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Meeting Physicians' Information Needs in the Electronic Health Record

By

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A Dissertation

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ABSTRACT

EHR adoption rates rose sharply in the early 2000s as a result of federal incentives and wide acclaim for the potential positive effects of EHRs on physician efficiency, quality care delivery, and patient safety. In light of untoward effects on patient care that were observed following EHR implementations, questions arose regarding EHRs' true impact on clinical workflow and medical care. In particular, lagging adoption rates among pediatricians and specialists compared to generalists suggested inequities in the ability of EHRs to meet all physicians' information needs. Furthermore, end-user behavior and training were found to be highly variable despite the need for clinicians to be able to access the same key clinical data.

First, we used a case study approach, studying the field of pediatrics, to investigate physicians' typical EHR usage and workflow when evaluating a new patient across a variety of practice settings and clinical specialties (Aim 1a). We also broadened this scope to look at work environment: inpatient versus ambulatory, specialist versus generalist, proceduralist versus non-proceduralist (Aim 1b). Second, we evaluated physicians' perceptions of EHR usefulness and current barriers to information access when evaluating a new patient across a variety of practice settings and clinical specialties (Aim 2). Third, we explored and characterized distinct information-gathering workflow patterns in practicing hospitalists (Aim 3).

Our research found that significant variability exists in how physicians use the EHR in their sequence of providing patient care, how long they took to do so, and what sections of the EHR they preferred or found helpful. There were clear distinctions in these

parameters based upon practice setting and type. Overall, however, certain core elements of the EHR were universally valued; these elements, such as chief complaint, past medical history, and history of present illness, are irrefutably essential to most any patient narrative. We found that physicians access information and create documentation using at least two different types of workflows. Further research is needed to evaluate the multitude of characteristics that providers' workflows have. Effective EHR design must afford for a variety of workflow types to be widely usable. Lastly, documentation in the EHR is a burdensome practice for physicians to both create and extract meaningful information from. This burden must be alleviated in order for physicians to be able to focus on building therapeutic relationships with their patients. This research lays some of the foundational knowledge necessary to engage in the provider-centered design process.

CHAPTER ONE. INTRODUCTION

The Sociopolitical Context of Health Care in the United States

In 1996, the Institute of Medicine (IOM), a non-governmental organization (NGO) and member of the National Academies, established The Committee on Quality of Health Care in America. The committee was tasked with establishing a longstanding effort to assess and improve the nation's quality of care[1]. At the time, the United States outranked all other Organisation for Economic Co-operation and Development (OECD) countries in total expenditure on health per capita at $3950 per year[2]. Conversely, the U.S. ranked 21st in life expectancy at birth, suggesting an incongruence between healthcare expenditure and overall health. In the same year, the Health Insurance Portability and Accountability Act (Pub. 104-191) was enacted by the United States Congress and signed into law by President Bill Clinton. In addition to certain health insurance protections, the law put forth several new policies for maintaining privacy and security of individual health information, programs to control health care fraud, and standards for the use and dissemination of health care information. This legislation signaled sweeping impacts upon the portability and accountability of health insurance coverage[3]. Taken together, these events indicated a national acknowledgement of certain deficiencies in U.S. health care, and sparked a nationwide re-examination of the delivery and administration of health care in the U.S.

In 1999, the IOM Quality of Health Care in America Committee issued its first report, entitled *To Err is Human: Building a Safer Health System*. The report delivered a hard criticism of the state of health care in the United States, citing between 44,000 and 98,000 deaths per year as a result of medical errors that could have been prevented[4]. In addition, the significant financial impact of lost productivity, disability, and the expense of additional care

totaled between $17 billion and $29 billion per year in U.S. hospitals. The report pointed to several factors: the fragmentation of the structure of health care delivery in the U.S., leading to incomplete patient information given to providers; the limited attention focused on medical error prevention in the health care culture; the formidable medical liability system; and lack of adequate financial incentives from third-party payers to improve quality and patient safety[5]. Overall, the report blamed faulty systems and processes for allowing the majority of medical errors to happen, rather than negligent individuals. The report recommended a four-tiered approach to improving patient safety: first, establishing a national focus on improvement of patient safety; second, tracking errors through a nationwide mandatory reporting system; third, raising performance standards among group purchasers of health care; and lastly, implementing safety systems in health care organizations[5]. As a result of the report, the Clinton administration appropriated $50 million to the newly renamed Agency for Healthcare Research and Quality to support several patient safety initiatives[6]. Though criticized for its overemphasis on medication errors and computerized order entry, the publication was widely credited with beginning the modern field of patient safety[7].

Shortly thereafter in 2001, the Committee issued a landmark report on the quality of healthcare delivery in the U.S. entitled *Crossing the Quality Chasm: A new health system for the 21st century*. The report described a "chasm" between where the current state of health care quality stood and the ideal system that could be – one that translated medical science and technology into routine practice. Also cited was the shift in burden of disease in the U.S. from acute, episodic care needs to the predominance of chronic conditions such as diabetes, asthma, and heart disease over the last century. Though hospitals were better equipped for dealing with episodic acute care, the leading cause of morbidity and mortality was now

attributed to chronic conditions; an infrastructure supporting the care of chronic conditions was sorely lacking. Similar to *To Err is Human*, the report pointed to the fragmentation or "silos" of health care organizations, often acting without the complete patient information needed to provide comprehensive care[8]. Six areas were identified as necessary for major gains in improvement:

- Safety – avoid injury to patients from the care that is intended to help them;
- Effectiveness – avoiding overuse and underuse of medical resources;
- Patient centeredness – provide care that is respectful of and responsive to individual patient preferences, needs, and values;
- Timeliness – reduce waits and harmful delays;
- Efficiency – avoid waste;
- Equity – provision of care that does not vary in quality because of patient characteristics such as gender, race, and socioeconomic status[9].

To achieve these aims, the report described several guidelines for health care system redesign: a reemphasis upon evidence-based medicine, aligning payment policies with quality improvement, and preparing the workforce for culture change rebuilt around patient quality and safety. Notably, the report examined the role of information technology in health care, acknowledging the tremendous potential for transformation of health care delivery. In particular, the possibility of widespread computerized medical records, virtual patient-physician communication, and automated systems for medication administration was examined. Substantial financial investments and prolonged commitments to building these systems would be needed[8]. Together, *To Err is Human* and *Crossing the Quality Chasm* had

profound impacts on how modern health care was viewed by bringing public attention to the complex quality and safety issues in the current system.

Throughout the first decade of the 21st century, this awakening of national awareness around quality and safety issues had profound political impacts, particularly within the realm of health information technology (HIT). In his 2004 State of the Union Address, President George W. Bush set forth the goal of ensuring that most Americans have electronic health records (EHRs) within 10 years[10]. The President outlined his Health Information Technology Plan to adopt health information standards, devoting $100 million to health IT demonstration projects, using federal payers to create incentives for use of electronic records, and creating a new sub-cabinet level position of National Health Information Technology Coordinator[10]. Five years later, the Obama administration signed into law the Health Information Technology for Economic and Clinical Health (HITECH) Act under Title XIII of the American Recovery and Reinvestment Act of 2009 (Pub. L. 111-5). Along with providing grants and loans funding for health IT education and research, improved privacy and security provisions, and specifications on the testing of health information technology, the HITECH Act established adoption and "meaningful use" of EHRs as a national goal. An extensive financial incentive program was established as well as the Office of the National Coordinator for Health Information Technology and committees for HIT policy and standards.

The EHR Value Proposition

The notion of recording individual patient information has existed as long as medicine itself. In ancient Egypt, physicians used wall carvings to describe the course and treatment in the tombs of the deceased[11]. The concept of a formalized medical record was

first described in the fifth century B.C.E. by Hippocrates, who believed that the medical record should [1] accurately reflect the course of the disease and [2] indicate the probable course of the disease[12]. Galen of Pergamon of the Roman Empire also documented the care he provided to his patients[13]. In the United States, the early pioneers of medical record keeping were the Massachusetts General Hospital, whose records of admissions started in 1821, and the American College of Surgeons, who set forth minimum standards for comprehensive documentation of medical records in 1919[14].

Early electronic medical records began to be used in the 1960s, notably COSTAR (the Computer Stored Ambulatory Record) developed in the laboratory of Octo Barnett at Harvard, TDS (Technicon Medical Information Management System) developed by Lockheed, and the PROMIS (Patient Reported Outcomes Measurement Information System) developed Jan Schultz and Lawrence Weed[15]. These early systems were avant-garde in their ability to function above a basic level of information storage, with some providing decision support and medication ordering. The concept of the problem-oriented medical record (POMR) was developed by Dr. Weed in 1968 as a readily understandable structure for recording and viewing the patient record[16]. Elements of these early systems and structures persist today, notably the SOAP (subjective objective assessment plan) format and the MUMPS (Massachusetts General Hospital Utility Multi-Programming System) programming language.

The Health Information Management Systems Society's (HIMSS) definition of EHRs is as follows:

> "The Electronic Health Record (EHR) is a longitudinal electronic record of patient health information generated by one or more encounters in any care

> delivery setting. Included in this information are patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data, and radiology reports. The EHR automates and streamlines the clinician's workflow. The EHR has the ability to generate a complete record of a clinical patient encounter, as well as supporting other care-related activities directly or indirectly via interface – including evidence-based decision support, quality management, and outcomes reporting."[17]

Because of the broad functionality and features of modern EHRs, they have long been described as holding great potential for achieving significant improvements in healthcare, notably in the realms of safety, quality, and efficiency[18-20]. To bolster this effort, the HITECH Act authorized incentive payments through the Centers for Medicare and Medicaid Services (CMS) totaling $27 billion over 10 years. Payment of eligible providers implementing EHRs was coupled to "meaningful use" measures – demonstrated achievement of certain objectives related to health care processes and outcomes[21]. These objectives include process measures such as computerized provider order entry (CPOE), drug-drug and drug-allergy checks, and e-prescribing[22]. The meaningful use program has had dramatic effects on the implementation rate of EHRs; in 2008, only 9.4% of hospitals had implemented a basic EHR; this proportion reached 27.6% in 2011, the first complete year of meaningful use attestation; by 2013, 59.4% of hospitals had implemented a basic EHR[23].

EHRs Today: Current Challenges

The surge in EHR adoption has caused rapid shifts in provider workflow[24], organizational culture[25], and even the patient-provider interaction[26,27]. In this context it is not surprising that provider satisfaction has decreased since the implementation of EHRs[28]. One

Massachusetts study of physicians found that those whose practice used EHRs were more likely to report dissatisfaction[29], and a RAND Corporation study found that though physicians appreciated the potential benefits of the EHR, the current state of EHR technology increased professional satisfaction compared to pre-implementation rates[28]. Among the causes cited were: poor EHR usability, laborious data entry, negative effect on face-to-face patient care, inefficiency, lack of EHR interoperability, and degraded quality of clinical documentation[28].

Usability is defined by Jakob Nielsen as consisting of five quality components: learnability, efficiency, memorability, affordance, and satisfaction[30]. With increased adoption of EHR systems, heightened awareness around usability issues has surfaced[31]. End-users have lamented the difficulty of EHR use in the clinical setting[32]; concerns regarding clunky interfaces and unintuitive workflows are common. The direct effects of poor design have been observed in clinicians who spend longer time with the computer, struggle to enter data efficiently, and attempt to adapt with inefficient work-arounds[33-39]. Historically, usability in EHR design has only been visited sporadically, unsystematically, and shallowly[40]; however, with increased awareness of EHR usability challenges among professional medical organizations, efforts to improve EHR usability for end-users have been redoubled[41,42]. Empirically, usability challenges remain a hurdle to EHRs enhancing care delivery.

EHR Adoption among Pediatricians

Within the field of pediatrics, EHR implementation has been associated with improvements in care such as better adherence to best practice guidelines[43,44], higher immunization rates,[45] and increased utilization of growth charts[46]. Adoption rates have been incentivized through grants provided by the Children's Health Insurance Program

Reauthorization Act (CHIPRA)[47]. EHR use is considered by the American Academy of Pediatrics (AAP) an indication of professionalism and a tool for improving healthcare quality, safety, and efficiency[48].

However, there are specific challenges regarding EHR functionality in pediatrics. The percent of office-based pediatricians using EHRs grew from 58% in 2009 to 79% in 2012; however, in 2014, only 14% of pediatricians reported that their EHRs were "fully functional and pediatric-supportive"[47,48]. Pediatric-specific features that are often lacking in the EHR include capability for rapid calculation and display of growth chart information, immunization tracking and forecasting, facilitation of weight-based dosing calculations, and age-based normal ranges for physiologic parameters such as vital signs[49-51]. Furthermore, EHR systems may not accommodate typical pediatric workflow issues such as identification and name assignment of newborns, adolescent privacy and consent considerations, and the incorporation of pediatric-specific terminology[49,51]. In addition to the above concerns, barriers to EHR implementation experienced by most physicians include large up-front cost, cumbersome data entry, insufficient time available to make the transition from paper records to EHR, and workflow changes[51].

EHR Adoption among Specialists

Despite the growing ubiquity of EHR systems, there is still substantial variability in adoption between different clinical disciplines[52,53]. Specifically, adoption rates within surgical specialties (21%) and medical specialties (27%) are approximately one half that of primary care physicians (52%). In addition to these disparities in adoption rates, concerns exist that different medical fields may have varying levels of compatibility with current-generation EHRs. Numerous medical specialty societies have expressed the need for specialty-specific

systems to meet the unique needs of their respective fields, including ophthalmology, orthopedic surgery, dermatology, oncology, obstetrics/gynecology, pediatrics, and pathology[47,54-59]. These unique needs include differing workflow, information gathering, and clinical documentation requirements along with variations in baseline clinical volume, billing and compliance requirements, and specialty-specific terminology. Nonetheless, the widespread adoption of EHRs in the United States continues to increase, driven largely by federal incentives through the Centers for Medicare and Medicaid Services (CMS) Meaningful Use program[23,60]. In 2015, penalties will begin to be levied against health care organizations that fail to meet several key EHR implementation requirements[61], further incentivizing EHR adoption and making the avoidance of EHRs less practical for physicians, regardless of how suitable such systems are to their specialty-specific needs.

There are numerous potential implications if current-generation EHRs do not function adequately in medical disciplines of all varieties. These include decreased physician and patient satisfaction, impaired productivity and efficiency, and difficulty meeting Meaningful Use requirements[62-65].

Prior Work Done in EHR Workflows

Electronic health records (EHRs) have become a central component of the modern clinical workflow, serving as a central documentation repository, an ordering mechanism, and a provider communication tool. EHRs have been promoted as a mechanism for improving quality of healthcare delivery, patient safety and provider efficiency[41]. Widespread adoption has been driven in part by substantial governmental incentives through the Centers for Medicare and Medicaid Services (CMS) Meaningful Use program, with 59% of U.S. hospitals and 48% of office-based providers using EHRs as of 2014[23,52].

Implementations of EHRs have been shown to dramatically influence clinical workflows[66,67]. End-user behaviors and training approaches are highly variable[68,69]. Adaptive end-user behaviors such as excessive use of copy-paste/copy forward[70], "overdocumentation"[71], and "upcoding"[71] may compromise health care quality and patient safety[34]; training and standardization may help reduce these practices[72]. Beginning efforts have been made to establish standard practices among EHR end users[69]. However, these efforts have largely focused on documentation and not on information review.

The challenges facing consistency in EHR training and use are diverse. Though back end databases are fairly consistent across instances of an EHR, user interfaces and workflows can be substantially different depending upon the institution and clinical environment in which the EHR is used[73]. Within an institution or practice group, the physician-level characteristics in usage of EHR features and usage intensity have been found to be highly variable and personalized[73]. The strong influence of personal experiences and preferences is thought to partly explain this variance.

Framework for Approach

Modern EHR systems are complex entities, often interfacing with and impacting the workflow of hundreds or thousands of health care personnel. This calls for equally sophisticated administration and active management of the system. Throughout the first decade of the 21st century, as health care providers and organizations readily underwent EHR implementation, reports of failed implementations were not rare[74-76]. The complex interplay of political and technical challenges, compounded by the variability in response among individuals influenced by personal experience and preference, has been described in the academic literature[77]. Several authors have described a sociotechnical approach to

understanding EHR implementation[78-84]. Common elements of sociotechnical approaches have examined 1) individual user characteristics; 2) the complexity of the work; and 3) the environment in which the work takes place. Sittig and Singh's model focusing more closely on EHR implementation includes eight components: people, workflow & communication, internal organizational features, external rules & regulations, measurement & monitoring, hardware & software, clinical content, and the human-computer interface[79]. Employing a sociotechnical approach can be beneficial to help provide understanding of how to better implement and administer the EHR.

