The Impact of Electronic Health Records on Physician Productivity at a Pediatric Practice

by

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Abstract

This study examined the impact that an electronic health record (EHR) system has on a pediatric practice by examining physician productivity over a 10-year period. Through a common metric of physician productivity, the relative value unit (RVU), the researcher evaluated changes in RVUs generated for each of 20 physicians who used the EHR for the entire 10-year period and compared the values to a benchmark year before the EHR was implemented. In addition, the researcher conducted in-person, in-depth interviews with each of the 20 physicians to gain insights into what each of them considered to be the benefits and challenges associated with using the EHR in the practice. The researcher evaluated the transcripts from the interviews to find themes and ultimately identified the top five themes and top five challenges associated with the use of an EHR system.

The top five benefits and top five challenges as well as the productivity information can be used by practices and administrators who may still be evaluating the adoption of an EHR system or who may be trying to understand the impact of their own implementation. The results of the study support much of the literature in so much that the implementation of an EHR did inhibit some physician productivity though not to the extent described in some of the studies. Despite the decline in productivity, the overall benefits described by the physicians from the in-person interviews outweighed the challenges indicating that the physicians may find the system to be of value.

Keywords: EHR, Electronic Health Record, EMR, Electronic Medical Record, EPM, Electronic Practice Management, HIE, Health Information Exchange, HIT, Health Information Technology, Meaningful Use, Physician Perception, Physician Productivity, Physician Practice, Physician Workload, RVU, Relative Value Unit

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"When you're curious, you find lots of interesting things to do. And one thing it takes to accomplish something is courage." -Walt Disney

Now… on to the next thing.

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Chapter 1: Introduction

Background

At the turn of the 20th century, when doctors traveled from patient to patient, little, if any, information regarding a patient's health was written down on paper or shared. If a patient was ill, and the physician was not available, the consequences could be dire since physicians did not keep records and treatment plans were not available for any other nearby medical professional. It was not until the 1920s that physicians began to keep paper copies of patient records in their offices and hospitals required standardized methods of patient record keeping (Gillum, 2013). Paper-based medical records were more easily transferable and thus spread throughout the medical community as a new way to track patient's health and to follow outcomes of treatment plans. Despite the advantages of implementing a paper-based record system, the disadvantages of the systems, such as illegibility of handwriting, inability to access the information remotely and the amount of physical storage for the records created significant barriers to its use (Bates et al., 2003). According to a 1994 study conducted by Tang, Fafchamps, and Shortlife, physicians in the 21st century, who forego the use of electronic systems, find themselves back in a patient data-deficit because some 36% of lab tests or procedures, 23% of medications and 31% of patient histories are missing in paper charts (Tang et al., 1994).

In the second half of the 20th century, as the world began to experience the information revolution, so too did the healthcare industry by way of the digitization of the patient records beginning with the Problem-Oriented Medical Information System (PROMIS) created by Dr. Lawrence Weed in the late 1960s (Cook, 1978). Dr. Weed's system utilized new computer database technologies to catalog medical information gleaned from medical books into a database that could be searched and used to help physicians make diagnosis decisions for their

patients. Using a series of decision trees, the PROMIS application could help physicians make a diagnosis by using the patient's symptoms as decisions in the tree, ultimately coming to a diagnosis conclusion. Dr. Weed populated his database with thousands of symptoms and diagnoses from various medical books, and by selecting symptoms, the system would display potential diagnoses from which the provider could use their expertise and choose. The diagnosis catalog and the individualized records for each patient were housed in a central computer and could be accessed by terminals throughout the hospital. Furthermore, the PROMIS system stored cost information on various common procedures which would eventually transform into an early hospital billing system.

Dr. Weed concluded that his system could be used in medical schools to train new physicians and could reduce medical student training time by years through the elimination of semesters of diagnosis memorization from books. Ultimately, the cost of the computers and the various terminals needed to support the system would be too costly for most hospitals and for private practices to afford and the precursor to the Electronic Health Record systems of the late 2000s, the Problem-Oriented Medical Information System (PROMIS) would largely be forgotten.

The spark created by Dr. Weed, however, was not lost to time and versions of his platform still exist. The next iteration of the PROMIS system was called Problem Knowledge Couplers and was an advancement on the original system. These couplers used similar decision trees but also used probabilities and rankings to help support the decisions and diagnoses of the physicians (McGowan & Winstead-Fry, 1999). With advances in the medical body of knowledge, doctors updated the Problem Knowledge Couplers with new diagnoses and new

combinations of symptoms as well as probabilities and in essence, continued to evolve and grow as the medical knowledge base grew.

In the early 1970s, the Indiana University Medical Center in Indianapolis, Indiana, created the first modern Electronic Medical Record system: The Regenstrief Medical Record System. Electronic Medical Record systems are database-driven applications capable of tracking a patient's problem list, radiology, medications, lab results, allergies, and include the capability of writing prescriptions and sending them to a pharmacy (McDonald et al., 1977). The system is structured and data is legible, portable and provides advantages over messy, disheveled charts with handwritten notes (Bates et al., 2003). Pioneered by Dr. Charles Clark and 35 patients he was treating at the time, the system was the first to have built in programs for patient data entry, a common structure for data storage and was able to produce printable patient reports (McDonald et al., 1999). In just over 20 years, the Regenstrief system had expanded to be able to handle prescription data, radiology report orders and could even be accessed remotely by dial-up Internet connections and was embarking on becoming accessible via Internet browser instead of dedicated applications (McDonald et al., 1999).

A Catalyst for Change

From the 1970s until the late 1990s, there was almost no advancement in any electronic health system. That is until The Institute of Medicine released its controversial report in 1999 called "To Err Is Human" claiming that between 44,000 and 98,000 deaths are caused each year by medical errors (Brennan, 2000). The report used data from studies in New York, Utah, and Colorado then extrapolated that data across the United States as if to demonstrate that healthcare facilities in the country were not making any progress in caring for its patients. Furthermore, the findings presented have a wide range of interpretations on what a medical error may be which

could inflate or deflate the potential numbers. The study made recommendations on reducing reported medical errors by 50% and laid some groundwork for what guidelines might be valuable (Brennan, 2000). Six years later, the devastation brought by Hurricane Katrina's arrival in 2005 resulting in the loss of paper-based health records for a large portion of the public in the areas devastated by damage and flooding as a result of Katrina meant that something had to change (Tang et al., 2006). The healthcare industry's severe lag in investments in technology had been far behind other industries and the time was coming quickly for a revolution (Baker et al., 2008).

Soon after the report and following the disaster, President George Bush announced an initiative to implement Electronic Medical Records across the entire healthcare industry by the year 2014. Additionally, President Barak Obama signed the American Recovery and Reinvestment Act in 2009 which included a goal of establishing a nationwide network to improve the healthcare system (Richards et al., 2012). President Obama's legislation created a set of financial incentives to start and a set of financial penalties to persuade any laggards to implement an electronic system rather than try to opt out via the Health Information Technology for Economic and Clinical Health Act (HITECH). This act set aside $27 billion in Medicare and Medicaid incentive payments to drive initial adoption of Electronic Medical Records, aid interoperability by the expansion of the Health Information Exchange patient data sharing networks, and give support to Meaningful Use (Gold & McLauglin, 2016). By 2015, and despite the financial incentives and penalties, 20% of large private practices and 35% of smaller or single provider practices are predicted to still not utilize EHR systems by 2019 (Mennemeyer et al., 2016).

Electronic Medical Records (EMRs) and Electronic Health Records (EHRs) are often used interchangeably by professionals in the healthcare industry and the government, but the two

terms are quite different from one another (Garets & Davis, 2006). The National Coordinator for Health Information Technology describes an Electronic Health Record (EMR) as a digitized version of a more traditional paper-based medical record and is typically bounded by data that exists solely as a particular care facility (Garrett & Seidman, 2011). An Electronic Health Record (EHR), on the other hand, contains patient data from external sources due to its heightened levels of interoperability and provides a more comprehensive view of the patient's overall health (Blind, 2017). Because the HITECH Act has requirements for health information technology to be interoperable with other technologies and systems, the Electronic Health Records is the system that meets the requirements for Meaningful Use and not the Electronic Medical Record and therefore, for the purpose of this study, Electronic Health Record (EHR) shall be the terminology used.

Statement of the Problem

The researcher has worked for the last ten years as the Chief Information Officer (CIO) for a pediatric practice in Southwestern Pennsylvania. In addition, to this role, the researcher has also performed in a consultant capacity for community health centers, teaching hospitals, and physician practices across Michigan, Pennsylvania, Virginia, and Texas. During that time working closely with hundreds of physicians, he has personally witnessed feedback from them suggesting that the implementation of Electronic Health Record (EHR) systems have altered the way they practice medicine and introduced clerical tasks that physicians do not feel is their proper role (Brotzman et al., 2009). Physicians are reporting lengthier office visits with patients due to the new documentation requirements of some of the programs, such as Meaningful Use, which may be adding as much as two hours' worth of documentation-related tasks for every one hour spent on clinical work with patients (Reisman, 2017). This increase in time is not because

the physician is spending more quality care time with the patient but because the physician has their back to the patient while typing on their laptop. Studies show that the increased administrative requirements of the systems are raising costs and slowing physician productivity by 11% (Meyerhoefer et al., 2016). Also, issues such as security, costs associated with system maintenance, and the lack of perceived benefits leave to wonder if the systems are worth the investment at all (Clayton et al., 2005). However, another study demonstrates a seven percent increase in charges captured by EHR system adopters compared to non-adopters (Cheriff et al., 2010). If the burden of the EHR system on productivity and changes in the volume of patients for whom the physicians can care for in a given period is true, this could have significant implications to a medical practice's financials and the overall health of the patient base.

Purpose of the Study

The purpose of this research is to understand how the implementation of EHR systems has impacted physician productivity over time by evaluating trends in a standard measure of physician productivity, the relative value unit (RVU), as well as to identify the benefits and challenges of using the EHR system.

Research Questions

The following research questions are central to this study:

1. What are the trends in physician productivity as measured by RVUs over a 10-year period?
2. What benefits and challenges do physicians report as a result of using an EHR system in the practice?

Significance of the Study

The findings of this study will help physicians and administrators have a better understanding of the long-term impact on medical practices from using an Electronic Health Record technology. This study examined empirical productivity data from physician encounters as well as investigated the physician's perceptions of how technology has impacted their productivity and the way they practice medicine through a series of interviews. A 2014 study revealed that before even seeing the system implemented, 82% of physicians believed that having an EHR system would decrease their productivity and 90% of physicians believed that having an EHR system would add significant burden to data entry tasks (Alasmary et al., 2014). Taking into consideration this study, administrators, physicians, and government entities will be able to manage their business and create business plans and set boundaries to guide EHR system usage requirements in the future.

Boundaries of the Study

This research is confined to a single pediatric practice in Southwestern Pennsylvania who has been using an EHR system for ten years at the time of this study. Before the implementation of the electronic health records, the practice was using an electronic practice management system made by a different vendor to manage appointment scheduling and billing but was still documenting patient visit information on paper charts. After the implementation of the EHR system, the practice converted the practice management system to that of the new EHR system vendor. All quantifiable data for this study is extracted from a combination of those two practice management systems. Qualitative data was gathered through interviews with shareholder physicians at the practice who have been on the EHR system for the duration of the systems use.

Overview of the Document

This research is organized into five chapters. In Chapter One, the history of Electronic Health Record (EHR) systems are discussed from the earliest technologies of paper-based records to the 21st century reincarnate based on computer technology. Chapter Two is a survey of the relevant literature and examples of studies supporting the use of EHR systems and the benefits, studies against the widespread implementations including the challenges of the software, and studies documenting the impact of the technology on physician productivity. Chapter Three focuses on the methodology of the research, a description of the sample, and how the data was collected and analyzed. In Chapter Four, the findings from the productivity data of 20 physicians and findings related to patient visit volume reports as a result of the implementation of the EHR system are presented. Lastly, Chapter Five synthesizes the findings presented in Chapter Four, recommends areas for future research and exploration, and discusses the limitations of this study. This document concludes with a list of references and appendices.

Chapter 2: Literature Review

Introduction

From approximately 2008 through 2020, the healthcare market has been experiencing an information technology renaissance that has brought an influx of new technology to an industry that has been lagging some 10 to 15 years behind other sectors (Goldschmidt, 2005). With the adoption of electronic health record systems (EHRs) came the promise not only of the modernization of the way the healthcare industry manages patient information, but also the promise of significant cost savings (Kumar & Bauer, 2011). A 2006 analysis by RAND Corporation, a government policy think tank, projected that the savings associated with a nationwide adoption of EHR systems could realize over $81 billion in annual savings (Sidorov, 2006). While the potential savings of using an EHR system was getting the attention of physicians and administrators, it was the potential of revenue growth that was getting even more attention.

The boost to productivity that could be realized due to automation and the elimination of manual tasks, could increase income while simultaneously reducing labor costs associated with running practices has tremendous appeal (Song et al., 2011). With virtual charts at their fingertips, physicians will no longer need to employ staff to pull and maintain charts, call in medical orders, pay for lab or radiology order entry labor costs, and cost savings can be realized through staff reductions (Song et al., 2011). Despite these promises, systems developed before the creation of the HITECH Act and resulting Meaningful Use program have resulted in practices having to install countless updates to their systems in order to comply with the new regulations (Smith Ryan et al., 2014). With each system update comes changes to the system that requires training and a subsequent learning curve that has an impact to the physician productivity.

This chapter reviews the research literature related to the measure of physician productivity used in this study, the relative value unit (RVU) and how electronic health record systems (EHRs) have had an impact on physician productivity. In addition, this literature review explores the current views on physician perceptions as they relate to the EHR systems and if factors such as the government's Meaningful Use program has had an impact on productivity.

The HITECH Act, Meaningful Use, and Patient Privacy

HITECH

The American Recovery and Reinvestment Act (ARRA) of 2009 contains an important piece of legislation called the Health Information Technology for Economic and Clinical Health (HITECH) Act which aimed to promote the diffusion of electronic health records as an essential tool for improving the overall health of all Americans (Gold & McLauglin, 2016). In addition to promoting the use of EHR systems, the HITECH Act sought to promote EHR system interoperability and to develop the ability to securely and easily facilitate the electronic transfer of patient data between disparate EHR systems through the implementation of Health Information Exchanges (HIEs) (Gold & McLauglin, 2016).

Meaningful Use

To encourage the adoption of EHR systems, and to encourage the use of the systems in a meaningful way, the HITECH act allotted $27 billion in Medicare and Medicaid funds to be paid over 10 years to private physician practices and hospitals who could attest to meeting the Meaningful Use (MU) requirements (Gold & McLauglin, 2016). In an attempt to reduce the initial burden of meeting the requirements, stages would be established, spread out over five years and different stages and requirements would be set wherein hospitals or physicians would have some degree of flexibility in which to choose which measures and programs to participate.

To meet stage one of Meaningful Use, a physician practice would need to meet 15 core objectives, five objectives out of a menu set of 10, and would need to successfully meet 6 Clinical Quality Measures (of which, three would have to come from a core set or an alternative core and an additional three out of a menu set of 38 measures set by the National Quality Forum (NQF)) (Centers for Medicare & Medicaid Services (CMS), HHS, 2010). The pediatric practice studied for this research attested to the core objectives, menu set objectives, and Clinical Quality Measures (CQM) listed in the following three tables for stage one of Meaningful Use. The full list of available core objectives, menu set items and CQMS can be found in Appendix E. Menu item NQF 0028 is divided into two parts, A and B, in which the practice selected both menu set options, bringing their total selection to the required minimum number; however, they are combined into one item in the table.

Table 1. Stage 1 Meaningful Use Core Objectives.

Description
Use of Computerized Physician Order Entry (CPOE) for medication orders
Implement drug-drug and drug-allergy interaction checks
Generate and transmit permissible prescriptions electronically (eRx)
Record demographics (preferred language, gender, race, ethnicity, date of birth)
Maintain an up-to-date problem list of current and active diagnoses
Maintain an active medication list
Maintain active medication allergy list
Record and chart changes in vital signs (height, weight, blood pressure, BMI, plot and display growth charts for 2-20 years)
Record smoking status for patients 13 years old or older
Implement one clinical decision support rule relevant to specialty or high clinical priority along with the ability to track compliance to that rule
Report ambulatory clinical quality measures to CMS or the States
Provide patients with an electronic copy of their health information (including diagnostic test results, problem list, medication lists, medication allergies), upon request
Provide clinical summaries for patients for each office visit
Capability to exchange key clinical information (problem list, medication list, medication allergies, diagnostic test results), among providers of care and patient authorized entities electronically
Ensure adequate privacy and security protections for personal health information

Table 2. Stage 1 Meaningful Use Menu Set Items.

Description
Incorporate clinical lab-test results into certified EHR technology as structured data
Send reminders to patients per patient preference for preventative/ follow up care
Provide patients with timely electronic access to their health information (including lab results, problem lists, medication lists, medication allergies) within four business days of the information being available to the eligible provider (EP)
Use certified EHR technology to identify patient-specific education resources and provide those resources to the patient if appropriate
The EP, eligible hospital or critical access hospital (CAH) who received a patient from another setting of care or provider of care or believes and encounter is relevant should perform medication reconciliation
The EP, eligible hospital or CAH who transitions their patient to another setting of care or provider of care or refers their patient to another provider of care should provide summary of care record for each transition of care or referral.

Table 3. Stage 1 Meaningful Use Clinical Quality Measures.

Description
Percentage of patient visits for patients 18 and older with a diagnosis of hypertension who have been seen for at least 2 office visits, with blood pressure (BP) recorded (Measure: NQF 0013)
Percentage of patients 2-17 years of age who had an outpatient visit with a PCP or OB/GYN and who had evidence of BMI percentile documentation, counseling for nutrition and counseling for physical activity during the measure year (Measure: NQF 0024)
a) Percentage of patients aged 18 years and older who have been seen for at least 2 office visits who were queried about tobacco use one or more times within 24 months. b) Percentage of patients aged 18 years or older identified as tobacco users within the past 24 months and have been seen for at least 2 office visits who have received tobacco cessation intervention (Measure: NQF 0028a, b)
Percentage of children 2 years of age who had four diphtheria, tetanus and acellular pertussis (DTap); three polio (IPV); one measles, mumps and rubella (MMR); two H influenza pox (VZV); four pneumococcal conjugate (PCV); two hepatitis A (Hep A); two or three rotavirus (RV); and two influenza (flu) vaccines by their second birthday (Measure: NQF 0038)
Percentage of patients aged 5 through 40 years with a diagnosis of asthma and who have been seen for at least 2 office visits, who were evaluated during at least one office visit within 12 months for the frequency of daytime and nocturnal asthma symptoms (Measure: NQF 0001)
Percentage of children 2-18 years of age who were diagnosed with Pharyngitis, dispensed an antibiotic and received a group A streptococcus (strep) test for the episode (Measure: NQF 0002)

Percentage of patients 50-50 years of age who were identified as having persistent asthma, had at least one face-to-face encounter and were appropriately prescribed medication during the reporting period (Measure: NQF 0036)
Percentage of patients aged 5 through 40 years with a diagnosis of mild, moderate, or severe persistent asthma who were prescribed either the preferred long-term control medication (inhaled corticosteroid) or an acceptable alternative treatment (Measure: NQF 0047)

Adapted from "Medicare and Medicaid Programs; Electronic health record incentive program; Final rule." 2010, *Federal Register*, *75*(144). Copyright 2010 by Centers for Medicare & Medicaid Services (CMS), HHS.

Patient Privacy

Although security and patient privacy protections were already established under the Health Insurance Portability and Accountability Act of 1996 (HIPAA) the HITECH Act established additional guidelines and set aside additional funding for education and enforcement for additional protections (Gold & McLauglin, 2016). The Privacy Rule, located at 45 C.F.R. Part 160 and Part 164 subparts A and E, define standards to protect the private health information of patients and set guidelines on the appropriate safeguards and appropriate disclosure of protected health information (PHI) (Kempfert & Reed, 2011).

The Relative Value Unit

The Relative Value Unit (RVU) is a tool for gauging physician compensation that was adopted by the Centers for Medicare & Medicaid Services (CMS) in 1992 (Kentros & Barbato, 2013). The goal of the RVU is to provide insurers and the government a baseline to reimburse the physician for the "usual, reasonable, and customary" expenses incurred during the treatment of a patient which can include the expenses associated with hiring staff, leasing space in which to conduct business as well as the cost of having insurance (Becker et al., 1988). The RVU establishes a particular value for each current procedural technology (CPT) code used when billing the patient or insurance companies. Because costs are for overhead expenses such as payroll and rent are not consistent across the United States, the system uses a geographical

practice cost index (GPCI) to adjust payments regionally across the country to promote equity (Seime & Manley, 1999). This value, based on the geographical area of the physician, is then multiplied by an assigned dollar amount and the resulting value is the amount of compensation entitled to the physician by CMS. RVUs are then calculated by combining the work effort required to see the patient and expenses associated with the practice as a business as well as the cost of malpractice insurance, see Figure 1 (Pickard, 2014).

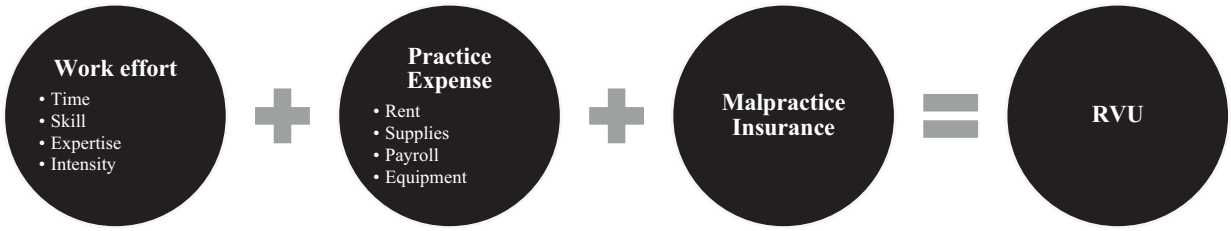

Figure 1. Factors associated with the calculation of an RVU

The measure of work effort, or intensity as it is called, is the amount of mental or physical effort expended by the physician or the amount of stress placed on the physician in order to care for the patient. In other words, the intensity of visits for patients typically seen by a surgeon could be between 50 to 65 percent higher than those patient seen by a typical family physician and as such, the calculated RVUs are relatively higher for the surgeon when compared to the family practitioner (Hsiao et al., 1993). As healthcare has shifted away from a fee-for service model in which the physician is compensated for seeing a patient without regard to the patient's recovery from illness to a pay-for-performance system where the physician is rewarded for preventative care and keeping the patient from emergency rooms, the traditional model for the RVU that reimburses physicians for each CPT code submitted has not changed. This lack of change leads some to argue that the antiquated model entices physicians to perform services that are not

necessary to keep CPT usage high, and thus, productivity high, though the services or tests have no impact on the health of the patient (Johnston et al., 2013).

Benefits of an Electronic Health Record Implementation

The potential benefits of an EHR systems implementation to a practice include increased access to patient information, reduced medication errors, lower overhead costs due to a reduced need for paper chart maintenance, and better evaluation and management coding (Barlow et al., 2004). In addition, the practice of recalling patients annually for routine visits, follow-up exams or for vaccinations such as influenza, which were once manual tasks, could be automated by electronic systems; reducing the staff burden and reducing the likelihood that patient recall opportunities are missed. Practices harnessing the power of these systems and who have successfully adapted or altered their workflows to take advantage of the electronic systems may experience these and other benefits as well as increases to physician productivity, netting a positive financial impact to the practice. The following sections explore some of these topics in further detail.

