The Effect of Electronic Health Records On Undergraduate and Postgraduate Medical Education: A Scoping Review

by

Ahmed Hadi Ali Omar

A thesis submitted in conformity with the requirements for the degree of Master of Science
Institute of Medical Science
University of Toronto

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2019

Abstract

Background: There is limited educational research on how EHRs impact medical education (MedEd). The purpose of our scoping review was to systematically examine the literature to help map and analyze the role of EHRs in MedEd.

Methods: Five databases were searched, and after screening 9186 citations, 82 articles were included in the final review for a quantitative and thematic analysis.

Results: Most articles were from the United States (85.4 %) and were descriptive (67.1%), with lack of longitudinal and theory-guided educational research. Residents spend substantial amounts of time using EHRs, with effects on workflow, documentation and communication. For medical students, main concerns included access to EHRs, with curricular development still lacking definition and standardization of EHR-related competencies and learning outcomes.

Conclusion: There is a lack of research related to EHRs effect on MedEd. Collaboration between medical educators, health informaticians, clinicians and learners is needed to help optimize EHRs that facilitate student and resident learning.
Acknowledgements

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<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ACE</td>
<td>Alliance for clinical education</td>
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<tr>
<td>ACGME</td>
<td>Accreditation Council for Graduate Medical Education</td>
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<tr>
<td>AI</td>
<td>Artificial intelligence</td>
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<tr>
<td>ASMT</td>
<td>Assessment</td>
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<tr>
<td>CCS</td>
<td>Clinical Classification Software</td>
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<tr>
<td>CDSS</td>
<td>Clinical decision support system/software</td>
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<tr>
<td>COMU</td>
<td>Communication</td>
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<tr>
<td>CPOE</td>
<td>Computerized Physician Order Entry</td>
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<tr>
<td>CT</td>
<td>Computed Tomography</td>
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<tr>
<td>DOC</td>
<td>Documentation</td>
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<tr>
<td>ED</td>
<td>Emergency Department</td>
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<tr>
<td>EDIS</td>
<td>Emergency Department Information System</td>
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<tr>
<td>EHR</td>
<td>Electronic Health Record</td>
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<td>EMR</td>
<td>Electronic Medical Record</td>
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<tr>
<td>EPR</td>
<td>Electronic Patient Record</td>
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<tr>
<td>HIT</td>
<td>Health Information Technology</td>
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<tr>
<td>HITECH</td>
<td>Health Information Technology for Economic and Clinical Health Act</td>
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<tr>
<td>ICD-9</td>
<td>International Classification of Diseases 9</td>
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<tr>
<td>ICU</td>
<td>Intensive Care Unit</td>
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<tr>
<td>IM</td>
<td>Internal Medicine</td>
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<tr>
<td>IT</td>
<td>Information Technology</td>
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<td>KNO</td>
<td>Knowledge</td>
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<tr>
<td>LC</td>
<td>Light coupling</td>
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<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>LCME</td>
<td>Liaison Committee on Medical Education</td>
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<tr>
<td>Med Ed</td>
<td>Medical Education</td>
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<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
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<tr>
<td>OSCE</td>
<td>Objective Structured Clinical Examination</td>
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<tr>
<td>PG</td>
<td>Postgraduate</td>
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<td>PGME</td>
<td>Postgraduate Medical Education</td>
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<tr>
<td>PHR</td>
<td>Personal Health Record</td>
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<tr>
<td>POMR</td>
<td>Problem-Oriented Medical Record</td>
</tr>
<tr>
<td>PRISMA</td>
<td>Preferred Reporting Items for Systematic Reviews and Meta Analyses</td>
</tr>
<tr>
<td>PST</td>
<td>Problem, Symptom and Treatment</td>
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<tr>
<td>RCT</td>
<td>Randomized Controlled Trial</td>
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<tr>
<td>RIME</td>
<td>Reporter, Interpreter, Manager, Educator</td>
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<tr>
<td>SBT</td>
<td>Simulation Based Training</td>
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<tr>
<td>SOAP</td>
<td>Subjective, Objective, Assessment, and Plan</td>
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<tr>
<td>SPSS</td>
<td>Statistical Package of Social Science</td>
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<tr>
<td>TC</td>
<td>Tight Coupling</td>
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<td>TCP</td>
<td>Tri-Council Policy Statement</td>
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<td>Ti</td>
<td>Title</td>
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<tr>
<td>TRN/SIM</td>
<td>Training and Simulation</td>
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<tr>
<td>UG</td>
<td>Undergraduate</td>
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<td>US</td>
<td>United States</td>
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<tr>
<td>USA</td>
<td>United States of America</td>
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<td>VP</td>
<td>Virtual Patient</td>
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<td>WF</td>
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Chapter 1

Background and Literature Review

1.1 Introduction

This chapter explores the literature base in relation to electronic health records (EHRs) in relation to undergraduate and postgraduate medical education. In order to contextualize the effect and role of EHRs in medical education, the history of medical records in general and their use in educational settings will also be explored, including how they evolved into the current electronic form. This will help to better understand how the medical record developed into a core educational instrument. I will review how medical education and in particular how medical students, have influenced the inception, innovation and evolution of traditional medical records over the centuries, particularly over the last few decades leading to the development of EHRs.

I will then explore current and prevailing opinions on the EHR’s role and effect on medical education and associated challenges. This will include the rationale for my research interest, which mainly deals with the aim of better defining and updating what we know about the current literature landscape for this particular topic area. There still remain many educational questions pertaining to how EHRs impact students and residents during their training. Although reviews discussing this subject have previously been published, there is a need for an updated review that employs a comprehensive and systematic approach to define the research landscape in terms of EHR systems and medical education. I will end this chapter with an outline of my formal research question and objectives which will help guide my scoping review.
1.2 Literature review introduction

In the last few decades electronic health records (EHRs) have transformed how clinical care is delivered. Health information technology’s development has mirrored the overall impressive technological developments during this period, making the resulting tools indispensable in the everyday work of healthcare providers. In essence, these technological tools, which include EHRs, are quickly becoming as foundational as the bricks-and-mortar of the institutions that house them. Thus it is vital that we do not ignore their effects, especially as EHR systems have progressively become an essential part of the healthcare infrastructure (R. H. Ellaway, Graves, & Greene, 2013).

The benefits of EHRs have advanced both clinical and administrative work and, with appropriate implementation, they have the potential to improve workflow, provider efficiency and clinical safety (Reis et al., 2013). Furthermore, EHRs have the potential to enrich healthcare-related research, both clinical and biomedical, and this potential is further enhanced by the incorporation of other data sources such as lab based and genomic data. These data combinations coupled with rapidly developing data mining software, will help to transform medical research (Jensen, Jensen, & Brunak, 2012).

EHRs have also been touted to have educational benefit, alongside their overall clinical benefits, these systems are also significantly changing educational environments, offering exciting research and scholarly prospects to transform resident and student education (Adibe & Jain, 2010). EHRs are transforming trainee and student workflows and have challenged conventional roles and practices. Traditionally, students and residents, used to spend significant amounts of their time acquiring clinical information, to be used during their supervised consultant ward rounds or ambulatory sessions. Currently, this crucial clinical data is instantly available by a click of a button or a touch of a screen (Mohan, Woodcock et al. 2016).
Other perceived EHR benefits will be outlined later in this chapter. However, with these benefits come challenges that also need to be considered. As established physicians still grapple to learn how better to use, operationalize and integrate these tools, medical students will increasingly graduate into this rapidly developing digital environment. Not only do such technological environments challenge traditional teaching and learning paradigms, the rapid nature of these advancements makes it difficult to establish grounding and thus makes it more difficult to keep pace with and study the effects of such technological tools on its users. This concern is important to realize, especially when considering how to adequately prepare medical students and residents to work in such environments.

Examples of ongoing concerns include how EHRs affect learner time. The benefit of rapid data acquisition does not necessarily equate to overall time savings. EHR-related advantages in certain aspects of healthcare work-flow have to be weighed against the new problem of learners and clinicians having to deal with vast amounts of clinical information created by these EHR systems which in itself is very much time consuming (Block et al., 2013). This is contrary to what was originally anticipated, when it was thought that immediate access to patient related data would create more time for trainees to see patients and improve their clinical skills. There is growing evidence to suggest this, with trainees spending increasing amounts of time on EHR systems since they have to deal with large amounts of rapidly changing patient information (Chen et al., 2016a).

Other EHR-related educational effects and challenges will be discussed in this chapter and overall thesis, but there is a recognized and growing need to better design and implement these technologies so that both students and established practitioners can benefit from them from an educational perspective (Pageler, Friedman, & Longhurst, 2013). Thus it is vital that we do not ignore their effects, especially as EHR systems have progressively become an essential part of the healthcare infrastructure (R. H. Ellaway et al., 2013).

To better contextualize the effect and role of EHR systems in medical education, it is important to appreciate the overall nature of the “medical record” and its relation to medical education, regardless
of its physical format, whether paper or electronic. Thus, the initial parts of this chapter will provide an important historical context of the actual “medical record”. This will be a focus on the historical development of the medical record and how it was closely tied to medical education from the beginning, demonstrating that the medical record evolution was a gradual process, taking decades if not more, to mature into the medical record we use today. In a sense, the field of medical education matured in parallel with the medical record, indicating their shared history and mutual influences.

1.3 Definition and function of the medical record

To facilitate understanding the issues, it is important to define what a medical record is from the outset, regardless of what form it takes. The medical record is essentially a repository that contains facts and information about a patient’s health-related status. A medical record has to contain:

“Sufficient data to identify the patient, support the diagnosis or reason for attendance at the health care facility, justify the treatment and accurately document the results of that treatment”. (Huffman, Finnegan, & Amatayakul, 1990)

The medical record, at minimum, should provide the following content: i) Accurate information on the identity of patient and the persons treating him or her; ii) What, when, where and why a certain clinical care was provided and iii) the outcome of any interventions. In addition to clinical information, medical records often contain administrative (demographics, identification details etc.), legal, financial and financial data. (World Health Organization & Regional Office for the Western Pacific, 2006).

As such, the medical record has essential functions from a clinical and educational perspective, which is related to documentation of patient history and progress, and it also serves as an essential communication tool facilitating patient continuation of care. Medical records also have well-established research functions as the data content is often used to help enrich clinical research. Last but not least, medical records have a very important educational role. (Gillum 2013), (Pacific 2006).
The educational role will be explored in detail throughout this thesis, but in summary, formulating and maintaining a medical record is one of the crucial skills that medical students and residents begin to learn at from the beginning of their educational journey. The crafting of the patient’s initial story, as well as their progress is an essential skill that not only provides training in accurate documentation, but also allows students to purposely reflect on the patient’s presentation and ultimately formulate a constructive narrative that can be useful to themselves and their colleagues (Gliatto, Masters, & Karani, 2009). The learners’ notes also provides an opportunity for educators and clinical supervisors to review their learner’s notes for formal and informal feedback and evaluation, a process that can assist in focused learning and ultimately also help in the development of clinical reasoning (Gliatto et al., 2009).

This educational function of medical records has long been recognized from a historical perspective and continues to be well established in education settings until today. In the next section, the history of the medical record will be further explored in more detail.

1.4 The history of the medical record and medical education

The medical record is not a new construct and from its early inception it has been intimately associated with medical education and teaching hospitals (Reiser, 2009) (Gillum, 2013). There is historical evidence showing that medical records, from the beginning, were developed to document interesting medical cases for didactic purposes, whether in ancient Egypt, Greece, or later on in the medieval period. As an example of this, Arab physicians during the middle ages constructed patient records by collecting and developing case histories for teaching purposes (Gillum, 2013).

Historically, physicians would keep their own personal notes about their patients, with no deliberate effort to produce institutionally based hospital or clinic medical records. This conduct slowly changed as more institutions began to demand that physicians and trainees keep hospital-based medical records. As such, during the 18th Century, both in Europe and America, retrospective patient notes began appearing. With time, this continued to mature and the medical record became more
organised, with medical students and trainees having a significant role in curating and maintaining them (Reiser, 2009).

As the twentieth century dawned, important figures emerged who revolutionized how we view and use medical records as educational tools. Walter Bradford Canon, (1871-1945), a medical student at Harvard University, who later became a world-renowned physiologist, questioned traditional medical education. He was concerned about inadequate patient numbers that students were exposed to, and their lack of patient continuity and follow-up. Furthermore, he was concerned about an over-reliance on lecture-based teaching instead of real life patient case-based teaching. To help remedy this, he suggested an ingenious solution in a paper he wrote in 1900. In it, he suggested that patient records could be used as a key instrument for teaching students. The following quote from Dr. Cannon illustrates his remarkable vision for his time, in which he explains why records can be a useful educational tool (Reiser, 2009):

“Cases of all the types, variations and complications of almost every disease are to be found in hospital records or in records of the private practice of instructors. These records include a history of family tendencies, notes of previous illness, an account of the onset of the attack, the results of physical examination at the hospital, the story of the ups and downs in the course of the disease, the treatment with its modifications as the symptoms changed, and, in case of death, possibly the findings of autopsy.”

Although one can easily take this proposition of using medical records as a teaching aid and repository for granted today, Cannon’s insight is better appreciated if one understands that this concept was fairly novel at the time. He effectively explained the function and structure of such records in his observation. This helped to further develop the medical record and with time, it slowly became more recognized as an educational tool over the subsequent years. This focus of the actual structure of notes will be explored in more detail the next section.

Another historical figure who influenced medical education last century was Abraham Flexner (1866–1959). In his now famous report, he was in fact was also one of the first people to formally
discuss the function and content of medical records in an educational setting (Shortliffe & Cimino, 2014).

In his report, Flexner, when evaluating the medical schools of North America, repeatedly questioned whether students had access to medical (hospital) records. Furthermore, he also reported on whether students were able to participate in formulating records and also commented on how “systemic” and adequate the records were. In essence, he used the medical record as one of the main assessment tools to evaluate the level of teaching and healthcare impact. (Flexner 1910).

To further illustrate this, the following is a quote from his report, when commenting on the importance of full records:

“…..Nor are loose habits, thus contracted, cured by an internship. Pupils are more apt to disappoint than to astonish their teachers; they do not generally better their instruction. In consequence hospital records made by interns graduated by these schools are scant and unsystematic. Defective methods at the University of Buffalo were extenuated on the plea that as interns they learn better; but the meager records of the Buffalo General Hospital disprove the claim. Whoever is responsible, poorly kept records are very apt to denote inferior bedside instruction. The situation is this: there lies the patient; teacher, interne, and students surround the bed. The case is up for discussion. A question arises that requires for its settlement now a detail of the patient’s previous history, now a point covered by the original physical examination, now something brought out by microscopic examination at some time in the course of the disease. If complete, accurate, and systematic records hang at the bedside, there is an inducement to ask questions; doubtful matters can be cleared up as fast as they are suggested. That, then, is the place for the records, full records, at that.”

(Flexner 1910)

His attention to student access to notes is an important lesson for us even today, as this remains a relevant issue even today with the advent of EHRs. As will be discussed in other sections, there is ongoing debate on how and when should students access EHRs (Welcher, Hersh, Takesue, Stagg Elliott, & Hawkins, 2018).
1.4.1 The medical record as a single “unit” and standardization

Prior to considering the next step in the record’s evolution as an educational tool, the development of the actual structure and organization of health records should be addressed.

An important aspect of the medical record’s development in the 20th Century was the focus on its quality. During this time, there were increasing calls for better organized and more structured charts. For example, previously, a medical record for a single patient would be scattered amongst the various specialties and hospital departments. This made the process of tracking and studying patients tedious and fraught with inaccuracies. In 1907, the Mayo Clinic, influenced by practices from business, began to assign each patient a “single unit” number and record, in effect, for the first time, combining all the relevant data in one single place (Gillum, 2013) (Reiser, 2009).

The idea was further developed in 1916 by Presbyterian Hospital in New York, with rules on how to structure the record and the demand to have a formal requirement to provide certain clinical data structured in a standard format. Having a unit medical record was not enough. The requirement to have this better structure and “standardization” of clinical information was to overcome marked deficiencies in the medical entries. Many notes were found to either completely skip documentation of important clinical events or procedures, or to contain minimal information. Subsequently, more hospitals and official bodies pushed for reform and began to demand and expect well kept records that followed specified quality standards (Gillum, 2013; Reiser, 2009; E. L. Siegler, 2010). This idea of quality standards and standardization would have an important influence on EHRs.

1.4.2 Problem-Oriented Medical Record (POMR)

The next major milestone in the medical record development was the “problem-oriented medical record” (POMR). When POMR’s appeared during the late 1960s, this revolutionary idea, was again stimulated by interactions with medical students (Jacobs 2009). Dr. Lawrence Weed (1923-2017) was the pioneering figure behind this idea, and like Walter Bradford Cannon before him, he also greatly influenced the way we view and construct medical records, especially from the educational aspect. The significance of this development is also related to the fact it also directly influenced how
computerized records were organized, something that Dr. Weed realized and predicted at the time (Jacobs, 2009; Weed, 1968).

In terms of how the idea came about in the 1960’s, Dr. Weed, when interacting with medical students and physicians, recognized the need to better structure and organise complex clinical problems to help students and residents better understand patients, and to prioritize their multiple problems. Exploiting his previous experience in dealing with how scientific problems were presented as a postgraduate student in biochemistry, he developed the concept of the POMR (Jacobs, 2009; Weed, 1968).

In terms of what advantages POMR possessed and what they represent, they are a method of recording data about the health status of a patient in a “problem-solving” manner. This form of data organization is meant to be easily accessible and to motivate ongoing assessment and revision of the healthcare plan by organizing and structuring the data around specific and identifiable patient-related problems. It also allows for better continuity of care (an important domain of medical records) and the potential for their use by subsequent physicians and learners as it allows for easier communication of the problems at hand. Additionally, these records can be better suited for feedback and auditing as it provides clear and identifiable problems and thus data points that can assessed and followed. Dr. Weed also hoped that such a problem-focused approach could stimulate basic scientists to become more engaged in collaborative work with clinicians as it aligns with the way they deal with and organize scientific data (Weed, 1968).

In respect to the structure of the POMR, there are varying interpretations and implementations of the POMR, but the core components are: 1) the database (history, physical examination, lab-related data etc.); 2) the patient problem list; 3) plan of action for each recognised problem; 4) daily progress note; 5) final progress note and 6) the discharge summary. It also purposefully incorporates the patient’s psychiatric, demographic and social data, something often taken for granted today, but which actually was a novel innovation at the time (Weed, 1968).
This novel idea quickly gained world-wide acceptance as physicians and educators began to realize how impactful this innovation was (Hurst, 1971; Jacobs, 2009). This logical concept was timely, as the idea of computerized records began to surface in the 1960’s and the first operational electronic prototypes were developed and utilized in real world settings during the early 1970’s. The logical structure of the POMR was perfectly suited for electronic records and this suitability was explicitly mentioned in Dr. Weed’s seminal paper that introduced the concept of POMRs and which also predicted the eventual transition to computerized records which began to appear in the 1970’s as prototypes, and then as functional “real world” tools in the 1980’s and beyond (Jacobs, 2009; Shortliffe & Cimino, 2014; Weed, 1968).

