not seen in 2009 or 2010, urban practices owned by a hospital and sites with a doctor of osteopathy present demonstrate a higher likelihood of adopting an EMR. This suggests that the influence of hospital ownership has been increasing over time, and that D.O.'s may have been increasingly important in encouraging EMR adoption. The primary interest in the 2011 data was the broadband variables for number of broadband providers and average upload/download speed. However, neither the number of providers or average speed was found to be significant in urban or rural areas.

The network effect does not seem to be particularly important, other than for rural areas in the early adoption stages. Those trends that remain consistent across the study period include psychiatric practices, solo physician offices, hospital association and having a nurse practitioner or physician assistant present at the site. Psychiatric practices located in urban areas were less likely to adopt an EMR system; however, rural practices demonstrated a significant difference as the shift is positively related to EMR adoption. Solo physician offices in urban areas were also less likely to adopt. Urban practices that were more likely to adopt were those associated with a hospital and those with a nurse practitioner or physician assistant present. The percent correctly predicted for EMR adoption increased over time, from 13.9 percent in 2009 to 41.4 percent in 2011; however, similar to Table 6, the R^2 for each of the models is relatively low.

One of the most important questions this research seeks to address is the relationship between broadband and EMR adoption. While the results in Table 6 and 7 demonstrate that there is no general relationship between the two, it may still be the case that very low levels of broadband adversely impact the likelihood of adoption. In order to check for a significant relationship between a *low* number of broadband providers / *low* average speed and EMR adoption, the model was modified to create dummy variables for a specific number of providers and average speed. The continuous broadband variables were converted to variables accounting for practices located in areas with a low number of providers (0-2) and low average speeds (less than 6 megabits per second) available. If a low number of providers and/or speeds are a barrier to adoption, a negative and significant parameter would be expected in association with these dummy variables. The results, displayed in Table 8, were similar to those found in Table 7. While the number of providers had a negative parameter, it was not significant. There is no significant influence on EMR adoption by either a low number of providers or a low average speed available in an area, adding a measure of robustness to the results.

Table 8. Logistic Regression Results: Rural-Urban Electronic Medical Record Adoption in Oklahoma Practices Focusing on Practices with Low Broadband Availability, 2011.

Variables	Urban		Rural	
	Coefficient	Standard Errors	Coefficient	Standard Errors
Practice Specialty				
Family Practice	0.0380	0.1457	0.3818	0.2432
Multi-Specialty	0.0354	0.1748	0.0446	0.3494
Internal Medicine	-0.2825	0.2019	0.3423	0.3505
Psychiatric	-0.7162***	0.2243	1.5611***	0.3959
Obstetrics/Gynecology	-0.6378***	0.2290	0.7651*	0.4214
Number of Physicians				
1	-0.6747***	0.1636	-0.3521	0.3971
2-3	-0.3109**	0.1528	-0.4455	0.3600
Patient Volume	0.0049***	0.0014	-0.0032	0.0031
Medicare	0.2809**	0.1424	-0.6508**	0.3109
Medicaid	0.1018	0.1244	0.5855**	0.2739
Hospital Association	0.3049*	0.1560	-0.2427	0.3235
Hospital Ownership	0.4750**	0.1998	-0.2901	0.3417
Doctor of Osteopathy	0.1821	0.1169	-0.1336	0.2103
NP / PA at site	0.3719**	0.1632	-0.2124	0.3333
NP/PA only	0.3732**	0.1816	-0.1325	0.2877
County Adoption Rate	-0.8514	1.0968	0.6192	1.2017
Broadband				
Less than 2 Providers	-0.0548	0.1056	0.2029	0.1891
Less than 6 MB Speed	0.1707	0.3443	0.1338	0.4236
Intercept	-0.0679	0.4899	0.1261	0.6882
Log-likelihood	-1750.7946			
Pseudo R2	0.0665			
Observations	2743			
Percent Correctly Predicted				
Adoption	41.6%			
No Adoption	81.5%			

Note: *, **, *** indicate statistically significant differences at the p = 0.1, p = 0.05, and p = 0.01 levels, respectively.