Increased Access to Patient Information

A series of surveys conducted in Canada between 2006 and 2017 gathered data from over 2,300 respondents regarding satisfaction levels, impact on quality of care as well as the impact on productivity of EHRs. While the results were often mixed among the various areas and respondents, the results were overall positive related to the net quality and benefits to productivity. With respect to increased access to patient information, the Canadian study reported an overall positive outcome in accessing diagnostic imaging and lab results, and perhaps more importantly, the study reported positive outcomes in the ability to share patient information among provider and to coordinate care (Tharmalingam et al., 2016). Researchers Baloushi and

Ramukumba expanded on the concept of sharing patient information by exploring the detailing some of the technological and database characteristics that are the underpinning of the EHRs. The systems allow multiple physicians to simultaneously view patient records and consult on images in real time, regardless of the geographical locations, to improve the quality of care for patients (Baloushi & Ramukumba, 2015).

Reduced Medication Errors

The reduction of medication errors is often mentioned as a reason why practices implement EHR systems and is between the fourth and sixth leading cause of death in the United States (Shalviri et al., 2018). Shalviri's article is important to this research because it defines three main phenomena, adverse drug events, adverse drug reactions, and medication errors by quoting from the World Health Organization (WHO). An adverse drug event is medical event that presents during treatment with a pharmaceutical product, even though the event may not have anything to do with the pharmaceutical product. Adverse drug reactions are responses which are harmful and unintended at doses normally used for humans. Lastly, the WHO defines medication errors as a preventable event which can cause or lead to a medication being inappropriately used or harm to a patient while the medication is in control of the healthcare professional or patient (Shalviri et al., 2018).

Chaudry et al. (May, 2006) examined 257 studies to understand the reported outcomes of the impact of EHRs on medication errors and reported their findings in a 2006 study. In the studied hospital settings, EHRs demonstrated significantly significant reductions in adverse drug events, from 28 events down to just four events in one hospital, for example, and an .6% decrease in antibiotic-related adverse-related drug events during the two-year study period. Another study highlighted in their research, performed by Bates et al. (January, 2003), also

demonstrated a 17% decrease in adverse drug events. In their research, Chaudry et al. also documented studies that revealed a statistically significant 55% decrease in serious medication errors at one location as well as a 86% decrease at another facility. Lastly, EHRs in the Chaudry et al. study not only decreased medication errors but have also improved medication dosing accuracy ranging from 12% to 21% within the recommended ranges for antibiotics and anti-coagulation medications (Chaudhry et al., 2006).

Standardization of Evaluation and Management Coding

In order for a physician to be able to bill an insurance company or Medicare/Medicaid for a patient visit, he or she must document the details of the visit along that much include detailed diagnoses for the patient as well as information around the type of visit and the amount of time spent with the patient. Instead of writing out sometimes long, complex names for medical terminology, the physician uses a series of codes, called Current Procedural Terminology (CPT) codes, that detail the services performed during that visit and also select from a series of codes that describe the complexity of the visit and decision-making level required to arrive at a diagnosis or treatment plan (Kurec, 2014). The American Medical Association is the governing body that is responsible for the codification of the medical terminology, the licensing of its use to all medical professionals as well as the oversight body for its modification and continual review process.

The process by which the physician selects the decision-making level and visit complexity is called “Evaluation and Management” coding or E&M coding and is required on every claim that is to be submitted to a payer. The codes are in clusters and are made up of five decision-making levels, each with a higher complexity than the previous. For example, 99211, 99212, 99213, 99214, and 99215 are all E&M codes that describe an office visit for an

established patient and may most likely be used for a non-routine, acute visit with a 99212 being higher than a 99211 and so on.

With each code comes a different level of reimbursement from the payers with higher codes receiving a higher payment than lower codes and undercoding or overcoding visits each come with their own set of risks. Undercoding, or submitting a code with a lower value than should be used for a visit with a specific length or complexity, will warrant reimbursement for less than the physician should be receiving if properly coded. A study released in 1998 revealed that 55% of codes submitted by physicians were coded incorrectly with undercoding and overcoding being approximately equal in use (King et al., 2001). Other studies, while still demonstrating general equality in under and overcoding, report the frequency closer to 20% of visits being incorrectly coded (Kikiano et al., 2000). Conversely, overcoding, or using a visit code higher than warranted for the type of visit could result in payers taking back reimbursements or legal ramifications in the event of an audit. EHR software products feature algorithms that evaluate visit documentation and suggest the appropriate level of coding. In a study conducted during an EHR system implementation in New York City among 75 physicians at a federally qualified health center (FQHC), the clinic experienced a 53 percentage point decrease in 99241 (office consultation for a new or established patient, 15-minutes) Current Procedural Terminology (CPT) codes and a 73 percentage point increase for 99243 (office consultation for a new or established patient, 40-minutes) CPT codes post-EHR system implementation when compared to pre-EHR system E&M coding distributions (De Leon et al., 2010). The decrease in the lower level, 99241 and increase in the higher level, 99243 suggests that the implementation of the EHR system and its integrated visit coding technology upwardly

suggested coding levels based on physician documentation which had a positive financial implication for the practice.

EHR systems can be a benefit to practices by helping to standardize the somewhat arbitrary practice of coding visits for reimbursement. By using built-in algorithms in the EHR system, the software suggests the appropriate visit code based on the amount of documentation on a patient visit as well as the documented time spent with the patient. Studies suggest that the EHR systems are able to assist with adjusting the coding distribution profiles for physicians to be aligned with ever-changing guidelines and trends in the industry while still being appropriately coded for the specific patient visit (Marting, 2018; Nicoletti, 2007). Physicians can be more confident that the submitted code is appropriate for the decision-making level and complexity for the patient visit and be less at risk in an audit of having insufficient documentation to justify the code that was submitted.

Challenges of an Electronic Health Record Implementations

Implementing an EHR system is not as simple as installing the software, starting the training videos for the users, and then standing back and watching everything run like clockwork. Once a system has been evaluated and selected, the arduous task of installation can take months or sometimes years and at a cost of $13,000-$44,000 per physician based on the complexity of the selected system and the size of the practice (Fleming et al., 2009). Beyond financial challenges are such challenges as training and learning, changes in physician productivity and challenges with physician perceptions regarding the usefulness of the EHR system in general that all must be thoroughly vetted or mitigated so as to not disrupt the normal operation of the practice as much as possible.

A study conducted at the Lehigh Valley Health Network in Eastern Pennsylvania from July 2007 through July 2009 utilized both a qualitative and a quantitative approach to understand the impact that an EHR system has on a set of four OB/GYN practices within the network. From a qualitative frame, the research first identified that significant learning is necessary not only for data entry tasks but also for data retrieval. The researchers found that the organization needed to create new policies and procedures to handle new issues as a result of the electronic health record (EHR) system implementation that did not exist with paper record systems. Lastly, significant process reengineering had to occur because existing workflows were no longer valid in the new electronic system (Meyerhoefer et al., 2016).

Measuring the productivity of a practice or a hospital is a difficult task because of the sheer number of variables at play. Changes in daily staffing, the different mix of patients presenting on a particular day, or technological issues that might arise make it difficult to set any sort of benchmarks. As practices implement EHR systems, measuring and reporting to stakeholders the impact of the EHR system on the productivity of the physicians can put the implementation project in danger if there is a decline in productivity or if care improvement thresholds are not met. In an attempt to educate stakeholders on the challenges of the implementations, researchers collected data from the American Hospital Associations annual survey from 2006-2008 to try to gain more understanding of performance as reported by hospital productivity and efficiency. The results of their study indicate that the hospitals studied are experiencing an overall decrease in efficiency of over four and a half percent annually however, the same hospitals are experiencing an overall productivity increase of just over three percent annually (Huerta et al., 2013). How could this be? As it turns out, these kinds of metrics are possible because hospitals, and by some extension practices, are becoming less efficient by using

EHR system workarounds or not engaging in process reengineering and trying to use the workflows they used when employing paper-based records for the new, electronic system. Gains in overall productivity are being realized by adding staff, such as scribes for physicians or by extending hours for clinical staff such as nurses (Huerta et al., 2013).

In a 2016 study, researchers Meigs and Solomon interviewed 16 primary care physician practices in the greater San Antonio, Texas, area to determine physician perceptions of EHR system use within their offices. The results of their study represent several challenges to the implementation of EHR system and the way that physicians again use workarounds in an attempt to minimize the impact of the technology on the way they run their practices. The most common of the workarounds that physicians employ is that they often do not document the patent visit on the computer during the office visit. Instead, they make notes on a piece of paper or notepad and document in the EHR system at a later time (Meigs & Solomon, 2016). Of the physicians studied, only 17% believed that the EHR system improved the care they were providing for the patients and 63% of the physicians disagreed with the Department of Health and Human Service's notion that EHR system helped improve patient care; going so far as to say that nearly 40% of physicians say that EHR systems might negatively affect the quality of care (Meigs & Solomon, 2016). Based on the work of Meigs and Solomon, physician workarounds and general attitudes toward EHR systems certainly represent a challenge to the efficacy of EHR systems in practices but there are other challenges that must be explored to understand the full impact of the software.

The Effect of an Electronic Health Record Implementation on Physician Productivity

It would be myopic to think that any issues related to the introduction of software in any environment would be the sole reason for changes in productivity. In this context, it is necessary

to study the capabilities of the physicians with regard to computer skills to understand any limitations they may have and how that might affect their perception and execution within a software environment. Researchers in Saudi Arabia studied correlations between training and computer literacy against productivity and user satisfaction to understand if any relationships exist. Their study found that less than 10% of users had the necessary computer skills to be successful with the physicians ranging from one percent to 27% when asked if they owned a home computer (Alasmary et al., 2014). Without ever having even seen or interacted with the system before, 90% of physicians already believed that having an EHR system would add to the burden of data entry and almost 82% of the physicians believed that it would decrease their productivity (Alasmary et al., 2014). Clearly, physician perception of an EHR system, even without ever experiencing one, is a challenge that is going to prove difficult to overcome if at all possible.

Concerns related to reduced physician productivity and losses in efficiency often take center stage when practices consider implementing EHR systems as these can have considerable negative implications. To minimize the real or perceived effects of the negative impacts to productivity, physicians and staff resort to workarounds such as not documenting in the EHR system while in exam rooms then documenting later. The net effect of the workaround is double documentation of the patient visit and a lowering the overall efficiency of the practice. Lastly, we must take into consideration the computer literacy skills of the physicians and how that will impact training and the overall implementation timelines as well as the productivity of the physician post go-live.

Study results range from reporting that the impact of the EHR system negatively affects the productivity of the physicians all the way to increasing productivity levels over pre-EHR

system implementation levels and everything in between. Lim et al. indicates that despite the implementation of an EHR system, there seems to be no indication of a change in productivity nor a change in the collection of any revenue post-implementation (Lim et al., 2015). The following section gives some examples of the various studies with respect to their results on how the EHR system implementation has impacted productivity within the population studied or if any impact has been noted at all.

Negative Impacts on Physician Productivity

With the implementation of nearly anything new, some users may experience some level of a learning curve. From a new phone or a new computer to a new car, there may exist some level of slowed productivity while we acclimate ourselves to our new surroundings. In the case of electronic health records systems (EHRs) , this is no different, with the productivity of some physicians dropping as much as 20% during the first three months post-implementation (Vanderhook & Abraham, 2017).

Proponents of EHR systems continue to promote the technology as a way to lower healthcare costs and increase the quality of care patients receive. With some cost estimates of EHR system implementations costing as much as $44,000 per full-time physician and over $8,000 per year in maintenance costs, any negative impact to physician productivity could have severe negative financial consequences for the practice (Brunt & Bowblis, 2014). Using a national survey, the Health Tracking Physician Survey (HTPS), researchers studied how health IT adoption impacted physician productivity, the amount of time physicians spent on administrative tasks, and the quality of the care provided. They concluded their study by reporting that physicians who have adopted an EHR system, saw five fewer office visits per week compared to physicians who did not adopt an EHR system technology and adopters spent

approximately three minutes longer per visit compared to non-adopters (Brunt & Bowblis, 2014). Brunt and Bowblis also reported that adopters experienced a 15% increase in the time it takes to complete administrative tasks, translating to an hour and 15 minutes additional working time per week. Similar data was reported by Lam et al., (2015) with Department of Ophthalmology at the University of Washington in Seattle, Washington who observed physicians seeing approximately 17% fewer patients each year compared to pre-EHR system patient volumes and needing almost seven more minutes to document each patient visit (Lam et al., 2015).

The quantitative study results from the Lehigh Valley Health Network research suggest that the challenges presented by the implementation led to an overall decrease in physician productivity of 11% and even though the productivity recovered just over eight percent, it still remained below the pre-implementation levels for the length of the study (Meyerhoefer et al., 2016). What is interesting to note is that while the rate of productivity, the relative value unit (RVU), decreased, Meyerhoeffer et al. note that treatment intensity of the visits increased. Intensity is the volume of physician services offered during a patient's visit. While an EHR system could be negatively affecting the number of patients a physician can see in a given day, the system may be assisting the physician capture billing opportunities that may have otherwise been forgotten or suggesting care opportunities that the physician may not have thought about and resulted in increased charges being documented for each patient visit (Meyerhoefer et al., 2016). This revelation gives merit to the reported benefits of EHR systems in so much that their evaluation and management (E&M) coding algorithms assist physicians with selecting the appropriate code for the visit based on the services rendered and the appropriate complexity level.

Negative impacts to physician productivity have been reported as a direct result of the implementation of EHR systems. The studies discussed in this section identify the impact manifestations ranging from additional work hours being added to the week to decreases in the volume of patient visits reaching as high as 17% few patients each year. No specific specialty appears to be immune as the studies reviewed in this section range from hospital systems to ophthalmology as well as internal medicine and the effects of the implementation can be felt in work areas ranging from visit documentation to administrative tasks completed by physicians.

Positive Impacts on Physician Productivity

Despite temporary decreases in productivity, studies also show that the drop appears to be temporary with performance returning to pre-EHR system implementation levels and even experiencing increased revenue within some timeframe post-implementation. This increase in productivity may suggest that the EHR systems are able to fulfill their promise of increased productivity (Fleming et al., 2014).

Using a retrospective, longitudinal observation study of the financial performance of 33 practices from the HealthTexas Provider Network from July 2002 through April 2006, which was implementing a new EHR system at the time, researchers attempted to understand what financial impacts an EHR system implementation can have on a company. Researchers observed a statistically significant positive ($P<0.05$) mean increase of 4.14% from 2003-2005 for work RVUs per physician. Though the mean number of patient visits, per physician, post-implementation experienced a -1.94% during the study timeframe of 2003-2005 (Fleming et al., 2009). Parallel to the Meyerhoefer et al. study in 2016, Fleming et al. also observed that post-EHR system implementation, practices experience an increase in per-visit RVU intensity as a byproduct of the EHR system suggesting different visit evaluation and management (E&M

Coding) levels, by suggesting additional services physicians might be missing, such as a missing immunization or identifying an undocument procedure code that would have otherwise gone unbilled by the physician (Fleming et al., 2009).

A 2004 study conducted at Partners Healthcare System in the greater Boston area revealed that physicians took about half a minute less to see a patient using the EHR system compared to the time needed to see a patient while documenting on a paper chart (Pizziferri et al., 2005). Though this small amount of time may seem insignificant, it is does illustrate the fact that the physician did not spend more time in the exam room per patient encounter while using the electronic system when compared to the time spent while using the more traditional paper system. It should be noted however, that the author of this study points out that 66% of physicians reported having to document patient visits outside of clinic hours (Pizziferri et al., 2005).

From March 2006 through September 2006, a community health clinic (CHC) around the New York City area was implementing an EHR system across their multi-specialty locations. Researchers at the sites studied how the clinics improved the delivery of healthcare through the use of health IT by measuring physician productivity before the EHR system implementation, during, and for a period of six months post-implementation. The researchers counted CPT codes for each visit and converted the codes to the corresponding RVU value in order to create the productivity metrics for each of the 75 physicians included in the study. Though the data demonstrates a slight decrease in the number of visits in the period immediately following the implementation, the number of encounters increased, resulting in a five percent increase in encounters per physician per month post-implementation compared to pre-EHR system levels (De Leon et al., 2010).

In the Alasmary (2014) study, in which the researchers were observing the relationship between training and computer literacy on user satisfaction and physician productivity at a hospital in Saudi Arabia which was about to begin an EHR system implementation. Towards the end of the implementation, the researchers indicated a statistically significant positive correlation between age and user satisfaction with the system and noted that post-implementation most physicians and nurses agreed their new perception was that indeed, the new EHR system increased clinical productivity (Alasmary et al., 2014). They also reported scores that indicated that the highest levels of satisfaction came from the physicians and that the participants reports being generally happy with the system.

Despite practices experiencing a decrease in physician productivity post-EHR system implementation, the studies cited in this section all experienced a positive trend in their productivity metrics with most meeting or exceeding pre-EHR system levels. On top of the increased productivity, practices also experienced increased coding levels and increased charge capture due to the EHR system's ability to better capture services rendered and procedure codes that often are missed by physician such as immunization injection administration codes. Practices using EHR systems also report faster patient visit documentation time and more complete patient visit notes as well as an overall increase in the number of visits physicians are able to complete in a given time period.

No Impact on Physician Productivity

While there are studies that portray the negative or positive effects of an EHR system on a physician's productivity, some studies demonstrate that EHR system implementations have no impact on physician productivity (Carayon et al., 2009; Pizziferri et al., 2005). In their 2009 study, researchers Carayon, Smith, Hundt and Kuruchittham explored the implementation of an

EHR system at a small clinic about 18 miles southwest of Madison, Wisconsin, to understand the impact of the EHR system on clinical performance and patient care. Through their research, they noted that tasks performed by physicians did not experience any significant change post-implementation when compared to pre-implementation levels, though there was a 38% decrease in the number of tasks normally completed by general clinical staff (Carayon et al., 2009). Additionally, the implementation did not significantly alter the amount of time physicians spent with their patients, but the time the physicians spent on computer entry tasks increased while dictation, phone call, and writing time decreased overall (Carayon et al., 2009). In the end, and parallel to the Pizziferri el al. study, the Carayon et al. research demonstrated no loss in productivity due to the use of an EHR system implementation at the practice.

Though some studies reported on the negative or positive impacts that the implementation the EHR systems had on physician productivity, other studies, like those mentioned in this section, reported a net zero change in the level pf productivity post-implementation. While the study noted in this section notes a general shift in tasks and who is responsible for completing the specific tasks, it does not identify any increases or decreases in the volume of patients physicians are able to see in a given period. The absence of change in productivity lends a level of doubt as to whether the implementation of an EHR system changes the productivity of a physician at all.

A Summary of The EHR System's Impact on Productivity

Studies related to how physician productivity changes as a result of an EHR system implementation vary in their findings from no impact at all to impacts ranging from a sharp decrease to increases in productivity. While the findings typically demonstrate no change in the amount of time physicians spend with each other patients, they often report that physicians spend

more time outside of clinic hours documenting visits in the EHR system and have more administrative burden than compared to pre-implementation levels. On the opposite side of the argument, while also reporting a drop in productivity immediately post-implementation, researchers in other studies are reporting that productivity soon returns to pre-EHR system levels and in some instances surpasses them. Still, other researchers report almost no impact at to the productivity levels despite some fluctuations in productivity immediately post-implementation.

Productivity aside, the question that still remains to be explored is in regard to the benefits and challenges that physicians experience as a result of using the EHR systems. Among the promised benefits was a reduction in medical errors due to illegible handwriting and a streamlining of workflows from within the offices. This research aims at understanding the challenges and the benefits associated with the implementation of these systems by looking at productivity trends over a 10-year period. Interviews with physicians who have used the systems for the 10-year period will help give insight into how workflows have changed, how patient care has changed as well as the benefits and the challenges associated with the utilization of the software in the course of the daily workloads of the offices.

This chapter was a review of the literature as it pertains to Electronic Health Record (EHR) system implementations. Topics discussed in this chapter included the HITECH Act which came out of the American Recovery and Reinvestment Act of 2009 and let to governmental programs such as Meaningful Use. The Relative Value Unit (RVU), its history and how it is derived, as a standardized measure pf physician productivity. Next, discussed in this chapter were the potential benefits of EHR systems which included: increased access to patient information, reduced medication errors, and the standardization of evaluation and management coding for patient visits. Lastly, in this chapter, the researcher counters the offering of potential

benefits by discussing potential challenges to the implementation of an EHR system by discussing such topics as cost and the potential changes to a physician's productivity. The next chapter will focus on a qualitative methodology and, using a case study approach, will study how 20 physicians at a pediatric practice in Southwestern Pennsylvania has been using an EHR system from 2008-2018 and will seek to understand their benefits and challenges as well as to report on any changes in physician productivity during the 10-year focus of this study.

Chapter 3: Methodology

The purpose of this qualitative case study is to understand how the implementation of Electronic Health Record (EHR) systems has impacted provider productivity by looking at standardized units of physician productivity. In addition to the calculated productivity data, this research includes interviews with physicians to study their perceptions of the EHR system technologies, benefits to their practice, and the challenges associated with the EHR system implementation. This chapter describes the details of the qualitative methodology that will be followed in pursuit of the data to help answer the questions that led to this research.

Purpose of the Study

The purpose of this research is to understand how the implementation of EHR systems has impacted physician productivity by looking at productivity calculations as well as to identify the benefits and challenges of using the EHR system.

Research Questions

The following research questions are central to this study:

1. What are the trends in physician productivity as measured by RVUs over a 10-year period?
2. What benefits and challenges do physicians report as a result of using an EHR system in the practice?

Research Design

The methodology that is used for this research is an instrumental case study and is designed to gain a better understanding of how the implementation of an EHR system has impacted the physicians at a pediatric practice in the mid-Atlantic region of the United States. Hancock and Algozzine (2017) describe an instrumental case study design as a way “to better

understand a theoretical question or problem" (p. 38). Grandy (2012) describes an instrumental case study as, "the study of a case (e.g., person, specific group, occupation, department, organization) to provide insight into a particular issue, redraw generalizations, or build theory" (p. 475). Creswell and Poth offer a description of qualitative research as a use of interpretative or theoretical frameworks which bring to the study, the researching of problems that affect individuals or groups of humans. The researchers continue on to say that in order to study the problems, qualitative researchers collect data from within the natural environment settings of the people and analyze the data using both inductive and deductive reasoning to establish patterns and themes. Their final written summaries reflect the voices they heard, offer the complex descriptions and interpretations of the problems witnessed, contain the reflexivity of the researcher, and a contribution to the literature or a call to the reader for chance (Creswell & Poth, 2018). This qualitative case study takes a constructivist philosophical worldview and seeks to understand the different ways in which the physicians approached the subject of the EHR system and perceived the benefits and the challenges of using the system. The determinants on which their perceptions are based are criteria such as their own experience with computers, training on the use of EHR systems, their views of the technology, and their own experience with using the system. The constructivist approach to research is appropriate because it seeks to understand the varied and subjective meanings humans develop as they experience the world around them and interprets the data to create generalized conclusions, theories, or patterns of meaning (Creswell & Creswell, 2018).