1.4.3 Key lessons learned from medical record history

As illustrated, one of the main historical points in the evolution of medical records was that medical students and trainees proved to be one of the major innovation drivers. This is important because these groups are intimately aware of their working and learning environments and over time, their input has lead to positive and meaningful improvements in health records. However, as medical records evolved and became computerized, and thus more sophisticated, there seems to be a growing divergence from this pattern of direct clinician influence. This divergence has been a concern for researchers in the field, as they realize the importance and benefits of continued physician and healthcare providers input in the development of electronic forms of health records. Thus, there is now active impetus for physicians (and also other important health care providers such as nurses) to sub-specialize in health informatics so they can continue to be involved in the EHR research, development and implementation. In fact there is now a board-certifiable subspecialty in the area, that seeks to drive physician specialization and also regulation in the field (Detmer, Munger, & Lehmann, 2010). With the revision of some of the historical lessons learned thus far, the next phase is more contemporary, which is the development of the Electronic health records.
Although this was not be covered in this thesis, it is also important to acknowledge the significant contributions of nursing to the evolution of the modern medical record as well, such as the contributions of pioneering figures like Florence Nightingale (Reiser 2009).

1.4.4 The advent of electronic health records

Operational EHRs made their debut in the early 1970's, mostly in America (USA), where most of the development was being done (Reiser, 2009). These early systems gradually evolved over the next two decades, and adoption levels were initially restricted given their expense and their relatively high end and expensive technical requirements during that period. This changed in the 1990's, when hardware became more powerful and importantly relatively cheaper. Thus by the late 1990's EHR systems were being progressively deployed, and were more increasingly used, especially in academic inpatient hospital settings.

Policy was a major driver of change and EHR adoption. In America as an example, adoption levels in ambulatory settings remained restricted until fairly recently, when the United State (US) Health Information Technology for Economic and Clinical Health Act (HITECH) initiative in 2009, which financially incentivised the adoption of EHRs according to certain set standards called “meaningful use”. The US government began to penalize users if they did not meet such standards after 2015 and this encouraged the rapid adoption rates which continues to this day (Blumenthal & Tavenner, 2010). Having explored briefly the historical context of medical records, the following sections provide an overview of EHRs, in terms of definition and clarification of related terms, structure, and function to allow for better understanding of the educational component.

1.5 Electronic health record definitions

It is useful to define the EHR and to describe its key components and functions. The continued and dynamic evolution of these systems over the years has lead to various technical and functional differences, which can make a comprehensive definition of these systems challenging. One useful working definition is the following:
“Electronic Health Record means a repository of patient data in digital form, stored and exchanged securely, and accessible by multiple authorized users. It contains retrospective, concurrent, and prospective information and its primary purpose is to support continuing, efficient and quality integrated health care” (Hayrinen, Saranto, & Nykanen, 2008).

As with all technology, as new developments and concepts arise, the components and functions of these systems will ultimately continue to develop.

1.5.1 Electronic health records versus electronic medical records and other terminology

Although EHR and electronic medical record (EMR) terminology are often used interchangeably, technically speaking, they are actually two different systems with overlapping features as explained by the following:

**E-Health:** Is an overarching and more encompassing term and has many definitions, including the useful version in the 2014 Royal college of Canada e-health CanMeds role report:

“eHealth is defined as the appropriate use of information and communication technologies for health service delivery, education, and research” (Ho, Ellaway, Littleford, Hayward, & Hurley, 2014).

Examples of eHealth would be that of EHRs, telemedicine, mobile communication facilitated Health (mHealth), and computerized decision support tools and order entry systems, and electronic prescribing applications are examples of e-Health technologies. The following sections will explore some these examples, primarily related to EHR systems. EHR functionalities will be further explored in section 1.5.3.

**Electronic Medical Records:** These are effectively the electronic version of the paper-record but have advantages over them. They store patient data and provide readily available electronic access to previous records and can improve medical care by through efficient access to relevant clinical and lab based data. These systems tend to reside within one medical institution or clinic and are not shared with other hospitals or providers. Thus data continuity stays within the same institution and not outside.
Electronic Health Records have the same functionalities as EMR systems, but they have broader reach. EHRs differ from EMRs, as they are designed to share health-related information across clinic and institutional boundaries, thus if these systems are adequately implemented, authorized users can even access them remotely, including from home. EHRs would often follow nationally agreed upon standards terms of how data is structured and utilized (Reddy et al., 2010).

Patient Health Records (PHR): These are data management systems that are designed for actual patient use. Patients have the ability to access and share their personal health information. Many institutions now provide access to PHR systems that provide their patients a secure method of retrieving their medical information, including clinical notes and investigation results, sometimes in a simplified manner and with educational components to facilitate their understanding of potentially clinical laboratory results or clinical concepts (Tang, Ash, Bates, Overhage, & Sands, 2006).

Computerized provider order entry (CPOE) applications: These applications allow health care workers to directly enter clinical orders via a computer system. Providers can electronically and potentially even remotely enter medication, admission, radiology, lab-based orders etc. as opposed to the traditional paper based or verbal systems (“Computerized Provider Order Entry | AHRQ National Resource Center; Health Information Technology: Best Practices Transforming Quality, Safety, and Efficiency,” n.d.). The theoretical advantages of these systems are that they facilitate order entry and reduce the potential for error as systems have computerized safety checks that can detect and warn of any potential errors. From an educational perspective, their benefit has been debated, especially in relation to the concern that they can potentially take more time to use. Furthermore, the function for certain pre-packaged order sets to automate order entry without the need to think of “what”, “why” and “how” to order clinically relevant interventions can constrain critical thinking and active learning by students and residents as will be explored in more detail later in this thesis (Knight, 2005).

Clinical Decision Support Systems (CDSS): While CDSS will not be specifically investigated and an individual entity in my study, only in relation to EHRs, it will be useful to define them, as they are
increasingly becoming an integral part of EHR systems. One widely cited definition of CDSS by (Wyatt & Spiegelhalter, 1991) is as follows:

“"Active knowledge systems which use two or more items of patient data to generate case-specific advice", in contrast to passive knowledge systems in which the user conducts the search through the system's knowledge”.

Despite their perceived efficiency and safety advantages, like CPOE systems, there is also educational concerns related to the automation of cognitive offloading that these systems can produce could impact active learning in medical students and residents (Knight, 2005).

1.5.2 What are the core EHR functionalities?

Both the definition and functionalities of EHR systems can differ according to vendor, with EHR capabilities evolving over the years. Initially, EHRs were seen as mere electronic versions of their traditional paper-based counterparts. As technology developed, new functionalities appeared, especially in terms of accessing patient results, sharing clinical information between healthcare providers and institutions and increasingly interactive functions such as newer advanced features like decision support aids, which aim to assist clinicians in making better clinical decisions and enhancing their workflow (Shortliffe & Cimino, 2014). It is useful to summarize the broad EHR functionalities in order the better understand how they can affect workflow, especially in relations to learners.

The Institute of Medicine (USA), produced a document in 2003 which outlines the main capabilities of EHR systems and this still remains relevant today (Institute of Medicine (US) Committee on Data Standards for Patient Safety, 2003). They outline eight core capabilities which are briefly described as follows:

1. Health information and data

One core attribute of EHR systems is to provide patient data, which is the raw material that allows for the other functionalities to occur. Readily available patient information facilitates clinical care and also patient safety, such as providing allergy alerts and timely clinical care reminders. Readily
accessible data also has the potential to avoid repetition and extra costs of re-ordering previous lab-based or radiology-based investigations.

One important downside to this information source is that it has the potential to be overwhelming. This is a significant issue which, as will be seen, can affect the medical education process and by extension learners. Information is readily available, but can be non-abating and excessive, potentially causing potential difficulties in processing and analyzing it in a practically relevant way. This information management component will be a major facet of my literature analysis. Figure 1 illustrates the main sources of EHR data.

2. Results management

EHR systems allow for timely, up-to-date collection of test results such as radiological and laboratory test reports. The added advantage of collecting all reports in one unit file that is accessible to all the authorized personal is that it allows for better coordination of care and as it avoids unnecessary repetition. These linkages should facilitate better and safer care, and ultimately better continuity and follow-up.

3. Order entry/management
Computerized order entry was introduced above. The main advantages of this application include:

**Safety:** Legibility reduces the risk of medication errors. Some systems also have built-in safety checks, such as allergy information, drug interaction calculators, dosing information and prompts to avoid prescribing errors.

**Cost and time saving:** The reduced paper and clerical work can lead to a decrease in consumables. Some systems have orders grouped in sets to facilitate more efficiency and accuracy. As previously mentioned, there are concerns that these systems can adversely affect students’ and residents’ ability to critically think about why and what to order when considering investigations and treatment (Knight, 2005). Despite this, there is also evidence to suggest that trainees do appreciate CPOE systems in optimizing their work–flow and efficiency (Rosenbloom, Talbert, & Aronsky, 2004).

### 4. Clinical Decision Support (CDS)

Decision support systems are increasingly being deployed and are rapidly developing. CDS is defined by Osheroff et al. (Osheroff & Healthcare Information and Management Systems Society, 2012) as a “process for enhancing health-related decisions and actions with pertinent, organized clinical knowledge and patient information to improve healthcare and healthcare delivery.”

Their aim is to provide intelligently tailored information and recommendations, specific to certain clinical contexts, with the goal of assisting health care providers in making clinical decisions and judgements. One apt way of defining the function of these systems is that they make the “right thing” easier to do, according to this, decisions support systems should perform the following five functions:

“Provide the **right information**, to the **right person**, in the **right format**, through the **right channel**, at the **right point** in workflow to improve health and health care decisions and outcomes”. (R. J. Campbell, 2013)

From an educational perspective, the way that CDSS affects student and resident education is debatable and there has been no in-depth research in the area. Despite this lack of research, these aids can improve work flow and adherence to certain clinical guidelines, but there is concern that
they can undermine the active thought process required for learning (Keenan, Nguyen, & Srinivasan, 2006). This is an important aspect that needs further research, as will be explored within this scoping review, as it is important to differentiate performance and actual learning within an EHR-related context, something that seems to be lacking within medical educational literature as will be detailed below.

5. **Electronic communication and connectivity**

Communication is an essential facet of medical care, both patient-physician and between professionals. The main concern related to this is how disruptive these systems can be towards how physicians and learners communicate with patients. (Crampton, Reis, & Shachak, 2016). This will be discussed in more detail later in this chapter.

EHR systems also have the potential to facilitate communication of relevant data to healthcare providers and other involved colleagues, via built-in or separate messaging systems which with ability to enhance continuation of care and facilitation of referrals (Halas, Singer, Styles, & Katz, 2015).

6. **Patient support**

Both computer-based educational initiatives and personal health records have been shown to benefit patients and promote health education (Tang et al., 2006) (Institute of Medicine (US) Committee on Data Standards for Patient Safety, 2003). It will be important to monitor how these systems develop to complement and facilitate patient-physician communication.

7. **Administrative processes**

As previously mentioned, the EHR systems collect essential administrative data that is often mandated by higher-level administration and governmental structures. This readily available data significantly reduces the amount of time required to garner such information, thus increasing administrative efficiency. They have also become important in appointment booking and scheduling.

8. **Reporting and population health management**

These systems are used for scheduling patient visits, tests and procedures. This also generates valuable and up-to-date data that could be utilized for auditing, health policy planners or potentially
and with ethical approval consideration of clinical trial participants. (Institute of Medicine (US) Committee on Data Standards for Patient Safety, 2003).

1.5.3 Differences between traditional paper records and EHR systems

The EHR shares many characteristics with a traditional paper-based record, but it is important to distinguish between the two formats. The EHR is not just a glorified version of the paper record but also extends the function of the traditional record. Table 1 summarizes the key differences.

Table 1.1 Major differences between Paper and Electronic Records

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Paper record</th>
<th>Electronic Health Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media</td>
<td>Restricted by paper medium.</td>
<td>Allows for textual data, but also multimedia, such as radiological images.</td>
</tr>
<tr>
<td>Accessibility</td>
<td>Restricted accessibility and previous records often stored off site, thus accessing them can take time.</td>
<td>Very accessible, and potentially across hospital boundaries if the system allows this</td>
</tr>
<tr>
<td>Information management</td>
<td>Patient data often limited and can be fragmented.</td>
<td>Potential for extensive data, often collected and stored over many years. Potential for information overload.</td>
</tr>
<tr>
<td>Organization</td>
<td>Potential for fragmentation across offices/sites with potential for data loss. Fragmentation could lead to inefficiency and repeated clinical testing or procedures.</td>
<td>Often organized and curated within one digital unit that is easily accessible.</td>
</tr>
<tr>
<td>Legibility</td>
<td>Historically a known problem, both in terms of text and the risk of physical degradation of record material.</td>
<td>Digitally stored information is more legible.</td>
</tr>
<tr>
<td>Cost</td>
<td>Less costly than EHR systems, although their storage does incur costs.</td>
<td>Can be very expensive to set-up and operationalize.</td>
</tr>
<tr>
<td>Risk of record loss</td>
<td>Risk of irreparable or complete physical damage to the record (fire, water damage etc.)</td>
<td>Risk of catastrophic software failure which could shut-down the system with potential for irreversible data loss</td>
</tr>
<tr>
<td>Privacy risks</td>
<td>Records can be stolen or copied, but this would have to be done physically and directly</td>
<td>Risk of privacy breach through unauthorized access or remote system hacking</td>
</tr>
</tbody>
</table>

*Adapted from (Shortliffe & Cimino, 2014).

Although EHRs are considered to be more legible, and provide readily available information, this information availability not without flaws. For example, some researchers have found that documentation inaccuracies tend to be higher in EHR systems as compared paper records as seen by
a study done by Yadav et al (Yadav et al., 2017). This maybe related to implementation measures and also documentation practices related to copy and paste phenomena, which will be further explored in later sections, especially from an educational perspective.

1.5.4 Use of EHR in inpatient versus ambulatory settings

Ambulatory based systems have developed in tandem with inpatient electronic records, however the penetration of the former was historically slower; nevertheless, their use is rising rapidly over the last few years, especially in the United States due to governmental requirements and incentives (Adler-Milstein et al., 2015; DesRoches et al., 2008; A. K. Jha et al., 2009) (Grabenbauer et al., 2011). Technically, hospital-based systems have to deal with a more complex and dynamic multi-disciplinary environments. Thus, it has more tailored tools, such as in-patient computer-ordering systems customized to the various ordering sets, such as radiology or in-patient medication orders. The intense nature of in-patient medicine is reflected in this structure, as it has to deal with sicker patients, with more information being generated, especially within a short period of time. Another important facet is the nature of accessing the interface. In-patient teams, including students and residents, tend to work on EHR terminals that are likely to be physically distant from patients. If they do access them in the presence of the patients, the context is during ward rounds, often involving multiple team members.

On the other hand, ambulatory systems can be either full-fledged EHR systems that have access to hospital records, or just local office EMR systems. Both are tailored to deal with outpatient medicine, thus there is more longitudinal information, often curated over many years. Ambulatory EHR systems are often equipped with tools to help doctors and trainees manage chronic disease, such as diabetes or hypertension (Rossi & Every, 1997). They often have decision support systems that help to tailor practice guidelines to specific patients. In terms of use in the clinical setting, they are often perceived as the third-person in the room, with multiple studies showing concern in terms of how it adversely affects communication (Alkureishi et al., 2016a; Shachak & Reis, 2009).
1.5.5 Advantages of electronic health records

Some benefits have already been described within the context of its core functionalities. The main emphasis of EHR design and incentivization is related to clinical outcomes, clinical safety and efficiency parameters (Chaudhry et al., 2006) (Menachemi & Collum, 2011).

The emphasis on these parameters is important to realize, as although these clinical and administrative goals could and often do overlap with medical educational goals, but there are still key differences to appreciate as seen during my review analysis. Clerical and administrative efficiency goals targeted at practicing physicians are often either intentionally or inadvertently applied to residents and increasingly students as well, with mixed results that do not necessarily mean they will garner the same benefits as independent physicians. For example, EHR usage with these clinically oriented goals but in an educational setting, as will be explained in subsequent sections, could lead to increased workflow and documentation burdens on learners using these EHRs, which can be to the detriment of the best use of their educational time and experience. The perceived benefits of EHRs in educational settings will be covered later on this chapter.

Returning to EHR-related advantages, especially from a clinical perspective, there is growing and consistent evidence that shows EHRs and their extended functionalities have increased clinical safety and efficiency measures, such as substantially reducing prescription errors (Bates et al., 1999) and increased adherence to medical guideline. Examples include evidence of increased vaccination rates (McDonald, Hui, & Tierney, 1992; Menachemi & Collum, 2011), diabetes, cardiovascular health guidance adherence and better inpatient care and outcomes (Reed et al., 2012), such as prescribing in patient Venous thromboembolism prophylaxis, with potential to save extra lives (Kucher et al., 2005). Conversely, there is also some evidence that EHRs do not lead to relevant improvements in outcomes in certain clinical settings (Wilson et al., 2015).

Other EHR advantages are related to administrative and broader societal benefit (Menachemi & Collum, 2011). Having such readily available access and legible past patient records and investigations avoids redundancy and repetition of clinical tests and EHRs have also cut down on
paper usage and by extension the costs of retrieval and transport of such records (Chang & Gupta, 2015; Chaudhry et al., 2006; Menachemi & Collum, 2011).

From a research perspective, the advantage of having vast amounts of EHR-stored information can be a potential gold mine for research and was one of the drivers of the 2009 legislation to implement EHR systems in the US, known as the Health Information Technology for Economic and Clinical Health Act (HITECH), (Chang & Gupta, 2015; Chaudhry et al., 2006; Menachemi & Collum, 2011). This benefit is poised to grow even more, with the imminent advancements of data and information management tools, such as AI augmented data mining tools which could not only transform clinical care and diagnosis, but also advance medical and scientific research, especially as it would enhance our potential for aggregating complex scientific data with the clinical EHR-related patient information. This with the increasing computational ability, will give us potential to decipher this complex information with promise to build new and ground-breaking health-related knowledge and scientific insights (Jiang et al., 2017).

1.5.6 Disadvantages of EHR usage

Although there is ample and growing evidence in terms of advantages as discussed in the last section, there are also disadvantages and drawbacks related to these systems, which could also act as barriers to their implementation.

One of the foremost concerns related to EHRs is expense. This is a commonly reported disadvantage of EHR systems, which is related to high set-up and maintenance costs, with large academic hospital implementation often requiring whole teams to ensure continuing functionality. Obtaining the necessary hardware and software can be very expensive and as there are no real future-proof systems and because technology tends to rapidly develop, there is also a significant cost in updating and maintaining these systems (Menachemi & Collum, 2011). These cost-related implications remain a major barrier of EHR acquisition and implementation.

Another often cited concern is related to workflow disruption, despite the covered evidence of certain EHR advantages in relation to certain aspects of workflow as covered previously. These
workflow-related concerns are a reoccurring theme, including within educational settings. As an example, learning how to use these systems takes time and this often leads to work related disruption, especially in the initial phases of EHR implementation when there is a steep learning curve for the end users, be it physicians or learners. Furthermore, this disruption in workflow could add to the expense of these systems during the initial phases related to lost productivity (Wang et al., 2003). Although such affects can be mitigated with increased experience and EHR training, other problems can contribute to workflow related problems. An example of this is evidence that increased administrative documentation done by clinicians leads to substantial workflow disruption, frustration and stress, with concern for burnout risk as will be explored in more detail in the review analysis and in the following section under medical education.