Specific Aims

With these issues in mind, in this work we performed a series of studies to examine several aspects of the physician-EHR interaction.

Specific Aim 1: Investigate physicians' typical EHR usage and workflow when evaluating a new patient across a variety of practice settings and clinical specialties. We developed and validated a survey that was distributed among practicing physicians to assess current EHR use patterns, preferences, and attitudes. Questions evaluated physician demographic information (practice setting, clinical training, computer/EHR experience), timing and order of clinical workflow with respect to EHR use, perceived usefulness, and barriers to optimal EHR use.

- Given the historically low adoption rates among pediatricians[85], we first studied EHR usage in pediatricians to capture an expected higher than average amount of problems with current EHR systems.
- Given the historically low adoption rates among specialists compared to generalists[52], as well as the disparity in adoption rates between fully-integrated "enterprise" EHR

systems and specialty-specific "best-of-breed" systems[86], we next compared survey results among generalists and specialists.

These results were evaluated to uncover differences among practice settings and specialties with respect to EHR usage and perceptions. The topic of information gathering about a new patient was used as it is universal to nearly all physician specialties, and provided insight into problems with information access among all physicians.

Specific Aim 2: Evaluate physicians' perceptions of EHR usefulness and current barriers to information access when evaluating a new patient across a variety of practice settings and clinical specialties. Using a qualitative approach, we analyzed the free-text responses of physicians participating in the survey to identify themes pertaining to barriers in EHR information gathering and overall usage. Qualitative analysis allowed us to gain a deeper understanding of the factors that govern and influence the physician-EHR interaction.

Specific Aim 3: Explore and characterize distinct information-gathering workflow patterns in practicing hospitalists. High-fidelity simulation allowed us to directly observe and measure physicians using the EHR. We characterized physicians' workflow patterns and information usage. This in part served as a way to validate the survey data, and also added richer detail to our understanding of how physicians use the EHR. Similar to the survey, demographic data was collected, to allow us to compare and contrast EHR usage characteristics among physicians of different backgrounds.

CHAPTER TWO. BACKGROUND

Prior Work and Gaps

EHR Adoption among Pediatricians

While identification of these desired EHR functionalities has been a crucial initial step toward improving EHR systems for pediatricians, a knowledge gap still remains with respect to how EHR systems impact the clinical workflow of pediatricians. The manner in which pediatricians use EHR systems has not been studied, the specific barriers to acquiring needed information have not been quantified. Macroscopically it is well known that pediatricians have yet to fully benefit from EHRs; a national survey of American Academy of Pediatrics members in 2012 found that only 3% of practicing pediatricians had EHRs that were "fully supportive" for pediatric care; this number only rose to 14% in 2014[85,87]. This information is necessary to understand the impact of EHRs on pediatrician function and delivery of patient care.

EHR Adoption among Specialists

To date there is no experimental evidence as to whether or not physicians in different clinical specialties actually experience disparities in EHR functionality, or what the nature of those differences in information-gathering needs might be. While various disciplines have expressed differing ideas of how the EHR should function and what it should provide, there is no evidence that these groups use current generation EHRs differently from each other in clinical practice[88,89]. In order to better meet the health information technology needs of all clinical disciplines, determining whether such interdisciplinary differences exist and identifying their precise nature is imperative.

Current Gaps in Understanding Physician Satisfaction with EHRs

EHRs are often blamed for creating potential clinical inefficiencies, decreased quality of care, and professional dissatisfaction. However, little published work has examined what specific aspects of EHR use are perceived by physicians to impact clinical workflow and overall effectiveness. Addressing this gap in knowledge through research to improve understanding of EHR user experiences can be leveraged to improve EHR function, and thereby satisfaction and healthcare delivery.

Current Gaps in Methodological Approach

As EHRs become increasingly commonplace, there is an ongoing need for assessment of clinicians' current attitudes, preferences, experiences and perceptions as they pertain to EHR interface design. Previous evaluations of EHR interface design have consisted largely of heuristic evaluations, user satisfaction questionnaires, and other subjective measures evaluating discrete tasks.[90-93] Assessment of end-user EHR behaviors has often been conducted via self-reports and surveys[94-97], direct observation[98], and meaningful use measure reporting[73]. Survey and reporting methods are useful for providing a high-level perspective of provider behavior, but do not capture individual workflows. Though quantitative measurement is an essential component of understanding clinicians' information needs, there is a paucity of controlled observation studies of use behaviors in the high fidelity simulation environment. Direct observation performed by humans may lack the granularity required to quantitatively evaluate differences between individuals or groups of individuals. Real-time eye tracking technology has been shown to successfully capture user behavior in online website searching, website interface design, visual attention and video

games[99-102]. Within the realm of medicine, it has been employed to study radiologic and electrocardiography interpretation, note reading, and medication administration[103-109].

Qualitative study has been underused to understand the challenges that face providers using the EHR. As providers accept EHR into their workplaces, a complex interplay of sociotechnical issues take place. Qualitative research is beneficial in that it allows issues to be examined in depth, unrestricted by specific questions or quantitative measures. Qualitative data are based upon the human experience, and the method can uncover subtleties and complexities about those being researched.[110] Successful qualitative research has been used to describe challenges with computerized provider order entry (CPOE)[111,112] and computerized decision support[113].

Lastly, just as there is not commonly accepted standard for EHR design, there is also no commonly accepted methodology for assessing information needs from clinicians for the purposes of EHR redesign. These knowledge gaps limit future development in physician-centered EHR design.

Justification for Methodology

User-centered design aims to improve human performance in a system by: understanding the users' needs and work context; involving users early in the design process; defining system goals in the context of the user; conducting usability tests; adapting the system design iteratively with user input; and more.[114] User-centered design has only recently begun to gain traction in the development of EHRs, though it has proven successful in many other fields, such as aeronautics and laptop computer development[115,116].

In the realm of health IT, physicians in the U.S. comprise a substantial user group of EHRs, playing key roles as the leaders of modern care teams, formulating diagnoses and

developing treatment plans. These roles must be fully supported and optimized in the EHR to ensure an adequate level of care delivery to patients. The natural question is, what work has been done in the field of provider-centered EHR design? Many research attempts have focused on summative evaluation[40,117,118], mainly in the form of user questionnaires and heuristic evaluation. There is a paucity of research in the realm of providers' needs assessment. Some of the work that has been done has mapped out providers' workflows through the EHR, showing that providers draw information preferentially from certain key sections[67]. Brown et al used eye-tracking research to pursue this question further, finding that providers fixate on certain areas of the clinical note[106,109]. There is still a need for multimodal research techniques, focusing on the same research question. There is also a paucity of qualitative research in this realm of providers' EHR needs. This must be further explored to fully inform user-centered EHR design.

We proposed taking a triangulated approach to assessing physicians' information needs for the purposes of EHR design in adult and pediatric patients. Combination of qualitative and quantitative measures created new insights into the clinician-EHR interaction and the design of EHR content. Using eye-tracking technology and classic quantitative methods, we observed, measured, and described the information that physicians gather when encountering a new patient. This project helped our understanding of physicians' information needs as they pertain to a new inpatient encounter and how they may differ between adult and pediatric patients. We explored the barriers between optimal information gathering in the EHR and the status quo. Lastly, we developed a portable methodology for assessing user information needs to inform user-centered health IT design.

High-fidelity simulation provides a unique opportunity to observe the physician-EHR interaction. Simulation has been used successfully in medicine to assess medical

performance in other areas: communication skills, professionalism, team building, use of medical devices and more. As eye-tracking technology has become exceedingly precise and unobtrusive, eye- and screen-capture can help provide new insights into how physicians interact with the EHR. Our group has created a robust, high fidelity EHR simulation environment to evaluate the readiness of medical trainees to detect early signs of morbidity and mortality[119]. Preliminary findings suggest that certain EHR use behaviors result in greater detection of medical issues, while other behaviors lead to poor detection. The natural next step is to characterize these use behaviors and determine what information is considered most critical. This is a quantitative approach that requires triangulation with qualitative results to provide rich descriptions of users' experiences and perceptions. Traditional qualitative methods such as observation, think aloud, and interview will provide these insights. A concurrent data collection design will be used so that the data can be more easily compared and so that iterative refinement of study instruments can take place[120].

CHAPTER THREE. PERSPECTIVES AND USES OF THE ELECTRONIC HEALTH RECORD AMONG US PEDIATRICIANS: A NATIONAL SURVEY

Objective

To assess pediatricians' current attitudes, behaviors, and workflow preferences with respect to gathering information about a new patient visit.

Methods

This study was approved by the Institutional Review Board at Oregon Health & Science University (Portland, OR). Acknowledgement of an information sheet was used in lieu of documenting informed consent.

Survey Development

We created a survey consisting of 18 multiple-choice questions to assess pediatricians' current attitudes, behaviors, and workflow preferences with respect to gathering information about a new patient visit (**Supplemental File**). We focused on the topic of information gathering about a new patient because this problem is relevant to all physician specialties, and because we felt it would best highlight problems with information access that are faced by all participating physicians. Follow-up visits were considered for study, but ultimately were excluded due to a greater degree of variability in chart usage among specialties. Participants were asked to report their experiences based on their predominant practice setting (inpatient vs. ambulatory).

Approximately one-half of the questions gathered demographic information such as the participants' gender, clinical specialty, years of clinical practice, history of EHR usage, and computer literacy. The remaining half asked participants how they typically used EHRs

when preparing for a new patient visit, and their perceptions about how well their primary EHR could deliver this information. For information display, participants rated their EHRs on a Likert-type scale from 1 to 5 (1 indicating the EHR was "very poor" at displaying that type of information, 5 indicating "very good"). With respect to barriers to information access, respondents rated six statements on a 1-5 scale with regard to how strongly each factor presented a barrier to obtaining needed clinical information from the EHR (1 indicating the factor was a "severe barrier," 3 indicating "moderately strong barrier," and 5 indicating "not a barrier"). An optional question asked participants to use narrative text to elaborate on the perceived barriers to information access, the results of which were analyzed using qualitative research methods (to be published elsewhere). Survey reliability was confirmed using test-retest and alternate form methods[121]. Survey content and construct validity were established through expert interviews and feedback[122].

Participant Selection and Survey Administration

A purposive sampling technique was used to increase the likelihood of participant response. Participants were approached via e-mail through three main mechanisms: (1) Members of the CMIO4Kids mailing list (Stanford University, Stanford, CA), a self-selected group of 81 chief medical information officers and medical directors of information technology with a pediatric focus, were contacted individually via e-mail and asked to distribute the survey among their hospital or practice sites. (2) Each section head of the AAP (Elk Grove Village, IL) was contacted and asked to distribute the survey to their section members. (3) Chief Medical Officers and other physicians in clinical leadership positions in local healthcare networks and associations were also contacted (Oregon Medical Association and Multnomah Medical Society, both Portland, OR; PeaceHealth Medical Group Oregon).

Follow-up messages were sent to all recipients after one month. The survey was administered using REDCap electronic data capture tools hosted at Oregon Health & Science University[123].

Statistical Analysis

Survey questions providing categorical response options were assessed descriptively using frequency tabulation, and those with continuous variables were analyzed with summary statistics. Participants were excluded if they were not a practicing physician or did not identify with pediatrics or a pediatric sub-specialty. Responses to the first half of the survey, which asked about demographic attributes (Questions 1-11, **Supplemental File**), were considered predictor variables while those in the latter half, which asked about EHR usage habits and attitudes (Questions 12-18), were pre-specified as outcomes. The main outcomes of interest were: (1) Addressing the duration of initial chart review (Question 14), (2) How well the EHR displayed various types of clinical information (Question 17), and (3) The severity of six potential barriers to information access in the EHR (Question 18). One question addressing the duration of initial chart review (Question 14) was compared parsimoniously to several of the predictor variables using bivariate categorical data analysis methods. Likert-type scale responses to sub-sections of Questions 17 and 18 were treated as discrete continuous variables, and an overall composite score for each question was determined by obtaining the group mean across all sub-sections. Each composite score was assessed using multivariable linear regression. Analysis of barriers based on specific EHR vendor was not conducted due to wide variability in vendor group sizes. All analyses were performed using Stata SE12 (StataCorp, College Station, TX).

Results

Baseline Demographics

From a total of 5,553 pediatricians who received the survey link via email, 808 (15%) responded. **Table 1** summarizes demographic characteristics and EHR vendors of respondents. There were slightly more female respondents (62%) than males, whereas primary practice setting (i.e. inpatient vs. ambulatory) was roughly equally distributed. The majority of respondents reported being "somewhat experienced" with computers (75%), and most were attending physicians (64%). Respondents had varying levels of clinical experience (mean (standard deviation, SD)) of 14.6 (12.8) years in practice, ranging from 1-55 years). The most common EHR vendors were Epic (Verona, WI) (58%), Cerner (Kansas City, MO) (14%), and Allscripts (Chicago, IL) (6%). **Table 1** also displays the sub-specialty distribution of respondents. Approximately 63% of respondents practiced general pediatrics.

Initial Chart Review

Table 2 summarizes methods used by respondents to gather information when evaluating a new patient. Respondents most often gathered initial patient information from the EHR chart (47%). A smaller number gathered information by direct patient interview (34%). The majority of respondents (90%) performed initial EHR review prior to entering the exam room. Most respondents (72%) indicated that the initial chart review typically took between 2-10 minutes to complete. The duration of chart review was not associated with gender, level of training, or clinical experience. However, pediatric specialists did spend significantly longer on this initial chart review than generalists ($p<0.01$), as did physicians practicing primarily in the inpatient environment ($p<0.01$) and those who reported less computer experience ($p=0.01$).

Figure 1 summarizes responses about pediatrician perceptions of the most important sections of the EHR for evaluating a new patient, divided into inpatient and ambulatory care settings. Pediatricians practicing predominantly ambulatory medicine found the chief complaint, history of present illness, problem list, past medical history, and medication list to be most important. Pediatricians in the inpatient setting had very similar rankings, but found laboratory values more important than the problem list. Sections perceived as less important included the past surgical history, social history, family history, and allergies.

Barriers to Information Gathering

Figure 2 displays pediatrician perceptions regarding barriers to obtaining information in the EHR (Question 18). Mean scores for each of the six statements ranged from mean (SD) of 2.3 (1.3) for the statement "Information in the chart is inaccurate" to 1.8 (1.1) for "Others don't record information consistently." The composite score of these six elements followed a nearly normal distribution with mean (SD) of 2.0 (0.9) (range: 1-5), indicating that these factors taken as a whole present a moderate-to-severe barrier to obtaining necessary clinical information from the EHR. Multivariable linear regression demonstrated a statistically significant association between this score and practice type ($p<0.01$). Specifically, pediatric specialists perceived these barriers to be stronger than general pediatricians; the composite severity score among specialists was 1.8 (95% CI: 3.1-3.3) compared to 2.1 (95% CI: 2.8-3.0) among generalists. However, the composite severity score was not associated with gender, computer experience, years in practice, practice setting, or level of training.

Display of Clinical Data

Figure 3 displays pediatrician perceptions about their EHR's ability to display various types of information (Question 17). Results ranged from mean (SD) of 2.9 (1.0) for "Vitals" and "Labs" to 2.3 (1.2) for "ICU Bedside Data." Therefore, the mean scores for all sections fell close to "neutral" on this subjective scale. The composite score representing the overall ability of the EHR to display relevant clinical information followed a nearly normal distribution with mean (SD) of 2.6 (0.8) (range: 1-5). Multivariable linear regression showed that this composite score was not dependent on specialty, gender, computer experience, years in practice, practice setting, or level of training.

Discussion

There is significant concern among pediatricians that current EHR systems do not meet the specific documentation requirements of the field[48,50]. This study was designed to address a crucial step in improving EHRs for pediatricians: understanding pediatricians' current workflows in non-pediatric-supportive EHRs and the challenges that impede the collection of new patient information. The key findings of our survey included: 1) The EHR chart was the initial source of information for most pediatricians in evaluating a new patient; 2) This 'first look' at the EHR usually lasts between 2 to 10 minutes; and 3) There were several potential barriers to pediatricians' ability to access information in the EHR, largely related to data organization, veracity, and presentation.

Our results showed that there was heavy usage of the EHR to provide the first look at a new patient, most often occurring prior to patient contact. Ninety percent of respondents using the EHR for a first look reviewed the electronic chart before even entering the patient's exam room. The results of this survey demonstrate the importance of the EHR in modern pediatric practice, particularly as physicians' initial source of information

about a new patient (**Table 2**). For this reason, the veracity and accessibility of information in the electronic record can have a significant impact on the quality and efficiency of patient care. This is of particular concern because MU measures have caused a surge of new functionalities and shifted emphasis to compliance with MU measures rather than safety or usability outcomes. These novel functions have generated safety concerns due to usability problems[124] from features not suited for real-world complex workflows[125,126].