This single-case study is a longitudinal case and explores how the implementation of an EHR system has had a long-term effect on an organization as a whole. The longitudinal rationale for a single-case study uses prespecified time intervals to capture data to uncover trends over

longer spans of time that would otherwise be difficult to uncover (Yin, 2018). Patient encounter data was captured on an annual basis for each provider over the entire 10-year span and then the RVUs were calculated for each year. A gap in the identified in the review of the literature reveals that previous studies of physician practices are not for longer than three years. Research over such a short span of time may not effectively document periodic software upgrade cycles, system upgrades, downtime, or changes in reporting requirements such as Meaningful Use that affect electronic systems in ways that would never affect paper-based systems and that may not be adequately captured when only observing a practice for a short span of time. For this reason, this research observes the physician productivity for a span of 10 years which includes the entirety of the Meaningful Use implementation period for the practice.

Using the research questions that are central to this study, a set of semi-structured interview questions was asked of physicians. The face-to-face interviews were conducted using a list of open-ended questions and utilized purposeful sampling to select a number of physicians who have had ten years of experience working with the EHR system. Creswell and Poth (2018) define purposeful sampling as an intentional sampling of a group of people who will best help the researcher understand the problem that is being examined. To allow for triangulation, data was gathered by utilizing productivity reports from the system, consistent with recommendations by Creswell and Yin in which they recommend that data from multiple sources be considered (Creswell & Creswell, 2018; Yin, 2018). The physician productivity data collected was from one-year pre-EHR system implementation to establish an early baseline and then ten years' worth of productivity data post-implementation. The open-ended question style interview methodology was selected in order to induce the participants to be more open and relaxed in their answers with the anticipation that answers to the questions will be more candid and honest, allowing the

researcher to get to the core of the problem being researched. Using the semi-structured approach allows the interviewer to have a fairly narrow list of topics to be discussed while giving the flexibility to allow the interviewee to go off topic in their response which can sometimes be where truly rich data-gathering can occur (Bryman & Bell, 2015). To understand how the EHR system may have added or detracted from the physician's overall ability to practice medicine, the researcher asked questions related to the benefits and the challenges related to the EHR system's usage that the physician has experienced. The intent of the interviews was partially to understand what, if any, changes to physician experience the EHR system has caused and what benefits and challenges the system caused.

Population and Sample

The Federation of State Medical Boards (2016), concluded that the number of active, licensed physicians in the United States was 1,005,295 with approximately 5% of those physicians practicing in Pennsylvania (The Kaiser Family Foundation State Health Facts, 2019).

Formed in 1996, the pediatric practice central to this study was southwestern-Pennsylvania's largest physician-owned practice until it was acquired by a large health system in early 2019. The practice was an early adopter of technology and was one of the first private companies to adopt and fully implement an electronic health record system. Over the years in business, the company first adopted an electronic practice management (EPM) system, called MicroMD, which handled the billing and patient scheduling aspects of the business only. Then, in 2005, the company purchased NextGen, a suite of applications such as an EPM, and EHR as well as integrated patient record scanning record scanning, and a host of interoperability options with other electronic health record systems and migrated the patient records to the new system. At the practice, there are 38 Doctor of Medicine (M.D.) or Doctor of Osteopathic Medicine

(D.O.) physicians, six physician assistants (PA) and eight certified registered nurse practitioners (CRNP) for a total of 52 providers who care for the patient population of the practice. To fully understand how the implementation of an EHR system has impacted physician productivity and gather as much information as possible during the interview process, it is essential to interview participants who have used the system as long as possible from the available participant pool. It is for this reason that the research used the purposeful sampling techniques described by Creswell and Poth (2018) to choose only those participants who have used the EHR system for its entire implementation length to date which, at the present time, is 10 years. In utilizing purposeful sampling, the researcher selects only those participants who can purposely inform on the problem central to the study (Creswell & Poth, 2018). In the case of this study, the researcher identified participants who have used the EHR system for 10 years and the sample was also be limited to providers with a degree level of M.D. or D.O. After the removal of the potential participants who do not meet the criterion, the potential sample size is reduced to 23. For this study, the researcher has a minimum sample of 12 participants and while it would be ideal to interview all 23 physicians, the target number of interviews is 20.

Instrumentation

This research relies on two forms of instruments to gather data which will be compared and contrasted with each other as well as with information gathered from the literature review. One instrument that was used in this study was the reports gathered through the practice's financial reporting system. This reporting system (the instrument) generated the number of times that physicians submitted visit and service codes to the billing system either to be sent to the patient's insurance carrier or to be paid directly by the patient. The RVU values used in the research are the 2019 Medicare published values for each CPT code billed by each physician,

regardless of the year in which the code was billed. This was done to set the values for each of the codes to one value as they can fluctuate from year to year. Medicare's system for arriving at this value combines the cost components of physician work, denoted as the time effort required to diagnose or treat the patient, a portion of the practices overhead expenses and a percentage of the cost of professional liability insurance which the physician is required to carry (Maxwell & Zuckerman, 2007). Each of the three values is multiplied by a number, called a geographic practice cost index (GPCI), which represents a value intended to raise or lower the payment across the country and account for such factors as cost of living, to arrive at a payment amount for the physician. According to the U.S. General Accounting Office, the average physician work represents approximately 52% of the payment, 44% is related to practice-related expenses and the remaining 4% is tied to malpractice insurance expenditures (*Medicare physician fees geographic adjustment indices are valid in design, but data and methods need re-finement*, 2005). The RVUs for each physician that will constitute the quantitative data for this study will be depicted through the use of bar graphs to demonstrate the changes in RVU output over time. Only the physicians who were included in the sample had their RVU data displayed and correlated with the qualitative interview data.

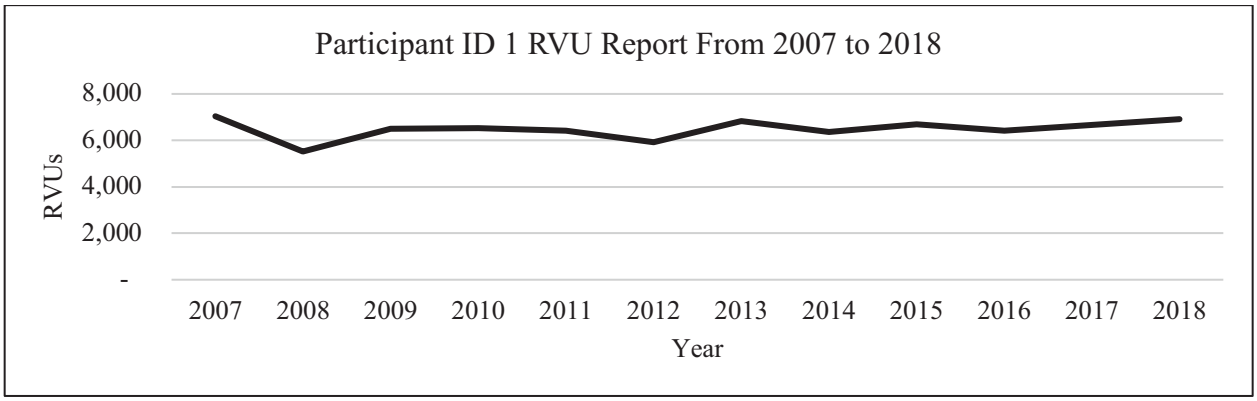

Figure 2. Longitudinal RVU report for Participant 1.

Interview Protocol

The interview protocol that was used for all participants can be found in Appendix D and consists of open-ended questions and a probe for some questions for which the interviewer anticipates may require more exploration. Each question in the interview protocol maps directly back to a research question or to a study discussed in the chapter two which the researcher wanted to further explore with the participants. This instrument was piloted on a physician who has recently retired from patient care but is still active in administrative duties within the practice.

The following research questions are central to this study:

1. What are the trends in physician productivity as measured by RVUs over a 10-year period?
2. What benefits and challenges do physicians report as a result of using an EHR system in the practice?

Data Collection Procedures

Interviews were scheduled for each of the participants in a quiet, private space within each of their practice locations as their schedule permitted and lasted approximately 30 minutes. Because each of the practices are physically located within a 20-mile radius of the Pittsburgh, PA area, the researcher traveled to all locations for a face-to-face interview. The purpose of conducting the interview in the physician's work location was to make them more comfortable and to hopefully extract more natural, more genuine responses to the interview questions. The intention of the open-ended style of case study style of interviewing was intended to be more of a guided conversation rather than a structured question and answer session and be more fluid than

rigid while still being able to get to the key data and insights provided by the participants (Yin, 2018).

In order to ensure that the researcher has captured the full transcript of each interview, an audio recording of each session was taken with the participant's permission. In addition to the audio recording, a notebook and pen was used to take manual notes during the interview to capture such data elements about the interview such as tone, gestures, or other expressions that the researcher deemed important. After each interview, the audio recordings were transcribed and merged with the handwritten notes to produce a master transcript which were then provided to the participant for their review. Once the participant reviewed their transcript and any discrepancies resolved, the material was considered the final version of the interview.

Data that was used in the calculation of the productivity was extracted from the organization's database and did not contain any patient-identifiable data. The data that was extracted did not consist of the physician's name in order to protect confidentiality, but did consist of, a patient encounter hashed value, encounter date, and the CPT code selected by the physician during that encounter. The patient encounter hashed value is a 25-character value primary key in each database table that is used to identify a particular patient encounter across all of the tables in the database but itself does not represent any patient-identifiable information. The use of this hashed value is necessary to ensure that no date is being duplicated and thus skewing the results. The Current Procedural Terminology (CPT) code is the code that is used to determine the complexity of the visit and the amount of time the physician spent with the patient and is used in the lookup of the RVU.

A backup of all electronic material will be kept in password-protected, encrypted cloud storage and all physical material will be kept at the researcher's residence; both materials will be kept for a period of seven years.

Confidentially of Participants and Data

This study was submitted for review to the Institutional Review Board (IRB) at of the practice along with all required supporting documentation. The practice approved this study on July 19, 2019. Following the approval of the study at the practice, the study, supporting documentation along with the IRB approval letter was submitted to the IRB of Robert Morris University (RMU) and was approved on July 26, 2019. Copies of the practice and RMU approval letters can be found in Appendix A and B, respectively.

At the beginning of each interview, the researcher introduced himself and give a brief overview of the study by reading a script to each of the participants. Each of the participants was required to read and sign a consent form and was asked to consent to have the interview audio recorded for transcription for the sole purpose of the researchers use. A copy of the consent form can be found in Appendix C. The participants could decline the audio recording and still participate in the study. Any audio recording to which the participant consents will be kept confidential and will not be shared. Lastly, all responses to all interview questions were kept confidential by the researcher and no names were recorded on any audio recordings. Instead, physicians were given a code name to identity them for thematic and research purposes. Quantitative data that was extracted from the electronic health record system consisted only of the counts of evaluation and management (E&M) codes in the form of CPT codes and were assigned the same code as the physician for whom they were calculated to avoid recording the names of any physicians.

Reliability and Validity

Yin (2018) states that one of the best ways for a qualitative researcher to position one's work to stand the test of reliability and validity is through thorough documentation and a well-defined interview protocol. Creswell & Creswell define reliability as the consistent approach of the researcher among different projects as well as across different researchers. Qualitative validity is defined by Creswell as the researcher checking the accuracy of the findings by employing methods such as triangulation, thick description, or employing external auditors (Creswell & Creswell, 2018).

The open-ended interview protocol and available probes are defined in Appendix D and were used as a guide throughout the interviews while still allowing for the participants to be able to share their true thoughts and feelings as they answer the questions even though it is accepted that they may stray from the point of the questions from time to time.

Another test of the validity of the data, is to test if the findings are generalizable outside of the setting in which the data was found and can be applied to other research; this validation is called external reliability (Yin, 2018). To address issues of external reliability, the researcher used a standard interview protocol for all of the interviews as well as the use of standard metrics of physician productivity, the relative value unit (RVU). A copy of the interview protocol can be found in Appendix D. This standardization, as recommended by LeCompete and Goetz, will allow for researchers at other organizations, who use the same tools, to reproduce the research methodology (Bryman & Bell, 2015). Together, the qualitative interview data as well as the quantitative RVU data will be used together in triangulation as an method of crosschecking the findings across methodologies (Bryman & Bell, 2015).

Data Analysis Plan

Once each of the interviews were conducted and transcribed, the researcher analyzed the data looking for themes. The researcher looked for themes related to the physicians medical training, their thoughts on any training on coding and EHR systems, reflections on how the systems have altered the way they interact with their patients, any changes the physicians note that the EHR systems have impacted the way they document their patient visits, as well as the thematic analysis of the benefits and challenges of the EHR system. Once the qualitative thematic analysis had been completed, the researcher turned his attention to the calculation of the productivity for each year that the physician has been using the EHR system and one year before the implementation of the EHR system. This data was plotted on a bar graph individually per physician and as an aggregate of all physicians and EHR system upgrades, implementations and new government program participation dates were noted on the graphs. The researcher identified any trends along the productivity graphs or changes that were coincidental with any system upgrades, implementations, or governmental programs in which the practice participated.

Summary

This chapter contains detailed information related to the methodology used for this case study which examines how the implementation of an electronic heath record (EHR) system impacts a pediatric practice. Using a semi-structured protocol, interviews were conducted with physician participants who have been using the EHR system for 10 years. A second set of data was in the form of relative value units (RVUs) which are a standard measure of physician productivity. The two datasets were then triangulated for reliability and validity. The confidentiality of the participants was protected by encoding the physician names at the time of the interviews and when producing their RVU data so at no time is any identifiable

information ever stored with their transcripts or RVU reports. In summary, the researcher is interested in understanding qualitative impacts on the physician's ability to care for their patients such as the EHR system's impact on the physicians ability to spend time with the patients, the quality of documentation, and the general challenges and benefits of using an EHR system.

Chapter 4: Data Analysis

The purpose of this study is to understand how the implementation of an Electronic Health Record (EHR) system impacts the productivity of the physicians using the software. If a negative effect is present, and physician productivity is lower when using an EHR compared to when documenting patient visits in paper charts, then serious financial implications could have negative consequences on the financial health of the practice and as a result of the physician being able to see fewer patients, the overall health of the patient population could suffer. Conversely, if the EHR system is found to be beneficial and has a positive impact on productivity, the practice could see increased billing income and potentially more patients could be seen in a day. This chapter provides a summary of the productivity values spanning 10 years, from 2008 to 2018, of EHR use and one-year pre-EHR for each participant in the research and a summary of the in-depth interviews conducted with physicians. The qualitative results are based on 20 in-depth, semi-structured interviews conducted at a pediatric practice during the summer of 2019 with participant physicians who have each had at least 10-years of experience working with the EHR system implemented at the practice.

This chapter summarizes productivity data as well as the results of the 20 interviews. Each of the respondent's answers were recorded, transcribed and thematically coded while being guided by the following research questions. The participants were each assigned a numeric identifier from 1-20 in an effort to protect their anonymity. This identifier was linked to both the productivity data as well as the in-depth interview transcript so that the researcher could identify the participant as well as to link the productivity data to the transcript for each participant for analysis.

Research Questions

The following research questions are central to this study:

1. What are the trends in physician productivity as measured by RVUs over a 10-year period?
2. What benefits and challenges do physicians report as a result of using an EHR system in the practice?

Productivity Data

The productivity data for each physician was collected by using reports from a legacy electronic practice management (EPM) system used by the practice from 2007 as well as the practice's current electronic practice management application which has been in use from 2008 until 2018, when this study concludes. An electronic practice management (EPM) system is an application which houses a computerized physician scheduling system, a billing system, and a reporting system. Reports from the legacy EPM system during the 2007 year and the current EPM system from 2008-2018 were used to collect data related to the number of Current Procedural Terminology (CPT) codes generated by each of the 20 physicians in the study as well as the number of patients visits per physician, each year, for the 10 years this study examined. The data from the legacy PM system used in 2007 is important to the study because during that time, the practice was still documenting patient visits on paper charts and had not yet implemented an EHR. In this way, the data from the legacy EPM system used in 2007 provided a baseline of how many Relative Value Units (RVUs), the standardized measure of physician productivity, each physician generated and how many patient visits each physician saw in the year before the implementation of the EHR.

The results of the productivity data gathered from the two electronic practice management (EPM) systems have been grouped according to those physicians who experienced an increase in RVUs after the implementation of the EHR during the 10-year period of 2008-2018 and those physicians who experienced a decrease in RVUs during the identical 10-year period from 2008-2018. In addition, data gathered from the PM system reports allowed the researcher to examine trends in patient visit volumes during the 10-year period of 2008-2018. The productivity data, measured in RVUs, as well as the patient visit volume data from 2007 are present in the analysis as a baseline for comparison as they represent a time when the practice had not yet implemented an EHR system and was still documenting patient visits in paper charts. The data presented in the following visualizations is intended to answer the first research question presented in this dissertation.

- [RQ1] What are the trends in physician productivity as measured by Relative Value Units (RVUs) over a 10-year period?

Physicians Experiencing an Increase in RVUs

In 2008, the practice implemented the EHR system that was in place for at least the duration of this study, from 2008-2018. Figure 3 below illustrates the productivity changes experienced by the physicians utilizing the system as measured by Relative Value Units (RVUs) as well as changes in patient visit volumes during the 10 years, from 2008-2018, after the implementation of the EHR system.

In 2007, one year prior to the implementation of the electronic health record (EHR) system, the practice as a whole experienced a company mean output of 5,293 RVUs per physician as illustrated in Figure 3 below. During the 2008 year, the year offices began their implementations, a sharp decline from 5,293 to 4,002 RVUS (-24.4%) happened by the end of

the year. However, by 2009, productivity returned to near pre-EHR baseline levels at 5,035 RVUs and remained relatively stable through 2018, even surpassing the pre-EHR RVU level of 5,471 RVUs in 2011 and 5,327 RVUs in 2012. By the end of the 10 years, from 2008-2018, the mean company RVU output for the 10 years was 4,945 RVUs, 348 RVUs (-6.58%) below the 2007, pre-EHR productivity level of 5,293 RVUS. Despite the slight overall company decrease of 6.58% in mean RVUs, five out of 20 physicians found their RVUs levels in 2018 to be higher than the pre-EHR level of 5,293 RVUs in 2007. Three of the 20 physicians were not working for the practice in 2007 and so a baseline of pre-EHR data could not be established and the remaining 12 experienced a decrease which will be discussed later in this chapter. While the company as a whole experienced a -6.58% change in overall productivity in the 10 years post EHR implementation, from 5,293 RVUs before the EHR implementation in 2007 to 4,945 RVUs in 2018, the five physicians out of 20 experienced a mean growth of from 3,337 RVUs in 2007 to 5,000 RVUs in 2018 (49.84%) in their mean RVU output during the time from 2007 to 2018.

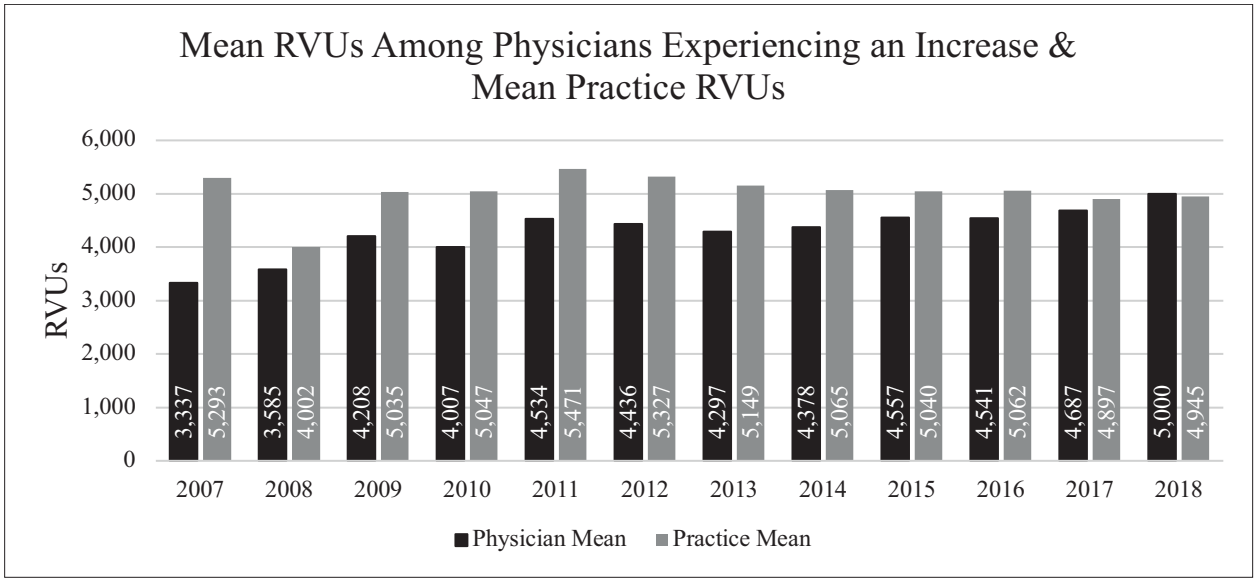

Figure 3. Mean RVUs Among Physicians Experiencing an Increase & Mean Practice Volume

To summarize these findings and how they pertain to the research question:

- [RQ1] What are the trends in physician productivity as measured by Relative Value Units (RVUs) over a 10-year period?

There exist five physicians out of 20 (25%) that belong to a cohort of physicians who experienced an increase in the mean amount of annual RVUs generated when comparing the volume of RVUs these five physicians generated in 2007, the baseline, pre-EHR year through the 10 years of data this study considered from 2008 to 2018. In 2007, the five physicians in this cohort experienced growth from a mean of 3,3337 RVUs in 2007 to a mean of 5,000 RVUs in 2018, a positive change of 49.84%. In contrast, the practice as a whole experienced a decline in the mean RVUs generated per physician per year of -6.58% from the baseline, pre-EHR year in 2007 of a mean of 5,293 RVUS per physician annually through the end of the study in 2018 which had a mean of 4,945 RVUs generated. While the small cohort of five physicians did experience a 49.84% productivity increase in the mean RVUs generated, the overall productivity trend for the entire practice is still negative at -6.58%.

Physicians Experiencing an Increase in Patient Visits

Figure 4 below represents a comparison between the physicians who experienced an increase in the number of patient visits from the baseline of 2007, the year before the implementation of the EHR system through the 10 years of data in this study, ending in 2018. Although some of the physicians who experienced a growth in the amount of RVUs generated are included in this measurement, this is a distinctly different metric from the RVUs. From 2007, the pre-EHR baseline year, through 2008, the first year on the EHR, a notable drop in the practice mean number of patient visits is identifiable. From 2007 to 2008, the practice mean number of patient visits fell from the 2007 mean of 4,545 patient visits to 3,627 in 2008, a loss of 918 patient visits or -20.20%. In 2009, however, the patient visit volume company mean increases to 4,659 visits,

surpassing the 2007, pre-EHR benchmark of 4,545 patient visits, and stays above the 2017 number in 2011 with 4,819 patient visits and in 2012 with 4,636 visits. During the timeframe from 2013 through 2018, the patient visit volume slowly decreases year over year until, ultimately reaching a company mean of 4,112 patient visits per physician in 2018, a -9.53% change from the pre-EHR benchmark from 2007 of 4,545 patient visits. Despite the decline in the company mean patient visits, seven out of the 20 physicians studied experienced an total increase of 57.20% in mean patient visits per physician when comparing the volumes at the end of the 10-year study in 2018 (4,267 mean patient visits) against the pre-EHR implementation benchmark in 2007 (2,715 patient visits). Of the remaining 20 physicians in this study, three did not work for the practice in 2007 and hence a baseline in 2007 could not be established and the remaining 10 physicians experienced a decrease in mean patient visit volumes which will be discussed later in this chapter.