CHAPTER V

CONCLUSION

This research is likely the first to mesh recently-available data on broadband availability with the EMR adoption decision of individual physician offices. It also adds to the discussion regarding differences between how rural and urban doctors are using EMRs and what characteristics are most influential in their adoption decision.

From a policy standpoint, the Federal Communications Commission (FCC) created a project known as the Healthcare Connect Fund (HCCF) in 2012 to expand broadband to healthcare providers. The goal of the HCCF is to increase broadband for healthcare providers (especially in rural areas), deploy broadband healthcare networks, and maximize cost-effectiveness of the healthcare program (FCC 2013). This research provides empirical evidence from Oklahoma related to the premise of the HCCF – that certain levels of broadband are needed for effective healthcare. However, the results from this research indicate there is no statistical relationship between EMR adoption for privately-owned physician practices and broadband availability. Therefore, focusing on specific numbers of broadband providers or available upload/download speeds in a location with the explicit purpose of increasing physician EMR adoption is likely misguided. It is important to note, however, that this research has focused solely on private physician EMR adoption and that the premise of the HCCF may be valid for other healthcare entities such as health departments or community health centers.

The results also allow for a more thorough discussion of the factors affecting physician-level EMR adoption and in particular, how those factors may differ in rural areas. The results demonstrate that the determinants of adoption do vary between rural and urban practices. Ultimately, policies that are tailored to specific geographies may be important for effectively increasing EMR adoption rates.

Throughout each region in the United States, Regional Extension Centers (RECs) are present to extend support to providers adopting EMRs. RECs assist healthcare providers in the EMR adoption process (healthIT.gov). Oklahoma's REC, Oklahoma Foundation for Medical Quality (OFMQ), works with Oklahoma healthcare providers to choose and implement an EMR system, reach meaningful use standards, and collect incentive payments. During the summer of 2013, the OFMQ partnered with Oklahoma State University's Office of Rural Health to educate rural health providers on health information technology. OFMQ educated 100 of Oklahoma's health care providers on current health information technology, including Stage 2 Meaningful Use and HIPPA Audits (OFMQ 2013). OFMQ also offers free webinars each month on topics including ICD-10 implementations, Stage 2 Meaningful Use, clinical quality measures and health information exchange vouchers. Knowing what characteristics of physicians' practices influence the EMR adoption decision could allow the OFMQ to target specific types of practices by engaging the physicians in specialized conferences/webinars. This type of tailored programming could encourage EMR adoption.

Figure 19 demonstrates that significant differences exist in EMR adoption rates across sub-categories of rural/urban practices. For example, EMR adoption for urban psychiatric practices is much lower than in their rural counterparts. The results in Table 7 suggest that these general patterns persist even after controlling for other factors. Similarly, small (1-3 physicians) urban practices continue to lag behind in EMR adoption. By focusing on creating specialized conferences/webinars for these urban practices lagging behind, adoption could begin to increase among physicians in these practices.

The final results show that rural practices accepting Medicare payments are less likely to adopt EMRs; however, rural practices accepting Medicaid payments are more likely to adopt. Accepting Medicare or Medicaid payments does not necessarily indicate the incentive program that a physician participates in. However, it is worth noting that only the Medicaid incentive program allows nurse practitioners and physician assistants to participate. Depending on where nurse practitioners or physician assistants are located, it could be important to place more emphasis on the Medicaid incentive program or perhaps change the existing incentive to allow NPs/PAs to participate in Medicare.

This research sought to determine the factors that influence EMR adoption using a unique dataset that meshed practice-level EMR adoption data with broadband availability data. Logistic regressions were used to determine which characteristics are most influential on EMR adoption. The results show that determinants do vary across rural/urban locations but that the role of broadband availability is not significant. From a policy standpoint, this suggests that future efforts in increasing EMR adoption should be focused on targeting specific categories of physicians with specialized conferences/

webinars or other types of outreach. However, the fact that each model had a relatively low R^2 suggests that further research on this topic is still necessary. In particular, while this study has clarified the limited role that broadband availability plays on EMR adoption, documenting the specific factors that DO have more impact on the adoption decision would be useful.