Privacy and EHR data security concerns are another disadvantage. With the vast amounts of patient related information stored in EHR systems comes great risk of privacy breaches. There have been instances of data-breachs in multiple settings and this risk is expected to rise in the future as increasing health care providers adopt EHR systems (Kruse, Smith, Vanderlinden, & Nealand, 2017).

1.6 Medical education and electronic health records

With increasing adoption of electronic records, students and residents are at the forefront of using these systems in hospitals and increasingly in ambulatory settings. The interplay of health-related technology, including EHR systems and medical education remain relatively undefined (R. H. Ellaway et al., 2013; Schenarts & Schenarts, 2012). Many challenges have been identified regarding how students and learners interact with these systems, but there remains a lack of research in the area, even though students and residents spend a significant amount of time using them (Block et al., 2013). There are increasing calls for a more focused and goal-oriented approach to help integrate these systems into the medical education process and to better prepare students to practice in environments where EHRs are becoming indispensable clinical tools. (Pageler et al., 2013) (R. H. Ellaway, 2016).
1.6.1 How electronic health records may impact the learner experience

There are potential benefits for medical students and residents in working with EHR systems. These benefits would be similar to what practicing physicians may also garner from such systems. These include immediate information access, efficiency improvements, and enhanced documentation practices in addition to preparation for future practice (Welcher et al., 2018). They have also been touted as potential learning tools if designed and used correctly (Seifan et al., 2013). This latter role, although much needed, has yet be realized or to be used routinely. There is a lack of educationally sound evidence that shows how best to implement EHRs in a way that learners can use it to further their education and also a lack of evidence in terms of what the long term effects of such systems will have on student learning and performance.

From the literature, there are few educational concerns that have been commonly cited for both medical students and residents, which may also overlap with what practicing physicians have to also contend with:

**Workflow**

There is concern that EHRs have increased resident workloads, including documentation and total screen time. One study reported that residents can spend approximately 40% of their time on EHR systems (Block et al., 2013) and another reported the doubling of time surgical residents spend performing documentation tasks after introduction of EHRs, a pattern that improved with time, but never returned to baseline (Wormer & Williams, 2015).

**Note-keeping/documentation**

EHR systems have changed the way notes are accessed and generated. Availability and accessibility of past and often comprehensive documentation has work-related advantages as mentioned in the previous sections, but from an educational perspective, there is concern that students and residents are increasingly relying on previous notes to help generate their clinical impressions, instead of formulating their own based on their clinical assessment and interpretations. One EHR-related documentation behaviours which is often cited as potentially problematic is the so called “copy-
paste” phenomena, where EHR users would copy previous notes and paste them and thus incorporate them into their own notes (Heiman et al., 2014) (March et al., 2013). Although this is often described as an efficiency enhancer, there is a concern that students and residents may be deprived of acquiring the cognitive skills and practice required to draft a meaningful notes, thus depriving them of critically thinking about their patients, with potential negative impact on clinical reasoning acquisition. Another aspect that is concerning is related to the increased documentation time as described in section 1.5.6 and how this could disrupt workflow and time commitments which could be used in educational activities.

Patient-doctor communication

Proper communication is essential in the patient-physician relationship, and this includes non-verbal communication (McGrath, Arar, & Pugh, 2007). There is increasing evidence that EHR systems can disrupt communication with patients, especially in ambulatory settings, where computers can act as a third party intruding on the doctor-patient relationship (Crampton et al., 2016). More educators are recognizing this issue and are trying to formulate methods to mitigate this problem. These steps include development of EHR-specific communication skills that are incorporated in teaching curricula with evidence of varying degrees of success (Borycki, Griffith, & Kushniruk, 2016). However, this area remains challenging and there are ongoing calls for further research (Duke, Frankel, & Reis, 2013; Shachak et al., 2015).

Student Access and Restriction of access for medical students/ Policy

Medical students traditionally had full access to medical records and were expected to develop patient-related notes as mentioned in the history section. However, with the advent of EHRs, some medical schools have restricted students’ ability to make notes, allowing the read-only access. (Welcher et al., 2018) The main cited reasons are related to legal liability concerns. (Gagliardi & Turner, 2016). This poses a problem because students need EHR access and related training, as these systems will be an integral part of their working lives once they graduate. Educators are increasingly calling for full student access EHRs with varying degrees of success. Some scholars and
stake holders are researching ways to compensate for the lack of full access by developing simulated EHR systems which attempts emulate real life EHRs so students can obtain realistic EHR exposure prior to graduation to help prepare them for residency (Welcher et al., 2018), something which will be covered in more detail as part of my review.

Electronic Health Record Training

EHR training, which encompasses teaching learners how to use these systems are varied in nature and often complicated by the sheer number of EHR vendors and different interfaces, which could make training more challenging for students and residents (E. Borycki, Joe, Armstrong, Bellwood, & Campbell, 2011). This form of training could mean just simply learning on the job, i.e. through exposure to real life EHR systems during clinical rotations, which could mean a steep learning curve and could also lead to learners missing out on more advanced features of EHRs at the expense of further proficiency and safety.

A more common form of training is usually a brief introductory session in a classroom prior to clinical rotations and then learners are left to learn experientially during their clinical rotations. Alternatively and ideally, training could be more formalized, with both lectures and on the job teaching and support that assists learners and physicians in becoming advanced and safer EHR users (E. Borycki et al., 2011). As such, there is a recognized need to better design and administer EHR training and provide ongoing support with ongoing evaluations to ensure consistency in EHR related competencies (Halas et al., 2015) (Hersh et al., 2014). There are obstacles that could hinder the response to such needs. For example, there is a lack of widely accepted standardized outcome measures and competencies by which to assess learners, this is one of the areas that will be explored within my review. More work is needed to define EHR-related competencies, but as medical records have transitioned into the electronic form, the design and the goal of EHR use is more geared towards pure clinical and administrative aspects vs. the “educational”, as Triola et al (Triola et al., 2010) remark, that the “ownership” of health information technology (HIT), including EHRs, at academic medical centers for example, has shifted to the “clinical enterprise”, which could be
“completely separate, both organizationally and culturally, from the medical education mission”. This again highlights how educators and learners seem to have lost their major influence in shaping medical records as they became electronic vs. the previous paper records, as noted in the previously covered historical overview.

1.7 Research rationale and study significance

In this Introduction, I have summarized the historical and technical context of the medical record and its role and effect on medical education and the evolution of the EHR in order to facilitate and contextualize understanding of the current landscape.

As described in this chapter, medical records have an important role to play in medical education, both for undergraduate and postgraduate medical education. As shown in previous sections, the importance of the medical record was recognized historically, including by Flexner as he even outlined within his famed report.

The calls for more scholarly work in this area are substantial, as noted from the above mentioned reviews. Furthermore, as part of my review of the literature database, I identified over 45 letters/commentaries that discussed EHRs and their relation to undergraduate and postgraduate medical education, with the vast majority calling for more research and scholarly work in the area.

Fundamental areas that need be still addressed include a need to better understand how EHRs impact the learning process and how students and residents interact and mature in environments increasingly influenced by these systems, especially in the long term. Thus we need to better understand their long-term educational consequences. There is recognition that they can be used as a learning tool, but no real systematic effort to study how we can best achieve this. Until then, questions will still remain about how to better design and use EHRs to aid the learning process in medical education.

Furthermore, in terms of past EHR-related educational research, and in order to inform future research and avoid redundancy and research repetition, we need to take a closer look at what type of
research has been already conducted; what methodologies were employed, whether they are appropriate for the research questions being asked and whether there is any lingering knowledge gaps that have not been addressed adequately.

Many of these questions remain unanswered, and a comprehensive literature review is needed to update our understanding of what the main issues related to role of EHRs in medical education and also to map and analyze the current literature base, this is especially important as these systems are rapidly developing and thus the need for a more updated and comprehensive literature evaluation. No comprehensive systematic evaluation has been undertaken to date to evaluate the expanse and current state of research in the area. From previous reviews, there is recognition that there are many knowledge gaps in the field (R. H. Ellaway et al., 2013; Schenarts & Schenarts, 2012), mostly pertaining to the reoccurring themes related to EHR usage, including workflow, documentation and communication. I have also identified some of the challenges in implementing EHR systems in learning environments, mainly related to workflow issues, communication and learner documentation.

To the best of my knowledge, there has been no systematic, scoping review and detailed mapping of this literature to date, which explores our target topic area. There are three published and widely cited reviews at the time of this research endeavour, (R. H. Ellaway et al., 2013; Schenarts & Schenarts, 2012) (Tierney, Pageler, Kahana, Pantaleoni, & Longhurst, 2013) , which provide some valuable insight. However, these reviews were non-systematic and were published more than four years ago, thus there is also a need for an update on the topic. My study will be valuable as it will inform future research and teaching practices as will be discussed in the results and discussion chapters. The next section will outline my research aims and questions.

1.8 Research aims and questions

The research objective and questions for this review were developed in collaboration with the research team. The main objective is to develop a broad understanding of the medical education
landscape as it pertains to EHRs. To achieve this objective, as per scoping review guidance, the primary research questions have to be “broad and encompassing” to allow the wide capture of the literature (Levac, Colquhoun, & O’Brien, 2010). This will allow us to garner enough information to achieve the goal of mapping the extent and type of literature. As such, my primary research objective and questions are as follows:

**Primary objective:** To map and analyze the state of the existing literature in terms of EHR use in a medical education setting at the undergraduate and postgraduate level.

**Specific research questions:**

1. What are the research topic areas and priorities that have been studied and identified related to EHR and medical education?
2. What methodologies have been employed to research these topics?

In relation to the main objective and research questions, I also aim to investigate, define and understand any relevant factors that influence learning in this environment.

Levac et al. (2010) recommend that key concepts related to the research focus on questions which are clearly articulated and defined to help clarify the subsequent steps. As such, the definition of EHR and related terms were defined in the previous sections with the relevant contextual information.

In terms of the concept of “Medical Education”, especially from a research perspective, I used this broad definition to help clarify the concept, as published by Collins, (2006), keeping in mind, I will adapt this definition for only undergraduate and postgraduate medical trainees, as per our research objective:

“A broad definition of medical education research would include any investigation related to the education of medical professionals, including research related to undergraduate (medical school), graduate (residency), and continuing medical education. Medical education research can focus on any number of topics, including curriculum development, teaching methods, student evaluation, teacher evaluation, course evaluation, faculty development, admission and preparation of
candidates for medical training, factors influencing career choice, research methodology, and use of technology in education”. (Collins, 2006)

Please note that the term “learner” will often be used to denote both undergraduate students and postgraduate residents and fellows if a certain educational entity or effect is related to these student or postgraduate trainee categorizations.

The rationale of using a scoping review as a systematic review methodology will be discussed in chapter 2.

1.9 Thesis outline

This thesis contains five chapters: Chapter 1 is the introduction and literature review. Chapter 2 outlines the methodology. This explains the reason and process of scoping review methodology, including description of the stages of the review undertaken, and a summary of the research questions and objectives. Chapter 3 outlines the results of the scoping review in two sections: 1) the basic characteristics of the selected articles and, 2) the thematic analysis. Chapters 4 provides the discussion of the findings, including study limitations. Chapter 5, the final chapter, will discuss suggestions for future work and will end with the conclusion.
Chapter 2
Methodology

2.1 Introduction

A scoping review methodology was selected to synthesize the available literature as per my research goals. The scoping review framework is designed to allow for a broad understanding of the current literature and can help to map the knowledge landscape.

I used a well-developed and highly cited framework as proposed by Arksey and O’Malley in 2005 and also utilized a subsequent report (Levac et al., 2010) which further clarifies and refines this process. These established scoping review frameworks provide an organized and a rigorous systemic protocol to help select and map the appropriate literature whilst allowing for iterative changes to help refine the selection process. Scoping reviews are especially useful when the literature has not been systematically reviewed, or is complex and heterogeneous in nature. This is particularly advantageous if the nature of the source literature cannot be included in a more focused systematic review (Khalil et al., 2016). Furthermore, as opposed to systemic reviews, which explore more focused questions and areas, scoping reviews are more broadly encompassing and are designed to explore and map the breadth of the knowledge for a particular topic. Unlike systematic reviews, current scoping review methodology is not designed to assess the quality of included research.

2.1.1 Why the scoping review method was chosen

As there was a lack of systematic knowledge synthesis in this area, the scoping review methodology was chosen as it allows for a more expansive examination of the available literature. From preliminary reading of the base literature and also after consulting people who have expertise in the field, scoping reviews was deemed appropriate, given the heterogeneous nature of the literature. This effectively aligns with my research objectives as discussed in the previous chapter. A scoping review
provides a broad understanding of the literature related to the research questions and objectives with the aim of filling an important knowledge gap and providing a platform from which could support and inform further more focused research and/or synthesis in the future.

In the following chapter sections, the Scoping review methodology I employed will be explained in further detail as it pertains to our research questions and aims.

2.1.2 Ethics approval

Ethics approval for this scoping review was not required as per Tri-Council Policy Statement, as the research is based on review of published and/or publicly reported literature and does involve any personal patient data (Medical Research Council (Canada), Natural Sciences and Engineering Research Council of Canada, & Social Sciences and Humanities Research Council of Canada, 2014).

2.2 Scoping review methodology

A preliminary assessment of the literature was conducted in order to establish if the literature of interest (EHR use in medical education) had been reviewed previously. As mentioned in the prior chapter, this assessment identified two broad reviews, neither of which employed rigorous systematic or scoping review methodology (R. H. Ellaway et al., 2013; Schenarts & Schenarts, 2012). Other reviews, as outlined in the Results chapter, are either narrative in nature or focused on a specific topic rather than the whole subject area as per our research goals.

I used the Arksey and O’Malley methodology (Arksey & O’Malley, 2005), as refined by Levac, Colquhoun, and O’Brien (Levac et al., 2010). The approach contains five stages:

Stage 1: Identifying the research questions

Stage 2: Identifying relevant studies

Stage 3: Study selection

Stage 4: Charting the data

Stage 5: Collating, summarizing and reporting results
Stage 6: Consultation (optional). This step was not done for this study

Further details about each stage is described in Table 2.1.

Table 1.1 Summary of scoping review stages

<table>
<thead>
<tr>
<th>Scoping Review Stage</th>
<th>Main Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1: identifying the research question(s)</td>
<td>Research questions should be broad in nature as they aim to give breadth of coverage. This is an important step, as it will guide the other stages.</td>
</tr>
<tr>
<td>Stage 2: identifying relevant studies</td>
<td>This includes: identifying where to search, what concepts/terms/keywords to use for this search. Reading key literature guides term/concept identification. Sources, time span and language type have to also be defined in this stage. Sources usually include: Electronic databases, key journals etc. Although breadth of search/inclusion is important, it has to be balanced against available resources and time constraints.</td>
</tr>
<tr>
<td>Stage 3: study selection</td>
<td>This involves post-hoc inclusion and exclusion criteria. These criteria are contextualized based on the research objectives and questions as well as gained understanding and familiarity of the reviewed literature. This is usually an iterative process, which allows for ongoing refinement.</td>
</tr>
<tr>
<td>Stage 4: charting the data</td>
<td>A data-chart form is constructed and used to extract data from each of the included studies.</td>
</tr>
<tr>
<td>Stage 5: collating, summarizing and reporting results.</td>
<td>An analytic framework and/or thematic construction is utilized to give a summary and synopsis of the breadth of the literature (not a synthesis). A numerical and a thematic analysis is then presented to help clarify the literature. Reporting results requires clarity and consistency.</td>
</tr>
<tr>
<td>Stage 6: Consultation (optional) . Not done in this study</td>
<td>This is an optional step. Gives opportunities for stakeholder involvement to give further insights and suggestions for future work and recommendations. This stage was not employed in this study and will serve as one of the study future recommendations.</td>
</tr>
</tbody>
</table>

*Table adapted from (Levac et al., 2010)

2.2.1 Stage One: Establishing the Research Question

As stated in Chapter 1, the research objectives and questions for this review were developed in collaboration with the research team. According to scoping review guidance, the primary research questions have to be broad and encompassing to allow the wide capture of the literature (Levac et al., 2010) and adequate mapping the relevant literature. To recap my research objective and questions:

- **Primary objective:** To map and analyze the state of the existing literature in terms of EHR use in a medical education setting at the undergraduate and postgraduate level.

- **Specific research questions:**
  - What are the research topic areas and priorities that have been studied and identified related to EHR and medical education?
  - What methodologies have been employed to research these topics?
The key concepts related to the aim and questions were defined in chapter 1.

2.2.2 Stage Two: Identifying Relevant Studies

This step requires developing: 1) an effective search strategy (including choosing the relevant keywords); 2) choosing the appropriate databases and reference sources; and 3) defining and limiting the search to a specific timeline/language.

2.2.2.1 Search Strategy

The search strategy was developed with the assistance of two health sciences librarians who had previous experience in systemic and scoping reviews.

The research objective and related questions were dissected to help develop key concepts and keywords.

A preliminary review of key literature also helped in discovering and defining key concepts and keywords to be employed when searching the databases. To help generate these key keywords, initial MEDLINE searches were conducted to identify keywords and medical subject headings. These keywords were also tested in the other chosen databases and minor modifications were made to allow for the differences between them. The search strategy, including these keywords, was refined via several search iterations.

Table 2.2 outlines some of the key concepts and keywords which helped to guide the search. Table 2.3 shows the search strategy used for the MEDLINE database, which was also translated to be used for the other database searches.

The population was limited to medical students, and medical/physician postgraduate trainees (residents, fellows etc.). Due to the extensive volume of literature and limited resources, other health-related specialties were excluded for this study (e.g. dentists, nurses, pharmacists etc.). There was also concern that EHR systems for some of these groups may differ substantially in their purpose and function when compared to physician targeted EHR systems, which may potentially misrepresent the
study results, especially as my target is to study “physicians” in training, whether medical students or residents.