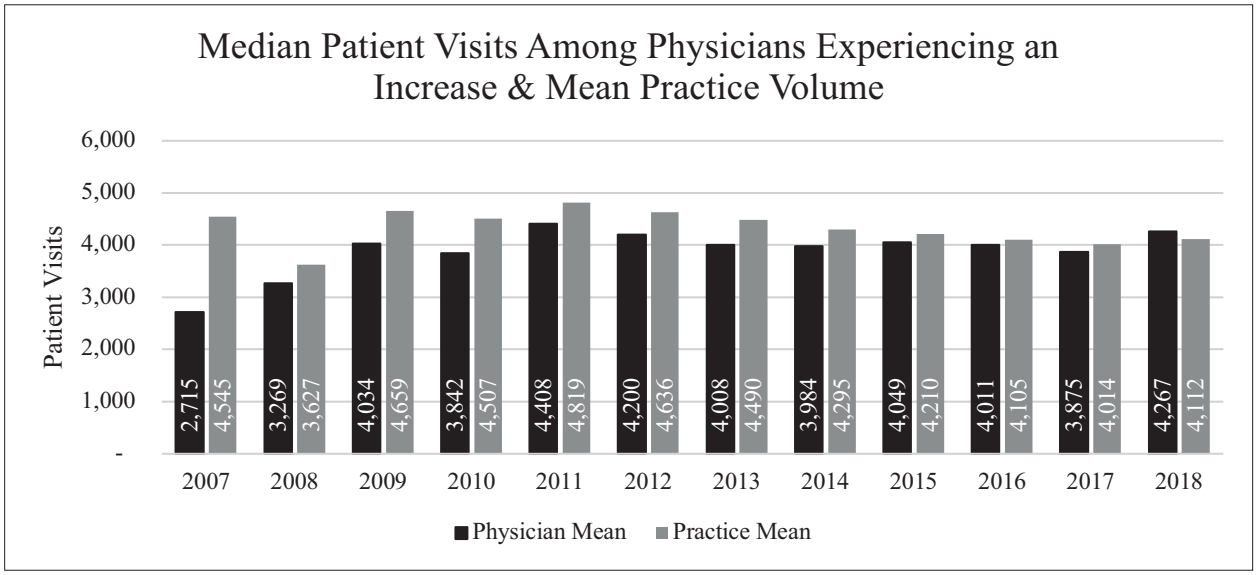

Figure 4. Mean Patient Visits Among Physicians Experiencing an Increase& Mean Practice Volume

To summarize these findings and how they pertain to the research question:

- [RQ1] What are the trends in physician productivity as measured by Relative Value Units (RVUs) over a 10-year period?

There exist seven physicians out of 20 (35%) that belong to a cohort of physicians who experienced an increase in the mean volume of annual patient visits when comparing the volume visits these seven physicians generated in 2007, the baseline, pre-EHR year through the 10 years of data this study considered from 2008 to 2018. In 2007, the seven physicians in this cohort experienced growth from a mean of 2,715 patient visits in 2007 to a mean of 4,267 visits in 2018, a positive change of 57.20%. In contrast, the practice as a whole experienced a decline in the mean volume of patient visits per physician per year of -9.53% from the baseline, pre-EHR year in 2007 of 4,545 patient visits through the end of the study in 2018 which had a mean of 4,112 visits. While the small cohort of seven physicians did experience a 57.20% increase in the mean number of patient visits, the overall trend for the entire practice is still negative at -9.53%.

Physicians Experiencing a Decrease in RVUs

Figure 5 below represents data from 12 physicians who experienced a decrease in RVUs during the 2007-2018 timeframe as well as data representing the company mean RVU values. Seven physicians discussed previously experienced an increase in the number of RVUs generated and the remaining three physicians out of the 20 included in the study were not employed at the practice and do not have a 2007, pre-EHR benchmark established. Figure 5 below, illustrates the decline in mean physician RVUs of the subset of physicians who experienced a decline in their RVUS from the pre-EHR time in 2007 through the conclusion of the study in 2018 compared to the mean practice decline in company RVUs. The practice as a whole experienced a - 6.58% change in the mean RVUs generated from 5,293 RVUs in 2007 to 4,945 RVUs in 2018. The mean practice RVUs generated increased from 4,002 in 2008 to 5,038 RVUs in 2009, the first full year after the implementation of the EHR system, from the baseline 5,293 in 2007. The mean practice RVUs generated continued to increase to 5,327 in 2011 but then decrease, finally

settling at 4,945 RVUs in 2018. Examining the RVU values of the 12 physicians who experienced a decrease in RVUs generated illustrates a much more dramatic decline in RVUs generated from the 2007, pre-EHR implementation time to the end of the study in 2018. From the pre-EHR implementation baseline, 2007 pre-EHR implementation mean RVU value of 6,108 RVUs, the 2018 mean value of 5,030 RVUs is a significant -17.65% change in the mean RVUs generated per physician from 2007-2018.

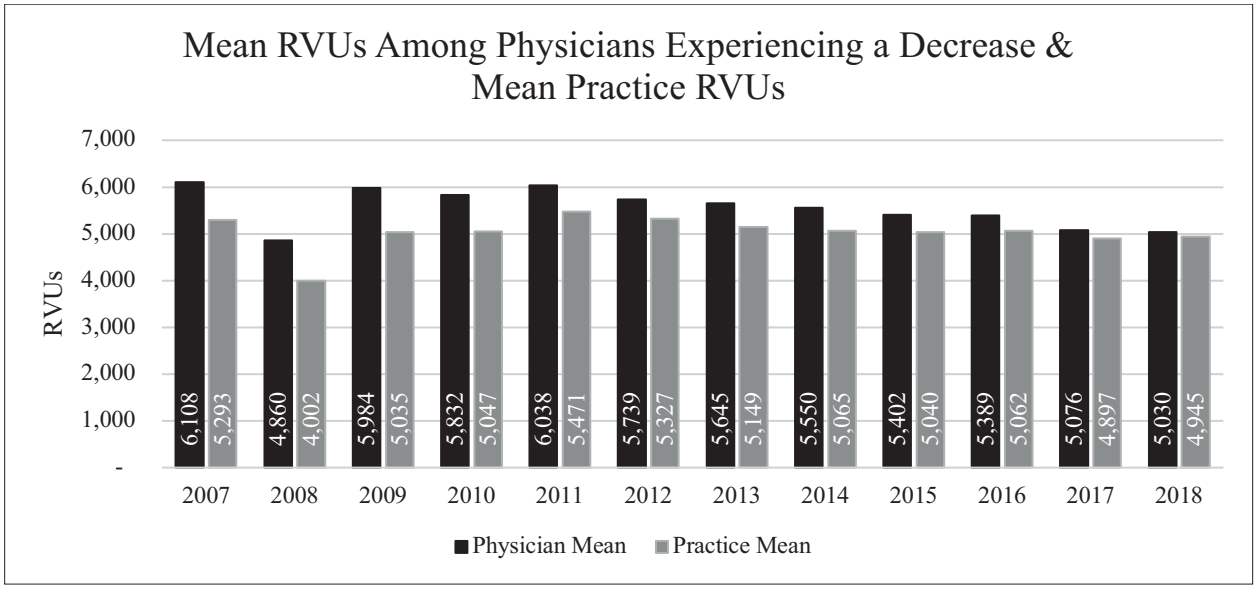

Figure 5. Mean RVUs Among Physicians Experiencing a Decrease & Mean Practice Volume

To summarize these findings and how they pertain to the research question:

- [RQ1] What are the trends in physician productivity as measured by Relative Value Units (RVUs) over a 10-year period?

The cohort of physicians who experienced a decrease in the mean annual RVUs generated contains 12 physicians out of 20 (60%). Three physicians were not employed by the practice in 2007 and therefore do not have a non-EHR baseline established and the remaining five physicians out of 20 in the study from 2008-2018 experienced an increase in the mean annual RVUs generated. In 2007, the 12 physicians in this cohort experienced a decrease from a mean of 6,108 RVUs in 2007 to a mean of 5,030 RVUs in 2018, a change of -17.65%. Similarly, the

practice as a whole experienced a decline in the mean RVUs generated per physician per year of -6.58% from the baseline, pre-EHR year in 2007 of 5,293 RVUs through the end of the study in 2018 which had a mean of 4,945 RVUs. Both the 12 physicians in this cohort that experienced a decrease in the mean RVUs generated as well as the practice as a whole experienced a negative trend in the physician productivity.

Figure 6 below illustrates the mean RVU levels for all 20 physician participants in this research without regard to their status of increasing or decreasing productivity during the study period from 2008 to 2018 and includes the pre-EHR benchmark year of 2007. Despite the cohort of five physicians who experienced an increase in RVUs during the study, the overall trend for all physicians is a decline from the pre-EHR RVU level of 5,293 in 2007 to the final level of 4,945 in 2018.

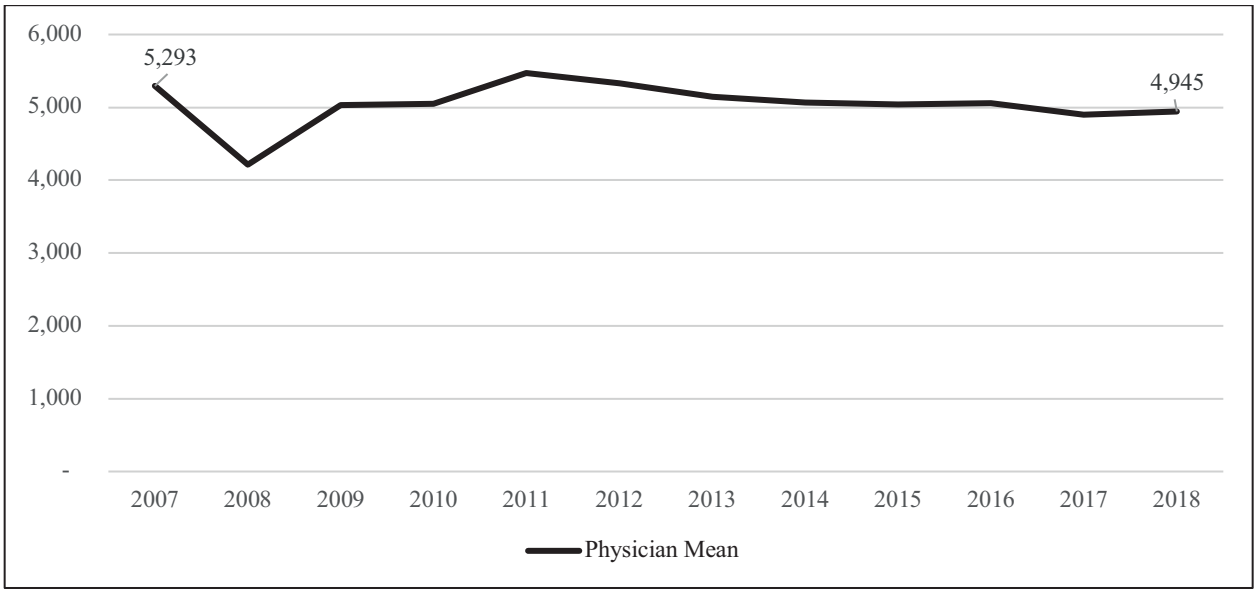

Figure 6. Mean Patient Visits Among Physicians Experiencing a Decrease & Mean Practice Volume

Physicians Experiencing a Decrease in Patient Visits

Figure 7 below illustrates the decrease in the mean number of patient visits per physician among those physicians who experienced a decrease in the number of patient visits post-EHR implementation in 2008. Included in this cohort are 10 physicians of the 20 who experienced a

decrease in the volume of patient visits at the end of the 10-year study in 2018. Although some of the physicians who experienced a decline in the RVUs generated may be included in the grouping of physicians who have experienced a decrease in patient visit volumes, this is an entirely separate metric. Three of the physicians of the 20 were not employed by the practice in 2007 and therefore a pre-EHR patient volume could not be established. The remaining seven physicians experienced an increase in patient visits during this 10-year timeframe which was previously discussed.

In the baseline year in 2007 when the practice had not yet implemented the EHR system, the mean number of patient visits was 5,826 annually but by the end of this study's timeframe, in 2018, the mean number of patient visits was 4,099 patient visits which equates to a total change of -29.64%. In the initial year after the implementation, 2008, a change from 5,826 patient visits in 2007 to 4,637 visits in 2008 (-20.41%) was experienced by the 10 physicians in this cohort.

From 2008 to 2009, the mean number of patient visits per physician increased by 25.79% from 4,637 in 2008 to 5,806 patient visits in 2009, which is near the pre-EHR visit volume but then steadily declined until reaching 4,099 in 2018.

The visit volume trends visible in the physician volumes depicted in Figure 6 below are closely reflected in the practice's overall patient volume trends for the same time period, the baseline year of 2007 as well as the study period of 2008-2018. During the period from 2008 to 2009, the mean number of patient visits increased from 3,627 visits in in 2008 to 4,659 in 2009 (28.45%), surpassing the mean baseline number of patient visits from the pre-EHR implementation year in 2007 of 4,545 patient visits per physician.

After a decrease in mean patient visits in 2009 from 4,659 to 4,507 (-3.26%) in 2010, the number of patient visits increased again from 4,507 in 2010 to 4,819 patient visits in 2011

(6.92%) and an overall increase (6.03%) from the 4,545 patient visits in 2007, the pre-EHR baseline year. After these increases, the mean number of patient visits began an overall decreasing trend where they finally settled at the of the observation timeline of this study in 2018 of 4,112 mean patient visits per physician post-implementation of the EHR system which is a combined -9.53% change from the company mean pre-EHR implementation baseline in 2007 of 4,545 patient visits.

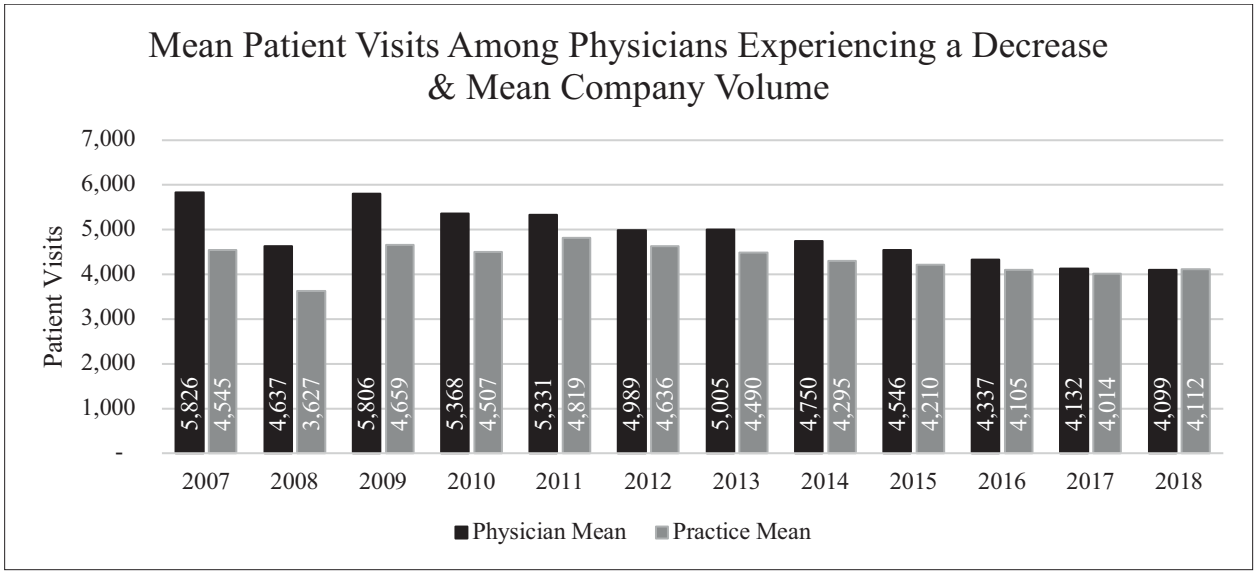

Figure 7. Mean Patient Visits Among Physicians Experiencing a Decrease & Mean Practice Volume

To summarize these findings and how they pertain to the research question:

- [RQ1] What are the trends in physician productivity as measured by Relative Value Units (RVUs) over a 10-year period?

This cohort of physicians who experienced a decrease in the mean annual volume of patient visits contains 10 physicians out of 20 (60%) included in this study. Three physicians were not employed by the practice in 2007 and therefor do not have a non-EHR baseline established and the remaining seven physicians out of 20 in the study from 2008-2018 experienced an increase in the mean annual patient visits. In 2007, the 10 physicians in this cohort experienced a decrease from a mean of 5,826 patient visits in 2007 to a mean of 4,099

visits in 2018, a change of -29.64%. Comparably, the practice as a whole experienced a decline in the mean patient visit volume per physician per year of -9.53% during the course of the study, from the baseline, pre-EHR year in 2007 of 4,545 patient visits through the end of the study in 2018 which had a mean of 4,112 visits. Both the cohort containing these 10 physicians experienced a decrease in the mean patent visits as well as the practice as a whole experienced a negative trend in the volume of patient visits.

Changes in Mean RVUs Generated per Patient Visit

Figure 8 below depicts how the mean number of Relative Value Units (RVUs) generated per patient visit have changed from the baseline, pre-EHR year of 2007 to the first year of the system's implementation in 2008 and through the conclusion of this study in 2018. In 2007, the year before the EHR system was implemented, the mean number of RVUs generated for the practice was 1.21 RVUs per patient visit. By the end of 2008, the first year of the EHR's use, the mean RVUs generated had decreased to 1.15 RVUs, down 4.96% from the 2007 baseline amount of 1.21 RUVs. The downward trend continued through 2009 where the mean number of RVUs generated per patient visit was 1.13, a change of -1.17% from the 2008 amount of 1.15 and a change of -6.61% from the 2007 baseline year of 1.21 RVUs per patient visit. After the initial two years of declining RVUs in 2008 and 2009, years 2010 through 2016 saw increasing mean RVUs per patient visit. From the 2007, pre-implementation baseline year mean of 1.21 RVUs generated per patient visit to 2016, the practice saw a growth of 0.07 RMUs to 1.28 RVUs or a growth of 5.79%. From 2016 to 2017 the mean RVUs per patient visit decreased from 1.28 to 1.25, a decrease in 0.03 RVUs, or -2.34%. The mean RVUs per patient visit maintained its value of 1.25 from 2017 through the end of this study's observation period in 2018. The overall change in the mean RVUs generated per patient visit from the 2007, pre-EHR, baseline year of

1.21 RVUs per patient visit to the 2018 RVU amount of 1.25 is 0.04 RVUs per patient visit or a positive change of 4.84%. In the year 2016, the practice greatly expanded by purchasing an established practice group at which two physicians in this study began to see patients. The effect of this acquisition may explain the sudden jump in RVUs in 2016 that appears to be an anomaly compared to the otherwise relatively linear RVU growth from 2009-2017.

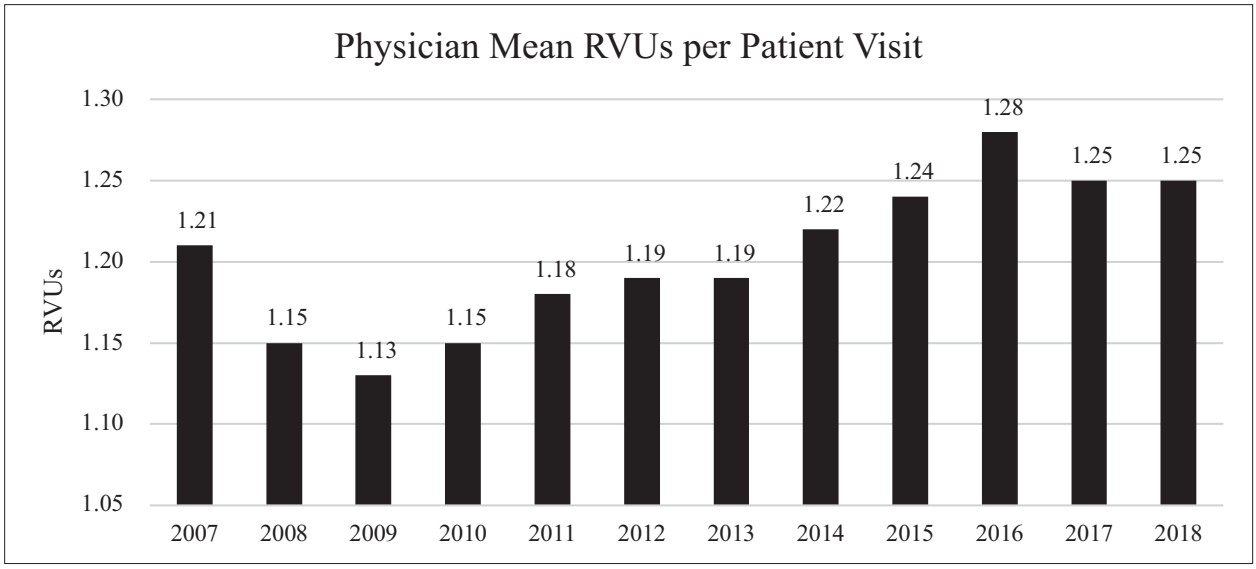

Figure 8. Mean RVUs Generated per Patient Visit

To summarize these findings and how they pertain to the research question:

- [RQ1] What are the trends in physician productivity as measured by Relative Value Units (RVUs) over a 10-year period?

In 2007, the pre-EHR year baseline year at the practice, physicians generated a mean, per patient visit Relative Value Unit (RVU) of 1.21. In 2008, the first year of the EHR's use at the practice, the mean RVUs per patient visit decreased to 1.15 RVUs from 1.21 in 2007, a decrease of 4.96%. The following year, 2009, the mean RVUs per patient visit decreased again to 1.13 from 2008's 1.21, a change of -1.17%. After 2009, the mean RVUs per patient visits began an overall upward trend through 2016, increasing to 1.28 in 2016 from the low of 1.13 in 2009, a 13.27% increase. Overall, the change from the 2007, pre-EHR benchmark mean RVU value per

patient visit changed from 1.21 RVUs to the RVU value at the end of the study in 2018 of 1.25 resulted in a positive change of 4.84%. When evaluating the 10-years of this study from 2008 to 2018, the RVU value of 1.15 RVUs generated in 2008 to the 1.25 RVUs generated in 2018 represents a 10.00% increase. This positive change demonstrates a positive trend in physician productivity measured in RVUs over the 10-year period from 2008 through 2018.

In-Depth Interview Data

From between July and October of 2019, the researcher met with each of 20 physicians to conduct the in-depth interview with the primary focus of understanding what each of them viewed as the benefits and challenges of working with an Electronic Health Record (EHR) system. The physicians selected to participate in this research study had all been using the EHR software from the time of the software's implementation in 2008 through at least the conclusion of the study's timeframe in 2018. In addition, 17 of the 20 participants worked at the practice at least one year prior to the start of the study, in 2007, so that a baseline year of pre-EHR productivity metrics could be captured for analysis. The time allotted for each of the interviews was typically one-hour with the average interview duration of 20 minutes and the longest interview being 30 minutes. All interviews were recorded on an audio recording device for transcribing and transcribed the day of each interview. Each transcription was emailed to the respective physician for her or him to review and approve before the transcription was used for the research.

The results of the in-depth interviews were categorized into two categories: benefits and challenges associated with using the EHR in the practice.