REFERENCES

Ayers, D., N. Menachemi, Z. Ramamonjiarivelo, M. Matthews, and R. Brooks. 2009. "Adoption of electronic medical records: the role of network effects." *Journal of Product and Brand Management* 18(2): 127-135.

Bates, D., M. Ebell, E. Gotlieb, J. Zapp, and H.C. Mullins. 2003. "A Proposal for Electronic Medical Records in U.S. Primary Care." *Journal of the American Medical Informatics Association* 10(1): 1-10.

Bell, D., D. Daly, and P. Robinson. 2003. "Is There a Digital Divide among Physicians? A Geographic Analysis of Information Technology in Southern California Physician Offices." *Journal of the American Medical Informatics Association* 10: 484-493.

Boonstra, A. and M. Broekhuis. 2010. "Barriers to the acceptance of electronic medical records by physicians from systematic review to taxonomy and interventions." *BMC Health Services Research* 10: 231-248.

Brailer, D. 2005. "Interoperability: The Key to the Future Health Care System." *Health Affairs-Millwood VA then Bethesda MA* 24(W5): 19-21.

Burt, C. and J. Sisk. 2005. "Which Physicians and Practices are Using Electronic Medical Records?" *Health Affairs* 24(5): 1334-1343.

Centers for Medicare and Medicaid Services. 2013. "Medicare and Medicaid EHR Incentive Program Basics. Available at http://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/Basics.html

Decker, S., E. Jamoom, and J. Sisk. 2012. "Physicians in Nonprimary Care and Small Practices and Those Age 55 and Older Lag in Adopting Electronic Health Record Systems." *Health Affairs* 31(5): 1108-1114.

DesRoches, C., D. Charles, M. Furukawa, M. Joshi, P. Kralovec, F. Mostashari, C. Worzala and A. Jha. 2013. "Adoption of Electronic Health Records Grows Rapidly, But Fewer Than Half of US Hospitals Had At Least A Basic System In 2012." *Health Affairs* 32(8): 1-8.

DesRoches, C., E. Campbell, S. Rao, K. Donelan, T. Ferris, A. Jha, R. Kaushal, D. Levy, S. Rosenbaum, A. Shields and D. Blumenthal. 2008. "Electronic Health Records in Ambulatory Care – A National Survey of Physicians." *The New England Journal of Medicine* 359: 50-60.

Dolan, P. 2012. "Patients worried about medical records going digital." *American Medical News.*

Federal Communications Commission. 2010. Connecting America: The National Broadband Plan. Available at www.broadband.gov/plan/10-healthcare/

Federal Communications Commission. 2013. Healthcare Connect Fund Fact Sheet. Available at http://www.fcc.gov/document/healthcare-connect-fund-fact-sheet

Federal Communications Commission. 2013. Rural Health Care Program. Available at http://www.fcc.gov/encyclopedia/rural-health-care

HealthIT.gov. 2013. "Meaningful Use." Available at http://www.healthit.gov/policy-researchers-implementers/meaningful-use

HealthIT.gov. 2013. "Regional Extension Centers." Available at http://www.healthit.gov/providers-professionals/regional-extension-centers-recs

HealthIT.gov. 2013. "Standards and Interoperability." Available at http://www.healthit.gov/providers-professionals/standards-interoperability

HealthIT.gov. "What is an Electronic Medical Record (EMR)?" Available at http://www.healthit.gov/providers-professionals/electronic-medical-records-emr

Jamoom E., P. Beatty, A. Bercovitz, D. Woodwell, K. Palso, E. Rechtsteiner. 2012. "Physician adoption of electronic health record systems: United States, 2011." NCHS data brief, no 98. National Center for Health Statistics.

Jha, A., C. DesRoches, E. Campbell, K. Donelan, S. Rao, T. Ferris, A. Shields, S, Rosenbaum and D. Blumenthal. 2009. "Use of Electronic Health Records in U.S. Hospitals." *The New England Journal of Medicine* 360: 1628-1638.