Problems with EHR design and usability were also reflected in narrative survey comments by study participants. For example, one participant said that the EHR is "not intuitive" with "many quirky features and opaque operations." Participants also responded that improvements to existing high-usage EHR sections such as the Chief Complaint, History of Present Illness, Past Medical History, Medication List, and Lab Results are needed (**Figure 1**). These findings are supported by survey work conducted by the Bipartisan Policy Center on pediatrician information needs[89]. For EHR vendors, this list may suggest where system design improvements should be made first. To evaluate success of system design improvements, experts have recommended that direct measures of quality, safety, and efficiency be taken at the institutional level, in addition to continued assessment after EHR implementation has taken place[124]. One such example is the development of the Safety Assurance Factors for EHR Resilience (SAFER) guides, a series of self-assessment tools to help clinicians and health care organizations optimize the safety of EHRs[127].

Pediatricians reported that their initial "first look" at the EHR for chart review required between 2 and 10 minutes (**Table 2**). This most likely indicates an increase in chart review times compared to published paper chart review times, in which providers were observed to take an average of 2.5 minutes per patient for all outside-of-exam-room charting

activities, including documentation[128]. This increase in chart review time may be related to increased data volume in EHRs compared to paper medical records, and to increased time demands required for navigating and using EHRs compared to paper records[45,63,129,130]. Regardless of the cause, EHRs' increased time demands on physicians[63,65,131] may have a concerning impact on the patient-provider interaction. As an example from one participant's narrative response in the survey: "15 minutes in the room with the patient but 30 minutes with the EMR. Saturdays are spent cleaning up the EMR." Taken together, these findings suggest the broader theme that physicians are concerned about the disproportionate amount of time required to use EHRs, and that this may have implications for the quality of physician-patient interaction.

Considering that EHRs are being aggressively promoted as a strategy for improving clinical efficiency[18], we believe that pediatric EHRs require further modifications to truly improve time efficiency. Novel collaborations may be a source for new solutions to persistent problems. Recently, consumer electronics companies such as Apple and individual academic institutions have partnered with EHR vendors to collaborate on developing novel EHR innovations, though the outcomes of such collaborations remain to be seen[132,133]. The intent of these collaborations is to bring new content expertise to parties that distribute EHR products. In the same vein, pediatricians and professional organizations such as the AAP, with pediatrics-specific knowledge, have a unique opportunity to focus on collaborations with vendors and informaticians that improve EHR efficiency for pediatricians.

Our third key finding is that there were several perceived barriers to information access in the EHR, particularly with regard to data accuracy and display. Participants admitted to being unable to find desired information because they were challenged by an

overabundance of data. Features such as "copy-paste", "copy-forward", and "all normal" have been shown to be sources of excessive, and potentially erroneous, documentation[134-136]. The use of "boilerplate text" in EHR notes to increase charting efficiency, and potentially maximize billing compliance and reimbursement, may result in a loss of succinct communication about the necessary clinical narrative[134,135,137]. Although features such as these are commonly blamed as negative aspects of the EHR, it is important to recognize that these are consequences of interactions between providers, the system, and the environment[68]. Said one participant, "The information in the chart is only as good as the people entering [data] and curating the chart." Optimization of EHRs for pediatric care requires an understanding of the technological deficiencies, as well as the environmental influences and user habits that may lead to poor documentation. In the future, standard EHR documentation guidelines may help improve the quality and efficiency of clinical care.

The emergence of medical scribes has begun to be described in the literature[138-141]. Medical scribes classically serve as unlicensed users of the EHR system that enter information at the direction of a physician or practitioner, usually through dictation[138]. Anecdotally, scribes may serve additional roles such as information gatherers and note signers. The impact of scribes on the clinician workplace is largely neutral with respect to patient satisfaction[139-141], but positive physician satisfaction and revenue are consistently reported[138]. Medical scribes offer a possible solution for the disruption in patient engagement and information management that EHRs may introduce. However, significant questions regarding safety remain. As of now, scribe education is not centrally regulated, and roles and contractual obligations may vary between institutions and between scribes[138]. This introduces substantial patient safety risks and quality irregularities. While scribes may improve provider

productivity and satisfaction, they do not address the critical design gaps that exist in the EHR, particularly to suit pediatric patients and the practice of pediatric care.

This study has several limitations. The first limitation is purposive sampling of distribution mechanisms prior to surveying populations, rather than a random sampling method. However, we used this sampling method to ensure the inclusion of opinions from a diverse array of practice settings, EHR vendors, and specialties. Still, this introduces potential bias if study respondents were not representative of practicing pediatricians from a diverse set of practice backgrounds and EHR vendors. In particular, academic-based pediatricians were disproportionately represented. Future studies involving a wider range of users may be warranted.

Second, the survey response rate (15%) in this study corresponds to the lower border of normal response rates for social science surveys of all types, with electronic surveys historically garnering lower response rates than mailed ones[142]. This reflects a general decline in survey response rates in present day, particularly with web-based surveys, which tend to have response rates 10-40 points lower than identical mail-based counterparts[143]. Participants who responded may disproportionately represent pediatricians who were pleased or displeased with their current EHRs. However, we note that standard deviations of questions involving quantitative responses were small, suggesting a high degree of uniformity in response. Though no formal non-responder analysis could be done, review of pediatrician workforce data shows 10% or less concordance in distribution of gender and specialty with survey respondents[144]. Discordance between responders' age distributions and workforce age distributions showed substantially more representation among pediatricians 0-10 years out of

medical school (25% discordance)[144]. Market share reports coincide closely with the distribution of EHR vendors represented in the survey[145].

Third, participants' time estimates regarding EHR usage may have been inaccurate. Drawing comparisons between self-reported EHR review times and observed paper review times may be inaccurate; data on information gathering times using paper charts is sparse. We will be directly measuring EHR usage times in a future study. Finally, Likert-type scale responses to questions were analyzed parametrically, which assumes that the intervals between ordinal categories are of equal size. For example, we assume the difference between "Not a barrier" (1 out of 5) and "Moderate barrier" (3 out of 5) is the same as that between "Moderate barrier" and "Severe barrier" (5 out of 5). However, this assumption was supported by the fact that mean responses to these questions followed nearly-normal distributions.

Conclusions

The nature of pediatric practice is changing rapidly because of EHRs. Our study shows that EHRs have become a crucial component of the initial patient evaluation (often even preceding any interaction with the patient), that pediatricians feel EHRs require more time commitment compared to paper records, and that pediatricians perceive numerous barriers to optimal EHR usage related to system organization and design. These findings have important implications for every practicing pediatrician, and suggest the need for collaborations by which pediatricians, researchers, system designers, and policy makers can work together to develop better EHRs which improve design flaws and support improved patient care.

Tables and Figures

Table 1. Characteristics of Survey Participants. Identifying characteristics of 808 pediatricians in a nationwide survey of physicians' opinions regarding electronic health records are shown.

CHARACTERISTIC	NUMBER
	n (%)
Specialty	
General Pediatrics	505 (62.5)
Neonatal-Perinatal	41 (5.1)
Critical Care	41 (5.1)
Hematology/Oncology	29 (3.6)
Endocrinology	24 (3.0)
Cardiology	20 (2.8)
Other	83 (10.3)
Gender	
Male	307 (38.0)
Female	501 (62.0)
Baseline computer experience	
Basic	60 (7.6)
Somewhat experienced	590 (75.0)
Very experienced	136 (17.3)
Level of training	
Resident	200 (25.5)
Fellow	83 (10.6)
Attending Physician	503 (64.0)
Years since medical school graduation	
1-10	390 (49.7)
11-20	157 (20.0)
21-30	116 (14.8)
31-40	95 (12.1)
>40	27 (3.4)
Primary practice environment	
Ambulatory	353 (44.9)
Inpatient	433 (55.1)
Primary EHR	
EpicCare	461 (58.1)
Cerner	108 (13.6)
Allscripts	48 (6.1)
Centricity	23 (2.9)
eClinicalWorks	20 (2.5)
MEDITECH	17 (2.1)
NextGen Healthcare	15 (1.9)
Other/No Response	101 (12.7)

Table 2. Method of Information Gathering When Evaluating a New Patient. Typical practices and opinions of pediatricians responding to a nationwide survey of physicians' opinions regarding electronic health records are shown.

SURVEY RESPONSE	NUMBER
	n (%)
Initial source of information on a new patient	
Patient chart	362 (47.0)
The patient	260 (33.7)
Other physician (referring provider)	124 (16.0)
Technician/ancillary staff	5 (0.6)
Other	20 (2.6)
Time of initial chart review	
Before entering patient room	694 (89.9)
In room with patient	50 (6.5)
After exiting patient room	28 (3.6)
Duration of initial chart review	
0-2 minutes	98 (12.7)
>2-5 minutes	321 (41.6)
>5-10 minutes	231 (29.9)
>10 minutes	122 (15.8)

Figure 1. The Most Important Information Sections of the Electronic Health Record (EHR). Percentages of 808 pediatricians who identified each section of the EHR as one of the 5 most important sections with regard to information gathering during the evaluation of a new patient are shown. HPI – History of present illness; Hx – History.

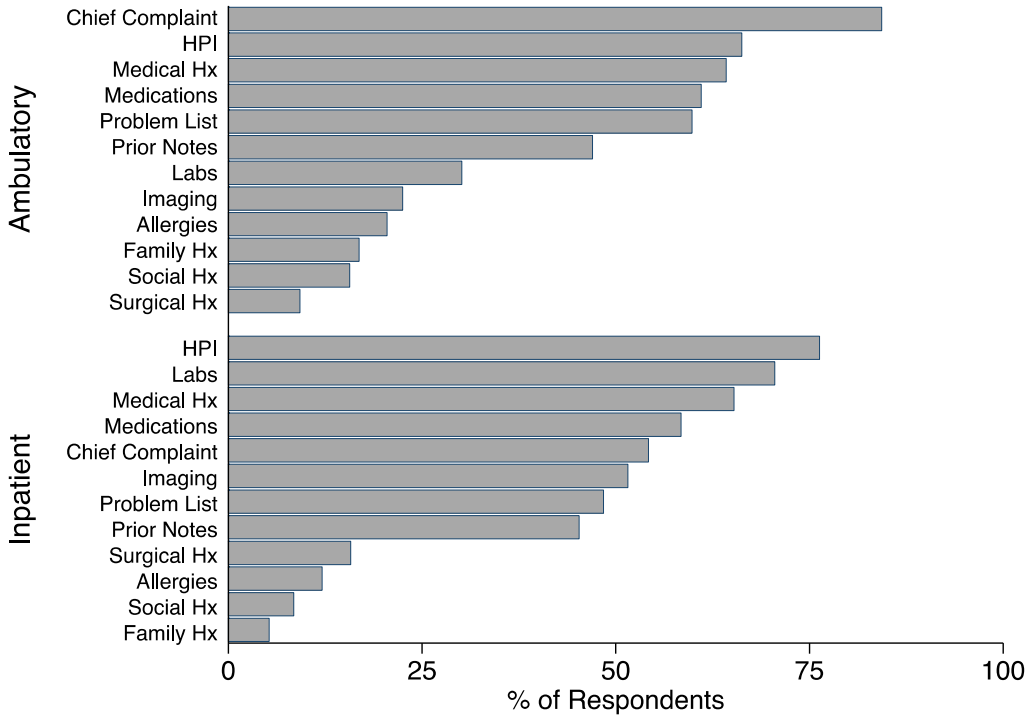


Figure 2. Barriers to Accessing Patient Information in the Electronic Health Record (EHR). Percentages of 808 pediatricians who rated 6 potential barriers to information access using a 5-point Likert-type scale (1=severe barrier, 5=not a barrier) are displayed.

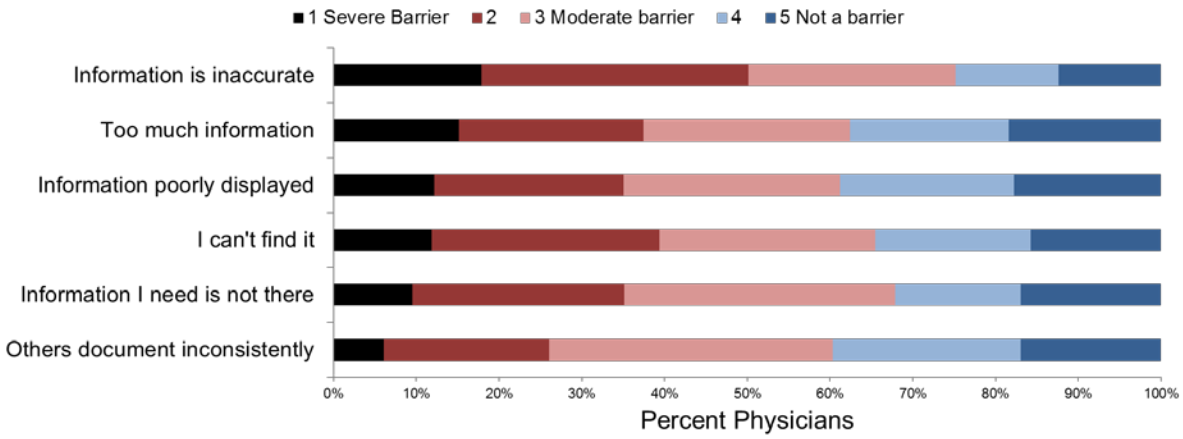
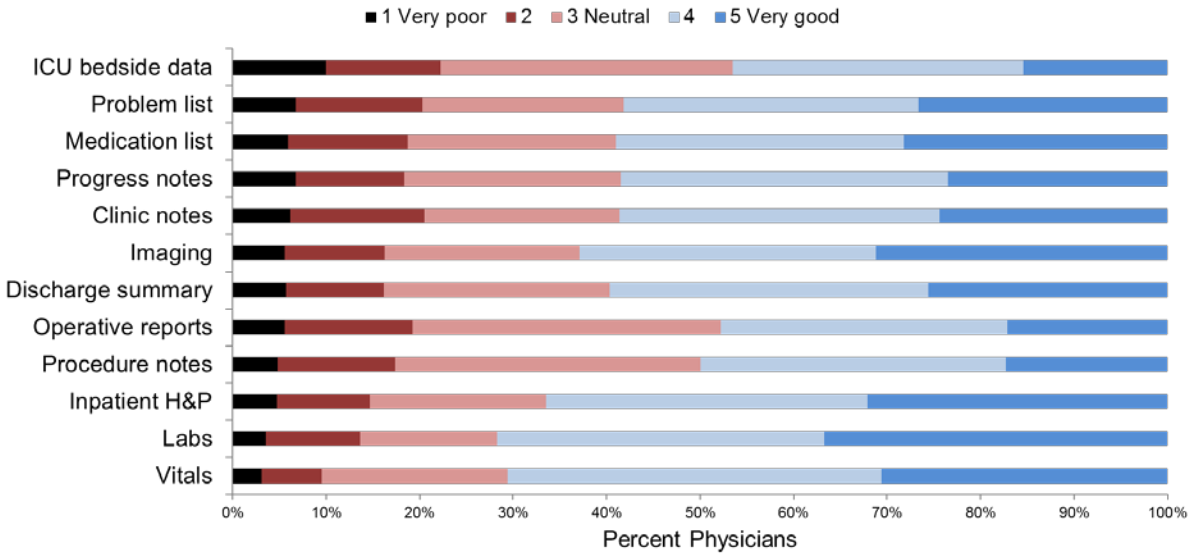


Figure 3. The Ability of the Electronic Health Record (EHR) to Display Necessary Clinical Information. Percentages of 808 pediatricians who rated the ability of the EHR to display various types of information on a subjective scale.



Chapter Four. Variability in Electronic Health Record Usage and Perceptions among Specialty vs. Primary Care Physicians and Proceduralists vs. Non-Proceduralists

Objective

To characterize three parameters of physicians' methods of clinical information gathering using EHRs; these were 1) How the EHR is incorporated into typical clinical workflow, 2) Which elements of the chart are most important and useful to the clinician, and 3) The strengths and weaknesses of the electronic chart in displaying relevant clinical information. These parameters were then compared between primary care and specialty physicians and proceduralist and non-proceduralist physicians to identify any differences that may exist.

Methods

This study was approved by the Institutional Review Board at Oregon Health & Science University (Portland, OR). Acknowledgement of an information sheet by survey participants was used in lieu of informed consent.