After all of the interviews were completed and the audio recordings transcriptions approved by the respective physician, the researcher embarked on the processes of thematic

analysis. To accomplish this, each of the 20 transcribed interviews were loaded into NVivo 12, a qualitative data analysis software tool, and coded each according to themes that emerged as the researcher analyzed each of the interview transcripts. NVivo is a software application that can be used for mixed-methods and qualitative research. The application can assist the researcher in the organization, coding, and analysis of unstructured data including interviews, journal articles and focus groups. The data presented in the following visualizations is intended to answer the second research question in this dissertation.

- [RQ2] What benefits and challenges do physicians report as a result of using an EHR system in the practice?

Methodology Summary

This research followed a qualitative design to understand how the implementation of an electronic health record system (EHR) impacted a pediatric practice in terms of the trends in physician productivity over a 10-year period from 2008-2018 as well as to understand what benefits and challenges physicians report as a result of using the system. The researcher identified physicians who worked at the practice one year prior to the implementation of the EHR system in 2008 and who were still working at the practice in 2018 so that 10 year's work of productivity data may be collected on the participant. Twenty physicians were identified, recruited for the study, and took part in interviews between July and October 2019. The researcher asked each physician a series of semi-structured questions during in-person interviews. Each of the interviews were recorded and subsequently transcribed and sent back to the participant for approval. After the physician gave the approval to the researcher to use the transcript, the document was loaded into NVivo 12 (data analytics software used for qualitative research) to analyze for themes, patters, and categories.

Generation of Themes

The identification of themes is a part of the qualitative data analysis and the process used for this study was patterned after the approach outlined by Creswell and Creswell (2018). Following their methodology, the first step the researcher undertook was to transcribe all of the interviews and removing any information that could be used to identify the participant. The researcher then loaded the transcripts into NVivo 12, organizing each participant as individual cases in the application. The second step in the process involved reading each of the transcripts for a deeper understanding of what the physicians were trying to explain. At this stage, the researcher made additional notes in his field notes regarding important comments made by the physicians as well as made note of quotes that supported the main argument the participant was trying to make to include later in the findings (Creswell & Creswell, 2018). In the third step, the researcher starting the coding process by using tools within the NVivo 12 software to highlight portions of text in a process called bracketing (Creswell & Creswell, 2018). During this process, the researcher segmented whole sentences or portions of sentences and labeled the phrase with a term based on the context of the highlighted text, often called an *in vivo* term (Creswell & Creswell, 2018). Merriam-Webster defies “in vivo” as “in the living” and perhaps this is from where NVivo takes their name as this process is a vital and integral part of using the software (Merriam-Webster, n.d.). As the researcher worked through the documents, codes became evident and the researcher continually grouped common codes together to refine categories to keep the codes organized and focused on the research questions. In the fourth step outlined by Creswell and Creswell (2018), the researcher applied the codes to all of the transcripts being sure to link all relevant words to the code in NVivo 12 so that frequencies various codes appeared could be generated and reports would contain the full text of coded instance that was intended by

the researcher. Lastly, the fifth step in the process is to represent the themes in a such a way that it forms a qualitative narrative. A common approach is to structure a narrative of interconnecting themes with visuals, tables as well as quotes from the participants and this is the approach that the researcher has opted to use to convey his findings. Figure 9 below is a visual representation of the steps undertaken by the researcher in the pursuit of this endeavor.

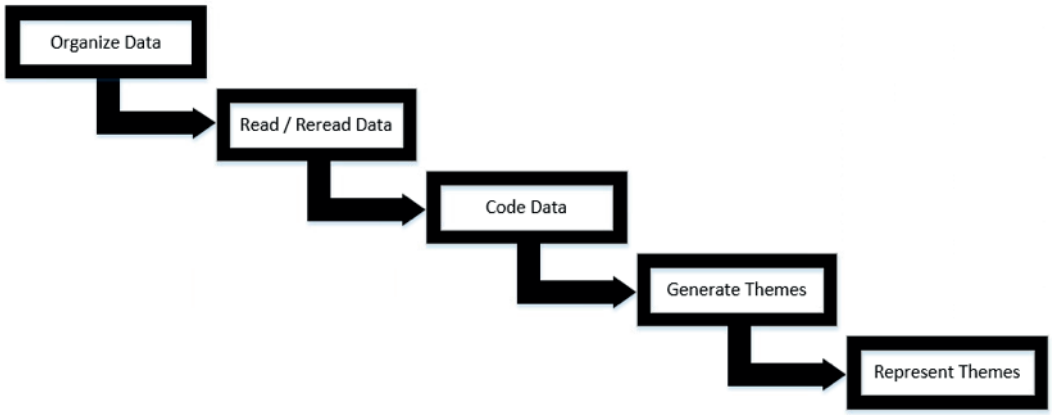

Figure 9. Overview of the Data Analysis Process

Codes and Themes

The researcher, while analyzing and coding the transcripts from the in-person interviews, identified 40 distinct codes which identified different benefits and challenges expressed by the participant physicians. The codes were evaluated and categorized into two themes related to the second research question:

- [RQ2] What benefits and challenges do physicians report as a result of using an EHR system in the practice?

Table 4 below lists the overarching theme of benefit or challenge, the subtheme that is rolled up into the overarching theme, and the number of references to the theme across all of the interviews. The number of references under each subtheme may not add up to the total reference count for the subtheme due to some text in the transcripts being coded directly as the subtheme.

Overarching Theme	*Subtheme*	*References*
Benefit	**Documentation Improvements**	**31**
	- More thorough documentation	17
	- Easier to document more thoroughly	5
	Complete Patient Picture	**29**
	- Access to data enables patient tracking	7
	- Better ability to keep track of things	7
	- More information about the patient	6
	- Interoperability	1
	Better Organization	**25**
	- No lost charts	2
	Visit Coding Improvements	**16**
	- Coding is more accurate after EHR	5
	- Improved visit coding	3
	- Support coding level	3
	- Better capturing of charges	2
	- Fast and efficient CPT coding	1
	- Makes coding easier	1
	- More confident coding	1
	Increased Legibility	**12**
Challenge	**Changes with Patient Contact**	**35**
	- Less time with patient	14
	- Less eye-contact with patient	11
	- Less personal	9
	- Less quality time with patient	1
	Documentation Challenges	**21**
	- More documentation	7
	- Excess documentation in charts	4
	- Government program documentation requirements	4
	- Reliance on others to keep data updated	2
	- Can be easy to document in wrong chart	1
	- Documentation under duress	1
	- Keeping patient data updated	1
	- Pressure to complete documentation	1
	- Documentation sounds mechanical	1
	More Time at Computer	**10**
	Takes Longer	**9**
	System Issues/Changes	**8**

	- System availability or problems can cause issues	4
	- System upgrades can be a challenge	3
	- Upgrades can be burdensome	1

Table 4. Code Categories and Reference Counts

Note: The references column represents the number of times that particular code appeared collectively across all interviews.

Benefits Associated with the Usage of an EHR

During the interview process and later through the encoding process, the researcher became aware of several themes that became evident throughout the interviews. The top five themes that were identified as benefits associated with having an EHR within the practice as well as the number of references within the transcripts are listed in Table 5 below.

Benefits to Using an EHR System

	Theme	References
1.	Documentation Improvements	31
2.	More Complete Patient Picture	29
3.	Better Chart Organization	25
4.	Visit Coding Improvements	16
5.	Increased Legibility	12
	Total	113

Table 5. Benefits to Using an EHR System

The following sections explain in more detail each of the benefits identified by the physicians.

Documentation Improvements

Documentation is the act of noting within the patient's chart the details of the visit and includes the patient's reason for visit, vitals, past medical history, surgical history, medication list, allergies, past and current diagnosis as well as the past and current treatment plans that the current and past physicians have designed for the patient. When using paper-based charts, the physicians anecdotally commented that they would often scribble down a few notes or check some boxes on a piece of paper, which would then become a part of the chart. In Figure 9 below,

physicians recounted 31 times out of 113 total references to benefits, or 27.43%, throughout the interviews that they have experienced improved documentation within the patient charts as a direct result of having an EHR system implemented within the practice. In contrast to paper-based notes which provides little guidance for the physician, the EHR system guides the physician through a series of templates and screen prompts for information related to the patient visit and builds the visit information as the fields or prompts are completed. Whereas when documenting a visit on paper, each physician may document a visit differently, in an EHR system, the templates and prompts tend to bring standardization to the documentation process and thus to the visit summary notes which are generated at the end of the visit. Regarding documentation improvements, the following quotes are extracts from the participant interviews:

> Things are more clear on what was actually examined and both the negatives and the positives show up in a note better. (Participant 3)

Other comments from physicians around the improvements to documentation include such phrases as “much more precise and comprehensive,” “more detailed and problem-focused,” and positive phrases containing the words “more thorough” were mentioned seven times throughout the interviews.

More Complete Patient Picture

The theme with the second greatest number of responses at 29 references of 113 benefits references, or 25.66%, is the theme that after the implementation of the EHR system, physicians have access to a more complete patient chart compared to the paper version of the chart. Within this theme, physicians identified topics such as access to patient population concepts, tracking lab results and X-rays easier, and better follow-ups with consultations.

> Access to data and information from outside sources has been better. Outside hospitals, ER visits, consults, labs, X-rays, just has been much easier, better access. (Participant 14)

> It is easier to go back and to check what was done, who saw the patient. Check all the consults, the vaccinations. You see very clearly all the weights and heights. (Participant 15)

> I don't know what I would be doing without [it] today to be honest. It has increased my capacity to know a lot of important diagnostic and clinical facts about the patient, and patient's clinical problems, within a very short period of time, and very accurately, and utilize that information to the benefit of the patient, also in a very quick fashion. (Participant 7)

Access to the data electronically has also enabled the physicians to have easier access to patient outreach in cases when new medication therapies become available. Instead of identifying patient cohorts via manual chart audits which can be time consuming, electronic charts stored in databases make the task easier and faster.

> If I was looking for a patient with a particular diagnosis that I'd found a new therapy for, I could ask for a report, send me all patients with X, and then I could find them and see if they were doing what they were supposed to do. (Participant 16)

Data regarding a patient's health can also come from external sources through interoperability capabilities of EHR systems and through health data exchanges; enabling physicians from across the city or across the country to care for patients in ways that would have been extremely difficult with paper-based chart systems.

> Children with special healthcare needs… it's much easier to keep up with the documentation now that we have ClinicalConnect, getting records from Children's [Hospital]. (Participant 3)

Even within a single building it could be difficult for multiple physicians to collaborate on care, where once pieces of paper may be locked away in different physician offices related to a single patient's care, EHR systems allow for better access by multiple people to a single chart.

> Retrieval of patient data, validation of what's been done in the past. Not relying on your memory. You can see what's been done in the past. You can get a better detail of what your partners have done when they saw the patient in the past or just even recently. You can see the past diagnosis are all listed so you don't miss things. (Participant 10)

Better Chart Organization

A better system for the organization of the data in a patient's chart emerged as the second of the top five themes as a benefit for implementing an EHR in a practice. Though an exaggeration, one physician is quoted as saying in their interview:

> There was 50 million papers stuck in the chart and it was really hard to find what you're looking for. So, this was easier. (Participant 15)

This sentiment was echoed by more than one physician.

> There's no more searching for paper charts. That used to take endless hours to find paper that was potentially in one of many piles. (Participant 4)

> It's just easier to find things like that. I think from a historical documentation standpoint, it's really nice, and it's much more organized. (Participant 5)

One enthusiastic physician even said that electronic health records (EHR) systems:

> [EHRs] certainly save time, instead of leafing through War and Peace, Tolstoy's volumes, I can go to the monitor screen and very quickly get all the information I need from my previous communication, other communications. (Participant 7)

Responses such as these and others account for 25 of the 113 references, 22.12%, related to just the top five benefits identified through this research for having an EHR system in a medical practice. Figure 9 below illustrates how this theme of better organization of the patient's charts fits within the benefits identified with having an EHR system implemented within the practice.

Visit Coding Improvements

The fourth of the top five benefits identified by the physicians of this study through in-person, in-depth interviews for having and electronic health system (EHR) implemented within a medical practice is to improvements in the coding of patient visits. Within each patient visit are two main different types of codes, one that is used when diagnosing and treating patients as well as a series of codes used for purposes such as patient billing. The codes that are meant to bring

some structure to the myriad of possibilities of diagnoses and the respective categories are published by the World Health Organization and are called the International Classification of Diseases, with the current revision being the 10th (ICD-10) (U.S. Department of Health & Human Services, 2019). A second set of codes used by physicians are called the Current Procedural Terminology (CPT) codes and are further divided into subsets to describe procedures, tests, and codes used for patient billing purposes. These CPT codes are published annually by the American Medical Association. The subset of codes which relate to patient billing, known as Evaluation and Management (E&M) codes, describe aspects of the patient visit related to the complexity of the visit and the decision-making level in which physicians engage to arrive at the diagnosing the patient. Together, the CPT and the E&M codes drive the cost of the visit and are submitted to insurance companies for reimbursement or are billed directly to patients.

In practices who do not have an EHR system, physicians will see the patient and complete their documentation; often circling CPT codes on a piece of paper on which is printed the most common CPT codes the office encounters. In some practices, the physician will also circle an E&M code or leave the task up to a back-office worker to find the appropriate E&M and CPT codes to bill. This can be an arduous task for the physician and a time consuming, laborious process for the office staff as the ICD-10 code library contains 71,924 procedure codes and 69,823 diagnosis codes (U.S. Department of Health & Human Services, 2019). The introduction of an electronic health record system (EHR) has the capability to automate the lookup of procedure and diagnosis codes for the physician and staff and be a significant contribution to time savings for both parties. Indeed, during the interviews of the 20 participants, improvements to the visit coding process was referred to 16 times of the 113 references, 14.16%, to beneficial references associated with the use of an EHR system. Physicians also noted that

they utilized the automated visit coding capabilities of the EHR system to ensure that they had completed enough documentation to support the visit code in which they had wanted to achieve for the particular patient visit.

> It makes me 99% confident that my very complex requirements for history and physical clicking have been done because it calculates it for me. (Participant 14)

> You're confident in the level of care that you delivered was appropriate for what you're billing. (Participant 14)

In order to support the code level they wish to achieve, the physicians have remarked that they use the automated coding and that it has coached them into being more detailed in their patient visit documentation.

> I think the diagnoses are more precise. (Participant 8)

> It's definitely forced me to be a little more detailed and a little but more thorough and that's probably a good thing that I have to pay attention to. (Participant 14)

Of course, the automated coding is not always met with cheers even though the physicians tend to see the value of the system in supporting their work.

> I don't always like it, but it's made me more aware of them, because I have to put them in otherwise, I can't support what I'm doing. (Participant 16)

Over time, system improvements and training has allowed the physicians to become better and faster at using the automated coding, allowing them to be more efficient and to appreciate the system's possibilities more.

> It makes it a lot simpler with, but we have a system designed to look for codes and we have Quick Pick lists to help easy access for coding. (Participant 18)

> I think it has streamlined [visit coding]. I'm able to do CPT coding very fast and efficiently, and its sort of integrated in the whole process of my consultation. Compilation of the letters that I generate after each visit, whether it's a new patient encounter or a return visit, and obviously each one is billed and CPT codes are involved. So yeah, it helped tremendously. (Participant 14)

Increased Legibility

The final theme in the top five benefits associated with implementing an EHR system as identified by 12 references of 113 references, 10.62%, from in-depth interviews with 20 physicians at a pediatric practice is that of increased legibility. Physician handwriting is often the fodder of jokes, often referring to a lack of legibility not just in signatures but often in medication prescriptions but also on visit or chart notes. What was revealed during the in-depth interviews is that physicians also often remark not only of the level of illegibility of another physician's handwriting but also of their own.

> My handwriting was never the most legible. So, if people have to take time to decipher what I was saying, no matter how good your thought process is, it doesn't help. (Participant 2)

> My handwriting is atrocious and when I wrote the script, I'm not convinced that they were always correctly…it was difficult for the pharmacy, it increased phone calls back and forth. (Participant 16)

The implementation of the EHR removes the handwriting aspect of physician documentation and replaces it with typing and clicking to fill out templates or free typing in comment fields and documents.

> I think it has been a tremendous benefit. In fact, of all things, that's probably been the biggest benefit. (Participant 16)

> Another benefit, you can much better decipher what other people have put in the notes. I mean sometimes you couldn't read other people's notes. Now you have to be able to read their notes. That's probably an important one. A better ability to decipher other information that's been put in the chart. (Participant 10)

Because the physicians also fill out templates or choose from picklists for creating prescriptions, the respondent's commented on the reduction in pharmacy calls with medication questions post EHR implementation.

> I think we get a lot fewer pharmacy calls, because the pharmacists can read the prescriptions. (Participant 9)

Figure 10 below represents the responses from the in-depth interviews recorded with 20 participant physicians who took part in this study and who were interviewed between July and October of 2019.

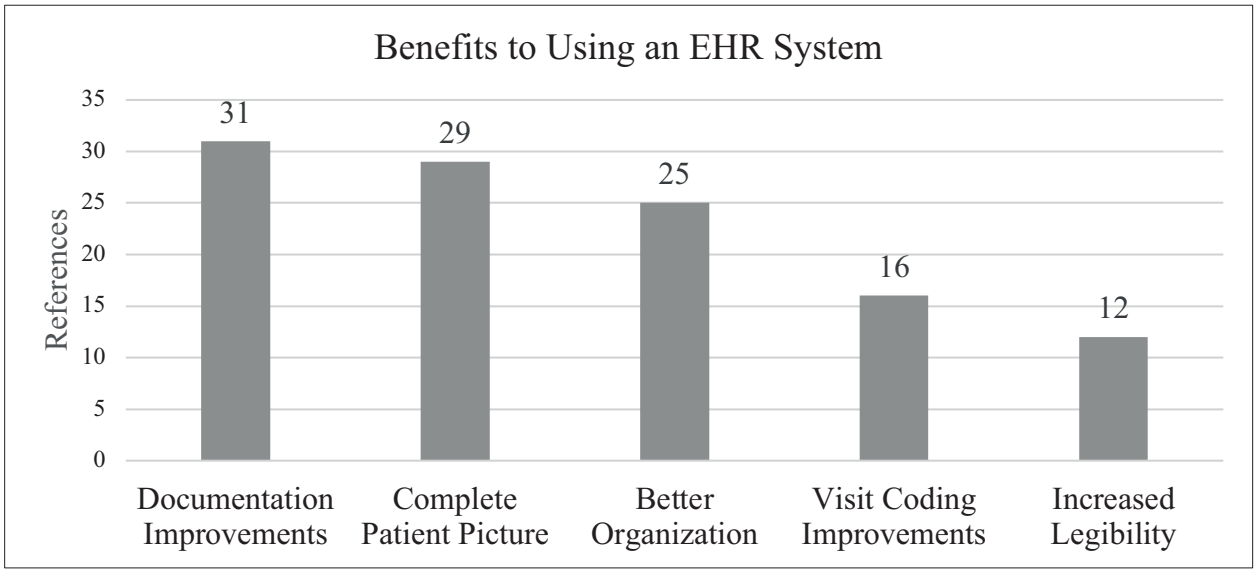

Figure 10. Benefits to Using an EHR System

To summarize these findings and how they pertain to the research question:

- [RQ2] What benefits and challenges do physicians report as a result of using an EHR system in the practice?

Between July and October 2019, the researcher interviewed 20 physicians to understand what benefits and challenges the physicians perceive as a result of having and electronic health record (EHR) system implemented in their practice. After transcribing the interviews and performing a thematic analysis on the data, the researcher selected the top five benefits and challenges as defined by the number of references the physicians made to the theme collectively in the interviews.

The themes listed in Table 3 above illustrate the top five themes that emerged as benefits from the in-depth interviews with 20 pediatric physicians and collectively received 113

collective references in the transcripts. The data contained within table 2 partially answers RQ2 by addressing the benefits associated with the usage of the EHR system. The next section in this chapter will address the challenges associated with the EHR's usage and will serve to complete the answering of RQ2.

- [RQ2] What benefits and challenges do physicians report as a result of using an EHR system in the practice?

Challenges Associated with the Usage of an EHR System

The implementation of an electronic health record (EHR) system is certainly not without its challenges. While the previous section in this chapter explored the themes that emerged through the thematic analysis of the 20 in-depth interviews as they pertained to the top five benefits associated with using and EHR system within a medical practice, this section will examine the top five challenges. Similar to the process followed for the identification of the benefits, the researcher performed a thematic analysis of the interview transcripts looking for themes related to instances of the physicians expressing difficulties with or challenges with the usage of the EHR system within their practice. After the identification of the themes, the researcher selected the top five themes which had the most references by the physicians collectively throughout the transcripts. The top five challenges associated with having an EHR system within the practice as well as the number of references within the transcripts are listed in Table 6 below.

Challenges of Using an EHR System

	Theme	References
1.	Changes with Patient Contact	35
2.	Documentation Challenges	21
3.	More Time at the Computer	10
4.	Takes Longer	9
5.	System Issues/Changes	8
	Total	83

Table 6. Challenges Associated with Usage of an EHR System

The following sections explain in more detail each of the challenges identified by the physicians.

Changes with Patient Contact

The first of the five themes regarding challenges associated with the usage of an EHR system within a medical practice is in respect to changes in the interactions between the patient and the physician and was referred to 35 times through the interviews. Within the theme of changes in the interaction between patient and physician, the interviewees remarked most often that the introduction of the EHR into the practice has introduced limits to the amount of time in which the physician can spend time with his or her patients.

I've had to literally truncate my patient time, time that I spent with my patients. (Participant 11)

In some instances, the physicians have remarked that the use of the EHR even take time away from patient visits.

> It certainly makes my time in the room a good five, five to ten minutes shorter probably per patient. (Participant 12)

In an effort to limit the amount of a distraction to the interaction between the patient and physician, the physicians do not even bring a computer into the exam room.

> I try to write things on the piece of paper, very often, and look at parents, instead of looking at the computer, and trying to document everything on the computer. (Participant 15)

A detraction from the amount of eye contact was a specific topic referred to by six physicians in their interviews and 11 of the 20 physicians interviewed made 18 negative references to “loss of eye contact”, “less personal,” “loss of face-to-face,” or “less contact” with the patient.

> Patient and human interaction and patient’s perception that while doc is just in her computer and reading in her computer and punching buttons. (Participant 14)

The feeling of loss of contact between the patient and physician was one of the most prevalent references in the theme related to changes between the interaction between patient and physician.

> Sometimes feel like I can’t make eye contact I want with my patients because I’m busy clicking buttons. (Participant 9)

The same physician, as the previous quotation, while acknowledging that that amount of time spend with the patients remains the same, about 15 minutes, noted that the quality of the time has been degraded after the implementation of the EHR system.

> I feel like it’s a different quality of time I’m spending with them, because I am looking at a computer screen instead of looking at them. (Participant 9)

Documentation Challenges

The second of the top five themes associated with the challenges with using an EHR with a medical practice as identified through thematic analysis from 20 interviews with physicians of a pediatric practice was that concerned changes in the way patient visits are documented. Of the top five themes associated with challenges with using an EHR within the practice, changes to the way in which patient visits are documented received 21 of the 83, or 25.30% of the references. In references by four of the twenty physicians interviewed, it was remarked upon negatively that forces such as Meaningful Use have required extra documentation during patient visits in order

to qualify for the payment programs and to get paid. Some physicians were discrete about how they called out the reimbursement programs, saying:

> Administrative/all the other forces are requiring increasing amounts of documentation. (Participant 11)

Other physicians simply came out and expressed their disdain with the burdens of the demands of increased documentation requirements.

> I think Meaningful Use, and kind of the having to click certain buttons just to click them to get paid. (Participant 9)

One particular physician expressed that the demands have changed the way that they interact with patients within the exam room.