King, J., M. Furukawa, and M. Buntin. 2013. "Geographic Variation in Ambulatory Electronic Health Record Adoption: Implications for Underserved Communities." *Health Services Research* 48(6): 2037-2059.

Makoul, G., R. Curry, P. Tang. 2001. "The Use of Electronic Medical Records: Communication Patterns in Outpatient Encounters." *Journal of the American Medical Informatics Association* 8: 610-615.

Miller, R., and I. Sim. 2004. "Physicians' Use of Electronic Medical Records: Barriers and Solutions." *Health Affairs* 23(2): 116-126.

Mills, B. and B. Whitacre. 2003. "Understanding the Non-Metropolitan – Metropolitan Digital Divide." *Growth and Change* 34(2): 219-243.

Oklahoma Foundation of Medical Quality. 2013. Available at http://www.ofmq.com/ /about-ofmq

Oklahoma Foundation of Medical Quality. 2013. "Quality Connection – Q3 2013" Available at http://archive.constantcontact.com/fs123/1102463560666/archive /1114391255635.html

Olson, L., S. Peters, and J. Stewart. 1998. "Security and confidentiality in an electronic medical record." *Healthcare Information Management* 12(1): 27-37.

Pediatric Practice Action Group and Task Force on Medical Informatics. 1999. "Privacy Protection of Health Information: Patient Rights and Pediatrician Responsibilities." *Journal of the American Academy of Pediatrics* 104(4): 973-977.

Ridsdale, L. and S. Hudd. 1994. "Computers in the consultation: the patient's view." *British Journal of General Practice* 44(385): 367-369.

Singh, R., M. Lichter, A. Danzo, J. Taylor and T. Rosenthal. 2012. "The Adoption and Use of Health Information Technology in Rural Areas: Result of a National Survey." *The Journal of Rural Health* 28(1): 16-27.

SK&A, A Cegedim Company. 2014. Available at http://www.skainfo.com

Sullivan, F. and E. Mitchell. 1995. "Has general practitioner computing made a difference to patient care? A systematic review of published reports." *British Medical Journal* 311(7009): 848-852.

United States Department of Agriculture Economic Research Service. 2013. "Rural-Urban Commuting Area Codes." Available at http://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes.aspx#.Uv0mx_ldX_I

Wang, S., B. Middleton, L. Prosser, L. Prosser, C. Bardon, C. Spurr, P. Carchidi, A. Kittler, R. Goldszer, D. Fairchild, A. Sussman, G. Kuperman, D. Bates. 2003. "A Cost-Benefit Analysis of Electronic Medical Records in Primary Care." *The American Journal of Medicine* 114:397-403.

Whitacre, B. 2010. "Rural Broadband Availability and Adoption in Oklahoma." *Choices: The Magazine of Food, Farm and Resource Issues* 25(4): 1-7.

Whitacre, B., L. Brooks, J. Bray. 2009. "Electronic Medical Records: What are They?" Current Report 1013. Oklahoma Cooperative Extension Service, Oklahoma State University.

Whitacre, B., L. Brooks, J. Kolarik, and C. Kaiser. 2010. "Electronic Health Records Incentive Program: the Payment Clock is Ticking! For Eligible Professionals." Current Report 1023. Oklahoma Cooperative Extension Service, Oklahoma State University.

Whitacre, B. and B. Mills. 2007. "Infrastructure and the Rural-Urban Divide in High-speed Residential Internet Access." *International Regional Science Review* 30(3): 249-273

Whitacre, B., R. Gallardo, and S. Strover. 2013. "Broadband Availability: Geography Matters." *Daily Yonder* Available at http://www.dailyyonder.com/broadband-availability-geography-matters/2013/08/07/6676

Xierali, I., R. Phillips, L. Green, A. Bazemore and J. Puffer. 2013. "Factors Influencing Family Physician Adoption of Electronic Health Records (EHRs)." *Journal of the American Board of Family Medicine* 26(4): 388-393.

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