Table 2.2 Key concepts and keywords that guided database search

<table>
<thead>
<tr>
<th>Concept</th>
<th>Examples of Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>Student*, Resident*, fellow*</td>
</tr>
<tr>
<td>Subspecialty</td>
<td>Clinical medicine, dermatology, emergency medicine, general practice, geriatrics, global health, hospital medicine, internal medicine, neurology, pathology, paediatrics, psychiatry, radiology, surgical specialties.</td>
</tr>
<tr>
<td>Medical Education</td>
<td>Medical education, clinical education, clinical clerkship, graduate medical education, undergraduate medical education, clerkship, continuing medical education, surgical training, medical training, curriculum development, train</td>
</tr>
<tr>
<td>Electronic Health Records</td>
<td>Electronic Health Record*, Electronic Patient Record*, Decision support system*, Personal Health Record*, EHR, EMR.</td>
</tr>
</tbody>
</table>

*=Wildcard
### Table 2.3 Medline search strategy

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>exp Electronic Health Records/</td>
</tr>
<tr>
<td>2</td>
<td>Health Records, Personal/</td>
</tr>
<tr>
<td>3</td>
<td>Decision Support Systems, Clinical/</td>
</tr>
<tr>
<td>4</td>
<td>electronic health record*.kw,tw.</td>
</tr>
<tr>
<td>5</td>
<td>(electronic adj1 record*).kw,tw.</td>
</tr>
<tr>
<td>6</td>
<td>electronic medical record*.kw,tw.</td>
</tr>
<tr>
<td>7</td>
<td>electronic patient record*.kw,tw.</td>
</tr>
<tr>
<td>8</td>
<td>EHR.kw,tw.)</td>
</tr>
<tr>
<td>9</td>
<td>EMR.kw,tw.</td>
</tr>
<tr>
<td>10</td>
<td>EHR*.kw,tw.</td>
</tr>
<tr>
<td>11</td>
<td>EMR*.kw,tw.</td>
</tr>
<tr>
<td>12</td>
<td>exp education, medical/</td>
</tr>
<tr>
<td>13</td>
<td>exp clinical clerkship/</td>
</tr>
<tr>
<td>14</td>
<td>education, graduate/ or education, medical, graduate/</td>
</tr>
<tr>
<td>15</td>
<td>Education, Medical, Undergraduate/</td>
</tr>
<tr>
<td>16</td>
<td>education, continuing/ or education, medical, continuing/ or education, professional, retraining/</td>
</tr>
<tr>
<td>17</td>
<td>Medical education.kw,tw.</td>
</tr>
<tr>
<td>18</td>
<td>surgical training.kw,tw.</td>
</tr>
<tr>
<td>19</td>
<td>medical training.kw,tw.</td>
</tr>
<tr>
<td>20</td>
<td>exp curriculum development/ or exp curriculum/</td>
</tr>
<tr>
<td>21</td>
<td>(&quot;undergraduate medical education* or clerkship&quot;).kw,tw.</td>
</tr>
<tr>
<td>22</td>
<td>clinical medicine/ or dermatology/ or emergency medicine/ or general practice/ or geriatrics/ or global health/ or hospital medicine/ or internal medicine/ or neurology/ or pathology/ or pediatrics/ or psychiatry/ or radiology/ or specialties, surgical/</td>
</tr>
<tr>
<td>23</td>
<td>(postgraduate* or graduate or undergraduate or scholar* or student* or learn* or fellow* or program* or train* or education or (residen* adj3 education) or teach*).kw,tw.</td>
</tr>
<tr>
<td>24</td>
<td>22 and 23</td>
</tr>
<tr>
<td>25</td>
<td>1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11</td>
</tr>
<tr>
<td>26</td>
<td>12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 24</td>
</tr>
<tr>
<td>27</td>
<td>25 and 26</td>
</tr>
<tr>
<td>28</td>
<td>limit 27 to (English language and yr=&quot;January 1990 –June 2017&quot;)</td>
</tr>
</tbody>
</table>

#### 2.2.2.2 Choosing the appropriate databases and reference sources

The following electronic databases were systemically searched: Ovid MEDLINE, Ovid EMBASE, Ovid PsycINFO, Cumulative Index to Nursing and Allied Health Literature (CINAHL) via EBSCO and Education Resources Information Center (ERIC). The different databases allow for reference capture from a broad range of disciplines.
-Other Search Strategies:

Journals specific to medical education were also searched for any published material on EHRs within the specified time period. Table 2.3 outlines the searched medical journals.

**Reference harvesting (Snowballing)**

Some selected article references/ bibliographies were also checked for an extra source of references and if appropriate, were included in the screening process. The harvesting was done via the help of Scopus® website.

**Table 2.2 Searched medical education journals**

<table>
<thead>
<tr>
<th>Journal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Medicine</td>
</tr>
<tr>
<td>Medical education</td>
</tr>
<tr>
<td>Advances In Health Sciences Education</td>
</tr>
<tr>
<td>Medical Teacher</td>
</tr>
<tr>
<td>Journal Of Surgical Education</td>
</tr>
<tr>
<td>BMC Medical Education</td>
</tr>
<tr>
<td>American Journal Of Pharmaceutical Education</td>
</tr>
<tr>
<td>Medical Education Online</td>
</tr>
<tr>
<td>Teaching And Learning In Medicine</td>
</tr>
<tr>
<td>Journal Of Continuing Education In The Health Professions</td>
</tr>
<tr>
<td>Perspectives On Medical Education</td>
</tr>
<tr>
<td>Journal Of Graduate Medical Education</td>
</tr>
<tr>
<td>Clinical Teacher</td>
</tr>
</tbody>
</table>

2.2.2.3 Defining and limiting the search to a specific timeline and language

The search timeline was limited from January 1990 to June 30th 2017. This period was chosen as the vast majority of literature related to our chosen topic was published during this era given the nature of the technological advancement and adoption as outlined in the previous chapter. Due to resource constraints, the search was only limited to literature published in the English language.

At the time of this study, it should be noted that some articles were available online first and in full text prior to their subsequent formal publication date, which was after our designated end date. We decided to include these studies.

2.2.3 Stage Three: Study Selection

After executing the search strategy outlined in the previous step in each database, the resulting
references were aggregated and duplicates were removed with the help of Endnote ® (Ver. x7). The resulting references were then uploaded to DistillerSR ® online reference management software (Evidence Partners, Ottawa, Canada) to facilitate the screening and subsequent selection process. After removing duplicates, a total of 9186 abstracts were included in the initial title and abstract screen.

For the initial title and abstract screening process, limited exclusion criteria was employed to allow broad inclusion and also further develop familiarity with the literature. This was recommended by Arksey & O'Malley, (2005) and by Levac et al., (2010). This was an iterative process and I kept in mind the balance between being broad and inclusive as preferred by the scoping review methodology but also keeping the reference count number and the feasibility of the review process as per available resources as suggested by the same authors.

After this process, post-hoc inclusion/exclusion criteria were developed and employed. The initial literature screen conveniently informed this process.

Prior to the screening process, a collaboration exercise was conducted between to 3 reviewers (A.O, N.I., D.L.) to test the initial screening exclusion criteria. If there was any discrepancy between the reviewers, these were then resolved by consensus and review of the eligibility criteria. The exercise helped to improve reviewer understanding of the criteria.

As will be outlined in the selection criteria, the studies had to have clear educational intent and declared educational content and to have to have used EHR as part of the content. I excluded opinion articles and commentaries/editorials, if they did not report novel results or educational interventions/tools. Articles which were technically oriented were also excluded if they did not have an explicit medical educational/curricular content.

Ten percent randomly selected articles for the initial screen were independently reviewed by the three reviewers (A.O, D.I. and N. C), to make a total of 920 articles to check for reviewer agreement in applying the eligibility criteria. The 920 articles were distributed as follows: A.O., 920 references compared with D. L., who reviewed 460 references, and with N.C., who reviewed 460 references.
Any discrepancy in the selection process was resolved by review of references and agreement by consensus and then optimization of selection criteria if needed.

For this 10% screen, a kappa score was calculated (values declared in results section) with the aim of achieving at least achieving a “substantial agreement”, i.e. a score of 0.61 to 0.80 (Landis & Koch, 1977), after which the rest of the initial title and abstract screening was completed by the primary author (A.O).

This method was also used for the next study selection process, the full text screen (A. O and D. L).

The final step of data extraction and thematic analysis was completed by the primary author (A.O).

The primary author made sure to review the final selected articles multiple times to ensure both accurate selection and extraction.

2.2.3.1 The final inclusion and exclusion criteria.

Inclusion criteria:

Criteria for selecting/including the articles were as per following:

1- Studies that described the use of EHRs for a medical education process aimed at our target population.

2- Studies/references that focused or described the inclusion of undergraduate medical students and/or postgraduate residents and fellows or any regional training or educational equivalents as per criteria number 1.

Exclusion criteria:

The developed exclusion criteria are as follows:

1- Articles with no educational intent or content. This includes technical articles on EHR’s with no evidence of any educational processes.

2- Population: Articles with no definition of the target population were excluded. e.g. just non-trainee independent physicians. Also, other healthcare professionals were excluded (e.g. nurses, dentists, pharmacists etc.).
3- Non-full text articles/ Conference proceedings: Opinion articles were excluded from the study. I also excluded abstracts with no available full texts and conference proceedings were also excluded from the study, as they would likely not contain enough details and bibliographies to allow for full analysis.

A PRISMA diagram (Figure 3.1) is used in the results chapter to outline the selection process as per guidance (Moher, Liberati, Tetzlaff, Altman, & PRISMA Group, 2009). As explained in chapter 3, 82 articles were finally selected for inclusion in the scoping review.

2.2.4 Stage Four: Charting the data

In order to clarify this process, the method of (Arksey & O’Malley, 2005) was utilized which describes charting as per their additional reference to the (Ritchie & Spencer, 1994) definition of charting:

“…charting describes a technique for synthesizing and interpreting qualitative data by sifting, charting and sorting material according to key issues and themes”.

For the data collection and abstraction, an online data collection form was developed via DistillerSR ® online reference management software (Evidence Partners, Ottawa, Canada). This electronic form allows for full text review and facilitates extracting and organizing the data from each included article. This form was tested and refined on 10 random articles prior to proceeding with the final charting process.

The extraction form included the following data extraction headings:

Publication type, study design/methodology, type of EHR platform explored, name of EHR vendor (if available), target study/article population, population subspecialty (if applicable), practice setting, geographical location, total number of participants (if applicable or declared), type of publication/journal, major theme of the article (as outlined in stage 5).
Basic statistical analysis was performed using SPSS Statistics version 22 (IBM, Armonk, New York, USA).

2.2.5 Stage Five: Collating, summarizing, and reporting the results

This stage was guided by the method of (Levac et al., 2010) according to the following three steps:

1. Analysis. This included an initial descriptive numerical analysis and qualitative thematic analysis. Some of the numerical data are presented via figures and tabular formats. The themes and key concepts used in the charting were developed iteratively from repeated full text readings and revisions of the final selected articles, which allowed adequate familiarisation of the content and findings for each study. Through this process, the primary reviewer listed the repeated and important themes and ideas obtained through the detailed review and interpretation. Common, important, and repeated themes and patterns were then registered and included in the data collection form, which were then used to categorize the reviewed articles. The resulting theme categories were as follows:

1. Work flow.
2. Medical student/resident documentation and note keeping.
3. Medical student/resident and patient communication.
4. EHR Training and Simulation.
5. Knowledge and Information Management.
6. Trainee assessment and tracking.

For the detailed thematic analysis, no formal consensus or researcher triangulation process was performed, as was done for the initial selection process. But assistance and advice was sought from the thesis supervisory committee as questions arose.

2. Reporting the results. This thematic analysis provided a framework that helped articulate and organize the results into these themes.

The 82 articles were analyzed for: research aims, studied population, methodology designation, type of EHR system, type of publication. This also included information about main findings and described limitations (including gaps if applicable), and a detailed thematic analysis was employed.
Here a qualitative, narrative analysis was done, organized according to the described themes.

3. **Meaning of the findings.** This is both outlined in the detailed thematic analysis (chapter 2) and discussion section (chapter 4), where the main findings are discussed in light of the current literature. The relevant issues are clarified with recommendations into how future work could be implemented to further research EHR as it related to medical students and postgraduate trainees.
Chapter 3

Results

The results of the scoping review are presented in two sections. Prior to this, the PRISMA diagram will be presented to show the numerical breakdown of the article selection process. The kappa scores will also be outlined for the initial two screening process as well.

The first section of the main results will outline the general characteristics of the 82 selected articles. This will provide a broad description of the included studies and will include a descriptive numerical summary analysis which will help elucidate some of the characteristics of the included articles as per methodology guidance (Levac et al., 2010). This initial analysis will include, but is not limited to: publication year, geographical distribution, article type, journal type, studied population, nature of medical practice and sub-specialty, research methodology type, and EHR subtype (where available).

The second section will present the results of the more detailed thematic analysis, which was outlined in the introduction and methodology sections. This analysis will help organise the data and also act as a lens, through which the disparate and complex data can be better clarified and focused. This will help answer the research question and achieve the objectives of the project.

For study selection, please refer to the PRISMA diagram (Figure 2.1) which clarified the selection process resulting in 82 articles which were included in the final analysis out of an initial 10682 articles.

3.1 Article selection result

The PRISMA diagram (Figure 3.1) outlines as per guidance (Moher et al., 2009) the study selection process, including the numbers of article exclusions. After applying the exclusion criteria for stage 1 and 2 of the selection process, 82 articles were included in the final analysis out of an initial 10682 articles.
Records identified through database searches
\(N = 10496\)
(Medline 1188, EMBASE 6877, PsycINFO 220, ERIC 125, Medical Education Journals search done via MEDLINE 195, and via EMBASE 181)

Additional records identified through other sources
\(N = 186\) (snowballing)

Records after duplicates removed \(N = 10682-1496 = 9186\)

Title and Abstract Screen:
Records screened \(N = 9186\)

Records excluded \(N = 8927\)

Full-text articles excluded, with reasons* \(N = 175\)
- Non-medical/ other Health professionals \(N = 5\)
- Practicing physicians (independent/ non training) \(N = 14\)
- Opinion/ Commentary \(N = 45\)
- Conference Proceedings/ Full report could not be retrieved \(N = 76\)
- Medical education not main focus of the study \(N = 16\)
- Unclear EHR usage in the study/article \(N = 22\)
- No students or resident inclusion \(N = 12\)
- Pure technical EHR study (No MedEd) \(N = 33\)

*Some reasons overlap for same reference

Studies included in synthesis
\(N = 82\)

---

Figure 3.1 PRISMA diagram outlining selection flow of included articles.
3.2 Inter-observer agreement scores for screening process.

As outlined in Chapter 2, the first and second stages of the review, 10% of the articles for each stage were randomly selected to assess the kappa score for the participants. The aim was to ensure “substantial agreement” before the primary researcher (A.O) could proceed to complete the rest of the selection process alone.

An adequate kappa score was obtained for both initial screening stages. For stage one “Title and Abstract screening”, the kappa scores were 0.68 (A.O, DL), 0.69 (A.O, NC) and for stage 2 “full text screen”, the kappa score was 0.7 (A.O, DL).

3.3 Section 1. Article general characteristics.

The general characteristics of the included studies discussed in these sections:

1- Geographical distribution
2- Publication year
3- Studied population
4- Subspecialty distribution (if applicable)
5- Practice setting
6- EHR type and vendor
7- Article methodology
8- Journal category
9- Broad article themes/ topics

3.3.1 Geographical distribution

Figure 3.2 outlines the geographical distribution of the studies included studies. There predominant number of studies were from North America, with 85.4% of the studies being from the United States of America (USA).
Figure 3.2. Country distribution of published articles.
* Indicates cross-country collaboration=Israel (2 Israeli articles+1 with USA) Canada (6 Canadian articles+1 with USA). N=82 articles. Figure created with aid of Microsoft Excel® version 16.15.

3.3.2 Publication Year

In the chosen period to review the literature, from 1990 to June 30th, 2017, there was only 1 included study from the 1990’s and the majority of the articles (87.6%) were from 2009 to 2017 (figure 3.3). As most of the publications were from the USA, this likely reflects the increased adoption of EHR systems, especially after the US governmental incentives which began around 2009 as outlined in chapter 1.
Figure 3.3 Frequency of publication “per year” of included articles (Jan 1994- June 2017).
N=82

3.3.3 Studied population

Out of the selected articles, the predominate group studied were postgraduate residents/fellows.

Undergraduate medical students were included in 25 articles. See Figure 3.4 for further details.

Figure 3.4 Studied population distribution in articles that met the criteria for inclusion.
N=82 articles.
3.3.4 Specialty Distribution

Internal medicine was the most represented in the selected studies, with 29% of the articles. Family medicine was also active as a specialty, which is a predominantly ambulatory specialty. Of the included articles, 18% or the articles did not specify the specialty as they had a predominantly undergraduate population. See Figure 3.5.

![Specialty Distribution](image)

**Figure 3.5** Specialty distribution of the selected articles (N=82). N/A= not applicable, IM=Internal Medicine.

3.3.5 Practice setting

In the articles that declared the practice setting, the outpatient/ambulatory setting was the most represented, followed by in-patient practice. The distribution is outlined in Figure 3.6. This is important as EHR usage between the two settings can differ as the workflow patterns are also different, including the patient-physician/trainee interaction and safety concerns (Webster et al., 2008). In ambulatory settings, the EHR is more likely to be directly present within the same room, thus it has more potential to effect direct and indirect trainee-patient communication and interactions (Crampton et al., 2016). In inpatient settings, traditionally, EHR is usually accessed via terminals.
remote from patient beds/rooms, which may represent a different effect on direct patient–resident communication. However, there is an increasing trend to use portable devices that can be carried into patient rooms, which can potentially have the same communication-related consequences as ambulatory EHR systems. The communication aspect is discussed in further detail in subsequent sections.

![EHR Practice Setting](image)

**Figure 3.6** Practice setting distribution. Outpatient=Ambulatory. Mix=Outpatient/Inpatient. N=82 articles.

### 3.3.6 EHR type and vendor information (if available)

Not all articles specified the type or EHR used or the vendor. I did not seek further information to look at the specific technical specifications for the reported types of EHR systems.

Simulated EHR’s were represented in 13.4% of the articles. Table 3.1 outlines the vendor types. 68.3% of the articles did not specify vendor details. The most frequently reported vendor is EPIC® (19.5%), which is in keeping with other literature, with EPIC being the most commonly used platform in the USA (Wickramasinghe & Schaffer, 2018). The table outlines some of the current heterogeneity of EHR setups within clinical setups. The challenges of this will be further discussed later in this chapter in the thematic analysis and also further analyzed in the discussion chapter.
Table 3.1. Reporting of EHR types and/or vendor name in selected articles

<table>
<thead>
<tr>
<th>EHR type and/or Vendor name</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No EHR vendor/type specified</td>
<td>56</td>
<td>68.3</td>
</tr>
<tr>
<td>EPIC® and subtypes</td>
<td>16</td>
<td>19.5</td>
</tr>
<tr>
<td>Cerner Corporation®/ Powerchart®</td>
<td>2</td>
<td>2.4</td>
</tr>
<tr>
<td>High-fidelity EMR system – Patient portal tool (Clicks by Roshtov and the Maccabi portal)</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>Canopy®</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>Centricity®</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>EHR-sim (virtual patient EHR simulation tool)</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>Logician®</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>Medical Support System (SAM – Portugal)</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>The Logician ambulatory care information system®</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>VistA CPRS®</td>
<td>1</td>
<td>1.2</td>
</tr>
</tbody>
</table>

3.3.7 Study Design and Methodology.

The research methodology distribution for the selected articles is outlined in Figure 3.7. For more details, please refer to Appendix Table 2, which outlines a summary for all the 82 articles.

As expected, the findings regarding research methods were heterogeneous. Overall, most of the papers employed more of a descriptive and observational type. The most prominent of which is the survey methodology, with 25 articles (30.5%) using this method for their research objectives. The general consensus from these surveys is similar for the same themes they studied, especially in relation to the subject area of student access to EHRs. These surveys are very informative, but some asked similar questions to similar populations, and thus had similar results. This redundancy is further discussed in chapter 4.

There were only 4 articles (4.4 %) that employed a randomized controlled trial (RCT) method. The RCT’s all looked at communication and the use of EHR. These RCT’s are detailed in the theme analysis section.