Survey Development

The authors developed an 18-question survey for the purposes of data collection (Appendix). When answering these survey questions, respondents were asked to envision the scenario of evaluating a new patient rather than performing a follow up visit. This was because the former is a situation that physicians of all specialties have experience with, and because it provides the greatest insight into the strengths and weaknesses of the interaction between physician and EHR. Demographic characteristics were also collected, including primary clinical specialty, gender, clinical experience (years since graduation from medical school), level of computer experience, and primary practice setting (ambulatory vs.

inpatient). The survey also included an optional free-text response eliciting any additional thoughts or comments. Survey reliability was confirmed using test-retest and alternate form methods[121]. Survey content and construct validity were established iteratively through expert interviews and feedback[122].

Survey Administration

An email containing a link to the questionnaire was distributed to all practicing physicians at three health care organizations in Oregon (Oregon Health & Science University/Portland VA Medical Center, PeaceHealth Medical System, and Legacy Emmanuel Medical Center) and one in Pennsylvania (Children's Hospital of Philadelphia). These institutions were selected because of the wide variety of disciplines represented at each site, and because they represented a mix of academic and community-based practices. The email was then resent to all recipients after one month. The survey was administered using REDCap electronic data capture tools hosted at Oregon Health & Science University[123].

Statistical Analysis

The primary purpose of this study was to compare several aspects of physicians' information gathering methods using the EHR across different clinical disciplines. In order to perform this comparison, individual disciplines were split into two comparison groups: 1) the Primary Care group and the Specialty group, and 2) the Proceduralist group and the Non-Proceduralist Group. Primary Care was considered to include General Internal Medicine, General Pediatrics, Family Medicine, and Geriatrics, in accordance with the definition of the term provided by Medicare[146]. The Specialty group was defined as any clinical discipline other than these four Primary Care disciplines, and in this case included respondents from Obstetrics & Gynecology, Ophthalmology, Orthopedics, General Surgery,

Surgical Sub-Specialties, Emergency Medicine, Internal Medicine Sub-Specialties, and Pediatric Sub-Specialties. The Proceduralist group was defined as General Surgery, Obstetrics & Gynecology, Ophthalmology, Orthopedics, and other surgical sub-specialties. The Non-Proceduralist group was comprised of all remaining specialties.

Three primary outcomes were compared: Outcome 1) How the EHR is incorporated into typical clinical workflow (Table 3); Outcome 2) Which elements of the chart are most important and useful to the clinician (Question 15; Figure 1); and Outcome 3) The strengths and weaknesses of the electronic chart in displaying relevant clinical information (Questions 17 and 18; Tables 4 and 5). Categorical response options were assessed using the Pearson Chi^2 test followed by multinomial logistic regression accounting for the covariates listed previously. Binary outcomes were assessed using the Pearson Chi^2 test followed by multivariable logistic regression. Ordinal outcomes were assessed using the Cochran-Armitage Test for Trend. One question (Question 15) provided multiple categorical responses for each respondent; in this case, proportions and 95% confidence intervals were compared between the Primary Care and Specialty groups for each potential response. Likert-type scale responses followed a nearly normal distribution and were treated as discrete continuous variables. An overall composite score was determined for each question by obtaining the group mean across all sub-sections, and these composite scores were compared between the two main predictor groups using multivariable linear regression. Thus overall scores of the ability of the EHR to display needed clinical information (Question 17) and of the severity of barriers to accessing needed information in the EHR (Question 18) were obtained from each respondent and compared between the groups. All analyses were performed using Stata SE12 (StataCorp, College Station, TX).

Results

Participant Demographics

Of the 11,377 physicians who received the survey link, 1,358 completed the questionnaire. This yielded a response rate of 11.9%. Fifty-four percent of respondents identified with a clinical discipline in the "Specialty" group, and 46% with a discipline in the "Primary Care" group (Table 1a). Twelve percent of respondents identified with a clinical discipline in the "Proceduralist" group, and 88% with a discipline in the "Non-Proceduralist" group (Table 1b). Subjectively, there were minimal differences between these groups with respect to clinical experience (number of years in practice), baseline computer experience, and level of training (Tables 2a and 2b). However, there was a slightly higher proportion of males in the Specialty group (57%) compared to Primary Care (51%). There were also more males in the Proceduralist group (61%) compared to Non-Proceduralists (44%). A total of 13 EHR vendors were utilized by study participants; the most common of these were Epic (Verona, WI; 71%), Centricity (GE Healthcare, UK; 5%), CPRS/Vista (US Department of Veterans Affairs; 5%), Cerner (Kansas City, MO; 3%), and Allscripts (Chicago, IL; 3%).

Incorporation of the EHR into Clinical Workflow (Outcome 1)

Approximately one half of physicians in both the Primary Care and Specialty groups used the EHR as the primary source of initial information when evaluating a new patient (Table 3a). A slightly lower percentage of Proceduralists relied on the EHR as the primary source of initial information (44%) compared to Non-Proceduralists (52%) (Table 3b). However, there were significant differences between the two groups with regard to the other sources of information utilized (Pearson Chi^2 test; $p=0.02$). Multinomial logistic regression confirmed this association even after adjusting for differences in level of training, amount of clinical experience, and practice setting. Specifically, Specialty physicians were significantly

more likely to utilize another physician as their initial source of information on a new patient (OR=2.09, p<0.01). Primary Care physicians were significantly more likely to utilize the patient as their initial source of information than their Specialty counterparts (OR=1.47, p=0.05). Proceduralists' EHR usage patterns closely reflected that of Specialists.

Of the Specialty physicians surveyed, 296/332 (89%) reviewed the chart prior to entering the room with the patient, compared to 244/295 (83%) of Primary Care physicians (p=0.02). This relationship was not confounded by gender, amount of computer experience, or level of training. After adjusting for the amount of clinical experience and primary practice setting (ambulatory or inpatient), Primary Care physicians were still significantly more likely to delay chart review until during or after the patient encounter than Specialty physicians (OR=2.15, p<0.01). The duration of this initial chart review session was quite variable in both groups, with the majority of respondents indicating a time frame of 2-10 minutes (64% in the Specialty group and 57% in Primary Care). There was no significant difference between the two groups with respect to duration of chart review (p=0.91).

Relative Importance of EHR Elements (Outcome 2)

Participants ranked several elements of the EHR to identify the top 5 "most important" when evaluating a new patient. Primary Care physicians ranked these sections as (in descending order of importance): 1: Medications, 2: Past Medical History, 3: Chief Complaint, 4: History of Present Illness, and 5: Problem List (Figure 1). Among Specialty physicians, the most important sections were: 1: Chief Complaint, 2: Past Medical History, 3: History of Present Illness, 4: Imaging, and 5: Lab Values. Two individual elements of the EHR were perceived as significantly more important by the Primary Care group compared to the Specialty group; the first was the Problem List, ranked among the top 5 most important sections of the EHR by 61% of Primary Care physicians (95% confidence interval

[CI]: 55-66%) compared to only 27% of Specialty physicians (95% CI: 23-32%). Secondly, the Medications section was ranked in the top 5 by 76% of Primary Care physicians (95% CI: 71-81%) compared to 44% of Specialty physicians (95% CI: 39-50%). One element of the EHR was significantly more important to Specialty physicians; this was the Imaging section, ranked in the top 5 by 50% (95% CI: 45-55%) compared to only 27% of Primary Care physicians (95% CI: 22-32%). Proceduralists had significantly different perceptions of which sections of the EHR were most important, notably ranking medical history, surgical history, and imaging much higher and ranking medication lists and laboratory values lower than non-proceduralists.

EHR Utility and Ease-of-Use (Outcome 3)

Two Likert-type scale questions assessed this parameter. The first (Question 17) asked respondents to rank how well information was displayed in various sections of the EHR on a scale from 1 to 5 (1 indicating the display was "Very good", 3 indicating "neutral", and 5 indicating "Very bad"). Average ratings of these sections ranged from mean ± standard deviation (SD) of 2.04 ± 1.08 for "Laboratory Results" to 2.64 ± 1.21 for "ICU Bedside Data" (Table 4). The composite score representing the overall ability of the EHR to display relevant clinical information had a mean ± SD of 2.40 ± 0.75 (range: 1-5). Multivariable linear regression showed a significant difference in this composite score between the Proceduralist and Non-Proceduralist groups ($p<0.01$), and no difference between the Specialty and Primary Care groups ($p=0.90$).

The second Likert-type scale question asked respondents to rank the severity of 6 potential barriers to accessing needed information in the EHR on a scale from 1 to 5 (1 indicating a "Not a barrier", 3 indicating "Moderately strong barrier", and 5 a "Severe barrier"). Average ratings of these barriers ranged from mean ± standard deviation (SD) of

2.86 ± 1.27 for "Information in the chart is inaccurate" to 3.32 ± 1.11 for "Others don't record information consistently" (Table 5). The composite score of these six potential barriers had a mean ± SD of 3.11 ± 0.86 (range: 1-5). Multivariable linear regression showed a small but statistically significant difference in this composite score between the Specialty (3.20) and Primary Care (3.01) groups ($p<0.01$). This association was not confounded by gender, amount of computer experience, level of training, clinical experience, or practice setting. The difference in composite score between Proceduralists (3.20) and Non-Proceduralists (3.07) was only slightly more pronounced ($p<0.01$).

Discussion

This study assessed potential differences in EHR requirements among different clinical disciplines. Key findings were: 1) All physician groups relied on the EHR as the most common initial source of clinical information; 2) There were significant differences between primary care and specialty physicians and proceduralists and non-proceduralists regarding which sections of the EHR were considered most important; 3) Specialists and proceduralists identified stronger barriers than primary care physicians and non-proceduralists with regard to ability to access clinical information in the EHR.

The first key finding was that all groups of physicians identified the chart as the most important initial source of patient information. This emphasizes the critical role of EHRs in modern health care, and the potential impact of using systems that do not adequately meet all providers' needs. Interestingly, while the importance of the EHR was uniform between all groups, its method of use and incorporation into clinical workflow were not. Specifically, primary care physicians and proceduralists were much more likely to delay initial chart review until during or after entering the patient room. These differences in workflow

provide additional opportunities for optimization of EHRs to meet the varying needs of different disciplines.

The second key finding identified several elements of the chart that were considered important by one group but not the other. Specifically, primary care physicians showed significantly greater interest in the Problem List and Medications sections than their specialty counterparts. Proceduralists, on the other hand, preferred Surgical History and Imaging sections. As one respondent stated, "I'm a surgeon…I write 2 or 3 prescriptions a month, but the patient's pharmacy is thrust before me in almost every screen." This sentiment was also echoed in the respondent comments; said one physician, "In image driven specialties, like neurosurgery, it is crucial to get actual outside imaging and not just reports. The difficulty in doing this often leads to unnecessary CT/MRI scans and better communication/transmission of these data would be valuable."

The third key finding was that specialists and proceduralists face slightly stronger barriers than primary care physicians in accessing needed information from the EHR. These differences were small but statistically significant, and is consistent with the complaints raised by numerous specialty societies. One respondent summarized this by saying, "I think that most of the major systems that try to serve multiple specialties are full of an unbelievable amount of bloat. My system is specialty specific and is tailored to do exactly what I need it to do." Said another, "The electronic medical record is very poorly organized for a pediatric ICU patient. We have to create workarounds to get the information displayed in a meaningful manner."

These results clearly demonstrate several differences between primary care and specialty and proceduralist and non-proceduralist fields with respect to which elements of the EHR are considered most important when gathering clinical information, as well as their

perceptions of how well these systems are able to provide such information. These differences have several important implications. The first is impaired satisfaction among physicians using systems ill-suited to their practice; one recent survey suggested that 31% of all surgical and medical specialists were "very dissatisfied" with their EHR systems, compared to only 8% of primary care providers[147]. In addition to physician satisfaction, inefficiencies introduced by poorly-integrated EHRs could impair clinical productivity and in turn affect patient satisfaction as well[148]. Another potential sequela of this situation is greater difficulty in achieving Meaningful Use criteria, with large potential impacts on reimbursement[62]. This is important, as it has been shown that EHR selection is heavily influenced by financial and organizational factors independent of clinical demands[149]. In response to this concern, several medical specialty societies have successfully advocated for the inclusion of rules, exemptions, and options in stage 2 of Meaningful Use to better suit the practices of specialists[62]. However, prior to this study there have been no data to guide these modifications, making their adequacy uncertain. Importantly, CMS does permit Meaningful Use exclusions for providers that do not collect core measures outside their scope of practice; however, these exclusions must be applied for on an individual provider basis[21,57]. This places the burden of appropriately collecting these measures on the end user rather than the system, and does not provide a large-scale solution to the problem.

The results of this study inform several potential interventions to address these concerns. First, EHRs must be targeted to meet the unique documentation needs of individual specialties. Several such "specialty-specific" systems already exist, but further assessment of the precise information-gathering requirements of each specialty is required to optimize these systems[150]. Second, the method of implementation of EHRs across health care organizations must be carefully considered. The vast majority of EHR-using physicians

in the United States practice in health systems employing a single EHR system incorporated across multiple clinical departments (the so-called "Enterprise" or "Single Vendor" EHR solution)[86,151]. This has benefits for interdepartmental communication and ease of logistical processes such as billing and scheduling, but as the results of this study suggest, it may be difficult for a single EHR to meet the needs of all specialties simultaneously. Alternatively, a "Best of Breed" approach involving a network of specialty-specific systems can be employed[150]. However, establishing this network of multiple products from a variety of vendors is extremely challenging from logistical and interoperability perspectives, and can result in a fragmented and ineffectual hospital information system[152,153]. More recently, a third strategy has emerged: the so-called "Best of Suite" approach[152,154]. This strategy involves a point-by-point assessment of the relative merits of integration vs. differentiation at each node of the information system, resulting in a framework falling somewhere between the "Single Vendor" and "Best of Breed" models. This approach may provide a more balanced solution, improving hospital efficiency[155] while simultaneously meeting the varying needs of different clinical disciplines as identified in this study.

This study has several limitations. First, the response rate is on the low-normal end for similar surveys of this nature[142]. Thus our respondent pool may not be representative of the population as a whole, and may be a collection of physicians with the most strongly-held beliefs on this topic. However, the wide ranges and standard deviations of responses to Likert-type scale questions indicate adequate variability of opinion among the respondents. Second, our grouping of clinical disciplines was fairly coarse due to overrepresentation of some disciplines compared to others. For example, there were many more pediatricians than surgeons in our respondent pool. However, subjectively there were minimal differences between individual specialties within groups, indicating an appropriate categorization

scheme. Additionally, these differences resulted in inadequate power to identify differences between individual specialties, requiring the grouping of disciplines into "Specialty" and "Primary Care" categories. Consequently, our results provide a broad assessment of differences between clinical disciplines, but future studies are needed to identify differences between individual disciplines. Third, not all EHR systems were represented in our study. However, our sampling scheme did capture several of the most heavily used products nationwide. Finally, Likert-type scale responses were analyzed parametrically, which assumes that the intervals between ordinal categories are of equal size. For example, we assume the difference between "Not a barrier" (1 out of 5) and "Moderate barrier" (3 out of 5) is the same as that between "Moderate barrier" and "Severe barrier" (5 out of 5). However, this assumption was supported by the fact that responses to these questions followed approximately normal distributions.

Conclusions

This study demonstrates several differences between 1) specialty and primary care and 2) proceduralist and non-proceduralist physicians in their methods of using EHRs for clinical information gathering and perceptions of the most important elements of these systems. This has important implications for clinical workflow and efficiency, patient satisfaction, physician satisfaction, and financial reimbursement. Future studies must continue to delineate the unique requirements of individual specialty fields to facilitate informed modification of EHR design, implementation, and governmental oversight.

Tables and Figures

Table 1a. Clinical Disciplines Represented. Within a survey of practicing physicians in the US with respect to EHR usage, attitudes, and preferences.

CLINICAL DISCIPLINE	*n (%)*
Specialty	350 (54)
Pediatrics Sub-Specialty	157 (24)
Internal Medicine sub-specialty	65 (10)
Ophthalmology	46 (7)
Surgical Sub-Specialty	26 (4)
Emergency Medicine	20 (3)
Obstetrics & Gynecology	17 (3)
Orthopedics	10 (2)
General Surgery	9 (1)
Primary Care	304 (46)
General Pediatrics	169 (26)
General Internal Medicine	101 (15)
Family Medicine	34 (5)

Table 1b. Clinical Specialties Represented. Breakdown of clinical specialties represented in a nationwide survey of 1358 physicians regarding EHR use.

CLINICAL DISCIPLINE	*n (%)*
Proceduralist	158 (12)
Ophthalmology	56 (35)
Surgical Specialty, Other	43 (27)
Obstetrics & Gynecology	32 (20)
General Surgery	14 (9)
Orthopedic Surgery	13 (8)
Non-Proceduralist	1200 (88)
Pediatrics, general and specialty	833 (69)
Internal Medicine, general and specialty	176 (15)
Family Medicine	47 (4)
Emergency Medicine	36 (3)
Psychiatry	14 (1)
Other	94 (8)

Table 2a. Demographic Characteristics. Within a survey of practicing physicians in the US with respect to EHR usage, attitudes, and preferences.