> I feel like I'm looking down at my keyboard more than I'm looking at and talking with and having conversations with families. It feels like I'm talking and typing. (Participant 14)

A physician remarked that they pre-document when possible in an attempt to save time.

> I think sometimes a lot of us that are following suffer meaningful use or patient-centered medical home, a lot of the stuff we pre-click before we're even seeing a patient, which is probably not great. (Participant 18)

On one hand, physicians seem to be clicking the checkboxes and typing as much documentation as they can into the systems to qualify for the reimbursement programs but some of them have other reasons for the amounts of documentation.

> You really try to document everything because you are afraid of being sued. (Participant 15)

On the other hand, there seems to be the feeling that the excess documentation is not always welcome by those reading the notes from another physician.

> It does create some unnecessary documentation that makes it hard to review other people's records. (Participant 10)

Another physician may have even coined a new phrase to describe what EHRs have done to the visit notes.

> I mean certainly you look at a note and there's a little bit of note bloat. (Participant 3)

One physician even had a unique perspective about sharing their records with outside physicians when consulting on patients in transitions of care.

> In sharing information with other physicians, they don't want to hear the Gettysburg Address. (Participant 16)

More Time at the Computer

The third of the top five themes related to the challenges associated with using an EHR in a medical practice was referred to by the physicians interviewed, thematically, as more time spent at a computer and account for 10 of the 83 challenges, or 12.05%. The references to spending more time at the computer pertain largely to the additional time necessary to complete data entry and documentation and typically takes place outside of the exam room.

> You are spending more time after hours trying to finish your notes, and be thorough, and have everything recorded, which is required. (Participant 15)

After explaining to the patient the care plan, the physician who elects to not take a computer into the exam room finds themselves at a workstation doing data entry tasks after the patient visit to document what was said.

> I do feel like outside of the room I have a lot more work to do clicking buttons and making sure all the correct things are in the chart. (Participant 9)

Sometimes, the physician feels that ordering a particular medication or diagnostic study is documentation enough but the EHR system requires more documentation to justify billing for a certain visit level of complexity.

> It's the time that I spend on summarizing the ideas that I have already expressed to the patient and already it's implemented in my prescriptions and my orders od laboratory testing or diagnostic procedures. (Participant 7)

Takes Longer

In the fourth of five themes related to challenges associated with the use of an EHR system in a medical practice, 9 references out of 83 references pertaining to challenges, or 10.84% were related to the use of the system taking longer when compared to the use of a paper-based system. Based on the in-depth, in person interview data, the reason that the physicians give for the EHRs simply "taking longer" often has to do with imputing data into the computer and the time it takes to navigate between screens or templates.

> I would probably estimate that everyday all those small little extra clicks add up to 20 minutes that I could save an easy, maybe 30 minutes a day if there was more flow. (Participant 17)

A common complaint is in regard to clicking around the system and the time it takes to do complete all of the clicking. The clicking is in reference to a mouse click and is used to click a checkbox or a radio button on a template to document, for instance, a symptom, create a medication order, or complete a treatment plan and has taken the place of handwritten activities that would have taken place when using a paper-based charting system.

> I now often have 10 minutes to two hours of computer clicking that I have to do at the end of the day or at home to complete the charts. (Participant 12)

System Issues/Changes

Lastly, the fifth of the five challenges associated with the use of an EHR system as identified by number of references from in-depth interviews with 20 physicians are challenges of system issues or availability and system upgrades and was referred to eight times out of the 83 challenge references, or 9.64%. Within this theme, the physicians had two main concerns: system unavailability due to power outages and software-related system upgrades. In a practice using paper-based medical record charts, electricity is hardly a concern when accessing a

patient's information. When the charts are fully digitized, a lack of electricity a halt operations or cause slowdowns in the workflow.

> If the system goes down, we're kind of paralyzed, because we don't have access to immunization records. (Participant 9)

In times when the power is on and system are available, even network or computer issues can hamper workflows and efficiency, such as a computer or screen freeze; issues that one might not encounter when using a paper-based chart system.

> Going back and forth from one panel to the other and having the freezing that involves. I think one of the biggest things is that sometimes the record doesn't move quickly and there's freezing. (Participant 10)

The second concern within this theme of system issues/changes is in relation to system software issues. Upgrades to the software to meet to new security compliance standards or because of new features released by the software vendor might compel a practice to upgrade their EHR system software on a periodic basis or more frequently. When the software changes a new learning curve may be introduced which could have an impact on productivity even with sufficient training for the user base. The physicians who took part in this study referred to system software changes in particular as challenges associated with working with an EHR in their practice.

> When you feel like you've got it down pat, it changes. (Participant 16)

One physician, in particular, says that they often find navigation confusing after the upgrades.

> I think it's when there are upgrades or changes, more so when it looks completely different. (Participant 18)

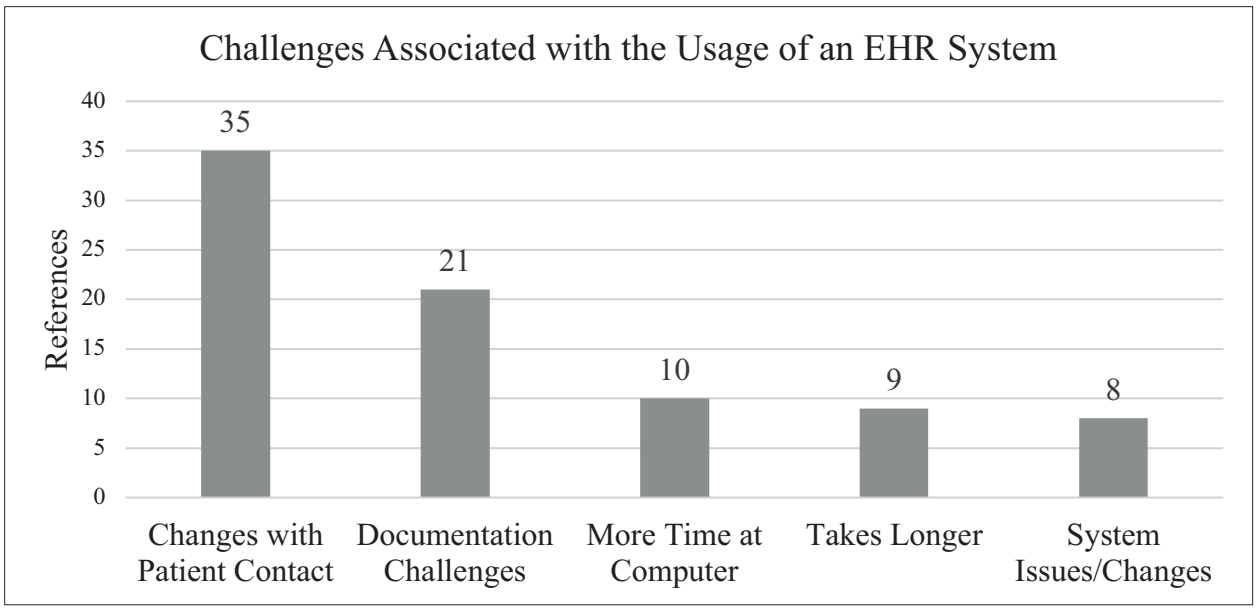

Figure 11. Challenges Associated with Usage of an EHR System

To summarize these findings and how they pertain to the research question:

- [RQ2] What benefits and challenges do physicians report as a result of using an EHR system in the practice?

During the summer and fall of 2019, July and October 2019, the researcher interviewed 20 physicians to understand what benefits and challenges the physicians perceive as a result of having and electronic health record (EHR) system implemented in their practice. After transcribing the interviews and performing a thematic analysis on the data, the researcher selected the top five benefits and challenges as defined by the number of references the physicians made to the theme collectively in the interviews.

The themes depicted in Figure 11 above illustrate the top five themes that emerged as challenges from the in-depth interviews with 20 pediatric physicians and collectively received 83 collective references in the transcripts. This data contained with the data related to the benefits data presented previously answers RQ2 by addressing both the benefits and challenges associated with the usage of the EHR system.

- [RQ2] What benefits and challenges do physicians report as a result of using an EHR system in the practice?

Summary

Productivity data was collected on each of the 20 participant physicians starting from the pre-EHR implementation year in 2007 and then through during the first year of the system's implementation in 2008 through 10 years, ending in 2018. The productivity data that was collected included the number of patient visits per physician per year during 2007 and then through 2008-2018 as well as the number of Relative Value Units (RVUs), a common unit of measurement for physician productivity, generated per year. With this data, the researcher created four cohorts of physicians based on trends in RVU output, increasing or decreasing over the 10-year span from 2008-2018, and the trends in patient visit volume through the same 10-year timeframe of 2008-2018 using the pre-EHR year of 2007 as a benchmark. Additionally, the researcher graphed trends in the mean RVU value per patient visit during the pre-EHR benchmark year of 2007 and then from the years 2008-2018, when the practice was using the EHR system.

After analysis of the productivity data, the researcher concluded the following regarding the trends in physician productivity and the data is intended to answer RQ1 of this study.

- [RQ1] What are the trends in physician productivity as measured by Relative Value Units (RVUs) over a 10-year period?

A small cohort of five physicians of the 20 participants did experience an overall increase in productivity as measured by the mean RVUs generated from 2008-2018 compared to the pre-EHR year of 2007 of 49.84% however, twelve other physicians from the participant pool experienced a decrease in RVUs of -17.64% during this timeframe. The three remaining

participants were not employed with the practice in 2007 and therefore do not have a 2007 baseline established and were not included in either cohort. Despite the small cohort of five physicians experiencing some growth in productivity the overall productivity of the entire practice as a whole trended negative from 2008-2018 compared to the pre-EHR productivity level in the baseline year of 2007 by -6.58%.

While a cohort of seven physicians experienced an increase of 57.20% in the mean number of patient visits from 2008-2018 compared to the pre-EHR year of 2007, 10 physicians from the 20 participants experienced a loss of -29.64% visits during the same time frame. The three remaining participants were not employed with the practice in 2007 and therefor do not have a 2007 baseline established and were not included in either cohort. Despite the cohort of seven physicians experiencing some gain in their volume of patient visits, the practice as a whole experienced a mean negative patient visit volume trend of -9.53% for the time from 2008-2018 compared to the pre-EHR year of 2007.

Lastly, the researcher examined trends in the mean RVUs generated per patient visit from 2008-2018 compared to the pre-EHR year of 2007. In 2007, the physicians earned a mean of 1.21 RVUs per patient visit which dropped to 1.15 RVUs in the first year of the EHR's implementation but grew to 1.25 by the conclusion of the study's data collection period of 2018. This increase of 4.84% from the pre-EHR implementation year to 2018 shows a positive trend in RVUs per patient visit for the time from 2008-2018 compared to the baseline time before the EHR system was implemented in 2007.

After analysis of the in-depth, in-person interviews of the 20 participant physicians, the researcher concluded the following regarding the benefits and challenges associated with the use of an EHR system in the practice and the following data is intended to answer RQ2 of this study.

- [RQ2] What benefits and challenges do physicians report as a result of using an EHR system in the practice?

During the summer and fall of 2019, July through October 2019, the researcher interviewed 20 physicians from a pediatric practice in southwestern Pennsylvania to gain a better understanding of their views on the benefits and challenges associated with using and Electronic Health Record (EHR) system within their practice. The practice at which these physicians worked implemented the system in 2008 and had been using the system for over 10 years when interviewed by the researcher. Through a series of in-depth, in person interviews with each of the 20 participant physicians, the researcher asked questions related to the perceived benefits and challenges of working with the EHR system. The researcher then analyzed the interview transcripts for themes related to either benefits or challenges and selected the top five of each based on the number of times the particular theme had been mentioned throughout the interviews. Table 7 below summarizes the top five benefits and challenges associated with using an EHR system within a medical practice as identified through thematic analysis of the in-depth interviews with 20 physicians of a pediatric practice.

	Benefits to Using an EHR System		Challenges of Using an EHR System	
	Theme	References	Theme	References
1.	Documentation Improvements	31	Changes with Patient Contact	35
2.	More Complete Patient Picture	29	Documentation Challenges	21
3.	Better Chart Organization	25	More Time at the Computer	10
4.	Visit Coding Improvements	16	Takes Longer	9
5.	Increased Legibility	12	System Issues/Challenges	8
	Total	113	Total	83
		Total 196		

Table 7. Benefits and Challenges of Using an EHR System

When examining the benefits and challenges from Table 6 above side-by-side, a total of 193 references were made, collectively, to the top five benefits and to the top 5 challenges. Of these 196 total references, 113 references, or 57.65%, are directed to benefits of the EHR system

and 83 references, or 42.35%, are directed towards challenges of working with an EHR system. With the exception of the top most referred to benefit or challenge, in the case of each of the four remaining benefits or challenges of the top 5, the benefits of having an EHR system score higher than the challenges in terms of the number of times the particular themes were mentioned in the interview transcripts. In the case of the topmost referred to benefit and challenge, the opposite is true, and the top challenge associated with the use of using and EHR within the practice, "changes with patient contact," scored higher than the top benefit by four references (35 vs. 31), "documentation improvements." Based on the number of references made by the participant physicians related to the benefits and challenges associated with using an EHR system within the practice, there are more benefits to using an EHR within the practice than there are challenges with 57.65% of references from the interviews associated with themes that are beneficial to the patient, physician, and the practice and 42.35% of references to themes that were deemed challenges.

In this chapter, the researcher presented data related to physician productivity in the commonly used Relative Value Unit (RVU) as well as data related to the benefits and challenges of using EHR systems as reported through in-depth, in-person physician interviews. The productivity data revealed a decline in overall patient visits as well as RVU performance from 2008-2018 when compared to the baseline, pre-EHR year in 2007. Despite the decline in productivity and patient visits, the practice did realize an increase in RVUs per individual patient visit which could indicate that the EHR system may have had some positive impact. The increase in RVUs per patient visit has the potential to generate additional revenue for the practice at a faster velocity than would efforts to add more patients to physician schedules. The term used to describe the increased RVUs per patient visit is called "RVU intensity" and has the

potential to counteract declines in visit volume by increasing the value of each kept visit for the practice (Hsiao et al., 1993; Meyerhoefer et al., 2016). Finding this phenomenon occur in the study directly reflects findings from the review of the literature.

Additionally, through thematic analysis of the transcripts of interviews with the 20 physicians of the study that the participants generally felt that the EHR was a positive impact on the practice, their patient visit documentation, and the care which they are able to provide. Though the physicians did find topics related to the usage of the EHR for which to provide negative feedback, their comments related to these items were often non-specific and nebulous. When identifying challenges associated with working with the EHR, the physicians often used non-descript items such as “takes longer” and were often not providing specific feedback. Compared to when the physicians where providing feedback on the benefits of the systems, the participants were often able to give specific examples of then the system made their day easier or positively impacted the care they were able to provide. This stark contrast in their behavior and ability to elaborate on the positives could indicate a more positive leaning opinion regarding the EHR system from the physicians.

Chapter 5: Conclusion and Discussion

The purpose of this chapter is to provide discussion points for the findings identified during the process of data collection and analysis. After reviewing the purpose of this study as well as the research questions which drove the data collection and analysis, a summary of the findings is presented and then interpreted. Next, the limitations of the study will be discussed as well as the researcher's reflections of the results and their implications and meaning. Lastly, suggestions for future research are recommended as well as a conclusion to this research.

Purpose of the Study

The purpose of this qualitative research was to understand how the implementation of EHR systems has impacted physician productivity over time by evaluating trends in a standard measure of physician productivity, the relative value unit (RVU), as well as to identify the benefits and challenges of using the EHR system through in-depth interviews with physicians.

Research Questions

The following research questions are central to this study:

1. What are the trends in physician productivity as measured by RVUs over a 10-year period?
2. What benefits and challenges do physicians report as a result of using an EHR system in the practice?

Summary of the Findings

Productivity Data Summary Relating to Trends in Physician Productivity

A small cohort of five physicians of the 20 participants did experience an overall increase in productivity as measured by the mean RVUs generated from 2008-2018 compared to the pre-EHR year of 2007 of 49.84% however, twelve other physicians from the participant pool

experienced a decrease in RVUs of -17.64% during this timeframe. The three remaining participants were not employed with the practice in 2007 and therefor do not have a 2007 baseline established and were not included in either cohort. Despite the small cohort of five physicians experiencing some growth in productivity the overall productivity of the entire practice as a whole trended negative from 2008-2018 compared to the pre-EHR year level in 2007 by -6.58%.

While a cohort of seven physicians experienced an increase of 57.20% in the mean number of patient visits from 2008-2018 compared to the pre-EHR year of 2007, 10 physicians from the 20 participants experienced a loss of -29.64% visits during the same time frame. The three remaining participants were not employed with the practice in 2007 and therefor do not have a 2007 baseline established and were not included in either cohort. Despite the cohort of seven physicians experiencing some gain in their volume of patient visits, the practice as a whole experienced a mean negative patient visit volume trend of -9.53% for the time from 2008-2018 compared to the pre-EHR year of 2007.

Lastly, the researcher examined trends in the mean RVUs generated per patient visit from 2008-2018 compared to the pre-EHR year of 2007. In 2007, the physicians earned a mean of 1.21 RVUs per patient visit which dropped to 1.15 RVUs in the first year of the EHR's implementation but grew to 1.25 by the conclusion of the study’s data collection period of 2018. This increase of 4.84% from the pre-EHR implementation year to 2018 shows a positive trend in RVUs per patient visit for the time from 2008-2018 compared to the baseline time before the EHR system was implemented in 2007.

Qualitative Data Summary Relating to Benefits and Challenges

	Benefits to Using an EHR System		Challenges of Using an EHR System	
	Theme	References	Theme	References
1.	Documentation Improvements	31	Changes with Patient Contact	35
2.	More Complete Patient Picture	29	Documentation Challenges	21
3.	Better Chart Organization	25	More Time at the Computer	10
4.	Visit Coding Improvements	16	Takes Longer	9
5.	Increased Legibility	12	System Issues/Challenges	8
	Total	113	Total	83
		Total 196		

Table 8. Benefits and Challenges of Using an EHR System

When examining the benefits and challenges from Table 8 above side-by-side, a total of 193 references were made, collectively, to the top five benefits and to the top 5 challenges. Of these 196 total references, 113 references, or 57.65%, are directed to benefits of the EHR system and 83 references, or 42.35%, are directed towards challenges of working with an EHR system. With the exception of the top most referred to benefit or challenge, in the case of each of the four remaining benefits or challenges of the top 5, the benefits of having an EHR system score higher than the challenges in terms of the number of times the particular themes were mentioned in the interview transcripts. In the case of the topmost referred to benefit and challenge, the opposite is true, and the top challenge associated with the use of using and EHR within the practice, "changes with patient contact," scored higher than the top benefit by four references (35 vs. 31), "documentation improvements." Based on the number of references made by the participant physicians related to the benefits and challenges associated with using an EHR system within the practice, there are more benefits to using an EHR within the practice than there are challenges with 57.65% of references from the interviews associated with themes that are beneficial to the patient, physician, and the practice and 42.35% of references to themes that were deemed challenges.

Interpretation of the Findings

Productivity Data Summary Relating to Trends in Physician Productivity

Five physicians found that their RVUs grew from the pre-EHR value of 3,337 on 2007 to 5,000 RVUs at the end of the study in 2018, a positive change of 49.84%. Yet, despite this increase, the company as a whole still declined in overall RVUs by -6.58%, falling from 5,293 RVUs in 2007 to 4,945 in 2018. Even though the five physicians experienced such significant growth, a much larger proportion of 12 physicians experienced a decline of -17.64%. Three physicians were not working at the practice in 2007 and therefor a benchmark could not be established. The larger proportion of physicians experiencing such a high rate of decline is a primary driver of the overall company's declining RVU performance over the span of the study period.

A similar trend of a small cohort of physicians is also identifiable when examining physicians who experienced an increase in their patient visit volume. A cohort of seven physicians experienced growth in the number of patient visits during the study period from 2008-2018 when compared to the pre-EHR benchmark year in 2007. This group of seven physicians experienced growth from 2,715 patient visits in 2007 to 4,267 visits in 2018, a growth of 57.20%. Three physicians were not working at the practice in 2007 and therefor a benchmark could not be established. Still, the 57.20% growth of these physicians was overshadowed by 10 physicians who collectively experienced an overall decline in patient visits from 2007 to 2018 of -29.64% and contributed to the company mean decline of -9.53%.

Upon closer examination of the data of the five physicians in the cohort which experienced a 49.84% increase as well as the cohort of seven physicians which experienced an increase in patient visits of 57.20%, all the cohort of physicians experiencing an increase in

patient visits contains all physicians who experienced the increase in RVUs plus two additional physicians.

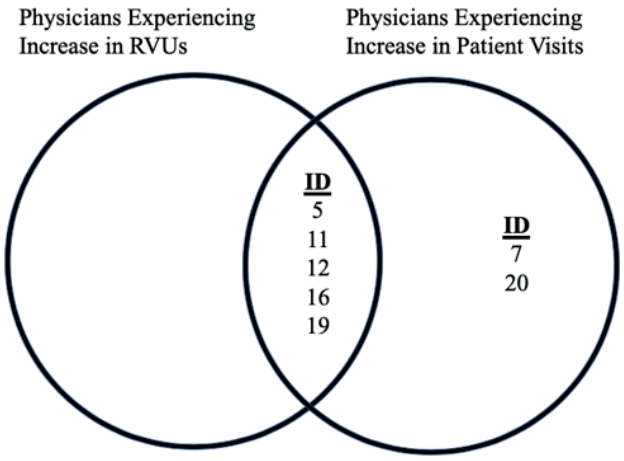

Figure 12. Physicians in Cohorts Experiencing Growth in RVUs and Visits

Of the physicians in the cohort which experienced growth in RVUs, two of them were relatively new hires to the practice and had low RVU values for the 2007 year. As their individual practices grew, so did their RVUs and patient visit volumes which created some extremely high growth percentages when compared to established physicians. This is illustrated in table 9 below. IDs 5 and 12 were new to the practice in 2007 and established lower benchmarks than their peers but by the end of the study, in 2018, were producing metrics closer to other established physicians like those of ID 16.

	Experienced Growth in RVUs			Experienced Growth in Patient Visits		
ID	2007 RVUs	2018 RVUs	% Change	2007 Visits	2018 Visits	% Change
5	2,049	4,689	129%	1,998	3,750	88%
12	1,044	5,097	388%	958	5,242	447%
11	4,965	5,333	7%	3,970	4,526	14%
16	6,511	7,283	12%	2,548	3,251	28%

Table 9. Physician Growth of Newer Physicians vs. Established

The number of physicians included in this study is one third of the physicians employed by the practice and was limited to this number only because the researcher was interested in physicians who had been employed the entire length of time in which the EHR had been utilized.

While the indicators here to show the company is in decline in terms of a negative growth for RVUs generated (-6.58%) and negative growth in terms of patient visits (-9.53%), this is only taking into consideration these 20 physicians. Outside of this data, the practice has experienced growth from the opening of four new offices and the acquisition of a practice from a retiring physician. Because of the practice's strong performance and history with the community, a large health system purchased the practice and its 16 locations to form its Pediatrics Institute in March of 2019 and has committed to opening more offices and is focused on more growth in the future.