In terms of fully implemented/protocolized systematic synthesis articles, there were only three articles that met this criteria; one scoping review which focused on how EHRs affect physician/patient communication (Crampton et al., 2016) and a systemic review looked at the usage of EHRs in the creation of virtual patients for teaching clinical decision-making (Bloice, Simonic, &
Holzinger, 2013). There was also a non-protocolized review (Schenarts & Schenarts, 2012) which looked at the impact of EHR’s on graduate medical education.

Qualitative research was well represented, with 8 articles, 3 of which used the grounded theory approach. One of the articles, also utilized the “think aloud protocol” for their task analysis (Farri et al., 2012). There was also qualitative representation in the mixed methodology papers. This method is especially useful as it manages to collect valuable personal insight on how trainees and physicians interact and experience these often-complex systems.

There were 9 “before and after studies” (pre/post studies), 2 of which were controlled. The themes explored within these methodological categories related to communication workflow, trainee safety of practice, and resident documentation/note keeping.

<table>
<thead>
<tr>
<th>Article Methodology Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
</tr>
<tr>
<td>Survey</td>
</tr>
<tr>
<td>Observational cohort</td>
</tr>
<tr>
<td>Qualitative</td>
</tr>
<tr>
<td>Before and after study</td>
</tr>
<tr>
<td>Statement / proposal</td>
</tr>
<tr>
<td>Narrative Review</td>
</tr>
<tr>
<td>Mixed Methods</td>
</tr>
<tr>
<td>Cross-sectional</td>
</tr>
<tr>
<td>RCT</td>
</tr>
<tr>
<td>Systematic Synthesis</td>
</tr>
<tr>
<td>Controlled Before and After</td>
</tr>
<tr>
<td><strong>Percent</strong></td>
</tr>
<tr>
<td>Frequency</td>
</tr>
<tr>
<td>Observational cohort</td>
</tr>
<tr>
<td>Qualitative</td>
</tr>
<tr>
<td>Before and after study</td>
</tr>
<tr>
<td>Statement / proposal</td>
</tr>
<tr>
<td>Narrative Review</td>
</tr>
<tr>
<td>Mixed Methods</td>
</tr>
<tr>
<td>Cross-sectional</td>
</tr>
<tr>
<td>RCT</td>
</tr>
<tr>
<td>Systematic Synthesis</td>
</tr>
<tr>
<td>Controlled Before and After</td>
</tr>
</tbody>
</table>

**Figure 3.7** Methodology distribution. N=82. RCT= Randomized Control Trial.
3.3.8 Journal Category.

Overall, approximately 50% of publications related to education and EHR systems and were published in education journals (48.8%), followed by Informatics journals representing 15.9% of the total. Figure 3.8 shows the full distribution. The “other” category includes Neurology, critical care, patient education and research and evaluation journals. Table 3.2 outlines the top 10 represented journals.

![Journal Category Distribution](image)

**Figure 3.8** Frequency/percentage of articles per journal type (n=82). MedEd= Medical Education journals.

<table>
<thead>
<tr>
<th>Table 3.2 outlines the top 10 most represented journals (n=82).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Journal name</strong></td>
</tr>
<tr>
<td>Academic Medicine : journal of the Association of American Medical Colleges</td>
</tr>
<tr>
<td>Journal of Graduate Medical Education</td>
</tr>
<tr>
<td>Medical Education</td>
</tr>
<tr>
<td>Teaching and Learning in Medicine</td>
</tr>
</tbody>
</table>
Thematic distribution and findings in the literature.

As explained in the methods section, the thematic analysis was first conducted by a detailed reading of the selected articles and thereby defining the important and reoccurring topics. The papers were then analyzed in detail, and the topics were coded via use of the DistillerSR instrument. The results of the thematic analysis designations are outlined in Table 3.3.

Broadly, the most common topics were related to workflow, documentation/note keeping, communication (how EHR affected patient/learner communication) and training. In the next section, each theme will be discussed in more detail as it relates to our study question and objectives.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Theme abbreviation Key</th>
<th>Article Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work flow</td>
<td>WF</td>
<td>40</td>
<td>48.8</td>
</tr>
<tr>
<td>Medical student/resident documentation and note keeping</td>
<td>DOC</td>
<td>35</td>
<td>42.7</td>
</tr>
<tr>
<td>Medical student/resident and patient communication</td>
<td>COMU</td>
<td>29</td>
<td>35.4</td>
</tr>
<tr>
<td>EHR Training and Simulation</td>
<td>TRN/SIMM</td>
<td>34</td>
<td>41.5</td>
</tr>
<tr>
<td>Knowledge and Information Management</td>
<td>KNO</td>
<td>12</td>
<td>14.6</td>
</tr>
<tr>
<td>Trainee assessment and tracking</td>
<td>ASMT</td>
<td>8</td>
<td>9.8</td>
</tr>
</tbody>
</table>
3.4 Section 2: Thematic Analysis.

The analysis will explore in more detail the selected article themes, which were outlined in section one. The thematic categorization of the articles is not mutually exclusive, as many of the articles had one more than one overlapping theme. The finding that the themes overlap is a known phenomenon when exploring electronic health records, and is in keeping with such complex systems. Sittig and Singh (Sittig & Singh, 2010) further elaborate on such overlapping themes/characteristics by describing such systems as being “not independent, sequential or hierarchical, but rather are interdependent and inter-related concepts”. As such, and as an example, documentation can be featured and influence workflow and vice versa.

To reiterate my research objectives and the analysis of each theme, the aim of the thematic analyses of the included articles was to understand how EHRs influenced the educational process (learning, teaching, assessment etc.) as described in Chapter 1. Furthermore, I sought to explore if there were any deliberate educational interventions that facilitated the learning or the educational process in each particular theme.

The Appendix 2 Table outlines the 82 article summaries with corresponding thematic categorizations as per outlined codes (bold typeface) in the following list:

1. Work flow, efficiency and time utilization (WF)
2. Medical student/resident documentation and note keeping (DOC)
3. Medical student/resident and patient communication (COMU)
4. EHR Training and Simulation (TRN/SIMM)
5. Knowledge and Information Management (KNO)
6. Trainee assessment and tracking (ASMT)

For the thematic analysis, the first four major themes will be analyzed in more detail than the latter two as they are more represented as reflected by the number of articles.
3.4.1 Theme 1: Work flow, efficiency and time utilization

This is the most prominent theme from the selected papers. The challenge of how to best optimize the learner’s time and workflow is a long-standing issue, and existed prior to the advent of widespread use of EHRs. In the following sections, the impact of EHRs on workflow will be discussed in more detail as described in the selected articles.

Prior to discussing the most important points related to this theme, it is important to provide some relevant context.

3.4.1.1 Definition of Workflow.

For the purposes of this thesis, (Schweitzer et al., 2014), provide a working definition of workflow, in which they state that workflow is defined...

“as a set of activities conducted in the hospital setting that lead to the achievement of a clinical result related with the assessment, diagnosis, or general supervision of the patient.”

Logically, these tasks require time. The challenge has always been how much of this time is used for educationally relevant tasks versus what can be perceived as non-relevant work from an educational perspective.

3.4.1.2 Education versus service.

The actual daily clinical work that students and residents undertake is an important consideration in any student or resident learning journey. Although this practical, clinical component is an essential factor in the medical education process, there has been a long running “service versus education” debate. The boundaries between the two are not as clear as they first appear and differentiating what is “service” based work, often described colloquially as “scut” work, and what is relevant and educationally useful practice can be challenging and a source for frustration for both learners and other related stakeholders. Hayward et al, (Hayward, 1991), defined “scut work” as, "any duty not providing the trainee with a learning experience". They also characterized this by the following three properties: 1) lack of educational reward, 2) expectation of service, and 3) nonmedical context.
Clerical work (e.g. requisitions, administrative paperwork etc.) is particularly seen as *santu* by learners. Interestingly, this could also mean performing tasks that they do not get feedback on, such as formulating discharge summaries without getting educational feedback from their clinical supervisors (Hayward, 1991). These directly tie into EHR-related work as many EHR related tasks are clerical in nature, and there is evidence that it has increased due to changes in scope of practice as administrative tasks are increasingly delegated to residents via the EHR instead of other administrative staff. This has been an increasing source of frustration for residents due to the perceived time burden for these kinds of tasks.

There is of course recognition that this “service” component does have practical and professional value as well, as it is an essential part of running any medical service. It also prepares students and residents for their future independent clinical work. Nonetheless, with a trend towards reduced resident/student hospital duty and on-call hours in many educational jurisdictions (Block et al., 2013), educators and learners are keen to make sure that precious clinical hours are used judiciously for educational purposes.

### 3.4.1.3 Workflow and Electronic Health Records.

Workflow by its very nature will require “time”, in order for the associated “clinical activities” to be accomplished. EHRs have become an integral part of this process.

Thematically, workflow and resident time utilization are the most recurrent themes within the total analyzed 82 articles, involving 40 articles (48.8%). This is to be expected since the daily workflow is logically an integral part of resident and student training. By virtue of the daily tasks, this particular theme overlaps with the other themes, as workflow also involves for example, “communicating” with patients and other colleagues, “note keeping” and writing relevant clinical “documentation”. Within this particular theme, a prominent and recurring concern is how EHRs have influenced student and resident time utilization and how they have impacted their learning process.
3.4.1.4 EHR and time utilization.

Estimates of how much time residents and students spend using EHRs varies. Table 3.4 outlines the studies that examined how much time residents and students spend on EHRs. Although the reported time formats differed, the results have a common pattern: residents spend a substantial amount of time working on EHRs, reaching up to 7 hours/day on computers as outlined by Table 3.4. The consensus is that learners spend at the very least 30% of their working day dealing with EHR-related work. In the study conducted by (Oxentenko, West, Popkave, Weinberger, & Kolars, 2010), they surveyed 16402 trainees IM residents about their EHR usage, specific to documentation times, 67.9% of residents reported spending over 4 hours daily on documentation; of these, only 38.9% reported spending this amount of time in direct patient contact.

It is important to note that resident’s perceptions of time may not reflect reality with some evidence indicating that students and residents do not accurately estimate their EHR time usage if asked to self-report this (Chi et al., 2014; Gilleland et al., 2014). Interestingly, when residents were asked about their perceived EHR time usage, they were more likely to overestimate their EHR time, quoting numbers nearly twice as high as that observed. The time-related data in the studies shown in Table 3.4 are not self-reported.

Block et al (Block et al., 2013) observed internal medicine interns for more than 800 hours at two sites and found on average that interns spend 40% of their time working on computers, with only 12% of their time spent on direct patient care. Chen et al, (Chen et al., 2016) expand this further and compared internal medicine interns’ EHR usage between July and January of the same academic year. They found resident EHR time was 7 hours/day in July, and although EHR familiarization reduced the amount of time to 5 hours/day by January, the EHR time commitment remained high.

When looking to see how medical specialties differ, Chi et al (Chi et al., 2014) in their cross-sectional study, compared undergraduate medical student EHR usage during their clerkship, in a single centre study. They found that students in internal medicine (IM) rotations had the highest number of hours of computer screen time compared to other specialties (6.19 hours/day (IM) vs. mean of 3.25/day...
hours for the specialties). Interestingly, this study also looked to see if the amount of EHR screen time affected their examination performance by examining computer time and exam scores and they found no impact.

Asan et al (Asan, Kushner, & Montague, 2015) investigated EHR usage amongst family medicine residents by directly observing resident behaviour and found that year 3/senior residents had more on screen time when compared to junior residents. This incremental increase seems to be related to growing responsibility for managing patients and supervising junior team members, which would typically require more EHR use.

Residents’ perceptions on EHR usage is discussed in more detail below, but suffice it to say that there are mixed results, with learner’s showing both negative and positive feedback on EHRs and how it impacted their education.

For example, the feedback from the survey done by Campbell et al (J. K. Campbell, Ortiz, Ottolini, Birch, & Agrawal, 2017), time used on the EHR was perceived as the least educational aspect of their service, and this time was substantial in their study, with an average EHR time of 3.4 hours/day.

Table 3.4 Time spent using EHR, summary of studies with relevant data.

<table>
<thead>
<tr>
<th>No</th>
<th>Article</th>
<th>Population</th>
<th>Reported average time spent on EHR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Block, L. et al, 2013.</td>
<td>Interns, Residents (IM)</td>
<td>40% of time.</td>
</tr>
<tr>
<td>2</td>
<td>Campbell, J et al, 2016.</td>
<td>Interns (Pediatrics)</td>
<td>33% of time</td>
</tr>
<tr>
<td>3</td>
<td>Chen, L. et al, 2016</td>
<td>Interns (IM)</td>
<td>7 hours/day in July and 5 hours/day by January</td>
</tr>
<tr>
<td>4</td>
<td>Chi, J. et al, 2014</td>
<td>Medical students</td>
<td>IM = 6.19 hour/day vs. 3.25 h/day mean time for other specialties (surgery, obstetrics etc.</td>
</tr>
<tr>
<td>5</td>
<td>Victores, A. et al, 2014</td>
<td>Otolaryngology residents</td>
<td>48.6% of resident time (clinic days only, did not effect operating room days)</td>
</tr>
<tr>
<td>6</td>
<td>Ouyang, D. et al, 2016</td>
<td>IM PG residents (interns)</td>
<td>Average 4.2 hours/day (36%)</td>
</tr>
</tbody>
</table>
3.4.1.5 EHR and direct patient contact.

Block et al in their observation of interns for over 800 hours found that only 12.3% of intern time was used for direct patient care. Campbell et al reported comparable results, with pediatric residents spending only 12% of their time in direct patient care vs 40% time on EHRs. Victores et al (Victores, Coggins, & Takashima, 2015) also noted a significantly reduced direct patient time when looking at otolaryngology residents working in an outpatient setting.

3.4.1.6 Remote Access and Workflow.

The accessibility of EHRs gives potential for students and residents to access patient information from home. This takes their work beyond the confines of the hospital and the official work and on-call hours. This “remote access” has the potential to negatively impact learner’s quality of life and can contribute to burnout risk.

Gilleland et al (Gilleland et al., 2014) and Deaño et al (Deaño, 2011) examined resident off-hours access to EHRs. Gilleland et al found that IM residents in one centre spent 1.2 hours/week using EHRs, via the use of electronic login/log out data. Deaño et al, when looking at IM residents (two sites), found that 93% of residents check patient lab results from home, with 45% of residents doing it on a regular basis, with 66% of them doing so on their off-call days.

Another way which the remote access has changed workflow is that senior supervision occurs remotely. Previously, direct attending or senior resident interactions can occur with junior members of the team being present to review their documentation and order entries, and this often fostered teaching moments.

One qualitative article by Wong et al (Wong et al., 2012), examined this aspect and their study provide valuable, real life insights. The following quote from a participant (a resident) from the Wong et al study is very useful:

“I think for the day-to-day issues that come up in the work, yeah it is an issue. You know, when I was a medical student and I was ordering things like potassium replacement or anti-coagulation orders and things like that, then I would have to show it to my senior resident. And they would teach me about those basic day-to-day things that most of us take for granted later on in residency but are a big part of medical student learning. And
Another aspect is that, although participants recognized remote access provides convenience for senior staff to monitor teams and patients remotely, it can fragment care and affect boundaries and resident autonomy, as work could be done for them by attending staff, thus taking away learning opportunities and the chance to gain valuable experience. This is especially true if supervising attending staff are not aware of this aspect and have a low threshold for intervention, especially as remote systems makes this much easier.

It is not all negative though and learners recognized in the same study some positive aspects if they deliberately used the tools at hand to enhance their teaching. Patient data is always available for the team to access, even if the paper chart is far away, thus team members can discuss patients remotely and this can readily facilitate teaching. Supervision can also be aided and is generally safer, if done in a manner that respects resident’s need for judicious autonomy.

3.4.1.7 Clinical information and workflow.

Although EHRs have eased access to huge amounts of patient data, there is concern about how this information is presented and how it could impact physician workflow, both in terms of the time required to process available data and also the time required to build and curate new data points. Note-keeping and documentation are an important workflow components and take up a significant amount of time. Bloom et al (Bloom & Huntington, n.d.) noted a negative impact on family medicine residents and physicians, in terms of how much time it took to document patient notes, with both resident and faculty perceived documentation times reaching up to 13 minutes per patient, for encounter lasting only 15 minutes. Neri et al (Neri et al., 2015) , directly observed residents and found that they spent 65% of their time with patients documenting on the EHR. The article by (Oxentenko et al., 2010) was discussed in the time utilization section, where over 67% of residents reported spending in excess of 4 hours a day on documentation.

Over the years, despite the hope that EHRs would improve efficiency, these documentation times have substantially increased, often taking up 4 hours from the working day (Schenarts & Schenarts,
When compared to paper-based records, EHRs seem to be more taxing in terms of how much is required documenting and reviewing charts. In fact, Wormer et al. (Wormer & Williams, 2015) noticed a doubling of documentation time when compared to paper-based documentation after EHR implementation. However after 6 months, with increased EHR familiarization, these timelines trended towards paper-based timelines.

With the increased documentation time accompanying the advent of EMRs, there has been recognition that over the years there has been a shifting of roles and scope of practice in the working environment. Increasingly, residents and physicians are doing administrative work (such as preparing letters and requisitions) which takes up a substantial amount of time and are negatively perceived by both residents and practicing physicians (Halas et al., 2015).

Another informative perspective was provided by Varpio et al. (Varpio et al., 2015), in a qualitative study which looked at the way a particular EHR in a pediatric hospital setting affected time and data interconnections and ultimately clinical reasoning. Varpio et al report that electronic records did not have the interconnected data that is present in paper records. The data in EHRs was “chronologically and contextually isolated”. Due to this, their study participants stated that they: 1) did not know patients evolving status, 2) they reported increased cognitive workload and 3) loss of clinical reasoning mechanisms.

In this study there was recognition that EHRs presented vast amounts of data, when compared to paper charts, and the challenge was how to sift through this data and make sense of this. To use a quote (Schenarts & Schenarts, 2012), clinicians and learners using EHRs would have to contend with a “data feast but a clinical thinking famine”. Varpio et al explain that this process was time-consuming and frustrating for the participants. One useful quote from one of their participants explains this frustration:

"Furthermore, the EHR interface presented all data points and displayed each point as equally important. This created an overwhelming display of undifferentiated data, forcing clinicians to spend excessive amounts of..."
time sifting through the data in order to ascertain the patient’s particular situation. Participants did not have time for this sifting work, which resulted in a sincere concern that clinicians did not comprehensively know their patients.”

The also explain the concept “narrative”, which they define via the literature as “set of events and the contextual details surrounding their occurrence, that is meaningfully organised chronologically”. This narrative allows clinicians to understand the patient’s clinical context via a chronological connection of events enabling clinical reasoning. EHRs disrupts this narrative due to the way they organize data into discrete units.

Interestingly, in the same study, senior doctors seem to have more difficulties with EHR when compared to medical students. There is no clear explanation for this finding. Is this related to clinical experience, which can influence how one deals with the EHR or is this a generational difference?

They report that students are more likely to appreciate the assistance and prompts from the EHR when taking notes and are less likely to overestimate their clinical reasoning skills.

In an informative qualitative review (Farri et al., 2012), the authors used a “think-a-load” method to elucidate the cognitive process that contributes to the synthesis clinical notes by interns. This article will be discussed in more detail in the documentation section, but from a workflow perspective, their analysis identified barriers that hinder the synthesizing of EHR documents, which could disrupt workflow. This included: 1) difficulty searching for patient data, 2) poor readability, 3) redundancy, and 4) unfamiliar specialized terms. All these can contribute to longer times on the EHR due to poorly synthesized and accessible notes.