CHARACTERISTIC	SPECIALTY	PRIMARY CARE
Gender	*n (%)*	*n (%)*
Male	200 (57)	156 (51)
Female	150 (43)	148 (49)
Baseline computer experience		
Basic	22 (7)	35 (12)
Somewhat experienced	262 (78)	193 (64)
Very experienced	54 (16)	73 (24)
Level of training		
Resident	20 (6)	56 (19)
Fellow	42 (12)	3 (1)
Attending Physician	276 (82)	242 (80)
Years in practice		
1-10	108 (32)	104 (35)
11-20	98 (29)	89 (30)
21-30	66 (20)	56 (19)
31-40	51 (15)	36 (12)
>40	14 (4)	15 (5)
Primary practice environment		
Ambulatory	154 (52)	158 (52)
Inpatient	140 (48)	143 (48)

Table 2b. Demographic Characteristics. Demographic characteristics of physicians participating in a nationwide survey of 1358 physicians regarding EHR use.

CHARACTERISTIC	PROCEDURALIST	NON-PROCEDURALIST
	n (%)	*n (%)*
Gender		
Male	91 (61)	519 (44)
Baseline computer experience		
Basic	13 (9)	109 (9)
Somewhat experienced	120 (81)	858 (74)
Very experienced	15 (10)	200 (17)
Level of training		
Resident	17 (12)	283 (24)
Fellow	7 (5)	118 (10)
Attending physician	124 (84)	775 (66)
Years in practice – mean (SD)		
Years	18.7 (12.3)	15.0 (12.8)

Table 3a. Comparison of EHR Use Practices between Specialty and Primary Care Physicians. Within a survey of practicing physicians in the US with respect to EHR usage, attitudes, and preferences.

	SPECIALTY *n (%)*	PRIMARY CARE *n (%)*	p
Initial source of information on a new patient			0.02
Other physician (referring provider)	53 (16)	23 (8)	
Patient chart	167 (50)	153 (52)	
The patient	98 (30)	109 (37)	
Technician/Ancillary staff	4 (1)	4 (1)	
Other	9 (3)	7 (2)	
Timing of initial chart review			<0.01
Before entering patient room	296 (89)	244 (83)	
In room with patient or after exiting the room	36 (11)	51 (17)	
Duration of initial chart review			0.91
0-2 minutes	57 (17)	63 (21)	
>2-5 minutes	124 (37)	97 (33)	
>5-10 minutes	90 (27)	72 (24)	
>10 minutes	61 (18)	63 (21)	

Table 3b. Comparison of EHR Use Practices between Specialty and Primary Care Physicians. Within a survey of practicing physicians in the US with respect to EHR usage, attitudes, and preferences.

	PROCEDURALIST *n (%)*	NON-PROCEDURALIST *n (%)*	p
Initial source of information on a new patient			0.07
Other physician (referring provider)	19 (14)	157 (14)	
EHR	62 (44)	593 (52)	
The patient	53 (38)	350 (31)	
Other	7 (5)	35 (3)	
Timing of initial chart review			
Before entering patient room	116 (82)	1,015 (89)	<0.01
In room with patient or after exiting room	26 (18)	123 (11)	
Duration of initial chart review			<0.01
0-2 minutes	39 (28)	164 (14)	
>2-5 minutes	58 (41)	420 (37)	
>5-10 minutes	26 (18)	324 (29)	
>10 minutes	18 (13)	228 (20)	

Table 4a. Severity of Six Potential Barriers to Accessing Information in the EHR
Ranked on a Likert-type scale from 1 (not a barrier) to 5 (severe barrier).

POTENTIAL BARRIER	SPECIALTY *Mean ± SD*	PRIMARY CARE *Mean ± SD*
"Information in the chart is inaccurate"	2.94 ± 1.29	2.76 ± 1.24
"Information I need is not in the chart"	3.11 ± 1.24	2.98 ± 1.18
"I can't find it in the chart"	3.23 ± 1.23	2.88 ± 1.28
"Too much information"	3.27 ± 1.31	3.20 ± 1.31
"Information is poorly displayed/difficult to interpret"	3.29 ± 1.20	3.00 ± 1.25
"Other don't record information consistently"	3.38 ± 1.09	3.26 ± 1.13

SD=standard deviation

Table 4b. Severity of Six Potential Barriers to Accessing Information in the EHR
Ranked on a Likert-type scale from 1 (not a barrier) to 5 (severe barrier).

POTENTIAL BARRIER	PROCEDURALIST *Mean ± SD*	NON-PROCEDURALIST *Mean ± SD*
"Information in the chart is inaccurate"	2.99 ± 1.22	3.07 ± 1.23
"Information I need is not in the chart"	3.35 ± 1.23	3.03 ± 1.27
"I can't find it in the chart"	3.16 ± 1.25	3.12 ± 1.27
"Too much information"	3.43 ± 1.87	3.13 ± 1.33
"Information is poorly displayed/difficult to interpret"	2.91 ± 1.27	2.78 ± 1.30
"Others don't record information consistently"	3.30 ± 1.04	3.30 ± 1.15

SD=standard deviation

Table 5a. Ease of Accessing Different Types of Information in the EHR. Ranked on a Likert-type scale from 1 (very good) to 5 (very bad).

EHR ELEMENT	SPECIALTY *Mean ± SD*	PRIMARY CARE *Mean ± SD*
Laboratory Results	2.04 ± 1.05	2.04 ± 1.11
Imaging	2.25 ± 1.24	2.25 ± 1.18
Vital Signs	2.27 ± 1.05	1.94 ± 0.96
Medication List	2.35 ± 1.18	2.23 ± 1.16
Procedure Notes	2.37 ± 1.04	2.62 ± 1.10
Operative Reports	2.37 ± 1.04	2.70 ± 1.10
History & Physical Documentation	2.37 ± 1.34	2.80 ± 1.74
Outpatient Clinical Documentation	2.42 ± 1.14	2.24 ± 1.08
Discharge Summary	2.43 ± 1.08	2.28 ± 1.06
Problem List	2.50 ± 1.17	2.40 ± 1.27
Inpatient Progress Notes	2.51 ± 1.20	2.44 ± 1.22
ICU Bedside Data	2.65 ± 1.20	2.61 ± 1.22

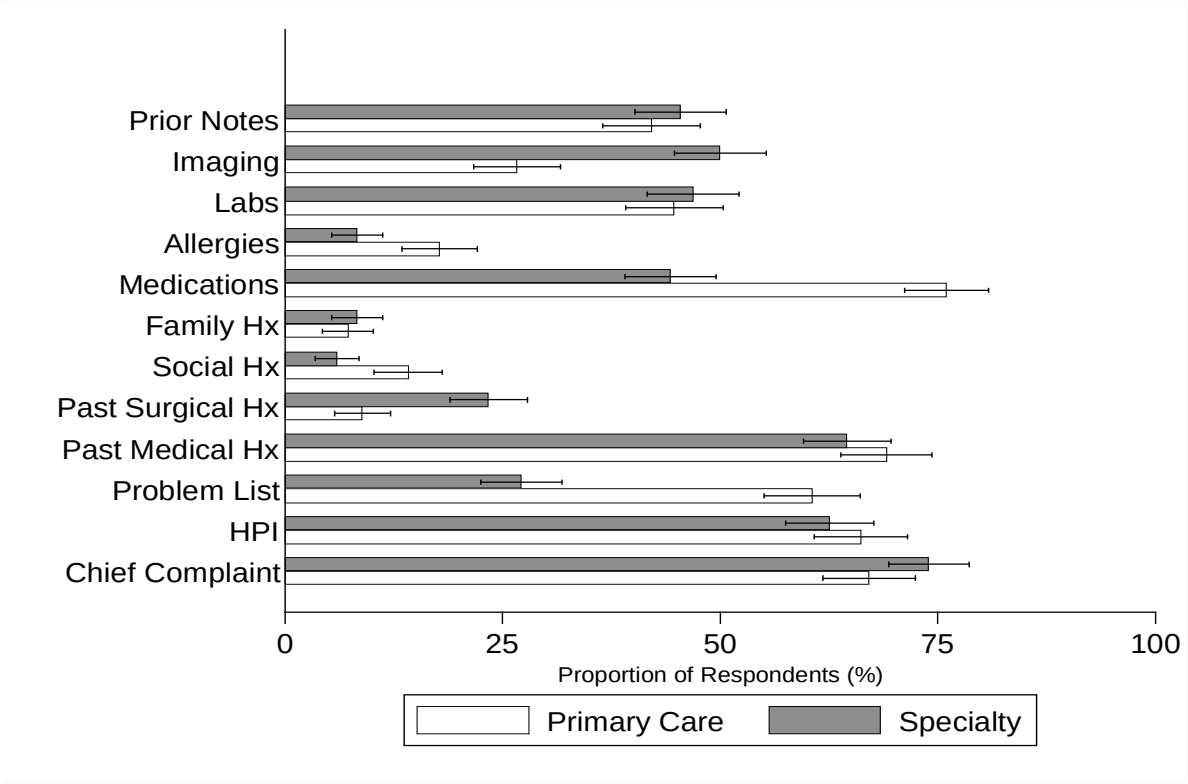
SD=standard deviation; ICU=intensive care unit

Table 5b. Perceived Usefulness of EHR Elements. Ratings of perceived usefulness of EHR elements on a Likert-type scale from 1 (very good) to 5 (very bad).

EHR ELEMENT	PROCEDURALIST *mean ± SD*	NON-PROCEDURALIST *mean ± SD*
Laboratory Results	2.35 ± 1.23	2.09 ± 2.09
Imaging	2.63 ± 1.37	2.39 ± 1.37
Vital Signs	2.78 ± 1.50	2.17 ± 1.13
Medication List	2.52 ± 1.21	2.39 ± 1.20
Procedure Notes	2.34 ± 1.11	2.76 ± 1.33
Operative Reports	2.25 ± 1.79	2.93 ± 1.46
History & Physical Documentation	2.65 ± 1.48	2.59 ± 1.58
Outpatient Clinical Documentation	2.64 ± 1.34	2.65 ± 1.63
Discharge Summary	3.10 ± 1.52	2.66 ± 1.50
Problem List	2.76 ± 1.25	2.56 ± 1.34
Inpatient Progress Notes	3.19 ± 1.67	2.92 ± 1.63
ICU Bedside Data	4.21 ± 1.77	3.62 ± 1.79

SD=standard deviation; ICU=intensive care unit

Figure 1. Relative Importance of Various EHR Elements among Primary Care and Specialty Physicians. Proportion of respondents ranking the indicated section among the top 5 "most important" EHR elements. Hx=history; HPI=history of present illness



CHAPTER FIVE. BARRIERS TO INFORMATION ACCESS IN ELECTRONIC HEALTH RECORDS DURING INITIAL PATIENT VISITS: A QUALITATIVE STUDY

Objective

We used a nationwide survey, with qualitative analysis of physician narratives regarding EHR usability, to identify and describe physicians' perceptions regarding information gathering and overall workflow when using electronic health records (EHRs) to evaluate new patients.

Methods

This study was approved by the Institutional Review Board at Oregon Health & Science University (OHSU; Portland, OR). Acknowledgement of an information sheet was used in lieu of informed consent.

Survey Creation

We created an 18-question multiple-choice and free text survey to assess physicians' current attitudes, behaviors, and workflow preferences with respect to gathering information about a new patient visit. The survey was based upon a previously-validated physician EHR adoption survey[156]. Participants were asked what EHR elements they considered most crucial to the initial patient visit and what barriers existed to obtaining desired information in EHRs. Quantitative analysis of multiple-choice survey questions will be published separately. This study involves qualitative analysis of an optional final question asking participants to comment about physicians' information needs in general or about the preceding multiple-choice questions. There was no limit placed on comment length.

Data Collection

The survey was administered using REDCap electronic data capture tools hosted at OHSU[123]. A variety of physician groups, including pediatricians, internists, surgeons, and family practitioners were contacted to obtain different perspectives: members of the CMIO4Kids mailing list (Stanford University, Stanford, CA), section heads of the American Academy of Pediatrics (Elk Grove Village, IL), and chief medical officers and other physician leaders in local healthcare organizations were contacted via e-mail and asked to distribute the survey (OHSU; Oregon Medical Association; Multnomah Medical Society; PeaceHealth Medical Group Oregon; Legacy Health; Providence Health & Services, all Portland, OR). Follow-up reminders were sent after one month to all potential participants.

Data Analysis

Physician comments were separated from demographic information and other responses. Preliminary exploratory analysis was conducted by creating a single document comprised of all comments, allowing the authors to gain familiarity with the data. A coding scheme was agreed upon by the authors. Two authors (JD, RK) used qualitative research software (NVivo 10; QSR International, Victoria, Australia) to individually create "nodes," or formative concepts based on words, and phrases found in the comments. Individual lists of nodes were discussed, and a central list of 22 nodes was synthesized. Nodes with <10 supporting quotations were removed. Natural groupings were created from the nodes to generate preliminary "themes," or overarching patterns salient to the research questions. A panel of 6 experienced clinical and qualitative researchers (JD, JA, MC, JG, VM, JM), was convened to refine the themes. Panelists had expertise in human factors, biomedical

informatics, internal medicine, pediatrics, and surgery. Preliminary results were discussed in detail and revised to create a final set of themes.

Results

1,470 physicians responded to the survey, 331 (23%) of whom submitted free-text comments (15,228 words total). Fifty-one percent of respondents were female, and 80% were attending physicians (Table 1). Ninety percent reported being "somewhat" or "very" experienced with computers. Primary care physicians (general pediatricians, general internists, and family medicine physicians) comprised 59% of participants. The majority of respondents (60%) used EpicCare EHR (Epic Systems Corporation, Verona, WI).

Table 2 lists the four major themes, eight subthemes, and representative quotations pertaining to each theme.

Theme 1: Workflow

Respondents indicated performing EHR tasks was a central component of physician workflow, though it often required difficult navigation through several areas of the electronic chart. Participants reported that clinical workflow was adversely impacted by poor interface design and the overall negative time impact of EHRs to complete tasks.

Subtheme 1.1: Intuitive Design

Physicians reported frustration with EHR interfaces, perceiving them as laborious: "Not intuitive... many quirky features and opaque operations." Others acknowledged the sophisticated functionality modern EHRs possess, but called for more ease of use: "The problem is cluttered screens and too many taps to get what you need." "Waiting for … the

user interface of electronic records to catch up to the level of simple iPhone apps out there." Others highlighted a need for customizability: "EHR customization needs much more individual control, similar to PC software." Certain EHR features were criticized for poor usability, namely medication and problem lists.

Subtheme 1.2: Time Impact

Physicians expressed concern about the disproportionate amount of time spent interacting with EHRs: "My productivity has significantly decreased, and I have to finish charting after the end of the clinical day." "15 minutes in the room with the patient but 30 minutes with the EMR. Saturdays spent cleaning up the EMR." Some were concerned about the impact of EHRs on physician-patient relationships: "Due to decreased efficiency, more time is spent on the EHR and less with the patient." "Docs turning their back on the patient to keypunch the entire visit is awful." The prevailing opinion was that time required to retrieve information using EHRs was excessive.

Theme 2: Documentation

Respondents commented about quality of documentation in EHRs. Respondents held EHRs, as well as other users, responsible for creating excessive data with relatively low clinical utility.

Subtheme 2.1: Quantity

Respondents stated that EHRs often made gathering new information about patients difficult: "Chart is cluttered with repeated entry of previous progress notes and lab data. Very difficult to find a concise summary of the present problem(s) and plan." "We are

required to wade through copious notes and still left wondering what clinicians are actually thinking and wanting to do with the patient."

Subtheme 2.2: Quality

Many respondents commented on the low quality of documentation in EHRs, even describing notes as "garbage" or "rubbish." Some noted that a lack of defined responsibilities resulted in breakdown of documentation quality: "The information in the chart is only as good as the people entering [data] and curating the chart." "Processes that are 'everyone's job' (e.g., medication reconciliation, problem list) are often inaccurate… [it] means no one is responsible, since someone else can do it."

Two EHR features were highlighted for causing poor documentation quality: copy-paste/copy-forward and note templates. Physicians believed these techniques often produced excessively long notes laden with irrelevant material: "Finding actual relevant information buried in an avalanche of copy forward … makes sorting through notes tedious and frustrating." At times, using copy-paste inappropriately led to misinformation and propagation of chart lore: "Once truly erroneous information is entered it often gets carried forward without review." Respondents often stated that template-imported data "adds little" to the chart, often containing "repetitive" and "inaccurate" information. "With most notes, the 'meat' of the note is in one paragraph but you have to sift through so much other stuff to get there."