Aside from looking at the decline of the RVUs generated as well as the patient visit volumes it would be valuable to examine the overall trends in population changes for the region in which this practice operated during the study period from 2008-2018. According to data from the U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates, the population among 0-19-year-old in Allegheny Country, the area served by this practice experienced declines that could have some impact on the practice as illustrated in Figure 13 below. From 20010's < 18 year-old population of 241,046 to 227,749 in 2018, Allegheny county's population declined by 13,297 children (-5.52%) (U.S. Census Bureau, 2018). Taking into considering this information and applying it to the company mean decline in RVUs of -6.58% and the company mean decline in total patient visits of -9.53% it is possible to conclude that the decline of -6.32% in the pediatric population in the area served by the practice has had an effect on the practice. While the practice experienced a downturn in patient visits from 2008-2018 which subsequently may have resulted in a decline in RVUs, the decline in visit volume and RVUs cannot necessarily be entirely be associated with the implementation of the EHR system in the light of the decline in the pediatric population in the region served by the practice.

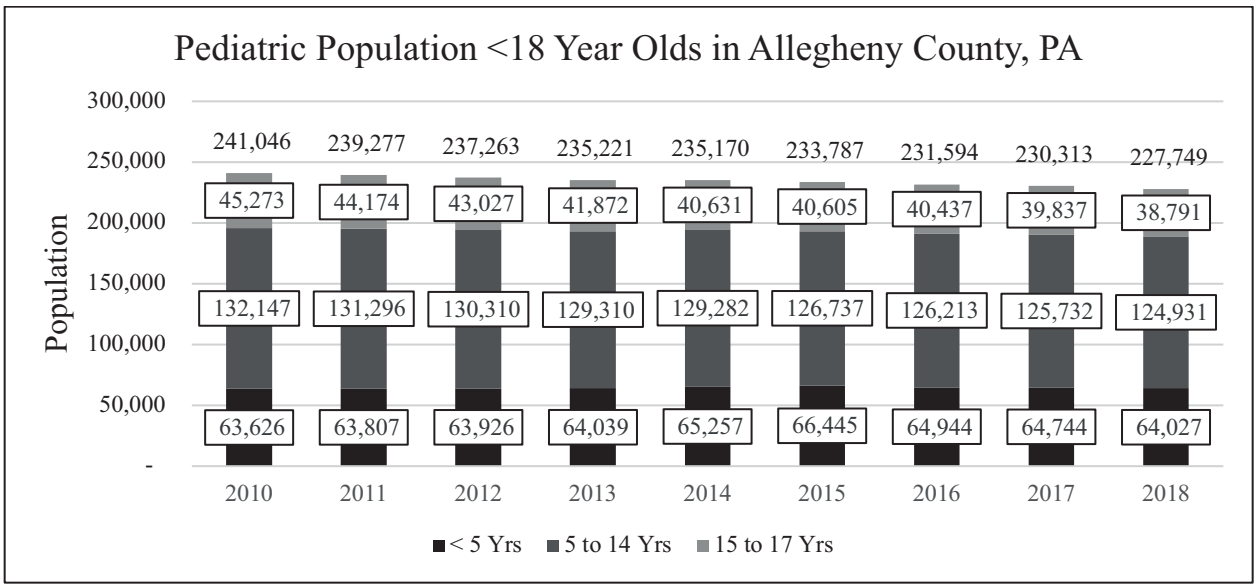

Figure 13. Pediatric Population <18 Years Old in Allegheny County, PA

Qualitative Data Summary Relating to Benefits and Challenges

Table 10 below is a summary of the data presented in Chapter 4 related to the top five themes extracted from the in-depth, in-person interviews with the 20 participant physicians of this study. The higher number of themes associated with benefits to using an EHR system (131 references) compared to the challenges associated with the use of the EHR (83 references) leads the researcher to the conclusion that the physicians generally found the systems to be of benefit to the practice and to the patient. When examining the individual subthemes themes that comprise the generalized benefits and challenges, the subthemes associated with benefits tend to have higher instances of references throughout the interview transcripts than the challenges. When giving examples during the interviews of specific benefits to the use of the system, physicians were often able to quickly give specific items such as “no more missing charts” or “better backup for my visit coding.” When the physicians would communicate challenges, they would often be vague and broad such as “it just takes longer.” It is the opinion of the researcher that for some of the subthemes listed under challenges, the physician has no specific complaint

or metric to which to tie a complaint other than that there is some characteristic about the system that they perceive to be an issue or negative experience.

	Benefits to Using an EHR System		Challenges of Using an EHR System	
	Theme	References	Theme	References
1.	Documentation Improvements	31	Changes with Patient Contact	35
2.	More Complete Patient Picture	29	Documentation Challenges	21
3.	Better Chart Organization	25	More Time at the Computer	10
4.	Visit Coding Improvements	16	Takes Longer	9
5.	Increased Legibility	12	System Issues/Challenges	8
	Total	113	Total	83
		Total	196	

Table 10. Benefits and Challenges of Using an EHR System

Theoretical Implications

Of two theories that have particular convergence with this research, one pertains to the installation of technology as a way to boost product productivity and the other pertains to the way users demonstrate their use of technology and adapt it to daily workflows.

The productivity paradox of information technology, described by Erik Brynjolfsson (1993), is the phenomenon wherein investments in information technology do not guarantee improvements in worker productivity (Brynjolfsson, 1993). At the time of publication, Brynjolfsson explains the issue to four categories: mismeasurement, lags, redistribution, and mismanagement. Mismeasurement refers to a failure to account for nontraditional sources of value. Lagging is in reference to the difference in time between when purchases are made to the time when benefits can be measured. Next, redistribution means investing in information technology at the incorrect level of the company, so that net benefits show up at higher levels in the company, but the technology may not be used by those who need it. Lastly, when defining mismanagement, the author is speaking of companies making IT investments in times when they should not be. In the article, the researcher discusses that the productivity slowdown can be most noticed in the service sector and discusses “white-collar” sectors such as finance. This

researcher feels that it is important to consider the healthcare industry as an industry now impacted by this paradox as IT is infused in every facet.

Twenty years later, researchers Hajli et al. reexamined the productivity paradox to understand its implications in 2012 and to report on if the paradox still holds true. Their research still cited some of the same causes associated with the historical notion of the paradox such as measurement errors, time lags, mismanagement and income distribution or redistribution. The main difference between the Hijli et al. research and that of Brynjolfsson's research from 20 years earlier was that the latter research rejects Brynjolfsson's and asserts that the paradox no longer existed post 1995 (Hajli et al., 2015). This could be due to more users becoming more familiar with the technology or the technology itself maturing and becoming easier to use.

With respect to healthcare, researchers Jones et al. (2012) examined the productivity paradox with regard to the healthcare setting to determine if the model fits. With respect to issues identified by Brynjolfsson and Hijali et al., Jones et al. also indicated problems with factors such as the measurements that are part of productivity metrics citing that less than two percent of performance measurements were suited for measuring the effects of health IT (Jones et al., 2012). Secondly, the researched cited lags between the time between when IT purchases were made and the time when productivity payoffs could be detected, often requiring long periods of process reengineering. The researchers also cite poor software design and low usability as reasons for low productivity gains. Instead of reengineering workflows to realize the full benefit of the IT's potential, healthcare companies are simply digitizing their old paper-based workflows (Jones et al., 2012).

It is the notion of simply recreating paper-based workflows in the digital world that introduces the second theory that drives this research, reflective technology assimilation.

Technology assimilation is the process by which companies adopt and deploy technologies across the organization and this assimilation is an ongoing and sometimes experimental process. The issue faced by some practices, particularly smaller ones which may experience resource constraints, is that the process of full assimilation quickly becomes "good enough" or satisficing in terms of technology integration (Baird et al., 2017). The researchers go on to say that the levels of use, in this instance, of EHR use, could be considered effective if the practice has a basic goal if having it up and running and may incorporate additional features over time. The reflective nature of the theory comes from habitual and periodic feedback loops from the users which are then acted upon through communities of practice, training programs or modifications to the software to expand efficiency and effectiveness of the system (Baird et al., 2017). The practice which was the focus of this study began in a very similar fashion as outline by this theory and after several years of refining the software's features and settings as well as periodically revisiting training for all users, was able to gain a more effective use of the entire system. The feedback loop was achieved through monthly meetings of stakeholder physicians and key administrative staff for the entire duration of the software's 10-year usage.

Limitations of the Study

This study was limited to 20 physicians employed in a pediatric ambulatory practice in southwestern Pennsylvania between 2007-2018 and all participants in the study had to be using the electronic health record (EHR) system from 2008-2018. According to the Association of American Medical Colleges, there are over 120 specialties and subspecialties of physician (Association of American Medical Colleges, 2019). This study examines the productivity habits through the use of one EHR system in particular of approximately 684 software vendors in the U.S. marketplace, though the software system used at this practice number four of the top five in

the country in terms of number of customers. (U.S. Department of Health and Human Services, 2017). Lastly, this study examines productivity and physician opinions on the benefits and challenges of EHR systems in out-patient care setting and does not examine data from hospital, in-patient care settings.

Recommendations for Future Research

Using the limitations of this study as a guide to drive future possible research, it would be valuable to recreate much of this study in a variety of scenarios and examine the data to determine if a change in software, specialty, or the care setting might have anything to do with the productivity of opinion of the physician changes. Each EHR software varies slightly in workflow, design, and operation and it would be a valid study to understand if physicians using software from other top vendors such as Epic, Centricity, Allscripts, eClinicalWorks, or Cerner compared to NextGen which is what was implemented at the practice in this study.

Additionally, it could be valuable to directly collect data on the age of each of the physicians in future studies to determine if age has played a part in productivity. This would be taken in two distinct directions: perhaps users of a more advanced age experienced slowed productivity simply because of age or that users who are older perhaps are less familiar with using the computer and therefor are slower than some of their colleagues who experienced more computer use as a part of their younger, more formative years. Computer training and literacy would also play a large part in this and could negate some age-related bias as physicians who may be a little older may take some computer training classes and then computer-related barriers would no longer be of concern.

Another future study would be to examine how trends in the overall health and size of local populations affect the productivity and patient visit volume of physicians. In areas of the

country where there are widespread health concerns related to pollution or some other environmental factors that affect health, the patient presenting to the physicians may have more complicated health needs requiring more time and care. This extra support results in higher billing codes and could artificially drive up productivity. Alternatively, widespread health-related concerns such as acute pollution could drive more people to their physicians temporarily increasing visit volumes. Furthermore, it would be beneficial to examine population statistics such as growth or declines in a particular region to determine what effect that may have on the visit volumes and productivity of physicians. If a region is experiencing a decline in the population of children, for instance, then a practice that serves the pediatric population may see a decline in visit volume which will also affect the number of RVUs generated annually however other types of practices, such as ophthalmology or cardiology, may not experience much of a decline in visits.

Lastly, this study only examines the opinion of the EHR system from the lens of the physician and does not take into consideration the opinion of the patient. A suggestion for a future study would be to survey patients who have been seen by physicians before and after the implementation of an EHR system to gather information on how their interaction with their physician may or may not have changed and to get insights on their opinion on the quality of care as well as the physicians productivity as a result of the implementation of the EHR system.

Conclusion

This study examined the trends in physician productivity after the implementation of an electronic health record (EHR) system as well as the benefits and challenges of using the system as reported by the physicians who have used it for 10 years. The results of the productivity data stemming from RVU reports from the EHR system supported the portion of the literature review

in that the implementation of an EHR system contributed to a decline in physician productivity however, not to the extent of the other practices in the cited articles. Furthermore, the implementation also supported the early research on the productivity paradox of information technology. The later revisiting of the productivity paradox by Hajli et al. are contrary to this researcher's findings in that post 1995 the productivity paradox still exists in this practice. Furthermore, though the majority of the physicians experienced a decrease in patient visits during the time of the study from 2008-2018 compared to the pre-EHR implementation year in 2007, it cannot be ruled out that the pediatric population decline in the area surrounding the practice did not contribute to this decline. The physicians did, however, experience an increase in RVUs per patient visit after the implementation of the EHR system and throughout the course of this study. Additionally, interviews with 20 physicians who each had been using the system for 10 years revealed substantially more benefits to using the system than challenges.

The findings of this research, both the qualitative and the quantitative, reflect the findings of the literature review in that depending on who one asks or what data is observed, EHR systems are a benefit and challenge to modern-day healthcare practices. Productivity data on a macro level does indeed suggest that EHR systems do tend to slow the productivity of the individual physicians however, the systems lead to increased RVU intensity on a per patient visit basis. So, while the physician may see fewer patients throughout the day, those patient visits which are completed tend to be more profitable for the practice individually. A marginal increase in the number of patient visits could render any loss in productivity negligible in terms of lost revenue for the practice. With respect to perceptions and opinions, the vast majority of physicians interviewed found the systems to be beneficial to their daily work and of benefit to

being able to care for their patient population. While there are, of course, some challenges with any computer system, the benefits outweighed the challenges and lead to better patient care.

EHR systems, in some form and function, are here to stay. This is the future. Physicians clinging to antiquated paper-based systems and workflows for handling patient information will continue to struggle in the digital world. Anecdotally, physicians long for a simpler time. One in which everything was easy, and they didn't have to do so much "clicking around." This researcher suspects that in a few more years, the software will continue to evolve, and the physicians will long for these days, in 2020, when they could just click around on a screen to get what they needed.

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Appendix A: The Practice's IRB Approval Letter

[redacted] [redacted]

July 19, 2019

Gary Janchenko
[redacted]

RE: **2019-169 "The Impact of Electronic Health Records on Physician Productivity at a Pediatric Practice"**

Dear Mr. Janchenko:

The [redacted] Institutional Review Board (IRB) is in receipt of the above-referenced protocol.

This protocol has been reviewed via the "*expedited review*" process (Category #5, 6, 7[b]) and is **approved** by the IRB in accordance with Institutional, Federal and State regulations. It is the responsibility of the investigator to obtain any other necessary approvals prior to implementation of the research. Your approved protocol will be subject to review within one year.

Approved: **July 19, 2019**

A stamped approved Informed Consent Form (v7.11.19) is attached for your use.

Please be aware of the record keeping responsibilities involved in your protocol.

Annual review of this research is no longer required provided the research is conducted as proposed. If there are modifications or changes to this study, (which includes changes to key study personnel) the Investigator must have the IRB review the study prior to initiating the changes. The PI continues to have the obligation to report applicable events per IRB SOP "Prompt Reporting to the IRB (Unanticipated Problems Involving Risks to Subjects or Others (UPIRSO), Adverse Events, Protocol Deviations, etc.) to the IRB Office. At any time the study is completed, please submit a Final Report to the IRB Office to allow the IRB to update the files and inactivate the study.

Please retain this letter as evidence of IRB review and determination of continuing review requirements for this research.

Since Annual review is no longer required for this protocol, post approval monitoring may occur at currently undetermined intervals. You will receive notice in 3 years from this notification requiring an update of the status of the study.

Sincerely,

Signed Friday, July 19, 2019 10:05:44 AM ET by [redacted]

[redacted]
Vice-Chairman
[redacted]

Appendix B: Robert Morris University IRB Approval Letter

Dear Janchenko, Gary J

Your application, entitled *The Impact of Electronic Health Records on Physician Productivity at a Pediatric Practice*, has been reviewed by the Robert Morris University Institutional Review Board (IRB). After extensive review, our reviewers have approved your application.

This email serves as final verification and approval of your application #201907192130. You may begin conducting your research. This application expires 3 years from this approval notice. If you wish to continue your research after that time, a new application must be submitted.

Robert Morris University
6001 University Boulevard
Moon Township, PA
15108-1189

412-397-3000

RMU..EDU

If you have any questions, please feel free to email us at irb@rmu.edu.

Regards,

The RMU IRB Committee

Appendix C: Informed Consent Form

INFORMED CONSENT FORM FOR A RESEARCH STUDY

The Impact of Electronic Health Records on Physician Productivity at a Pediatric Practice [redacted]

Investigator
Gary Janchenko, [redacted]

Concise Summary

The purpose of this research is to understand how the implementation of EHR systems has impacted physician productivity by looking at productivity calculations as well as to identify the benefits and challenges of using the EHR system. This project is considered research and participation is voluntary.

Upon enrollment in this research, you will be interviewed by the researcher during a brief, 30-minute interview session. Provided you give consent, your responses to the interview questions will be recorded and transcribed. In addition, the researcher will query the practice management system to report your individual RVU totals for each year. All data will be encoded with an identifier so that no information related to your individual RVU information is directly identifiable. Your participation will last approximately three months.

There is a potential risk of loss of confidentiality and discomfort with interview questions. There is no intended benefit to participation. If you are interested in learning more about this study, please continue reading below.

What you should know about a research study

- Someone will explain this research study to you.
- Being in a research study is voluntary.
- Whether or not you take part is your decision.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind.
- Whatever you decide it will not be held against you.
- Feel free to ask all the questions you want before you decide.
- "You" refers to you as a participant in this study.

Who can I talk to if I have questions?

If you have questions, concerns, or complaints, or think the research has hurt you, you should contact the principal investigator: Gary Janchenko, [redacted]

This research has been reviewed and approved by [redacted] Institutional Review Board. You may talk to them by calling this toll-free number, [redacted], for any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.

[redacted]

- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.
- Why are you doing this research?

We invite you to take part in a research study because you have been using an electronic health record system for 10 years.

The purpose of this research is to understand how the implementation of EHR systems has impacted physician productivity by looking at productivity calculations as well as to identify the benefits and challenges of using the EHR system.

How long will the research last?

We expect that you will be in this research study for three months.

How many people will be studied?

We expect about 23 people will be in this research study out of 52 providers in [redacted]

What happens if I say yes, I want to be in this research?

The researcher will contact you to setup a time and a place for a short, 30-minute interview. In the event that an in-person meeting cannot occur, the researcher will setup a telephone interview with you that will also last approximately 30 minutes. After the interview, you will have an opportunity to review the transcribed version of your interview and will be able to make corrections to the document. Your changes will be incorporated into the document and you will be presented with an updated transcription document to be reviewed. This process will continue until you are satisfied with the transcription and you approve the document to be the final version of your interview. You also have the option to refuse the audio-recording of your interview. In the event of your refusal to be audio-recorded, the researcher will take hand-written notes during the interview. After the interview, the process for reviewing the notes will be the same as if you were reviewing transcribed notes and you will have the ability to review and make changes to the notes until you agree on the final version of the interview notes.

Your individual relative value units (RVUs) will be reviewed in the practice management system to identify trends such as volume increases and decreases, and to identify milestones such as the beginning and end of meaningful use.

What happens if I say no, I do not want to be in this research?

You may decide not to take part in the research and it will not be held against you. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled.

This is not a treatment study. Your alternative is to not participate in this study.

What happens if I say yes, but I change my mind later?

If you agree to take part in the research now you may stop at any time and it will not be held against you. You may discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled.

Is there any way being in this study could be bad for me?

There are no physical risks associated with this study. There is, however, there is a potential risk of loss of confidentiality. Every effort will be made to keep your information confidential; however, this cannot be guaranteed. Your name will not be recorded during data collection for this study. All individual audio-recordings, hand-written notes, and data files will be stored as password-protected electronic files and stored in encrypted cloud storage for a period of 10 years. Some of the questions we will ask as a part of this study may make you feel uncomfortable. You may refuse to answer any of the questions, and you may take a break at any time during the study. You may stop your participation in this study at any time.

Will being in this study help me in any way?

We cannot promise any benefits to you from your taking part in this research.

Will my information be kept confidential?

Your identity and data related to this study will be kept confidential, except as required by law and except for inspections by the U.S. Department of Health and Human Services (HHS), , the , the (the committee formed to protect the rights and welfare of human subjects involved in research activities being conducted under its authority)) and the . Results of the research may be published for scientific purposes or presented to scientific groups, however, your identity will not be revealed.

Are there costs of participating in this study?

This kind of research study is not expected to result in any costs to you.

Will I be paid to participate in this study?

You will not be paid for your participation in this research study.

Consent – (Signature Block for Capable Adult)
Your signature below indicates your permission to take part in this research:

Signature of Subject	Date
Printed Name of Subject	Time – include AM/PM

Signature of Person Obtaining Consent	Date
Printed Name of Person Obtaining Consent	Time – include AM/PM

Appendix D: Interview Protocol

1. During your medical education, what kind of EHR system training or experience you presented with?
    a. Probe: Were you presented with any EHR system training or experience during your residency?
2. During your medical education, please describe how you were taught to use CPT codes.
    a. Probe: How has the EHR system impacted your patient visit coding?
3. Do you feel the EHR system has impacted the thoroughness of your documentation?
    a. Probe: If yes, in what ways?
4. Do you feel that the implementation of an EHR system has changed the way you practice medicine?
5. Do feel the EHR has impacted the quality of the care that you provide? If yes, in what ways?
6. How do you feel the EHR system has impacted the time spent with the patient?
7. Could you explain your patient visit documentation process starting from before you enter the exam room?
    a. Probe: Do you document the patient visit in the exam room?
    b. Probe: Are you able to complete your documentation during the business day?
    c. Probe: Do you find yourself documenting patient visits after business hours?
8. What benefits do you feel have been achieved as a result of the implementation of the EHR system?
9. What have been some of the challenges associated with having to work with the EHR system?