3.4.1.8 Workflow optimization.

Although a large number of the included studies reported the affect of EHRs on workflow, there still a lack of specific research on how to best optimize workflow, especially in a manner that enhances student and resident learning. All the research within this theme is descriptive or qualitative and there
have been no interventional studies or RCT’s that aimed to help understand how to best optimize these systems to promote a better learning environment.

Two of the studies did report interesting findings that contribute to elucidating this problem. Neri et al (Neri et al., 2015) employed a mixed methods approach in order to understand emergency department (ED) physicians’ use of EHR documentation, especially to attempt to identify usability and workflow considerations that could be used to design of future ED information system (EDIS) physician documentation modules. The ED residents participated in a simulation in which they were asked to document a clinical encounter with the aid of an EHR while interacting with a simulated patient actor, during which their performance was recorded by video. The results corroborated the general perceived trend regarding workflow and documentation. The participant residents spent 65% of their time with patients using the EHR to document the findings. The task analysis and qualitative feedback raised several issues, particularly the need for more well designed systems that facilitate workflow and clinical thinking. Another recommendation was to customize EHR systems according to different patient scenarios so that documentation could be easily facilitated as per patient category (emergent versus cold cases), and having the ability to easily draw diagrams etc.

The second study by Nuovo et al (Nuovo, Hutchinson, Balsbaugh, & Keenan, 2013) observed interns across different specialties (IM, pediatrics, surgery, family medicine, psychiatry, community medicine) to obtain insight into how these residents performed in completing certain EHR-related tasks for both inpatient and outpatient workflows. For ambulatory workflow skills, 70%–100% of the interns were competent. The skills that interns needed the most assistance with were in: (1) Generating and routing a result note (25%), (2) deleting or changing a medication dose (reconciling medications) (15%), (3) locating results for past 90 days (15%).

For inpatient workflow skills, 63%–100% of interns showed the required competence. Three skills in which interns required most help were with: (1) creating a referral order at discharge (34%), (2) finding patient temperature on a flow sheet and accessing trending data (21%), and (3) generating a discharge summary, getting it reviewed, and then forwarding it to the patient’s primary care doctor.
(21%). Although they did not obtain the resident’s baseline EHR skill assessment, their findings provide an example of how assessing resident EHR skills can be used to tailor EHR training, which can maximize EHR proficiency and thus better workflows.

Simulation has an important role to play in this context, which can help further analyze how learners use EHRs. This would be invaluable to help better design systems and workflows (Mohan et al., 2016).

Although we do not have enough data on how to best design and implement these systems in an educational setting to allow for better learner workflow, there is evidence that EHR familiarization alone does help to bring down EHR screen time as also noted by several authors (Chen et al., 2016; Shriner & Webber, 2014; Wormer & Williams, 2015).

For example, Chen et al (Chen et al., 2016) reported that after 6 months of residency training, interns begin to gradually save time, reaching 2 hours per day saved per resident after they gain EHR experience, which is a significant amount of time that could be used for other educational activities. This presents a compelling argument that medical students should acquire EHR experience and gain familiarization prior to residency training so they can start residency training being EHR-proficient (Welcher et al., 2018). This would give them the advantage of gaining valuable extra education time during their crucial initial 6 months of training (which is 17% of a 3-year residency program).

3.4.1.9 Other workflow related issues.

There was reported concern for computer downtime and whether learners are being trained on how to deal with this (M. J. Tierney, Pageler, Kahana, Pantaleoni, & Longhurst, 2013; Wormer & Williams, 2015); (Aaronson, Murphy-Cullen, Chop, & Frey, 2001). But there have been no clear recommendations on how to best deal with this and how to build contingency. Computer provider order entry (CPOE) is being increasingly used to help with workflow. It has great potential for helping to streamline workflow and clinical safety, but some studies were concerned that it could negatively affect clinical reasoning and also impact how clinical knowledge is gained or processed (Tierney et al., 2013; Wong et al., 2012). With regard to actual workflow, the study by Shriner and
Webber, (Shriner & Webber, 2014) in a pediatric setting documented that residents reported an initial increased workflow commitment when COPE’s first replaced traditional paper order entry, but by 12 months this difference disappeared and residents developed a preference for the newer technology. This highlights the importance of adequate training and time for these technologies to be accepted while closely following the process to ensure successful implementation.

In summary, EHRs have been shown to significantly affect workflow, both for learners and teachers. Optimizing EHR workflows to reduce the significant time that residents spend on these systems will free them to participate in other well-established educational activities and importantly, to gain more time for direct patient contact and experience. This outlines the potential impact that further educational research could achieve if leveraged to improve how we can better design EHRs and how we can best work with them. Although there is a scarcity of research in this area, there are notable opportunities to further this particular area and greatly impact student and resident education as a whole.

3.4.2 Theme 2: Medical student/resident documentation and note keeping.

This theme was the second most represented theme from the selected articles, involving 35 articles (42.7%). The Master Table (Appendix Table 2) provides a full summary of this theme’s articles, with a “DOC” theme code designation.

As noted in the opening chapter, the skill of proper clinical documentation is an essential part of medical training. The process distils clinical thinking onto a storage medium (paper or electronic) that can help to guide the clinical reasoning process and provides building blocks for future work. It also logs patient progress that helps to guide clinical care and provides an indispensable route of communication to the caring team. During these process, clinical notes should always be accurate, timely and clinically relevant and of appropriate length, avoiding redundancy and information overload.
The most three important components of an EHR include: 1) clinical documentation (notes), 2) patient data (e.g., labs, radiology results, other test results), and 3) computerized order entry (for tests and medications) (Keenan et al., 2006). For the purpose of this theme, the terms *documentation* and *notes* will be used interchangeably.

In essence, documentation is an essential facet of EHR’s function. Medical students and residents have always been involved in the curating and documenting patient data. This role has further developed with the advent of EHRs. Although EHRs are largely replacing paper records, some of the paper record functions have carried over in the same manner to their electronic counterpart, but this medium has also expanded the repertoire of this technology and has provided both new opportunities and new challenges. Electronic documentation, via EHRs, offer better legibility, accessibility and reduced costs (O’Donnell et al., 2009). However, there also many challenges which affect how a learner documents and processes information, of which the workflow-related component of documentation was already previously discussed.

The main topics that are addressed within this thematic group are represented in Table 3.5, with their corresponding methodologies. Each topic will be reviewed individually. The student access section will be discussed as part of the broader theme of “Student Access to EHRs”.

### Table 3.5: Representation of most prominent topics discussed in the Documentation theme.

<table>
<thead>
<tr>
<th>Main Focus of research</th>
<th>Quantitative</th>
<th>Qualitative</th>
<th>Mixed</th>
<th>Review (other)</th>
<th>Total (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copy-paste Phenomena</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10 (33.3)</td>
</tr>
<tr>
<td>Note templates</td>
<td>5</td>
<td>1</td>
<td></td>
<td></td>
<td>6 (20)</td>
</tr>
<tr>
<td>Student Access/participation</td>
<td>5</td>
<td>1</td>
<td></td>
<td>1</td>
<td>6 (20)</td>
</tr>
<tr>
<td>Teaching strategies</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td></td>
<td>5 (16.7)</td>
</tr>
<tr>
<td>Learner Assessment (specific to or including)</td>
<td>3</td>
<td></td>
<td></td>
<td>1</td>
<td>4 (13.3)</td>
</tr>
</tbody>
</table>
3.4.2.1 Copy-paste phenomenon.

This is a prominent topic within this theme. Increasingly physicians and medical trainees who have access to EHRs are using the copy-paste function to help construct new or updated notes. This function is often used because it enhances efficiency, however there is concern that it can promote poor practices and may raise clinical safety issues.

3.4.2.1.1 Definition of copy-paste.

Depending on context, the literature provides a number of definitions for this function. Tsou et al. (Tsou et al., 2017), provides a useful definition in which they define the copy-paste function in this context as:

“Selecting data from an original or previous source to reproduce in another location; obtaining this data volitionally from another part of the record and reusing it without retyping any information”.

Other terms, also used in our selected articles include but not limited to: “copy forward”, “auto-population of data”, “cloning” etc. This is not to be confused with the term “chart biopsy”, which is also a practice that is increasingly enabled by EHRs. This refers to a process whereby a certain part of a patient’s clinical data is selectively collected in order to gather relevant clinical information which aims to orient the physician to the patient and provide clinical context prior to seeing the patient (Neri et al., 2015). This is generally regarded as getting the “gist” or “overview” of the patient from the EHR notes prior to seeing the patient.

3.4.2.1.2 Prevalence of copy-paste practice.

Some of the included papers provide some data, 2 via a self-reported survey and 2 by observational means. Overall, the prevalence of this practice is reported to be relatively high, at all levels of seniority. Table 3.6 outlines the results, which range from 20 to 95% depending on context and
extent and type of copying. This is consistent with other published data (Tsou et al., 2017).

Interestingly, the evidence shows that medical students who have access to EHRs also use this function to prepare their notes, as seen by the Heiman et al (Heiman et al., 2014). This study described a policy at Northwestern University School of Medicine that allows copying from a learner’s own note, but not from others’ notes. But only 42% were aware of this policy, and 90% of students did not believe it acceptable to copy from others in any case. The vast majority of students reported that they were seeing their supervisors perform the copy-paste practice and their overall opinion of the exercise seemed to be ambivalent, with 83% believing it improves efficiency, but only 11% believing that it improves safety.

Table 3.6: Papers that reported prevalence of copy-paste practice

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Method</th>
<th>Prevalence of copy-paste practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heiman, et al, 2014.</td>
<td>Undergraduate (UG) medical students</td>
<td>Survey</td>
<td>86% report seeing residents copying data from other providers’ notes. 60% reported observing attending physicians doing this. Most students (95%) report sometimes copying from own previous notes and 66% frequently/always. 22% reported copying from residents. Only 10% indicated copying from other providers acceptable. 83% believe copying from their own notes is acceptable.</td>
</tr>
<tr>
<td>(Heiman et al., 2014)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O'Donnell et al, 2009,</td>
<td>Postgraduate residents and attendings (Internal</td>
<td>Survey</td>
<td>90% of physicians (both residents and attendings) used copy/past in daily notes, with 78% of whom are high copy-paste users. Residents 3x more likely to be high copy-paste users vs. faculty</td>
</tr>
<tr>
<td>(O'Donnell et al., 2009)</td>
<td>Medicine and pediatrics)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>March et al, 2016,(March et al., 2016)</td>
<td>Postgraduate residents</td>
<td>Observational cohort</td>
<td>48% of residents notes had copy-paste elements</td>
</tr>
<tr>
<td>Dean et al, 2015 (Dean,</td>
<td>Postgraduate residents (pediatrics)</td>
<td>Before and after study</td>
<td>Pre intervention data: 20% of physical exam notes did not appear to be newly written (i.e. they looked copied) as well as 52% of assessment notes did not appear to be newly written.</td>
</tr>
<tr>
<td>Eickhoff, &amp; Bakel, 2015)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.4.2.1.3 Perceived advantages and disadvantages from the copy-paste practice related to learning

The high prevalence of the copy-paste practice is attributed mainly to the efficiency factor. As indicated in the Workflow theme, there is an overall increased time burden because of EHR use, thus these efficiency functions are often used and appreciated as they help to offset this time and additional work burden.

To illustrate this, one interesting analysis was provided in the mixed methods study by Aylor et al, (Aylor, Campbell, Winter, & Phillipi, 2017), where a pediatric resident provided this on the copy forward (copy-paste) function:

“If we could not do that (copy forward), 75% of our day would be, like, notes.”

There are however, a few reported disadvantages to this function, principal of which is patient safety. In a review by Tsou et al, (Tsou et al., 2017), in which they summarize the mechanisms by which this feature can cause harm, they conclude the following: 1) The cut-paste function facilitates the introduction of new note inaccuracies, and by virtue of EHR accessibility, it 2) can accelerate the circulation of inaccurate information, 3) can promote the creation of inconsistent notes, and 4) can cause “note bloat”, with the pasted notes often being long, which can hide and obscure important clinical information. The latter is also called “note clutter” (Dean et al., 2015).

Along these lines and of concern, O’Donnell et al (O’Donnell et al., 2009), noted that 25% of respondents reported that the copy-paste function is more likely to lead to a mistake in patient care and 71% thought that these notes are more likely to be out-dated. There were no reported patient outcome data from the selected papers. One other study, unrelated to medical education, looked at the rate of diagnostic errors in a primary care setting, and they observed that copy-paste mistakes contributed to 35.7% of errors (Singh et al., 2013).

Importantly for my educational objectives, there was also significant concern that the copy-paste function can inhibit learning. Hammoud et al (Hammoud, Margo, et al., 2012), in their Alliance for Clinical Education (ACE) collaborative statement, reported that the copy-paste function can hinder
student thinking, especially in potentially losing the process of obtaining then synthesizing clinical information.

Since the information is already available, this is further exacerbated by electronic template usage. This view is also expressed by Mintz et al (Mintz et al., 2009), and Welcher et al (Welcher et al., 2018). The ability to synthesize clinical information and then to make sense of it is essential in the development of clinical reasoning skills.

Concerning the process of actual note synthesis Farri et al (Farri et al., 2012) analyzed this in detail via a qualitative method. Their “think a load” protocol managed to garner very useful information. Their analysis concluded that interns establish correlations of meaning in problem, symptom and treatment (PST) which informs hypotheses generation and clinical decision-making. Barriers identified with synthesizing EHR documents include difficulty searching for patient data, poor readability, redundancy, and unfamiliar specialized terms. PST process should be considered for better EHR interface design with barriers. Thus the recommendations include: 1) Cues for Improved visualization of patient documentation sections, 2) Highlighting Status changes (to counter redundancy, esp. related to copy/paste), 3) Glossary to explain specialized terms.

Poor organization (i.e. difficulty obtaining data) can lead to poor motivation which could lead to increased chances of inaccurate clinical judgment.

There is also an ethical and legal perspective, which can impact both learning and clinical practice and these two aspects constitute barriers that have prevented some students from obtaining full EHR access in some medical schools (Mintz et al., 2009). Authors have also cited the ethical risk of plagiarism, whereby learners can copy-paste notes of actions that were never actually written by the learner. These ethical and legal concerns, were largely shared and reiterated by Hammoud et al (Hammoud, Margo, et al., 2012).

3.4.2.1.4 Proposed solutions for the copy-paste phenomenon.

Dean et al (Dean et al., 2015) used an educational bundle to try to improve resident’s EHR progress notes, which included strategies to reduce the copy-paste behaviour. The interventions they used
included: establishing note-writing guidelines, developing an aligned note template, and educating the interns about these guidelines and the use of this template. Their before/after study did not show any change in the copy-paste behaviour, although there was an improvement in terms of “note-clutter”. Fanucchi et al (Fanucchi, Yan, & Conigliaro, 2016) also conducted a controlled before/after study, with IM residents as the study group, and an educational intervention through either a lecture, or a lecture with individual note related feedback. Amongst the educational components was the reduction of the copy-paste behaviour. Overall, the results showed no impact from the intervention, but they did not show the specific copy-paste data.

In terms of gaps, there have been no clear, evidence based recommendations and no RCT studies have examined this issue. Despite the ubiquity of this practice, there is no educational study examining how this behaviour impacts clinical reasoning or long-term educational outcomes. Such a study would be useful as properly designed studies can inform future educational practice. Although some medical schools have policies in place that restrict this practice, it is not clear how effective or appropriate these are. As the practice is widely used and the studies to date have failed to change this behaviour, one possible route is to study how to best use this function. Some have suggested a technological mechanism to highlight copied-pasted texts for safety and educational reasons, so that learners and clinicians can readily ascertain old vs. new information and also avoid redundancy (Tsou et al., 2017). Another recommendation is better mentorship, especially as attending staff tend to readily use this function. Attending staff should be aware of the potentially negative aspects of this function and provide active feedback on student and resident notes (Mintz et al., 2009).

3.4.2.2 Teaching strategies regarding documentation

There are no clearly defined evidence based documentation teaching strategies in terms of EHR usage in a medical education setting. In terms of the selected articles, there were 5 articles, 3 used a quantitative/descriptive methodology, one was a qualitative study, and one was mixed quantitative/qualitative.
There is clear recognition that better teaching strategies need to be employed in the education community. In a survey done by Atwater et al (Atwater A.R. et al., 2016), a survey of education experts was conducted via the Delphi method that aimed to develop teaching strategies to teach EHR skills to postgraduate residents. For the documentation section, they suggested the following teaching approaches for resident EHR charting education:

- Review note with trainee
- Compare the fixed or changed note to initial note
- Provide feedback on the trainee’s notes
- Review imaging with trainee/team
- Produce a list of interesting cases
- Faculty should model how to use the EHR to trainees.

Interestingly, the panel of experts felt that classroom didactic approach to EHR was not as effective as hands or “just in time” training.

Hammound and Dalrymple et al, (Hammoud, Dalrymple, et al., 2012), in their Alliance of Clinical Education statement, recommend that medical schools develop clear set of competencies related to student documentation in the EHR which students must achieve prior to graduation. Their summary of recommendations states that: (a) Students must document in patients’ charts and their notes should be reviewed for content and format, (b) students must have the chance to practice EHR order entry prior to graduation, (c) students should be exposed to decision aids that accompany EHRs, (d) schools must develop a set of student competencies related to EHR charting and an accompanying assessment plan.

In terms of teaching advantages, a survey done by Hammound and Margo et al, (Hammoud, Margo, et al., 2012) stated that EHRs have the ability to provide point-of-care education. This is could include features such as contextual imbedded tutorials, decision aids that help with diagnostic support, medication interactions etc. There have been no studies addressing how to best use these tools.
In the qualitative study by Halas et al (Halas et al., 2015), teachers expressed concern that their EHR-related workflow affected their teaching time, but no information was provided on how to deal with this. There was a recognition that there is a “huge learning objective” to learn how to use the EHR. There was also appreciation for the ability to simultaneously view a patient’s documentation and listen to resident’s present that particular patient to provide instant feedback, which was seen as a teaching and learning advantage.

An interesting perspective was also provided by Seifan et al (Seifan et al., 2013) where they studied the integration of a knowledge management system within an EHR as a teaching/learning tool. This is further discussed in the EHR knowledge theme. From the corresponding article survey, the participants viewed the tool positively as a learning tool if implemented correctly.

There also needs to be a better understanding how EHRs affect clinical reasoning, to avoid any unintended and long term consequences for learners, whether students or residents. As previously explored in the “workflow” theme, Varpio, Rashotte’s et al (Varpio et al., 2015) qualitative study found that clinical reasoning support mechanisms were lost due to the way that data is presented in EHRs. This resulted in a loss of patient data interconnections and as a result, narrative and chronological flow were negatively affected. Being aware of this phenomenon means that teaching strategies should consider this aspect and purposely compensate for any loss of data connectivity so as to aid in the development of clinical reasoning. Unfortunately, there is still a lack of research to inform how to best do this and EHR design has yet to evolve to this compensate for this lack of data connectedness.