Conversely, several respondents cited potential benefits of EHRs for workflow and patient care because much more data is available compared to paper records: "EHR has been a great tool in accessing up-to-date information about patient status." Numerous participants expressed frustration over inability for EHR systems to exchange data (lack of

interoperability), but appreciated potential benefits of accessing information from other hospital systems when this feature was implemented successfully.

Theme 3: Communication

EHRs increasingly assume a role as communication intermediaries between users because they are central hubs for patient data. This role influenced users' perceptions of 1) other physicians and 2) other professions sharing care of the same patient.

Subtheme 3.1: Relations with Other Physicians

Respondents expressed frustration that EHRs affected their communication with physician colleagues: "Computer generated office notes are pretty much junk. I cannot figure out what the referring MD is thinking." "It is hard to know what the doctor recommends. It is not due to [EHR software] but the doctor." Perceived misuse of EHRs by other physicians at times led several respondents to question their integrity: "Doctors that do not complain are the ones that do not use the system as they are intended; rather they are willing to click boxes, cheat and take chances (with patients' health)." One wrote that EHRs negatively impacted workplace collegiality by causing "discord in an otherwise congenial group of colleagues."

Subtheme 3.2: Relations with Non-Physician Providers

Some respondents attributed their difficulty with accessing information in the EHR to actions of other professionals: "I thought doctor's notes were uninformative, but I'm becoming more frustrated with the nursing notes." Lack of familiarity with documentation conventions of non-physician providers led to uncertainty about data reliability. "Bedside data is not up to date because the [nurse] has to put it in – this happens at variable times."

Some users attributed these communication issues to EHR interface differences: "It is difficult to figure out where nurses have charted multiple things as their configuration of the system is vastly different from the physician side of things." "With multiple clinicians using the same chart in different capacities, information is scattered throughout the chart, not all users use the EHR in the same manner."

Theme 4: Trust

Respondents made numerous comments about distrust toward EHR vendors and clinical administrators. This included dissatisfaction with EHR designers and clinical administrators.

Subtheme 4.1: Trust of EHR Software and Vendor

Respondents commented that EHRs were unable to accurately portray patients' entire clinical pictures: "It's easy to miss something important hidden in a flowsheet I've never heard of … it is difficult to trust EHRs … you never feel like you've seen the whole chart." Several respondents wrote about distrust toward EHR vendors, citing lack of sufficient motivation or knowledge to create clinically useful tools: "[EHR vendor] is not adequately incentivized to move the bar quickly to get a more appropriate EHR…" "Current EMR is designed by user-hostile database engineers, not Apple/iPhone style." "It does not appear the software was developed by clinicians." Some suggested a higher level of accountability: "EHR companies should be held accountable for providing safe, effective EHRs."

Subtheme 4.2: Trust of Clinical Administration

Respondents also criticized clinical administrators for selecting EHR software that poorly served the needs of physicians, because systems were perceived to be overly focused on billing and regulatory compliance: "Resources of EHR vendors are put into making a system that appeals to the HOSPITAL. This puts all the focus on billing, regulatory stuff, quality … and puts minimal (if any) resources into usability for the physician end user." "EHRs are administrative & coding centric rather than clinically centric." Some respondents also expressed frustration over administrators squandering resources on EHRs: "Our hospital has sunk a ton of money into this sinking ship… I sincerely hope the company folds so our hospital is forced to change."

Discussion

To our knowledge, this is the first large-scale qualitative study of physician preferences and attitudes on EHR use to evaluate new patients. Our key findings were: 1) Physicians struggle with unintuitive workflows and negative time impact; 2) Physicians find EHR documentation excessive and often of poor clinical value; 3) Provider-provider communication is negatively impacted by EHR challenges; and 4) Frustration with EHRs leads to mistrust of vendors and hospital administration.

The first key finding was that physicians struggle to use EHRs efficiently. Usability issues such as cluttered displays and unintuitive workflows were felt to contribute to substantial negative time impact, and physicians felt this constrained their clinical performance. Previous studies have reported mixed findings about the impact of EHRs on clinical efficiency, with some showing prolonged documentation time after implementation[63,131,157] and others showing a neutral or positive impact on time[158,159]. However, other concerning signs of compromised clinical performance have been reported.

EHRs have been associated with reduced eye contact with patients in the exam room[27], worsened rapport, and less provision of emotional support[26]. This points to a growing concern that the EHR is a third 'party' in the exam room that demands physicians' attention and time[27]. Further study of the impact of EHRs on physician-patient interaction, particularly the psychosocial and emotional aspects of the interaction, is needed.

Usability problems in the EHR have been well documented in previously published studies. Workarounds, or 'non-standard procedures [due to] deficiencies in system or workflow design[160], are extensively described and abundant in medical practice[161]. Usability flaws have also been linked to slower adoption of EHRs[162], impaired physician workflow[74], safety concerns[163], and other unintended consequences[164]. Improved health IT policy and increased vendor involvement is necessary to conclusively address usability challenges. Professional organizations such as the American College of Physicians (ACP) and the American Medical Informatics Association have begun to release specific policy recommendations focusing on EHR system design and identifying best practices[69,165].

Our second key finding was that physicians find documentation excessive and often of poor clinical value, and often struggle to find relevant clinical information within an overabundance of figures and text. Several previous studies have also pointed to "copy-paste" as a common cause of lengthy, hard-to-read records and propagation of clinical misinformation in EHRs[68,135,136,166]. The ease of copying and pasting a previous note's text into the creation of a new note is tempting, and may be overused. Our participants also found templates to be a cause of poor documentation, making it potentially too easy to import text reflecting a complete physical exam, to document an extensive review of systems, or to insert phrasing for billing purposes. On the other hand, templates are often

considered useful and have helped providers consistently meet care standards in pediatrics and infectious disease[167,168]. Lastly, poor documentation was not limited to clinical notes. We found that other EHR sections suffered from poor stewardship, particularly the problem list, because it placed the burden on the collective group of providers to manage content length and scope. The problem list would therefore make an excellent first example for the introduction of institution-specific chart stewardship standards to emphasize shared responsibility, brevity, and relevance.

Our third key finding was that EHRs served as major communication channels, albeit imperfect ones, between providers. Although one of the purported benefits of EHRs is enhanced communication, respondents stated that inconsistent documentation practices often led to confusion among colleagues. Similar change management strategies have been successfully used to implement other major workflow changes, including medication administration safety[169], telehealth[170], and quality improvement[171]. Emphasis on chart stewardship at the organizational level could help to reduce variability in documentation styles and improve information display in EHRs. Policy recommendations for clinical documentation have been put forth by the ACP and could serve as a starting basis for organizational culture realignment[69].

Our final key finding was that frustration with EHRs led to mistrust of vendors and hospital administration. Reports have acknowledged that there may be lack of sufficient startup companies to challenge dominant EHR vendors, leading to the EHR market becoming "calcified"[172]. With implementation costs up to $1 billion or more[173], health systems are often unable to switch EHRs despite their dissatisfaction with and poor performance of the systems[174]. The presence of hospital-vendor contract clauses that

mitigate the obligation of vendors to fix usability issues is problematic[175,176]. A logical step would be policy that protects intellectual property of vendors while appropriately assigning some legal accountability for vendors designing systems with poor usability[118]. Professional organizations such as the American Academy of Pediatrics and American Medical Association that have successfully facilitated legislation in other areas of health care reform may be positioned to advocate for physician-centered EHR usability design. Hospital administration-brokered collaborations between end users and EHR vendors would also help improve usability and build trust between parties.

Study limitations include: (1) Surveys were distributed using non-random distribution techniques. This may have garnered a non-representative sample, potentially leading to study findings that may not fully describe the EHR perspectives of the "average" physician. We chose to forego a random sampling method so that a broad range of practice types, vendors, and specialties could be represented. (2) Study data were collected from optional free-text comments in a larger survey. Because this portion was optional, results may reflect views of physicians most motivated to vocalize their opinions. Comparison of commenters versus non-commenters found a small but statistically significant decrement in mean EHR usefulness rating among commenters (0.2 point difference on 5-point scale, $p=0.01$). (3) Surveys were distributed to participants by email. For confidentiality purposes, participants were not tracked through a unique survey "link". It would have been possible for the survey to have been taken multiple times by one person. We felt the likelihood of this would be small, and wanted to ensure that participants felt truly anonymous and free to express their true opinions.

Conclusions

EHRs are changing the nature of clinical practice, yet this study finds that they are creating multifaceted challenges such as inefficient workflows, increased time demands, inconsistent documentation practices among providers, and physician dissatisfaction in vendor product development and selection. This has important implications for all practicing physicians. Policy efforts to stimulate usability research, organizational efforts to connect end-users with EHR vendors, and user efforts to establish and maintain chart stewardship standards are all needed.

Tables and Figures

Table 1. Baseline Characteristics of Survey Participants. In a qualitative study of physicians' EHR usage, preferences, and attitudes.

	n (%)
Specialty	
Family Medicine	12 (4)
Internal Medicine	48 (14)
OB/GYN	10 (3)
Ophthalmology	14 (4)
Pediatrics	190 (57)
Surgery	17 (5)
Other or no response	40 (6)
Gender	
Male	163 (49)
Female	168 (51)
Baseline computer experience	
Basic	36 (11)
Somewhat experienced	237 (72)
Very experienced	58 (18)
Level of training	
Resident	39 (12)
Fellow	26 (8)
Attending Physician	266 (80)
Years since medical school	
1-10	99 (30)
11-20	75 (23)
21-30	76 (23)
31-40	65 (20)
>40	16 (5)
Primary practice environment	
Ambulatory	174 (55)
Inpatient	143 (45)
No response	14 (4)
Primary EHR	
EpicCare	194 (60)
Cerner	28 (8)
Centricity	16 (5)
eClinicalWorks	12 (4)
NextGen	12 (4)
Allscripts	11 (3)
Other or no response	59 (16)
Total	331

Table 2. Themes, Subthemes, Brief Description and Quotations. In a qualitative study of physicians' EHR usage, preferences, and attitudes.

Theme/Subtheme	Brief Description/Quotation
Workflow	Physicians struggle to use EHR efficiently.
1. User Interface	Poor usability currently hinders physician efficacy. *"Not intuitive," "Many quirky features and opaque operations"*
2. Time Impact	Physicians feel too much time is spent using EHR. *"My productivity is significantly decreased"*
Documentation	EHR documentation is excessive and often of poor clinical value.
1. Quantity	Chart is overloaded with data, making information hard to find. *"Chart is cluttered," "Required to wade through copious notes"*
2. Quality	Abundant misuse of copy-forward and templates. *"Repetitive," "Bloated with 'fluff'"*
EHR as a Team Communication Medium	Provider-provider communication is impacted by EHR challenges.
1. Interdisciplinary Relations	Physicians often critical of other physicians' chart usage styles. *"[Others] are willing to click boxes, take chances, and cheat with the patients' health"*
2. Interprofessional Relations	Challenge to integrate many documentation habits in one central program. *"Difficult to figure out where the nurse has charted things"*
Trust	Frustration with EHRs leads to mistrust of vendors and hospital administration.
1. Toward EHR Vendor	Perceived lack of physician involvement in EHR design and product selection. *"Current EMR is designed by user-hostile database engineers"*
2. Toward the Clinical Administration	Underlying beliefs that EHR is implemented for reimbursement and staff management purposes. *"Administrative/coding centric rather than clinically centric"*

CHAPTER SIX. USING HIGH-FIDELITY SIMULATION AND EYE TRACKING TO DETECT AND DESCRIBE EHR WORKFLOW PATTERNS AMONG HOSPITAL PHYSICIANS

Objective

The purpose of this study is to address this gap in knowledge by characterizing the workflow patterns of physicians using the EHR. This is done using a mixed methods approach employing a high-fidelity EHR simulation environment equipped with eye and screen tracking, surveys, and semi-structured interviews to characterize the typical EHR usage by a group of hospital physicians (hospitalists) as they encounter a new patient.

Methods

This study was approved by the Institutional Review Board at Oregon Health & Science University (OHSU; Portland, OR). Participants signed a consent form prior to participation.

Development of Simulation Cases

An instance of our EHR environment (EpicCare, Epic Systems Inc., Verona, WI) was created to house simulated patient cases. This simulation environment imports all end-user customizations from the actual EHR environment, so the interface looked exactly as it would for each participant. Simulated cases were based upon real patient cases with common principal diagnoses (i.e., among the top 10 most common ICD-9 diagnoses for adults upon hospital discharge)[177]. Two patient cases (Cases A and B) were created and independently reviewed for medical accuracy and clinical realism by domain experts in accordance with previously published recommendations for high-fidelity case creation[178]. Both patients had previously established care at our institution, but were now presenting to the emergency department (ED) for evaluation of a new set of symptoms. Each case contained historical

data in each of the categories listed in **Table 1**; the current ED visit contained vitals, intake/output, laboratory data, EKG, chest roentgenogram, and a half-completed ED resident note stating the history of present illness, physical exam findings, and review of systems.

Recruitment and Testing of Participants

Attending physicians from the OHSU Division of Hospital Medicine comprised the study population. Simulations were conducted on a representative active patient ward to mimic external distractions encountered by physicians as they use an EHR. Participants were asked to act as the admitting hospitalist, review both patient charts, and create a history and physical (H&P) note complete with assessment and plan for each patient. Simulation time was not limited. Case order was held constant for all participants throughout the study. After completing the cases, participants were asked to verbally describe their typical workflow for admitting a patient. Semi-structured interview questions were used to elicit details about when they use the EHR during that process, their principal sources of information, note writing strategies, and the nature of the patient interaction. Lastly, participants were asked to complete a questionnaire regarding demographic information, EHR experience, and general computer experience.

Eye and screen tracking were conducted using a Tobii X2 60 Eye Tracker (Tobii Systems, Danderyd Municipality, Sweden), a non-invasive tracker mounted below the computer monitor. All testing was conducted using a standardized computer station with consistent and static screen and chair height. Before each simulation, the eye tracker was calibrated to each participant using a 1-minute 9-point calibration algorithm provided by the manufacturer. Upon commencement of the simulation the screen tracking software (Tobii

Studio, Tobii Systems, Danderyd Municipality, Sweden) captured screen video, keystrokes, mouse clicks, ocular saccades, and eye fixations. A velocity threshold identification filter was used to identify sets of fixations (gazes), using the standard definition of a fixation as lasting a minimum of 100 ms[179]. Each video was coded manually by a member of the research team (JD). Videos were coded by recording the information type upon which the gaze was situated at each second of the case.

Data Analysis

Simulation gaze data were divided into two major categories: informational and navigational. Informational gazes pertained to any kind of clinical data (all entries in **Table 1** except 14); navigational gazes were defined as lacking clinical data, and frequently occurred on toolbars, menus, and up/down scrolling arrows. Documentation was considered a subset of the informational gaze category. Comparisons between group means were conducted using two-sided t-tests.

Several metrics were used to evaluate the data. First, we measured the average duration of each participant's gaze on each information type (**Table 1**), calculated by their total duration of gazes on that information type divided by the number of gazes on that information type during the case. Next, we calculated the total number of transitions between information types for each patient case, and the total number of informational gazes for each case.

We used first-order Discrete Time Markov Chains (DTMCs) to model transitions between information types. A Markov Chain consists of a series of successive state-to-state transitions (Equation 1, **Figure 1**), which form a transition matrix. Equation 2 illustrates an example of a transition matrix, which has three states. The row i (i = 1,2,3) shows the

transition probability distribution from information-type i to other information-types j. For example, p_{13} is the probability that a participant transitions from information-type 1 to 3. Higher probabilities in the matrices indicate the information-type pairs that are more likely.

Results

Participant Characteristics

From a total of 23 eligible participants, 17 (74%) participants completed a total of 33 patient cases. Fifty-nine percent of participants were male; the mean length of time since medical school graduation was 13.3 years. One hundred percent of participants described themselves as "somewhat" or "very experienced" with computers. The mean length of time using the study EHR (EpicCare) was 6.5 years.

Simulation Characteristics

The participants were divided into two groups based upon how long into the case it took them to begin composing a note. This division was based upon a natural grouping observed in average note start times per participant (**Figure 2**). Participants in Group 1 (n=8) began composing a note on average less than 2 minutes into the case; participants in Group 2 (n=9) began composing a note on average more than 2 minutes into the case.