Appendix E: List of all Meaningful Use Core Objectives, Menu Set Items, and Clinical Quality Measures

Description	Core/Menu Set/Core CQM/Menu CQM
Use of Computerized Physician Order Entry (CPOE) for medication orders	Core
Implement drug-drug and drug-allergy interaction checks	Core
Generate and transmit permissible prescriptions electronically (eRx)	Core
Record demographics (preferred language, gender, race, ethnicity, date of birth)	Core
Maintain an up-to-date problem list of current and active diagnoses	Core
Maintain an active medication list	Core
Maintain active medication allergy list	Core
Record and chart changes in vital signs (height, weight, blood pressure, BMI, plot and display growth charts for 2-20 years)	Core
Record smoking status for patients 13 years old or older	Core
Implement one clinical decision support rule relevant to specialty or high clinical priority along with the ability to track compliance to that rule	Core
Report ambulatory clinical quality measures to CMS or the States	Core
Provide patients with an electronic copy of their health information (including diagnostic test results, problem list, medication lists, medication allergies), upon request	Core
Provide clinical summaries for patients for each office visit	Core
Capability to exchange key clinical information (problem list, medication list, medication allergies, diagnostic test results), among providers of care and patient authorized entities electronically	Core
Ensure adequate privacy and security protections for personal health information	Core
Implement drug-formulary checks	Menu
Incorporate clinical lab-test results into certified EHR technology as structured data	Menu
Generate lists of patients by specific conditions	Menu
Send reminders to patients per patient preference for preventative/ follow up care	Menu
Provide patients with timely electronic access to their health information (including lab results, problem lists, medication lists, medication allergies) within four business days of the information being available to the eligible provider (EP)	Menu
Use certified EHR technology to identify patient-specific education resources and provide those resources to the patient if appropriate	Menu

The EP, eligible hospital or critical access hospital (CAH) who received a patient from another setting of care or provider of care or believes and encounter is relevant should perform medication reconciliation	Menu
The EP, eligible hospital or CAH who transitions their patient to another setting of care or provider of care or refers their patient to another provider of care should provide summary of care record for each transition of care or referral	Menu
Capability to submit electronic data to immunization registries or Immunization Information Systems and actual submission	Menu
Capability to submit electronic syndromic surveillance data to public health agencies and actual submission	Menu
Percentage of patient visits for patients 18 and older with a diagnosis of hypertension who have been seen for at least 2 office visits, with blood pressure (BP) recorded (Measure: NQF 0013)	Core CQM
Percentage of patients 2-17 years of age who had an outpatient visit with a PCP or OB/GYN and who had evidence of BMI percentile documentation, counseling for nutrition and counseling for physical activity during the measure year (Measure: NQF 0024)	Core CQM
a) Percentage of patients aged 18 years and older who have been seen for at least 2 office visits who were queried about tobacco use one or more times within 24 months. b) Percentage of patients aged 18 years or older identified as tobacco users within the past 24 months and have been seen for at least 2 office visits who have received tobacco cessation intervention (Measure: NQF 0028a,b)	Core CQM
Adult Weight Screening and Follow-up (Measure: NQF 0421)	Core CQM
Percentage of children 2 years of age who had four diphtheria, tetanus and acellular pertussis (DTap); three polio (IPV); one measles, mumps and rubella (MMR); two H influenza pox (VZV); four pneumococcal conjugate (PCV); two hepatitis A (Hep A); two or three rotavirus (RV); and two influenza (flu) vaccines by their second birthday (Measure: NQF 0038)	Core CQM
Preventive Care and Screening: Influenza Immunization for Patients 50 Years Old or Older (Measure: NQF 0024)	Core CQM
Diabetes: Hemoglobin A1c Poor Control	Core CQM
Diabetes: Low Density Lipoprotein (LDL) Management and Control	Core CQM
Diabetes: Blood Pressure Management	Core CQM
Heart Failure (HF): Angiotensin-Converting Enzyme (ACE) Inhibitor or Angiotensin Receptor (ARB) Therapy for Left Ventricular Systolic Dysfunction (LVSD)	Core CQM
Coronary Artery Disease (CAD): Beat-Blocker Therapy for CAD Patients Prior Myocardial Infarction (MI)	Core CQM
Pneumonia Vaccination Status for Older Adults	Core CQM
Breast Cancer Screening	Core CQM
Colorectal Cancer Screening	Core CQM
Coronary Artery Disease (CAD): Oral Antiplatelet Therapy Prescribed for Patients with CAD	Core CQM

Heart Failure (HF): Beta-Blocker Therapy for Left Ventricular Systolic Dysfunction (LSVD)	Core CQM
Anti-Depressant Medication Management: (a) Effective Acute Phase Treatment, (b) Effective Continuation Phase Treatment	Core CQM
Primary Open Angle Glaucoma (POAG): Optic Nerve Evaluation	Core CQM
Diabetic Retinopathy: Documentation of Presence or Absence of Macular Edema and Level of Severity of Retinopathy	Core CQM
Diabetic Retinopathy: Communication with the Physician Managing Ongoing Diabetes Care	Core CQM
Asthma Pharmacologic Therapy	Core CQM
Asthma Assessment	Core CQM
Appropriate Testing for Children for Pharyngitis	Core CQM
Oncology Breast Cancer: Hormonal Therapy for Stage IC-IIIC Estrogen Receptor/Progesterone Receptor (ER/PR) Positive Breast Cancer	Core CQM
Oncology Colon Cancer: Chemotherapy for Stace III Colon Cancer Patients	Core CQM
Prostate Cancer: Avoidance of Overuse of Bone Scan for Staging Low Risk Prostate Cancer Patients	Core CQM
Smoking and Tobacco Use Cessation, Medical Assistance: a) Advising Smokers and Tobacco Users to Quit, b) Discussing Smoking and Tobacco Use Cessation Medication, c) Discussing Smoking and Tobacco Use Cessation Strategies	Core CQM
Diabetes: Eye Exam	Core CQM
Diabetes: Urine Screening	Core CQM
Diabetes: Foot Exam	Core CQM
Coronary Artery Disease (CAD): Drug Therapy for Lowering LCL-Cholesterol	Core CQM
Heart Failure (HF): Warfarin Therapy Patients with Atrial Fibrillation	Core CQM
Ischemic Vascular Disease (IVD): Blood Pressure Management	Core CQM
Ischemic Vascular Disease (IVD): Use of Aspirin of Another Antithrombotic	Core CQM
Initiation and Engagement of Alcohol and Other Drug Dependence Treatment: a) Initiation, b) Engagement	Core CQM
Prenatal Care: Screening for Human Immunodeficiency Virus (HIV)	Core CQM
Prenatal Care: Anti-D Immune Globulin	Core CQM
Controlling High Blood Pressure	Core CQM
Cervical Cancer Screening	Core CQM
Chlamydia Screening for Women	Core CQM
Use of Appropriate Medications for Asthma	Core CQM
Low Back Pain: Use of Imaging Studies	Core CQM
Ischemic Vascular Disease (IVD): Complete Lipid Panel and LDL Control	Core CQM
Diabetes: Hemoglobin A1c Control (<8.0%)	Core CQM

Adapted from "Medicare and Medicaid Programs; Electronic health record incentive program; Final rule." 2010, *Federal Register*, *75*(144). Copyright 2010 by Centers for Medicare & Medicaid Services (CMS), HHS.

Appendix F: Productivity Data Tables

Physicians Experiencing an Increase in RVUs

		YEAR												% Difference
ID	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
1	7,038	5,521	6,501	6,526	6,429	5,924	6,819	6,369	6,705	6,407	6,676	6,918	6,185	-1.70%
2	6,163	5,170	6,477	5,985	6,174	5,869	5,713	5,324	5,409	5,424	4,777	4,712	4,021	-23.55%
3	6,116	4,945	5,648	5,666	5,654	5,750	5,212	5,479	4,953	4,980	5,562	5,776	5,410	-5.55%
4		3,796	6,262	5,510	6,209	6,064	5,978	5,210	4,829	4,842	4,951	4,365	3,272	14.98%
5	2,049	4,088	4,787	4,775	4,833	4,658	4,597	4,617	4,533	4,470	4,679	4,689	4,420	128.81%
6	7,070	5,368	7,126	6,693	6,949	6,629	6,322	5,560	5,197	4,761	5,251	4,689	4,299	-33.68%
7	4,866	4,085	5,329	5,640	6,274	6,325	6,234	6,155	5,323	6,077	3,969	4,383	4,240	-9.94%
8	5,509	4,186	5,466	4,891	4,878	4,573	4,438	4,568	4,379	4,180	3,625	3,671	3,826	-33.36%
9	5,265	4,247	5,133	4,817	5,113	4,757	4,796	4,928	5,030	4,947	4,519	4,469	4,998	-15.11%
10	7,586	6,062	7,037	7,473	7,878	6,917	6,569	6,597	6,051	5,709	4,917	4,744	4,732	-37.46%
11	4,965	4,539	4,815	3,755	4,923	5,225	4,865	4,654	4,841	5,032	4,730	5,333	5,465	7.42%
12	1,044	2,737	4,456	4,866	5,224	4,226	3,869	3,873	5,395	3,251	3,575	5,097	4,735	388.42%
13	7,087	5,309	6,362	6,787	6,192	5,623	6,418	6,675	6,398	6,103	5,899	5,857	5,322	-17.36%
14	6,063	4,607	5,945	5,653	6,108	5,808	5,575	5,235	5,835	5,909	5,867	5,381	5,325	-11.25%
15	5,739	4,762	6,047	5,828	5,809	5,805	5,415	5,254	5,246	5,658	5,565	5,275	5,064	-8.08%
16	6,511	4,462	4,791	4,942	5,153	5,942	6,197	7,128	6,151	7,554	7,935	7,283	6,385	11.85%
17			792	5,277	5,872	5,850	4,444	4,596	4,746	4,924	4,943	5,683	6,009	617.21%
18		15	792	131	2,212	3,579	3,324	3,010	3,625	4,099	3,691	3,482	4,340	339.36%
19	2,118	2,097	2,193	1,699	2,540	2,128	1,955	1,616	1,867	2,396	2,516	2,597	3,492	22.66%
20	4,788	4,054	4,743	4,020	5,003	4,888	4,232	4,457	4,297	4,509	4,286	4,486	4,909	-6.30%
Physician Mean	3,337	3,585	4,208	4,007	4,534	4,436	4,297	4,378	4,557	4,541	4,687	5,000	4,899	49.82%
Practice Mean	5,293	4,213	5,035	5,047	5,471	5,327	5,149	5,065	5,040	5,062	4,897	4,945	4,822	-6.58%

Physicians Experiencing a Decrease in RVUs

		YEAR												% Difference
ID	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
1	7,038	5,521	6,501	6,526	6,429	5,924	6,819	6,369	6,705	6,407	6,676	6,918	6,185	-1.70%
2	6,163	5,170	6,477	5,985	6,174	5,869	5,713	5,324	5,409	5,424	4,777	4,712	4,021	-23.55%
3	6,116	4,945	5,648	5,666	5,654	5,750	5,212	5,479	4,953	4,980	5,562	5,776	5,410	-5.55%
4		3,796	6,262	5,510	6,209	6,064	5,978	5,210	4,829	4,842	4,951	4,365	3,272	14.98%
5	2,049	4,088	4,787	4,775	4,833	4,658	4,597	4,617	4,533	4,470	4,679	4,689	4,420	128.81%
6	7,070	5,368	7,126	6,693	6,949	6,629	6,322	5,560	5,197	4,761	5,251	4,689	4,299	-33.68%
7	4,866	4,085	5,329	5,640	6,274	6,325	6,234	6,155	5,323	6,077	3,969	4,383	4,240	-9.94%
8	5,509	4,186	5,466	4,891	4,878	4,573	4,438	4,568	4,379	4,180	3,625	3,671	3,826	-33.36%
9	5,265	4,247	5,133	4,817	5,113	4,757	4,796	4,928	5,030	4,947	4,519	4,469	4,998	-15.11%
10	7,586	6,062	7,037	7,473	7,878	6,917	6,569	6,597	6,051	5,709	4,917	4,744	4,732	-37.46%
11	4,965	4,539	4,815	3,755	4,923	5,225	4,865	4,654	4,841	5,032	4,730	5,333	5,465	7.42%
12	1,044	2,737	4,456	4,866	5,224	4,226	3,869	3,873	5,395	3,251	3,575	5,097	4,735	388.42%
13	7,087	5,309	6,362	6,787	6,192	5,623	6,418	6,675	6,398	6,103	5,899	5,857	5,322	-17.36%
14	6,063	4,607	5,945	5,653	6,108	5,808	5,575	5,235	5,835	5,909	5,867	5,381	5,325	-11.25%
15	5,739	4,762	6,047	5,828	5,809	5,805	5,415	5,254	5,246	5,658	5,565	5,275	5,064	-8.08%
16	6,511	4,462	4,791	4,942	5,153	5,942	6,197	7,128	6,151	7,554	7,935	7,283	6,385	11.85%
17		-	792	5,277	5,872	5,850	4,444	4,596	4,746	4,924	4,943	5,683	6,009	617.21%
18		15	792	131	2,212	3,579	3,324	3,010	3,625	4,099	3,691	3,482	4,340	339.36%
19	2,118	2,097	2,193	1,699	2,540	2,128	1,955	1,616	1,867	2,396	2,516	2,597	3,492	22.66%
20	4,788	4,054	4,743	4,020	5,003	4,888	4,232	4,457	4,297	4,509	4,286	4,486	4,909	-6.30%
Physician Mean	6,108	4,860	5,984	5,832	6,038	5,739	5,645	5,550	5,402	5,389	5,076	5,030	4,822	-17.64%
Practice Mean	5,293	4,002	5,035	5,047	5,471	5,327	5,149	5,065	5,040	5,062	4,897	4,945	4,822	-6.58%

Physicians Experiencing an Increase in Patient Visits

		YEAR												% Difference
ID	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	
1	6461	4,957	5,748	5,798	5,393	4,823	5,643	5,156	5,278	5,037	5,209	5,397	4,580	-16.47%
2	6837	5,109	7,188	5,091	4,880	4,429	4,068	3,790	3,939	3,824	3,314	3,347	2,946	-51.05%
3	5630	4,499	5,334	5,025	4,787	5,117	4,641	4,691	4,114	4,006	4,390	4,640	4,302	-17.58%
4		3,275	5,513	4,893	5,234	5,142	4,949	4,040	3,656	3,594	3,608	3,271	2,433	-0.12%
5	1998	3,771	4,494	4,484	4,517	4,316	4,357	4,203	3,876	3,744	3,958	3,750	3,556	87.69%
6	6255	5,686	7,117	6,177	6,459	6,115	6,186	5,088	4,519	3,997	4,492	3,792	3,452	-39.38%
7	3458	4,356	5,780	6,608	7,657	8,140	8,071	7,673	7,261	8,430	6,749	6,652	6,352	92.37%
8	4588	3,613	4,713	4,234	4,264	3,541	4,375	5,918	4,821	3,121	2,731	2,642	3,014	-42.41%
9	4694	3,993	5,327	3,827	4,131	5,522	5,430	3,822	3,716	3,752	3,607	4,512	4,189	-3.88%
10	5704	5,558	6,149	7,371	7,802	5,527	4,703	4,686	4,654	5,597	3,827	3,554	3,615	-37.69%
11	3970	4,044	4,422	3,481	4,820	4,524	4,006	3,753	4,118	4,118	4,187	4,526	4,519	14.01%
12	958	2,405	4,437	4,430	4,945	3,620	3,310	3,874	5,256	3,030	2,835	5,242	4,446	447.18%
13	6139	5,022	5,846	5,979	5,265	4,824	5,207	5,394	5,031	4,666	4,541	4,578	4,038	-25.43%
14	6004	4,005	5,403	5,116	5,273	5,110	5,217	4,536	5,121	4,952	4,959	4,517	4,411	-24.77%
15	5952	3,930	5,235	5,059	5,052	4,878	4,578	4,415	4,271	4,416	4,252	4,013	3,768	-32.58%
16	2548	2,004	2,105	2,218	2,299	2,672	2,740	3,179	2,687	3,266	3,438	3,251	2,819	27.59%
17		-	687	4,550	5,074	5,275	3,944	4,059	3,904	3,985	4,531	5,398	5,365	685.74%
18		11	687	128	1,908	3,029	2,795	2,423	2,830	3,067	3,704	2,704	3,265	293.60%
19	1919	2,089	1,919	1,534	2,145	1,735	1,585	1,304	1,495	1,885	1,995	2,099	3,140	9.38%
20	4151	4,213	5,078	4,140	4,471	4,390	3,987	3,901	3,652	3,606	3,960	4,352	4,499	4.84%
Physician Mean	2,715	3,269	4,034	3,842	4,408	4,200	4,008	3,984	4,049	4,011	3,875	4,267	3,935	57.20%
Company Mean	4,545	3,627	4,659	4,507	4,819	4,636	4,490	4,295	4,210	4,105	4,014	4,112	3,935	-9.53%

Physicians Experiencing a Decrease in Patient Visits

		YEAR												% Difference
ID	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	
1	6,461	4,957	5,748	5,798	5,393	4,823	5,643	5,156	5,278	5,037	5,209	5,397	4,580	-16.47%
2	6,837	5,109	7,188	5,091	4,880	4,429	4,068	3,790	3,939	3,824	3,314	3,347	2,946	-51.05%
3	5,630	4,499	5,334	5,025	4,787	5,117	4,641	4,691	4,114	4,006	4,390	4,640	4,302	-17.58%
4		3,275	5,513	4,893	5,234	5,142	4,949	4,040	3,656	3,594	3,608	3,271	2,433	-0.12%
5	1,998	3,771	4,494	4,484	4,517	4,316	4,357	4,203	3,876	3,744	3,958	3,750	3,556	87.69%
6	6,255	5,686	7,117	6,177	6,459	6,115	6,186	5,088	4,519	3,997	4,492	3,792	3,452	-39.38%
7	3,458	4,356	5,780	6,608	7,657	8,140	8,071	7,673	7,261	8,430	6,749	6,652	6,352	92.37%
8	4,588	3,613	4,713	4,234	4,264	3,541	4,375	5,918	4,821	3,121	2,731	2,642	3,014	-42.41%
9	4,694	3,993	5,327	3,827	4,131	5,522	5,430	3,822	3,716	3,752	3,607	4,512	4,189	-3.88%
10	5,704	5,558	6,149	7,371	7,802	5,527	4,703	4,686	4,654	5,597	3,827	3,554	3,615	-37.69%
11	3,970	4,044	4,422	3,481	4,820	4,524	4,006	3,753	4,118	4,118	4,187	4,526	4,519	14.01%
12	958	2,405	4,437	4,430	4,945	3,620	3,310	3,874	5,256	3,030	2,835	5,242	4,446	447.18%
13	6,139	5,022	5,846	5,979	5,265	4,824	5,207	5,394	5,031	4,666	4,541	4,578	4,038	-25.43%
14	6,004	4,005	5,403	5,116	5,273	5,110	5,217	4,536	5,121	4,952	4,959	4,517	4,411	-24.77%
15	5,952	3,930	5,235	5,059	5,052	4,878	4,578	4,415	4,271	4,416	4,252	4,013	3,768	-32.58%
16	2,548	2,004	2,105	2,218	2,299	2,672	2,740	3,179	2,687	3,266	3,438	3,251	2,819	27.59%
17		-	687	4,550	5,074	5,275	3,944	4,059	3,904	3,985	4,531	5,398	5,365	685.74%
18		11	687	128	1,908	3,029	2,795	2,423	2,830	3,067	3,704	2,704	3,265	293.60%
19	1,919	2,089	1,919	1,534	2,145	1,735	1,585	1,304	1,495	1,885	1,995	2,099	3,140	9.38%
20	4,151	4,213	5,078	4,140	4,471	4,390	3,987	3,901	3,652	3,606	3,960	4,352	4,499	4.84%
Physician Mean	5,826	4,637	5,806	5,368	5,331	4,989	5,005	4,750	4,546	4,337	4,132	4,099		-29.64%
Company Mean	4,545	3,627	4,659	4,507	4,819	4,636	4,490	4,295	4,210	4,105	4,014	4,112	3,935	-9.53%

Mean RVUs Generated Per Patient Visit

		YEAR												% Difference
ID	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	
1	1.09	1.11	1.13	1.13	1.19	1.23	1.21	1.24	1.27	1.27	1.28	1.28	1.35	17.68%
2	0.90	1.01	0.90	1.18	1.27	1.33	1.40	1.40	1.37	1.42	1.44	1.41	1.36	56.17%
3	1.09	1.10	1.06	1.13	1.18	1.12	1.12	1.17	1.20	1.24	1.27	1.24	1.26	14.60%
4		1.16	1.14	1.13	1.19	1.18	1.21	1.29	1.32	1.35	1.37	1.33	1.34	15.12%
5	1.03	1.08	1.07	1.06	1.07	1.08	1.06	1.10	1.17	1.19	1.18	1.25	1.24	21.91%
6	1.13	0.94	1.00	1.08	1.08	1.08	1.02	1.09	1.15	1.19	1.17	1.24	1.25	9.40%
7	1.41	0.94	0.92	0.85	0.82	0.78	0.77	0.80	0.73	0.72	0.59	0.66	0.67	-53.18%
8	1.20	1.16	1.16	1.16	1.14	1.29	1.01	0.77	0.91	1.34	1.33	1.39	1.27	15.73%
9	1.12	1.06	0.96	1.26	1.24	0.86	0.88	1.29	1.35	1.32	1.25	0.99	1.19	-11.69%
10	1.33	1.09	1.14	1.01	1.01	1.25	1.40	1.41	1.30	1.02	1.28	1.33	1.31	0.37%
11	1.25	1.12	1.09	1.08	1.02	1.15	1.21	1.24	1.18	1.22	1.13	1.18	1.21	-5.78%
12	1.09	1.14	1.00	1.10	1.06	1.17	1.17	1.00	1.03	1.07	1.26	0.97	1.06	-10.74%
13	1.15	1.06	1.09	1.14	1.18	1.17	1.23	1.24	1.27	1.31	1.30	1.28	1.32	10.82%
14	1.01	1.15	1.10	1.11	1.16	1.14	1.07	1.15	1.14	1.19	1.18	1.19	1.21	17.97%
15	0.96	1.21	1.16	1.15	1.15	1.19	1.18	1.19	1.23	1.28	1.31	1.31	1.34	36.34%
16	2.56	2.23	2.28	2.23	2.24	2.22	2.26	2.24	2.29	2.31	2.31	2.24	2.27	-12.34%
17			1.15	1.16	1.16	1.11	1.13	1.13	1.22	1.24	1.09	1.05	1.12	-8.72%
18		1.34	1.15	1.02	1.16	1.18	1.19	1.24	1.28	1.34	1.00	1.29	1.33	11.63%
19	1.10	1.00	1.14	1.11	1.18	1.23	1.23	1.24	1.25	1.27	1.26	1.24	1.11	12.14%
20	1.15	0.96	0.93	0.97	1.12	1.11	1.06	1.14	1.18	1.25	1.08	1.03	1.09	-10.63%
Physician Mean	1.21	1.15	1.13	1.15	1.18	1.19	1.19	1.22	1.24	1.28	1.25	1.25	1.27	3.31%

Mean RVUs For All Physician Participants

	YEAR												
ID	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	7,038	5,521	6,501	6,526	6,429	5,924	6,819	6,369	6,705	6,407	6,676	6,918	6,185
2	6,163	5,170	6,477	5,985	6,174	5,869	5,713	5,324	5,409	5,424	4,777	4,712	4,021
3	6,116	4,945	5,648	5,666	5,654	5,750	5,212	5,479	4,953	4,980	5,562	5,776	5,410
4		3,796	6,262	5,510	6,209	6,064	5,978	5,210	4,829	4,842	4,951	4,365	3,272
5	2,049	4,088	4,787	4,775	4,833	4,658	4,597	4,617	4,533	4,470	4,679	4,689	4,420
6	7,070	5,368	7,126	6,693	6,949	6,629	6,322	5,560	5,197	4,761	5,251	4,689	4,299
7	4,866	4,085	5,329	5,640	6,274	6,325	6,234	6,155	5,323	6,077	3,969	4,383	4,240
8	5,509	4,186	5,466	4,891	4,878	4,573	4,438	4,568	4,379	4,180	3,625	3,671	3,826
9	5,265	4,247	5,133	4,817	5,113	4,757	4,796	4,928	5,030	4,947	4,519	4,469	4,998
10	7,586	6,062	7,037	7,473	7,878	6,917	6,569	6,597	6,051	5,709	4,917	4,744	4,732
11	4,965	4,539	4,815	3,755	4,923	5,225	4,865	4,654	4,841	5,032	4,730	5,333	5,465
12	1,044	2,737	4,456	4,866	5,224	4,226	3,869	3,873	5,395	3,251	3,575	5,097	4,735
13	7,087	5,309	6,362	6,787	6,192	5,623	6,418	6,675	6,398	6,103	5,899	5,857	5,322
14	6,063	4,607	5,945	5,653	6,108	5,808	5,575	5,235	5,835	5,909	5,867	5,381	5,325
15	5,739	4,762	6,047	5,828	5,809	5,805	5,415	5,254	5,246	5,658	5,565	5,275	5,064
16	6,511	4,462	4,791	4,942	5,153	5,942	6,197	7,128	6,151	7,554	7,935	7,283	6,385
17			792	5,277	5,872	5,850	4,444	4,596	4,746	4,924	4,943	5,683	6,009
18		15	792	131	2,212	3,579	3,324	3,010	3,625	4,099	3,691	3,482	4,340
19	2,118	2,097	2,193	1,699	2,540	2,128	1,955	1,616	1,867	2,396	2,516	2,597	3,492
20	4,788	4,054	4,743	4,020	5,003	4,888	4,232	4,457	4,297	4,509	4,286	4,486	4,909
Physician Mean	5,293	4,213	5,035	5,047	5,471	5,327	5,149	5,065	5,040	5,062	4,897	4,945	4,822