3.4.2.3 Note Templates.

Template-based documentation, like the copy-paste phenomena, is meant to be used as an efficiency tool. It is also utilized to help ensure consistency, which is especially important for data collection. Furthermore, templates can promote a certain quality and safety standards for clinical notes. (Hammoud, Dalrymple, et al., 2012). Templates are pre-structured forms that guide and remind
learners or practitioners to ask relevant historical questions and prompt them to perform important parts of the physical examination (Keenan et al., 2006).

This topic featured in a significant manner in 7 articles. Table 3.7 summarizes the main points.

Additional details are included in the Master Table (Appendix)

Some authors expressed concern that EHR templates can impair student learning as they can diminish the information-gathering skills required to develop clinical reasoning. Although many medical schools allow medical students to use EHR, many also restrict template usage out of this concern. As stated in Table 3.7, Hammoud et al (Hammoud, Margo, et al., 2012), only 26% allowed students to access templates.

The published studies do not provide any guidance or evidenced-based recommendations of how templates can be maximized for teaching or student/resident learning.

Table 3.7 Article summaries of template information and education.

<table>
<thead>
<tr>
<th>Article</th>
<th>Population/ Methodology</th>
<th>Main findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aylor et al, 2017 (Aylor et al., 2017)</td>
<td>Pediatric Residents/ Mixed Methods (Quantitative(before and after), Survey, Focus groups-qualitative)</td>
<td>- Shorter note length with new templates. Survey response: 89% liked the new note templates, 78% indicated new templates facilitated note completion. - Residents didn’t believe that new note templates made a difference in reflection on their own decision making but 33% reported that new note templates allowed them to more easily understand their colleagues’ decision making. - Resident focus group revealed ambivalence toward the EHR’s contribution to note writing.</td>
</tr>
<tr>
<td>Hammoud and Morgo et al, 2012, (Hammoud, Margo, et al., 2012)</td>
<td>Clerkship directors (undergraduate medical education)/ Survey (quantitative and qualitative)</td>
<td>Out of survey respondents, 74% reported that EHR templates for notes or orders exist within their</td>
</tr>
<tr>
<td>Study</td>
<td>Participants</td>
<td>Context</td>
</tr>
<tr>
<td>-------</td>
<td>--------------</td>
<td>---------</td>
</tr>
<tr>
<td>Heiman et al. (2014)</td>
<td>Undergraduate Medical Students/ Survey</td>
<td>Most students use templates and auto-inserted data for vitals and labs: Students used templates for entire notes: 85% Students used templates for physical examination: 83% For creating problem list via auto-insert: 31% Auto-insert for vitals/lab data: 98%</td>
</tr>
<tr>
<td>Mintz et al. (2009)</td>
<td>Postgrad directors/ teachers (Clerkship Directors in Internal Medicine institutional members at U.S. and Canadian academic health centers.)</td>
<td>Some respondents raised following concerns regarding templates and medical education of undergraduate medical students (total respondents 15, n= number of respondent per that one point/comment), quotes from article: “Note templates do not allow students to understand important items that need to be documented; students “just click ‘n go’” (n =1) Pre-typed template notes “document too much” (n =1) “Templates and “pick-lists” (i.e., drop-down menus) result in a note that can make little, if any, sense (“n =1)</td>
</tr>
<tr>
<td>O’Connell, Cho, Shah, Brown, &amp; Shiffman (2004)</td>
<td>Pediatric and internal medicine residents/ Survey</td>
<td>Medicine subjects were less likely to believe that template-based documentation improved their efficiency vs. pediatric residents. 56% of IM residents and 91% of pediatrics residents believe that templates teach about recommended practices.</td>
</tr>
</tbody>
</table>

### 3.4.2.4 Learner Note Assessment.

The medical record is an important part of the medical education process and is often considered one of the important modalities to assess student/resident competencies (Friedman, Sainte, & Fallar, 2010). One advantage of the EHR is that it allows better note visibility due to the accessibility allowing residents to get more timely feedback on their notes.
In terms of formal curriculum that incorporates assessment, in the survey conducted by Freidman et al (Freidman et al, 2010) of medical school deans in the United States, 68% of respondents indicated they had a formal didactic curriculum to teach students how to write, then assess their own progress notes. This encompassed both paper and EHR notes, with the focus mostly for third year medical students. Similarly, Solarte et al (Solarte et al, 2017) report from Colombia that only half of the medical school deans and students there report: 1) the existence of a formal program to teach how to write and assess progress notes in EHR and 2) the existence of a policy regarding the placement of student notes in EHR.

Hammoud et al (Hammoud, Dalrymple, et al., 2012) laid out a student documentation evaluation framework which includes assessment of knowledge and skills, with methods such as “checklists for content and Likert scales for issues such as quality and accuracy of data, organization, completeness, and originality of the note”. The latter was important as the copy-paste practice could obscure proper assessment and mechanisms are needed to evaluate this. They highlighted how the RIME framework (Reporter, Interpreter, Manager, Educator) could be used to assess the learner note to ascertain the qualities for these RIME components. They also discussed other ideas such as automatic capture of student notes that could be incorporated into students’ portfolios and sent to their teachers/supervisors for evaluation and feedback. In terms of testing a practical approach to assessing note-taking competency, Nuovo et al (Nuovo et al., 2013) evaluated 68 first year residents in EHR competencies after they received baseline training. The testing included tasks such as: “Write a note using the Smart Text template” and “For rounding; entry progress note and have it reviewed by the chief resident”. 93% of the participants reached competence for these tasks and 79% managed to complete a discharge summary. The authors did not provide sufficient detail on how note quality was assessed. Barriers to providing learner note feedback include increased EHR-related workflow’s for attending staff and supervisors (Halas et al., 2015).

With regards to assessing note quality, March et al (March et al., 2016), developed a high fidelity EHR exercise that assessed the quality of IM interns’ notes. The residents received no training and
the testing was done 3 months after the interns began their training. They were asked to review a simulated chart of a patient, which contained 5 days worth of clinical information and then to formulate a progress note based on this data. On assessment, 48% of the notes contained copy-paste data, with 19% duplicating the previous day’s data. There were also some safety issues, with 47% of participants failing to document certain vital patient facts. This novel exercise provides an example of how notes can be assessed and how feedback and training can be tailored and conducted in a simulated environment.

One interesting study by Stewart et al (Stewart et al., 2015) can shed light on different perceptions of what the EHR note is meant to do and how it is assessed. The authors surveyed both house staff and attending staff about internal medicine progress notes. When specifically asked about the copy forward function, there was discrepancy between the house staff and their attending staff, with house staff favouring it and their attending staff the opposite. One explanation that the authors suggest is that attending staff are more likely to look at resident notes using the RIME lens and assess their ability to synthesise the clinical picture appropriately, as opposed to the trainees who see the task of note as more of an information gathering exercise. This is important to know so that residents and learners can be taught early on the objectives of record keeping and how this can facilitate clinical thinking and further their education, and the purpose is not only that of information collection.

There is evidence that learners appreciate feedback on their notes. Rouf et al (Rouf, Chumley, & Dobbie, 2008) surveyed of third year medical students (Texas, USA) and found that approximately 40% of students reported that they received more feedback on their electronic charts versus when they used paper charts, which is considered as a positive finding. This does seem to be centre dependent, as the survey conducted by Heiman et al (Heiman et al., 2014), also in the US, found that only 12% of their 3rd year student respondents report getting feedback on their EHR notes (97% of them report using the EHR frequently). In terms of preceptors, in the survey study by White et al (White, Anthony, WinklerPrins, & Roskos, 2017), for those who allow students to write progress
notes, all of them report providing feedback to students on their notes. In the survey of Oxentenko et al (Oxentenko et al., 2010), most residents (56.5%) and program directors (63.0%) believed feedback on documentation happened less than 50% of the time, with program directors more likely to view feedback on documentation as highly important compared to residents.

With concern to how EHRs effect feedback on student progress notes, 30.5% of subjects stated that the EMR made no difference, 40.9% reported that the EMR made providing feedback somewhat or a lot harder, and 28.6% reported that the EMR made providing feedback somewhat or a lot easier.

Furthermore, a cross sectional study done by Wittels et al (Wittels, Wallenstein, Patwari, & Patel, 2017) of emergency medicine clerkship directors, when asked if they provided feedback on resident notes, approximately 95% of respondents provided feedback on student documentation. Of this, supervising faculty provide 92% of the feedback, followed by residents at 64%, the feedback is usually provided orally only in 75% of the time, and both oral and written feedback given 25% of the time. No details were provided for these studies as to whether a specific format was utilized for the feedback.

3.4.3 Theme 3: Medical student/resident and patient communication

The third central theme is that of patient/learner communication and how it related to the EHR. There are 29 articles within this theme, representing 35.4% of the total number of articles. For this section, “communication” is meant to denote “patient-learner” or “patient-physician communication”, unless otherwise stated.

Patient-physician (including learners) communication is one of the most important components of healthcare and serves a central function in building the therapeutic relationship. If communication breaks down and becomes dysfunctional; dissatisfaction and major disruption in patient care can result (Ha & Longnecker, 2010). Illustrating how important communication is, both the Accreditation Council for Graduate Medical Education (ACGME) (Stephens, Gimbel, & Pangaro, 2011) and CanMEDS (Ho et al., 2014) state that communication skills as one of their core
competencies that both students and resident trainees must aspire to achieve and their competency frameworks have been tailored to EHR use. Research in this area is a growing and important field given the way EHRs are seen to affect communication.

As mentioned in the other themes, EHRs require a major on-screen commitment due to the quantity and frequency of information. A study done by Margalit et al (Margalit, Roter, Dunevant, Larson, & Reis, 2006) found that primary care physicians focused on the screen as much as 42% of the visit, and “heavy keyboard use was evident in 24% of the studied encounters”. The “screen gazing” was found to be inversely related to physician engagement and emotional responsiveness with patients. Given the attention that computers demand, it is often seen as the “third person” in the room that can influence, indeed disrupt, the connection between caregiver and the patient. Central to my objective is to try to understand how this process impacts medical trainee education and to see what has been done to mitigate the recognized problems from an educational perspective.

A summary of all relevant articles are presented in Appendix Table 2, with the EHR/communication theme coded as “COMU”, which outlines all the articles that included communication in their content.

### 3.4.3.1 Positive versus negative EHR influences.

It is be important to understand the potential negatives and concerns to further help contextualize the effect of EHR on communication. This will lay the groundwork for addressing how these effects can be used to help train learners effectively use the EHR, i.e. how the negative aspects can be mitigated when educating trainees and how the positives effects can be reinforced. This could help guide future work on curricular design and implementation (Wald, George, Reis, & Taylor, 2014).

The studies by Crampton et al and Shachak et al (Crampton et al., 2016; Shachak & Reis, 2009) provide valuable insight from the literature, as they had a broader scope to look at this topic and distilled information from the non-educational literature as well. They reported broad mix of both
positive and negative effects of EHR in terms of communication, with some studies having neutral conclusions. The negative vs. positive aspects are summarized in Table 3.8.

Important to note is that the EHR often just magnifies baseline personal communication skills and traits, with naturally effective or well trained communicators being more likely show better EHR-related communication performance and better adaptability vs. those who are not (Frankel et al., 2005; Shachak & Reis, 2009).

In terms of how EHRs may effect communication in undergraduate medical education, a survey of clinical directors in the United States by Hammoud et al (Hammoud, Margo, et al., 2012) showed that most subspecialties were neutral in terms of how EHRs effect the patient-doctor relationship, except for Internal Medicine, who were more negative.

Table 3.8 Positive and negative aspects of EHRs on patient/physician/learner communication.

<table>
<thead>
<tr>
<th>Positive aspects: Related to better exchange of information:</th>
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<tr>
<td>EHRs facilitate exchange of medical information.</td>
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<td>EHRs facilitated completeness and accuracy of patient data by facilitating clarifications and information prompts.</td>
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<tr>
<td>Patient satisfied that way EHR information is presented on screen considered to be better and easier to understand vs. paper counterpart. This is especially true for patients who were non-English speakers.</td>
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<td>Some patients appreciated ability of computers to increase visit efficiency.</td>
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</table>

<table>
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<tr>
<th>Negative aspects: Related to reduction in patient centeredness.</th>
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<td>Patients notice reduced physician eye contact due to increased EHR screen gaze and typing time.</td>
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<td>Less rapport with the patient as physicians need more time to review information and also enter information into EHRs</td>
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<tr>
<td>Doctors listened less when using EHRs</td>
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<td>Some patients perceived less dedicated patient/doctor time when EHRs are used in the office</td>
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<tr>
<td>Concern for loss of privacy</td>
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</table>

*Adapted from (Crampton et al., 2016; Shachak & Reis, 2009) and (Lanier, Domincé Dao, Hudelson, Cerutti, & Junod Perron, 2017)

3.4.3.2 Article method distribution

The distribution is outlined in Figure 3.9. Unique to this particular theme is that the methodologies employed seems to be relatively more developed, as out of all the themes this had the only RCT’s (results summarized in Table 3.9). This theme also had the most rigorous systematic synthesis, in the form of a scoping review conducted by Crampton et al (Crampton et al., 2016), which explored the
role of health information technology (HIT) on the clinical encounter, both in general and in patient/clinician communication.

![Communication theme Article methodology distribution (n=29)](image)

**Figure 3.9** Outline of methodologies employed to study communication theme.

### 3.4.3.3 Effect of computers/EHRs on clinical encounter

Human interactions are complex by their very nature, and when adding a third active element, in this case the EHR, into the mix, it is bound to add more complexity. One interesting finding by Fogarty et al (Fogarty C.T., Winters P., & Farah S., 2016) was that despite the EHR being the significant “other” in the room, only 41.6% of residents introduced the computer as a tool to assist their clinic visit.

Crampton et al (Crampton et al., 2016) attests to this very fact. In their comprehensive scoping review, they studied the literature to better understand the impact of EHR on clinical encounters. Their research resulted in formulating the following major themes:
1) Patient attitudes toward clinicians’ use of EHR; 2) Impact of EHR on visit time and the time spent on various tasks; 3) Effect of EHR on the clinical encounter; 4) Physical setting; and 5) Clinical styles.

Their examination of the literature revealed that use of EHR affects clinical consultations in the following “complex ways”: It impacts (1) eye contact and gaze, (2) information sharing, (3) building relationships, (4) pauses in the conversation.

In terms of how these changes were perceived, the positive and negative opinions were discussed above. These perceptions depend on elements such as room layout (physical setting), where certain settings were inclusive (allowing screen sharing with patients) vs. exclusive (no screen sharing).

Another factor was clinical styles of physicians, whereby 5 types of styles are described, including such factors as body posture, amount of typing, screen sharing and gazing habits etc. Strategies are also explored in terms of how to mitigate known issues are also described, such as screen sharing, verbal and postural adaptations that aid communication and engage patients. These EHR-specific communication adjustments have been adapted into some recognised patient-centered communication models to help inform EHR communication-focused educational interventions.

Some of these will be discussed in section 3.4.3.6.

3.4.3.4 Attitudes and perceptions: Students, residents, physicians and patients.

The described themes often overlap in a significant way. Patient-physician communication is often affected by the workflow and documentation commitments. The challenges they pose were described in more detail in the earlier sections. The amount of information that learners and care providers have to deal with can be daunting, and the time required to process this often takes up time and inevitably influences the patient/doctor interaction.

In the study by Asan et al (Asan et al., 2015) conducted by direct observation of family medicine residents via video, they found that all residents had significant computer screen gaze time, with a mean percentage of 34%. Interestingly, third year residents had highest at 43%, vs 30% and 28% for 1st and 2nd year residents respectively. Typing behaviour was also studied, the mean percentage of
visit time for all years was 14.2%, and again, 3rd year residents had the highest percentage at 18%, vs 9.2 and 13% for first and second year residents respectively.

In terms of interpersonal communication, gazing behaviour between patients and residents, average visit percentage times were as follows: resident to patient gaze 49%, patient to resident gaze 51%, and mutual gaze was 35%.

In the same study, concomitant patient survey results, revealed patients felt that computers made the visit less personal and more frustrating, with this being more significant when they saw senior residents. No explanation was actually sought to find why senior residents trended to having more screen and typing time, but the authors speculated that this was due to increased knowledge and comfort when it comes to using the EHR whilst dealing with patients as apposed to more junior trainees who may avoid using the EHR whilst seeing patients as they were less comfortable using the computer or taking notes during their patient interaction. It is important to note that in this particular study group, they never received any formal EHR-related training.

An important question is whether this trend of seniority and increased computer screen time further increases when residents transition into being attendings and/or faculty. Rouf et al (Rouf, Whittle, Lu, & Schwartz, 2007) found that patients reported that if they were seen by residents, computers reduced the amount of interpersonal engagement vs. that of faculty. Patients also agreed that computers adversely affected the amount of time residents spent on the following when compared to faculty vs. residents: talking (34% vs. 15%), looking at them (45% vs. 24%), examining (32% vs. 13%). The visits were deemed to more likely to be “less personal” (20% vs. 5%). All these differences were statistically significant.

Only a few patients thought computers interfered with their relationship with their doctors. Although residents reported general computer knowledge that was similar to faculty, this does not refer to specific EHR knowledge and skills, thus extra experience with the EHR system will likely improve performance in relation to communication skills.
Another fascinating way to investigate the differences between trainees/novice learners and senior physicians or trainers is the concept of adaptive and routine expertise. The term “adaptive expertise” was made famous by the works of Giyoo Hatano and Kayoko Inagaki from Japan in the 1980’s (Hatano & Inagaki, 1984). Adaptive experts in this context are those that are able to apply novel solutions and procedures, in addition to their past experience, to problems they may encounter as opposed to routine experts (novice learners), who approach problems through the experience they garnered via routine and repetitive practice, which results in efficiency but is likely to lack novelty and adaptability. So in essence, the two important terms in this context would be that of “efficiency” for the routine and “innovation” for the adaptive expert.

Further to this, Varpio et al (Varpio, Schryer, & Lingard, 2009) in their qualitative review found that staff members (senior doctors) demonstrated adaptive expertise vs. novices, with the latter often using routine expertise to deal with problematic EHR-mediated communications or workflow-related issues. Adaptive expertise allows staff physicians to balance both knowledge and effective flexibility without forsaking efficiency and this allows them to go “beyond routine competencies” which are often leveraged for efficiency.

This flexibility and knowledge is also used to provide them with the skillset to deal with novel problems. Staff physicians for example, when dealing with electronic health record related problems can employ workarounds, but would recognize the communication problem such a workaround may cause, such as shifting from an electronic order to paper order due to an EHR-related problem, and will often make sure nursing colleagues for example are aware of this change to make sure the request is processed, thus ensuring completion of the task its safety. Novices, such as junior residents may not be aware of this.

Although this study looked at inter-professional communication and workflow, the concept of adaptive expertise may influence the way staff physicians communicate with patients while using the EHR. The authors recognize that the gap between the two domains needs to be better studied in this
context so as to help in finding educational interventions that can bridge this gap, to make novices think and act like experts.

In terms of how EHR affected medical students, another report by Rouf et al (Rouf et al., 2008) surveyed undergraduate medical students perceptions of EHR usage specific to communication. The authors looked at third year medical students, and found that only 64% of students reported satisfaction with the doctor-patient communication in relation to the EHR, and 48% of students reported that they spent less time looking at the patient vs paper records.