The proportion of men in Group 1 (87.5%) was significantly greater than the proportion of men in Group 2 (33.3%, p=0.02) (**Table 2**). Using a Likert-type scale to assess self-rated computer experience (1, less experienced; 2, somewhat experienced; 3, very experienced), Group 1 reported a higher mean experience score compared to Group 2 (2.5 and 2, respectively; p=0.03). Time since medical school graduation and length of EpicCare experience did not differ significantly between the groups.

The average time for Case A was significantly longer than Case B (mean±SD, 28:12±8:05 and 21:56±6:35 respectively, p=0.02). To evaluate a potential learning effect, the note start times were normalized to total case times and compared among the groups from Case A to Case B. There was a slight difference in the decrement in note start time ratio between the groups, with Group 2's note start ratio dropping more in Case B, but this was not significant (G1 = 0.04, G2 = 0.07; p = 0.33). Number of transitions per second was evaluated as well. Whereas the transitions per second for Group 1 decreased slightly from Case A to Case B, the transitions per second for Group 2 increased slightly, but the difference between the two was not statistically significant (G1 = 0.006, G2 = -0.005; p = 0.14).

Group 1 had significantly more gazes (G1=81.7, G2=62.3; p=0.04) and transitions (G1=75.5, G2=57.5; p=0.04) over the course of each case. There was no difference between the groups in average case time, navigation time, and average number of unique information types accessed within each case.

Semi-Structured Interviews

Self-described workflows elicited from the semi-structured interviews were consistent with categorization into Group 1 and Group 2. Representative quotations are shown in **Table 3**.

Clinical Content

The information types with the longest total gaze durations are shown in **Figure 3**. For both Groups 1 and 2, total duration of gazes for documentation (composition of the H&P note) was much higher than all non-documentation information types (G1=851 seconds, G2=745 seconds). The non-documentation information types with the greatest

average and total duration of gazes (greater 10 seconds) were imaging results, inpatient progress notes, lab values, medications, and ambulatory clinic notes. These five information types were also the most often visited throughout the simulations. Group 1 gazed at laboratory values significantly more often than Group 2 (G1=13.3, G2=8.2, p=0.02). Differences were observed in less frequently visited information types as well. Past medical history (G1=0.75, G2=1.6, p=0.06), problem list (G1=1.4, G2=2.9, p=0.08), family history (G1=0.7, G2=0.2, p=0.04) and other information types (G1=3.88, G2=2.53, p=0.04) all showed slight differences in visitation frequency between groups. These trends in frequency remained consistent when the gaze values were normalized by the total number of visits to all information types.

Transition Visualizations

Figures 4a and **4b** show circle visualizations of normalized Markov Chain frequencies of information types for both groups. Nodes situated around the rim of the circle represent the various information types, ordered by size moving counter-clockwise. The sizes of the nodes are proportional to their gaze number distribution frequencies, and the thickness of the lines connecting nodes indicate the normalized frequencies of transitions (transition probability) between the two information types. For clarity, only the top 80% of total transitions are depicted here.

The general patterns are the same between the two groups: most of the transitions are centered around documentation, which is also the most frequently visited information type. We can identify the top 5 most frequently visited information types, which are consistent between the two groups: documentation, lab values, inpatient progress note, vital

signs and imaging results. In addition, because documentation played a larger role in group 1 than it did in group 2, there were fewer high frequency transitions compared with group 2.

One important observation from the visualization is which information types were closely related. For example, the social history, past medical history, family history, and past surgical history nodes are co-located because they were similar in visitation frequencies. In Group 1, there are more bold lines from documentation to other information types, capturing the notion that Group 1 transitioned more frequently between documentation and other information types.

Discussion

This study assessed characteristics of physicians' information search patterns in an EHR as they created a note for a new patient. There were two discrete types of users based upon information review and documentation tasks. The key findings from our analyses are: 1) There were strong similarities across the groups in the information types the physicians looked at most frequently; 2) While there was no overall difference in case duration between the groups, we observed two distinct workflow types between the groups with respect to gathering information in the EHR and creating a note; and 3) A majority of the case time was devoted to note composition in both groups.

Both groups showed the same preferences for a small subset of information types, in terms of how long they looked at each information type (**Figure 3)**. Imaging results, progress notes, laboratory values, medications, and prior clinic notes were looked at longest. The total number of unique information types also did not differ between groups. This suggests some uniformity in clinical reasoning that may be explained by their mutual medical specialty, common clinical environment, and/or similarities in medical training. Differences

between groups were only found in lower-frequency information types; members of Group 1 spent less time reviewing past medical history and problem lists, and more time reviewing the family history.

Groups 1 and 2 exhibited significantly different workflow types, despite no overall difference in case completion time. Group 1, characterized by early note creation, transitioned frequently between information types in the EHR after starting the note (**Figure 4**). Group 2 physicians, characterized by later note creation, tended to dwell on information longer before starting to compose the note. Group 1 showed a markedly higher number of transitions and gazes compared to Group 2, confirming a higher rate of switching from one information type to another. We found significant differences between the groups in how the simulation time was used. Overall, Group 1 spent substantially longer time in the documentation phase of the simulation. Participants' self-described workflows (**Table 3**) supported a dichotomy between early and late note creation. Participants in Group 1 mentioned starting a note as one of their first activities prior to information gathering (and "jumping around" in the EHR when gathering information) whereas Group 2 members described reviewing a variety of information prior to note creation.

Both groups spent a much higher amount of time on note composition than any other task, including reviewing clinical information (**Figure 3**). The time and burden associated with documentation is noted in the literature[157,180,181]. What this study highlights is the finding that documentation time may overshadow all other tasks, including time to read or review the clinical data. This raises the question of whether the time and burden of documentation relates to the untoward effects of EHR implementation on patient care that have been observed[34,182]. Further research is needed to elucidate the interplay between EHR documentation burden, clinical reasoning, and patient care.

This research raises several questions about the nature of EHR information seeking and patterns in end-user behavior. Several models have been proposed to describe this process[183-186]. Traditionally information seeking is viewed as a sense-making process in which the user formulates a personal perspective through finding meaning[187]. A common thread shared by most proposed models of information seeking is that it is a dynamic process, where the users move non-linearly through levels of certainty based upon information encountered and judgments of relevancy and specificity. The resultant perspective or decision is not necessarily the same among individuals[187] and is dependent upon the effectiveness of the user's information retrieval[188]. This becomes problematic in the realm of clinical medicine, where standard of care dictates that there be some baseline level of uniformity in clinical reasoning to ensure patient safety. Ensuring some baseline level of competency in information retrieval becomes crucial when considering the complexity of modern EHR systems, where it has already been demonstrated that end-user behavior is highly variable[67,69,134]. This research suggests that users take different pathways to arrive at a common endpoint. The information used and the time to complete the task may not differ, but the order in which the end product (clinical note) is created may differ depending on the user. One of Nielsen's five criteria for usability is affordance[30]. The different workflows described in this study support the need for interfaces to afford for 1) fluctuation between varying levels of certainty in the meaning-finding process and 2) a variety of approaches in clinical documentation.

Of note, significant differences were observed in the gender composition and self-rated computer experience level between Group 1 and Group 2. With respect to the gender difference, though the sample size of the current study is too small to draw firm conclusions from this observation, our results raise the question of whether different genders may

approach the tasks of EHR information gathering and documentation differently. Gender differences in clinical reasoning and information processing have been explored previously[189-195]. Myers-Levy's theory of selectivity and information-processing research in other disciplines suggest that women are more likely to employ elaborative information processing strategies regardless of the task complexity, whereas men are more likely to utilize heuristic processing strategies, only switching to elaborative strategies on more complex tasks[189-191,194]. Conversely, in the medical literature no significant gender-related difference has been found in diagnostic reasoning[195]. With the insertion of the EHR into clinical workflows we must consider the electronic interface as an additional layer of complexity. Research conducted on website audiences has shown that differences in perception and satisfaction can vary greatly among gender groups[196]. Females have demonstrated greater proficiency in computer display navigation and optical cue responsiveness on the screen[197]. Taken together, prior research suggests that there may be several factors that contribute to gender differences in EHR usage; further research is needed. With respect to the difference in self-rated computer experience, it is unclear whether this outcome is independent of the strong gender differences between the groups. Conflicting research exists on gender differences in perceptions of self-efficacy and attitudes toward computers[193,198]. If it is an independent outcome, it is not clear that the higher level of computer experience in Group 1 translated into better performance in the simulation task.

There are several important limitations to this study. First, though simulations were conducted in a high-fidelity environment, participants were aware that the cases were fictional patients. There were no actual patients to interact with and participants relied upon the content of the history of present illness, review of systems, and physical exam as it was documented in the EHR. Though this may have diminished the realism of the cases, it is

expected that it would exert a uniform effect on the participants. Cases were made to be slightly less complicated than the "average" patient seen at our institution, a tertiary care facility, for the purposes of simulation time. Second, interpretation of the eye tracking gaze data is still in its infancy in clinical informatics research, and it is unclear how well gazes and transitions represent clinical reasoning processes. Third, the notes created during the simulations were not evaluated for accuracy and completeness, thus we cannot comment on whether differences in search patterns affect clinical reasoning and medical decision making. Lastly, the study was conducted among one specialty of physicians at one institution.

Conclusion

This study demonstrates the presence of two information-gathering and documentation workflows among hospitalists using the EHR to admit a new patient. This has important implications for EHR interface design, specifically with respect to affordances for multiple information-gathering pathways. Future studies must continue to examine the workflow differences among individuals, specifically pertaining to note quality, clinical accuracy, and efficiency.

Tables and Figures

Table 1. Information Types. Twenty-one information types used in video coding.

1. Social history
2. Laboratory values, pathology, microscopy, cytology
3. Allergies
4. Procedure notes
5. Vital signs and weight
6. Outside records
7. Other
8. Past medical history
9. Imaging results and EKGs
10. Outpatient clinic note
11. Operative reports
12. Intake/output
13. Documentation (note)
14. Navigation
15. Past surgical history
16. Medication list
17. Inpatient clinic note
18. Problem list
19. Discharge summary
20. Documentation (non-note)
21. Family history

Table 2. Demographic and simulation characteristics. Characteristics of Group 1 and Group 2 members.

	Group 1 n = 8	Group 2 n = 9	p-value
Participant Characteristics			
Gender, % male	87.5%	33.3%	0.02*
Self-rated computer experience, level	2.5	2	0.03*
Years since medical school graduation	15.3	11.5	0.42
EpicCare experience, years	7.3	5.7	0.27
Simulation Characteristics			
Transitions	75.5	57.5	0.04*
Gazes	81.7	62.3	0.04*
Documentation, number of gazes	32.9	21.4	<0.01*
Navigation, number of gazes	17.6	17.8	0.47
Number of unique information types	12.5	12.4	0.85
Case length, mm:ss	25:29	24:29	0.72

Table 3. Representative quotations from semi-structured interviews.

Group 1
Early note composition, greater frequency of transitions between information types
"I often start my note right away as I go about my chart review."
"I tend to be non linear… I jump around."
"I usually start with a note because it autopopulates with the information I need."
Group 2
Information review with longer duration per screen and less transitions, followed by note composition
"I review all the current data, labs, and imaging. Then look at last clinic note, meds, and clinical history. I start writing a note after that."
"I look at the meds, prior notes and imaging, then start putting a note skeleton together."
"I do a quick review of the chart before I go see the patient. Then I build my problem list and when I create the note, it auto-imports the information I've collected."

Figure 2. Distribution of note start times.

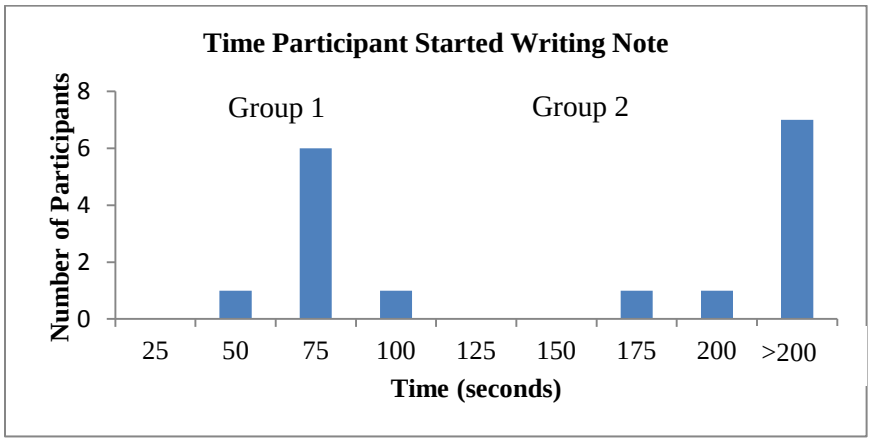
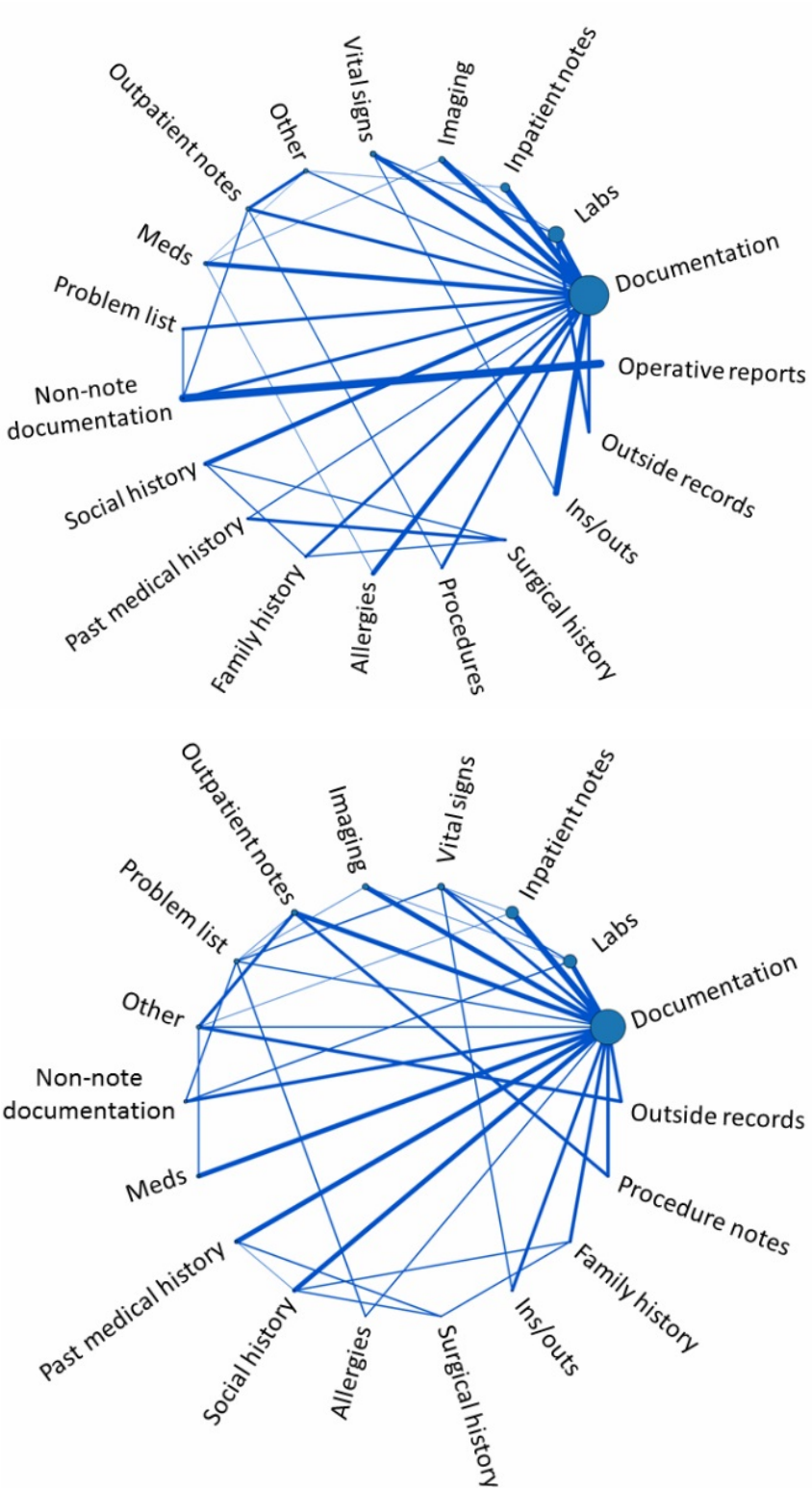


Figure 4a and b. Transition Diagram. Transition visualizations for Group 1 (top) and Group 2 (bottom).



CHAPTER SEVEN. DISCUSSION

Summary of Findings

In summary, we sought to characterize several aspects of the physician-EHR interaction. First, we used a case study approach, studying the field of pediatrics, to investigate physicians' typical EHR usage and workflow when evaluating a new patient across a variety of practice settings and clinical specialties (Aim 1a). We found that pediatricians acquire information about new patients from EHRs more often than any other source. Pediatricians also report important barriers to EHR usage, such as scattered data display and unintuitive system design. We also broadened this scope to look at work environment: inpatient versus ambulatory, specialist versus generalist, proceduralist versus non-proceduralist (Aim 1b). Specialists versus generalists and proceduralists versus non-proceduralists had significantly different perceptions of which elements of the EHR were most important and how well these systems were suited to displaying clinical information.

Second, we evaluated physicians' perceptions of EHR usefulness and current barriers to information access when evaluating a new patient across a variety of practice settings and clinical specialties (Aim 2). We found that barriers such as inefficient workflows, increased time demands, and inconsistent documentation practices exist in EHRs that prevent ideal information gathering when evaluating a new patient. Third, we explored and characterized distinct information-gathering workflow patterns in practicing hospitalists (Aim 3). Physicians exhibited at least two distinct information-gathering and documentation patterns despite no overall difference in case duration. There were strong similarities across the groups in the information types the physicians looked at most frequently. A majority of the case time was devoted to note composition in both groups.

Synthesis of Findings

A predominant trend throughout the survey results was the strong influence of practice setting on EHR usage and preferences. Pediatricians demonstrated distinct information type preferences depending upon their inpatient/ambulatory practice setting, and preferences reflected the clinical setting. A comparison of generalists and specialists showed not only differences in information type preferences, but also in attitudes regarding EHR usefulness and barriers to information access. These specialty-specific needs were well articulated in the free text comments used in the qualitative analysis. Overall, specialists preferred imaging results greatly, whereas generalists preferred medication lists and problem lists more greatly. Inpatient-based physicians preferred laboratory results and imaging, whereas ambulatory physicians were more focused on family history, social history, and problem lists. These findings add more specific knowledge to previously published findings regarding physicians' information preferences when evaluating a new patient[89].

In the debate over whether EHR systems should take the form of fully integrated "enterprise" systems or specialty-specific "best of breed" systems, these findings support a shift toward more specialty-specific EHRs that offer the seamless interoperability that is often perceived to be a trait of enterprise EHRs. This has been reflected in position statements released by several medical professional societies[47,53,56,58,59]. What our study adds is the further information about differences in perceived usefulness and barriers to information access among several parties that have advocated for specialty-specific systems. Namely, lower ratings among specialists and proceduralists suggest that inadequate information delivery to these groups likely negatively impact how physicians regard EHR efficacy and satisfaction.

Despite differences in EHR preferences among physician groups, several strong consistencies were found. They manifested in two major ways: 1) stated information type preferences and 2) actual measured information type usage. Across the groups surveyed, there was a uniformly strong preference for prior notes, chief complaint, past medical history, and history of present illness. These findings support previously published stated physician preferences[89]. When directly measured in the simulation, similar trends remained: prior notes, medications, laboratory results, and imaging were the most frequently gazed upon. In both the survey and the simulations, there was very little to no difference in strength of preference or usage among physicians of varying computer experience level, length of time since medical school graduation, gender, practice setting, and practice specialty. These profession-wide commonalities may be explained by some elements of uniformity the medical training process and/or universal features of clinical practice. Overall, there are several high-traffic EHR features that all physicians use somewhat heavily, and physicians' opinions on these features are constant. These findings suggest that physician advocacy efforts for improvement of these high-traffic features need not be defined by experience level or practice environment. One example of this action taking place is the advocacy work of the American College of Physicians, which represents a variety of internal medicine specialties as well as medicine generalists[69].

When taking into consideration the findings of the admission simulation study, another layer of complexity is added to physicians' overall needs for improved EHR design. Our results showed that although physicians used different workflows to complete the assigned task, there was no difference in the overall most frequented information types. In other words, certain content and layout is universally valued, but the means of access are not universal. Previous studies of provider workflows have not uncovered distinct differences in

workflow patterns between participants, only describing patterns in aggregate[67,199]. This suggests that not only do the high-traffic features need to be optimized for heavy use, but the software must facilitate access to these high-traffic areas from a number of different starting points. Our research only used one parameter to create workflow classifications: information-gathering versus documentation. It is expected that if other parameters were used, many other workflow classifications would arise. For example, one could evaluate attention paid to narrative information versus tabular or graphical information. Usage of screens may also elucidate distinct user types. Zheng et al has successfully employed sequential pattern analysis (SPA) using a similar information type classification scheme to ours to optimize provider workflow through a reengineered user interface[67]. The findings would likely show that each individual physicians' workflow tendencies are multidimensional and unique (e.g., an early note-starter may not fall into the same group with respect to narrative versus tabular information compared to his fellow early note-starters). The features and allowances of an EHR system may, in turn, affect each user differently. Evaluating workflows from several perspectives is necessary to uncover hindrances embedded in the EHR design that may not be apparent when focusing on individual, static screens. It also raises the question of how customizable systems should be for individual users. In light of the simulation findings, and the potential existence of a multitude of workflow types, it is likely that a high level of customizability is beneficial.

A major unexpected theme throughout the studies was the burden of documentation, or note writing, on the clinical workflow. Previous studies evaluating EHR workflow have identified it as a major element of providers' work, but have not quantified the overwhelmingly disproportionate amount of time spent on clinical documentation that was found by us[199]. This was most pronounced in the qualitative and simulation studies. The

task of note writing has become more elaborate and time-consuming compared to documentation in the era of paper records. In the simulations, time devoted to documentation greatly outweighed time devoted to reviewing any information type. We learned from the qualitative study that this time impact negatively affected time spent seeing patients, doing other clinical work, and even personal time (i.e., nights and weekends). Documentation time is not the only challenge. Inconsistency in documentation quality causes users to be frustrated when extracting data from a note. This quality can be compromised due to overuse of documentation shortcuts such as copy-paste/copy-forward and automated note templates. The findings of our research adds to the body of documentation knowledge in two ways: first, by directly measuring the time burden of electronic documentation during a new patient encounter; and second, by showing how physician frustration with documentation can corrode professional satisfaction and relationships.

Limitations

Selection and Precision of Measurement Instruments

Said Emmet, "We must beware always of thinking that because a word exists the 'thing' for which that word is supposed to stand necessarily exists too."[200] We have conducted research based upon the assumption that measurements exist for abstract concepts such as physician preference, need, and cognitive input. We must accept that the assignment of numbers to these concepts may very well be imprecise, and interpret their results accordingly. This represents, in part, the limitations of current research to understand these concepts. We are responsible for selecting the best means of measurement and conducting the measurement as accurately as possible, given the research question. Efforts

have been made in this series of inquiries to appropriately select and execute the research methods. A triangulated approach was employed to ensure that the veracity and dimensionality of the results was adequately captured. Moving forward, we must be cognizant of the effect that operationalization has on biomedical research, and frame our research questions and methods accordingly[201].

By the same token, the characteristics of the concepts of interest can be measured imperfectly – "we should not expect complete congruence between a measure and truth"[201]. This relates to reliability, or the extent to which the repeated use of a measure yields the same values when no change has occurred, and validity, the extent to which a measure is an accurate representation of the concept it is meant to measure[201]. The research studies described in this work employed survey, semi-structured interview, and eye-tracking methods. All three methods must be presumed to have some degree of imprecision, though it is not clear just how imprecise each of them are. Web-based surveys have accuracy that is highly dependent upon survey validation and reliability[202], which was established during the creation of our survey. Research suggests that other factors that influence accuracy include using probability sampling, and lower completion and response rates[202]. This is contrary to classic survey wisdom and is likely highly dependent upon the population and surveying method. Cell phone surveys are showing improved accuracy over web-based surveys and represent a future possibility for work of this kind[203]. With regard to eye-tracking, studies of temporal characteristics of eye movements have established fixations lasting greater than or equal to 100 milliseconds as an 'industry standard[179].' Tobii Systems has released a methodology guide for maximizing accuracy using their systems[204]. This includes eye calibration, head position, gaze angle, and lab illumination parameters. All of these parameters were followed closely during the execution of our study. These are estimations

based upon a broad sample of studies, and it is unclear where the precision of these instruments fall with respect to the specific research questions studied.

Future Directions

This work explored several aspects of the physician-EHR interaction and can be expanded upon in several ways. First, survey data reflected physicians' behaviors, preferences, and attitudes in one point in time. Redistributing the survey in 5-10 years, when EHR adoption will likely be closer to 100%, will help us understand whether continued improvement of the EHR has translated into improved usefulness and satisfaction. Second, the simulations were only conducted on physicians belonging to one clinical specialty (hospital medicine). To evaluate the generalizability of our results, and potentially find interesting differences between physician groups, physicians of other specialties will need to be studied in the same way. The natural choice is to expand the simulations to pediatricians, medical specialists, and surgical specialists to adequately cover the groups focused upon in the survey. Third, the clinical notes generated from the simulations must be examined for quality as well as agreement/disagreement with information-gathering patterns. Lastly, the possibilities for physician-EHR simulation studies are vast. Of particular interest to this researcher is the impact of EHR layout on documentation quality and efficiency and the role of clinical distractions in documentation workflow. Several elements of EHR usability were not studied here, and need to be conducted in order to have evidence-driven EHR interface design.

The natural questions of how to improve EHRs will shift as systems become more advanced. In the last decade, we have seen a shift in the literature from barriers to implementation to how to fix the problems in current EHRs that a majority of health care

organizations now use. As usability and function flaws are corrected, the national dialogue will shift toward how to meaningfully use EHRs to improve the health of patients and populations. Provider efficiency, particularly around documentation, is still a major hurdle that would benefit from further workflow studies. Work is currently underway at OHSU evaluating clinician workflow on a macroscopic level, looking at length of patient visits and ways to optimize provider-patient interaction while minimizing patient wait time. As the center of the modern health care team, the EHR stands to play a significant role in helping to optimize the flow of patients in the clinic. This is still largely unexplored.

Chapter Eight. Conclusion

EHR adoption rates rose sharply in the early 2000s as a result of federal incentives and wide acclaim for the potential positive effects of EHRs on physician efficiency, quality care delivery, and patient safety. In light of untoward effects on patient care that were observed following EHR implementations, questions arose regarding EHRs' true impact on clinical workflow and medical care. In particular, lagging adoption rates among pediatricians and specialists compared to generalists suggested inequities in the ability of EHRs to meet all physicians' information needs. Furthermore, end-user behavior and training were found to be highly variable despite the need for clinicians to be able to access the same key clinical data.

Our research found that significant variability exists in how physicians use the EHR in their sequence of providing patient care, how long they took to do so, and what sections of the EHR they preferred or found helpful. There were clear distinctions in these parameters based upon practice setting and type. Overall, however, certain core elements of the EHR were universally valued; these elements, such as chief complaint, past medical history, and history of present illness, are irrefutably essential to most any patient narrative. We found that physicians access information and create documentation using at least two different types of workflows. Further research is needed to evaluate the multitude of characteristics that providers' workflows have. Effective EHR design must afford for a variety of workflow types to be widely usable. Lastly, documentation in the EHR is a burdensome practice for physicians to both create and extract meaningful information from. This burden must be alleviated in order for physicians to be able to focus on building therapeutic relationships with their patients. This research lays some of the foundational knowledge necessary to engage in the provider-centered design process.

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APPENDIX ONE. SURVEY

Electronic Health Record (EHR) New Patient Information Gathering Behaviors & Attitudes Survey

Question 1

Are you a practicing physician (M.D., D.O., or equivalent)?

* must provide value

- ○ Yes
- ○ No

Question 2

What is your main clinical department?

* must provide value

Question 3

What is your main clinical subspecialty?

* must provide value

Question 4

What is your gender? (Choose one)

* must provide value

- ○ Male
- ○ Female

Question 5

What is your level of experience with computers?

* must provide value

- ○ Not experienced (e.g., browse web, check email, or less)
- ○ Somewhat experienced (e.g., edit photos, use spreadsheet)
- ○ Very experienced (e.g., create web page, write computer programs, or more)

Question 6

What is your current level of medical experience?

* must provide value

- ○ Resident
- ○ Fellow
- ○ Attending physician

Question 7

Please enter the year you graduated medical school.

* must provide value

Enter 4-digit year

Question 8

Do you use electronic health records (EHRs) regularly?

* must provide value

- ○ Yes
- ○ No

Question 9

Please indicate all of the systems you have used for clinical care.

- ☐ EpicCare (Epic Systems Corporation)
- ☐ CPRS/VISTA (Veterans Affairs)
- ☐ Cerner
- ☐ MEDITECH
- ☐ Allscripts
- ☐ eClinicalWorks
- ☐ NextGen Healthcare
- ☐ Centricity (GE Healthcare)
- ☐ PrimeSUITE (Greenway)
- ☐ Practice Fusion
- ☐ Horizon Clinicals (McKesson)
- ☐ athenaClinicals
- ☐ e-MDs
- ☐ Can't remember the name
- ☐ Other

Question 10

Of the EHR systems you selected, which do you use the most? Please refer to your experiences using this system when answering the rest of the survey.

Question 11

Do you spend the majority of your working clinical time in the ambulatory or inpatient setting?

* must provide value

- ○ Ambulatory
- ○ Inpatient

reset

Please refer to your selection when answering the rest of the survey.

Next Section Header

For the rest of this survey, imagine that you are asked to see a new patient. You do not know anything about this patient yet. The rest of the questions in this survey refer to your information gathering activities, and not documentation activities.

Please answer the questions using the practice setting you selected previously (ambulatory or inpatient).

Question 12

Where do you most often get initial information about a new patient? (Select one)

- ○ Other physician (e.g., referring provider)
- ○ Patient chart
- ○ The Patient
- ○ Technician or other ancillary staff
- ○ Other

Question 13

When do you most often initially review the patient's medical record?

* must provide value

- ○ Before entering patient room
- ○ In the room with the patient
- ○ After exiting patient room

Question 14

How long is this first review of the patient's medical record?

- ○ 0-2 minutes
- ○ >2-5 minutes
- ○ >5-10 minutes
- ○ >10 minutes

Question 15

What information is most important to you to know about a new patient? Please select the top 5.

* must provide value

- ☐ Chief complaint/reason for consultation
- ☐ History of present illness
- ☐ Problem list
- ☐ Past medical history
- ☐ Past surgical history
- ☐ Social history
- ☐ Family history
- ☐ Medication list
- ☐ Allergy list
- ☐ Laboratory values
- ☐ Imaging results
- ☐ Previous clinic note assessment & plan
- ☐ Other

Question 16

Of the top 5 selected, please rank them in order of importance, with 1 being most important and 5 being least important.	
Past medical history	▼
Past surgical history	▼
Social history	▼
Family history	▼
Medication list	▼

Question 17

In the EHR that you use, please indicate how good each section of the system is at displaying the information you need (1 = very good, 3 = neutral, 5 = very bad).							
	1, Very good	2	3, Neutral	4	5, Very bad	N/A, Not a feature of my EHR	
Inpatient admission note (H&P)	○	○	○	○	○	○	reset
Outpatient clinic notes	○	○	○	○	○	○	reset
Inpatient progress notes	○	○	○	○	○	○	reset
Procedure notes	○	○	○	○	○	○	reset
Operative reports	○	○	○	○	○	○	reset
Medication list	○	○	○	○	○	○	reset
Problem list	○	○	○	○	○	○	reset
Laboratory values	○	○	○	○	○	○	reset
Imaging results (in the EHR)	○	○	○	○	○	○	reset
Vital signs	○	○	○	○	○	○	reset
ICU bedside data (Ins/outs, ventilator, telemetry)	○	○	○	○	○	○	reset
Discharge summary	○	○	○	○	○	○	reset

Question 18

The following are potential barriers to physicians obtaining the information they need in the EHR. Please rate the severity of these barriers in preventing you from getting the information you are looking for. (1 = not a barrier, 3 = moderate barrier, 5 = severe barrier)

	1, Not a barrier	2	3, Moderate barrier	4	5, Severe barrier	N/A, Not a feature of my EHR	
Information I need is not in the chart	○	○	○	○	○	○	reset
I can't find it in the chart	○	○	○	○	○	○	reset
Information is poorly displayed/difficult to interpret	○	○	○	○	○	○	reset
Too much information	○	○	○	○	○	○	reset
Information in the chart is inaccurate	○	○	○	○	○	○	reset
Others don't record information consistently	○	○	○	○	○	○	reset
Other	○	○	○	○	○	○	reset

Question 19 and Conclusion

OPTIONAL: Please share any comments you may have about any of the specific questions or about physicians' information needs in general.

Expand

This concludes the survey. Thank you for your time.