Some of the insightful comments in this article that were reported by students in relation to EHR and communication included: "...more challenging to talk to the patient and type at the same time...

Another comment stated: "I don't like not to be able to keep good eye contact."

Further student feedback on an EHR training exercise, reported by Biagioli at al (Biagioli et al., 2017) found that students reported that their clinical preceptors can influence the students, as they engage in such behaviours such as typing during patient/physician interactions. This again highlights the importance of EHR-specific role-modeling to ensure that students acquire good communication habits from their senior clinical supervisors. This also aligns with what seen in the documentation theme, when copy-paste behaviour was practiced by faculty and there was concern that this can negatively influence students and residents (Mintz et al., 2009).

In the reported student feedback from the Biagioli study (Biagioli et al., 2017) an important and perceptive comment was made by one of the students on how the EHR should be used during a clinical encounter: “I wouldn’t have a stethoscope in my ears the whole visit. You use it only when needed. So why should I use the computer the entire visit?”

3.4.3.5 Differences between EHRs and paper records in relation to communication.

There is recognition of both the advantages of EHRs in terms of certain aspects of documentation and the disadvantages in terms of time utilization as previously noted. A survey done by Hammoud
et al (Hammoud, Margo, et al., 2012) reported that across the studied specialties (internal medicine, surgery, family medicine, neurology, emergency medicine, pediatrics and psychiatry), 36% of respondents felt that students preferred EHRs to paper charts, but 46% were not sure. O’Connell et al (O’Connell et al., 2004) found that both pediatric and medicine residents preferred the use of EHRs over paper records.

More specifically when it comes to looking at preference of EHRs vs paper records related to communication, the RCT by Taft et al (Taft, Lenert, Sakaguchi, Stoddard, & Milne, 2014), summarized in Table 3.9, reported the greater ability of first year residents to communicate with EHR vs. paper charts.

As previously indicated, Crampton et al (Crampton et al., 2016) showed that there is greater satisfaction with EHR in terms of information exchange vs paper records. The negative reports noted in Table 3.9 were more related to the actual personal interaction. The findings of Rouf et al (Rouf et al., 2008) were also noted earlier in relation to this topic.

3.4.3.6 Communication skills training and curriculum interventions

The evidence points towards the slow adoption and application of educationally sound practices that promote evidence and scholarly guided EHR educational initiatives (Wald et al., 2014). These practices as well as the required evidence needed to direct such initiatives remain lacking despite a widespread recognition of the need to do so.

At an undergraduate level, there is a general consensus that undergraduate medical students should have exposure to EHRs and that there general communication skills training should also be leveraged to train students how to effectively communicate and maintain patient-centeredness with EHR use (Hammoud, Dalrymple, et al., 2012)

An understanding of the optimal EHR communication practices would be required to understand what some of the curricular interventions entail in this context. Out of the selected articles, two
(Crampton et al., 2016; Shachak & Reis, 2009) comment in detail about the various techniques employed to guide EHR communication training based on the literature. Many of these are based on well established interpersonal communication models such as the Robert Smith model of communication, as it has RCT evidence (Fortin & Smith, 2012).

One particular technique is recommended and was modified by Shachak et al (Shachak & Reis, 2009) and was based on the ten tips model for better patient/doctor communication developed by Ventres et al (Ventres, Kooienga, & Marlin, 2006). Figure 3.10 summarizes this recommendation. Duke et al (Duke et al., 2013) also take a similar approach, and employ similar methods to formulate 5 comparable recommendations. Both techniques emphasize establishing rapport with the patient, the importance of eye contact with the patient, and minimizing screen gaze and typing. Introducing the EHR to the patient and explaining its use and then sharing the screen and EHR knowledge with the patient are also considered as constructive behaviours. Furthermore, throughout the encounter maintaining verbal communication about what is being done through techniques such as signposting (orienting patients) is also considered valuable. There is also encouragement to allow patients participate in providing the required information to help build their chart. These are the main ideas and broad concepts, with evidence that similar approaches are often used and adapted to teach EHR-related communication skills as well be seen.
3.4.3.7 Research findings

In the faculty/educator survey by Atwater et al (Atwater A.R. et al., 2016), looking at the EHR-related teaching strategies, their core response was communication-related, stressing on the importance of balancing focus on EHR documentation with “patient engagement” in the patient encounter.

In the controlled “before and after” study by Silverman et al (Silverman et al., 2014), they employed a novel approach to teach medical students communication skills via ergonomic training. This entailed the following:

1) Instruction on how to introduce the use of EHR into a simulated patient encounter by explaining
benefits of EHR usage, 2) positioning laptop to share EHR with patient, 3) allowing active reviewing of their information.

In this study, student EHR use showed significant positive effects due to EHR ergonomics skills training on \( P < .005 \). They reported a minimum of 3 ergonomic training sessions needed to see an overall improvement in EHR use. Students who got trained via this method reported the following as per their report they could 1) utilize EHRs more effectively to engage with patients, 2) better explain benefits of using the EHR to patients 3) better address patient concerns, 4) appropriately position the EHR device, 5) better integrate the EHR into patient encounters.

In the pre-post intervention study by Lanier et al (Lanier et al., 2017) looking at resident communication skill training, the research group used an EHR teaching method, employing a scheme adapted from previous studies (Duke et al., 2013; Ventres et al., 2006), similar to what was outlined above in figure 3.10. The training was deployed over 3 months, which included both group and individualized sessions. Their results of the post intervention feedback from residents was encouraging, with resident positive feedback and significant improvement in communication performance, especially related to better signposting. Residents felt more comfortable using EHRs and felt them to be less of a communication barrier post-training. Although this was a single centre and uncontrolled study, this suggests that training can improve resident communication skills.

### 3.4.3.8 RCT and other evidence

For interventional evidence, there were 4 RCT’s that showed improvement of communication skills for both medical students and residents when they received training. The RCT’s are summarized in Table 3.9.

For assessing student communication skills, Biagioli et al (Biagioli et al., 2017) , developed an OSCE to assess medical clerkship students at two US-based centres for communication skills. This “EHR-OSCE” was designed to test “EHR skills” not medical knowledge, thus the simulated scenarios were
deliberately straightforward to allow focus on the intended EHR-related skills. Documentation and communication skills were assessed. In terms of communication skills, over 90% were seen to have adequate eye contact while using the EHR and also shared relevant information with their simulated patients. However, many other students did not perform well on other aspects such as was seen in one of the centres where there was lack of establishing rapport related to the fact they moved too quickly to access the EHR. The other centre did better in this regard. There was a difference in EHR-related skills between the two centres, one reported reason was that the in centre that performed worse their student EHR training was 14 months prior, which could reflect shortened retention. This may mean that EHR training for students should be suitably timed before entry to residency, especially for students who do not have access to EHR and rely on medical school simulated EHR training.
<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
<th>Subject/theme</th>
<th>Study aim(s)</th>
<th>Population</th>
<th>Intervention</th>
<th>Control</th>
<th>Assessment instrument</th>
<th>Outcome measure</th>
<th>Main Results</th>
</tr>
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<tbody>
<tr>
<td>(LoSasso et al., 2017), 2017, Academic Medicine.</td>
<td>Enhancing Student Empathetic Engagement, History-Taking, and Communication Skills During Electronic Medical Record Use in Patient Care</td>
<td>EHR Communication Skills</td>
<td>To examine whether an intervention on proper use of electronic medical records (EMRs) in patient care could help improve medical students' empathic engagement, and to test the hypothesis that the training would reduce communication hurdles in clinical encounters.</td>
<td>3rd Year Medical Students N=38</td>
<td>One-hour training session on EMR-specific communication skills, including discussion of EMR use, role-plays.</td>
<td>N=32 No training</td>
<td>Both groups completed the Jefferson Scale of Empathy (JSE) at the clerkship's start and end (6 weeks). SP and Faculty assessment via the Jefferson Scale of Patient Perceptions of Physician Empathy (JSPPE), and a history taking assessment.</td>
<td>Empathic engagement in simulated patient encounters, using the Jefferson Scale of Patient Perceptions of Physician Empathy (JSPPE), and their history-taking and communication skills</td>
<td>Faculty mean ratings on the JSPPPPE, history-taking skills, and communication skills were significantly higher for the intervention group than the control group. Both groups' JSE mean scores increased pre-test to post-test, but the changes were not significant.</td>
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<tr>
<td>(Morrow, Long, Mihalic, &amp; Wagner, n.d.) Journal: Family Medicine, 2009</td>
<td>First-year medical students can demonstrate EHR-specific communication skills: A control-group study</td>
<td>EHR Communication Skills</td>
<td>Establish the feasibility and practicality of teaching EHR-specific communication skills to early first-year medical students.</td>
<td>1st year Medical Students N=9</td>
<td>EHR-specific communications skills using guided discovery, brief didactics, and practice role plays.</td>
<td>N=8 No communication skills intervention.</td>
<td>Assessed by standardized patients (SP) via an in-house developed EHR-specific Communications Skills Checklist. Accuracy of assessment confirmed by authors</td>
<td>Scores in EHR communication specific measure (covers multiple communication and interpersonal domains/descriptors)</td>
<td>Students receiving EHR communication skills training performed significantly better than controls in EHR communication skills.</td>
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<td>(Reis et al., 2013)</td>
<td>The impact of residents' training in EHR Communication</td>
<td>EHR Communication</td>
<td>To Compare 2 training</td>
<td>Family medicine N=18</td>
<td>Assessed by standardized</td>
<td>Scores in EHR communication specific</td>
<td>No difference between the two</td>
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<td><strong>Electronic Medical Record (EMR) use on their competence: Report of a pragmatic trial</strong></td>
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<td><strong>Skills</strong></td>
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<td>Programs for doctor–patient–computer communication</td>
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<td>Residents</td>
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<td>Simulation based training</td>
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<td>Traditional lecture based training</td>
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<td>Patients (SP) via an in house developed EHR specific Communications Skills Checklist. + physician observers</td>
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<td>Measure (covers multiple communication and interpersonal domains/descriptors)</td>
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<td>Groups in terms of communication related measures. Training satisfaction scores were higher in the intervention group.</td>
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*(Taft et al., 2014)*

**Effects of electronic health record use on the exam room communication skills of resident physicians: a randomized within subjects study**

<table>
<thead>
<tr>
<th><strong>EHR Communication Skills</strong></th>
</tr>
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<tbody>
<tr>
<td>To evaluate the effects of EHR use compared with paper chart use, on novice physicians’ communication skills.</td>
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<tr>
<td>First-year internal medicine residents.</td>
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<tr>
<td>N=32</td>
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<tr>
<td>Residents interview, diagnose and initiate treatment of simulated patients while being recorded, either using a paper chart and a sequential EHR system (cross over).</td>
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<tr>
<td>N=32 (cross over)</td>
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<tr>
<td>Video recordings of interviews rated by 3 trained observers using Four Habits scale.</td>
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<tr>
<td>Communication skills as measured by the Four Habits scale</td>
</tr>
<tr>
<td>The overall average communication score was better when using an EHR vs. the paper chart.</td>
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</table>
3.4.3.9 Conclusion

Patient-physician/learner communication in the context of EHR use is recognized as one of the key facets of modern clinical practice. There is evidence to support better education and practice in the field, but there still exists a gap in understanding how to best teach students and residents to better use the EHR in their communication with their patients. This field is promising, as evident by the fact that this theme was the only one that had published RCT’s, all of which pointed towards improvement with EHR-specific communication training. Further interventional studies, preferably multi-centered, are required as with the other themes. Researchers need to further look into what human factors affect patient-physician interaction when using EHRs. Also, studies should examine role-modelling that physicians provide to students and residents and how this can affect student and residents in terms of EHR usage and how to best optimize this aspect of clinical supervision. More work also needs to be done to better design EHRs, to reduce screen gaze time and typing and to especially the way data is presented to facilitate doctor workflow and reduce cognitive load. This can ultimately free up the mental burden required for information management, which in turn can help learners focus on interacting with their patients (Shachak & Reis, 2009a) (Farri et al., 2012).

3.4.4 Theme 4: EHR training and simulation

This theme incorporated general EHR training and simulation as a subset. The number of articles in this theme are 34 out of 82 articles (41.5%). Simulation is a major component within this section, and will also be discussed separately within this theme.

The importance of both student and resident EHR training is recognized by learners themselves (Aaronson et al., 2001) and by medical educators and informatics specialists. Such training can promote better workflows, enhanced patient-learner communication and enhanced safety practices (Hammoud, Margo, et al., 2012; Mintz et al., 2009; Tierney et al., 2013). Without such training, there is risk of undermining learner development and preparedness for future independent
practice (Crampton et al., 2016; Harle & Gruber, 2014; Mintz et al., 2009; Reddy et al., 2010; Wittels et al., 2017). There is also an ongoing debate about undergraduate medical student access to EHRs, specifically when students can access EHR systems and how restrictive policies can influence their education and development. There is considerable overlap between this theme and the first three themes (workflow, documentation and communication), as their importance would make them targets for educational and training interventions. The master Table in Appendix 2, outlines the article summaries for this theme (TRN/SIM)

3.4.4.1 Student access to EHR training and barriers to training

There is a consensus amongst educators that medical students should access medical records during their undergraduate training (Hammoud, Dalrymple, et al., 2012; Welcher et al., 2018) to help facilitate EHR familiarity and training which would prepare them for future residency training, regardless of specialty they wish to undertake.

Even though the importance of EHR access is generally recognized, student access is a contentious topic in some educational jurisdictions. From the selected articles, which are predominately U.S.-focused, student access remains variable both in terms of actual access to EHRs and authorization to utilize note-keeping and more advanced functions such as order entry.

Six articles provided survey results which questioned undergraduate directors on their EHR practices and beliefs, which included information about student EHR access (Table 3.10). One additional article (Reddy et al., 2010) using similar methodology looked at internal medicine residents EHR access in continuity clinics. This provides a useful comparison to student access and is outlined with 5 of the student focused articles in Table 3.10.

The sixth student access-focused article (Welcher et al., 2018) provided unpublished data from the Liaison Committee on Medical Education (LCME), which showed that almost all U.S. medical schools accredited by the LCME (134 schools) allowed at least some EHR access to medical students, as per following data which spanned over 3 years: 2011–2012: 97% access; 2013–2014:
98% and 2015–2016: 96% access. The degree of access did vary widely across the studied institutions with significant percentage of these only allowing students to read records, not enter or modify information (approximately 25% allowing read only access).

**Barriers to Student access**

Several studies (Hammoud, Dalrymple, et al., 2012; Mintz et al., 2009; Welcher et al., 2018) all report similar barriers. These are summarized as follows:

1. **Financial, technical and structural barriers:** Training students, setting up and maintain student accounts is time consuming and is financially burdensome.
2. **Lack of technical standards and EHR heterogeneity:** There is many EHR vendors, each having different user interfaces and functionalities which adds to the challenge of training students and residents who often have to rotate in different hospitals, each having a differing EHR system. This can disrupt workflow and can lead to increased stress and loss of time. Hammoud et al (Hammoud, Dalrymple, et al., 2012) report that data shows that academic institutions used more than 80 different EHR systems. This number is even more for other hospital settings.
3. **Concern for patient privacy.**
4. **Legal and financial concerns:** In the U.S especially, EHRs are designed around a billing system and there risk of billing errors which can have financial and legal consequences.

Overall, student access is still not universal and where it does exist, there are varying degrees of students access to EHR functionalities, with a significant number of schools or institutions still preventing students from writing electronic notes, a skill which is recommended by professional student bodies and is considered an important competency (Welcher et al., 2018) (Hammoud, Dalrymple, et al., 2012).

Inadequate access and training during medical school could lead to errors or gaps in EHR information retrieval (Yudkowsky, Galanter, & Jackson, 2010). Furthermore, this has the potential
for serious downstream consequences, especially during the early phases of residency training, as pointed out by March et al (March et al., 2013), where they found within their study population of medical interns, where a significant number of quality-related issues were found with resident notes. They suggested that this is related to inadequate attainment of EHR-specific skillsets in the early part of internship, which may point towards the lack of training or access during residents time as students in medical school. Thus they proposed that earlier medical school input would better prepare medical students for their internship/residency and ultimately future independent practice.
Table 3.10 Learner access to Electronic Health Records, results of national/international surveys.

<table>
<thead>
<tr>
<th>Study</th>
<th>Study population</th>
<th>Surveyed population</th>
<th>Aims</th>
<th>Main Results in relation to Student/learner Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mintz et al (Mintz et al., 2009).</td>
<td>Undergraduate medical students in the U.S. and Canada</td>
<td>Cross-sectional survey of the Clerkship Directors in Internal Medicine institutional members at U.S. and Canadian academic health centers. Response rate 82/110 (74.5%)</td>
<td>To describe current use of EMRs by medical students at U.S. and Canadian medical schools.</td>
<td>Data presented not clear about general student access to EMRs. They report student EMR documentation access for those who responded and use EMR in their settings: Ambulatory: 48% allowed students to document in the EMR, the rest do not. Inpatient: 41.6% of respondents allow students to use inpatient EMR to write notes.</td>
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<tr>
<td>2. Reddy et al, (Reddy et al., 2010)</td>
<td>Postgraduate (Internal Medicine) residents (U.S. Study)</td>
<td>U.S. accredited ambulatory clinic directors Response rate 221/356 (62%)= ~50% or accredited programs.</td>
<td>To determine the current roles and functions that health information technology (HIT)/EHRs in ambulatory clinic settings of internal medicine (IM) residents.</td>
<td>General Access: 56% of the clinics, residents had access to EHRs. Other EHR functions: 67% of residents used electronic data systems (practice management), with 28% of them using to generate patient lists, with bigger programs more likely to have them then smaller ones (67% vs. 53%). Electronic prescription, more likely in bigger programs (57% vs. 42%). Drug related decision systems were also utilized to varying degrees (approximately 10-32%).</td>
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<td>3. Hammoud et al, (Hammoud, Margo, et al., 2012)</td>
<td>Undergraduate medical students (U.S. Study)</td>
<td>Clerkship directors (undergraduate medical education). Response rate: 32% (based on 133 U.S. medical schools).</td>
<td>To describe current use of EHRs by medical students in the USA and explore the opportunities/challenges of integrating EHRs in education/teaching of medical students.</td>
<td>Student EHR Access and use of EHRs: 64% of total respondents allowed student access. Only 2.5% reported no plans to give students access to inpatient EHRs. Access rates were equal for inpatient, outpatient, or emergency room EHRs. Permitted levels of use: - 32% allowed them to only view the record - 41% allowed them to view and write notes - 27% allowed them to view the record, write notes, and enter orders to be co-signed. Interestingly, 4% percent stated that students use a resident or faculty sign-in to access EHR.</td>
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<td>4. Solarte et al, (Solarte &amp; Könings, 2017)</td>
<td>Undergraduate medical students (Columbian Study)</td>
<td>Undergraduate medical students, postgraduate residents, medical school deans in Colombia</td>
<td>To investigate Colombian medical student and medical school deans perspectives in relation to EMR use by students, especially in terms of quality of education and patient care and to also determine any concerns.</td>
<td>No absolute numbers provided for student access. Student reported EMR usage more than deans. Perceptions of EMR usage and student access differed between deans and students, signifying real life student usage which was not officially recognized or managed. About~50% medical schools had learning programs and policies about the use of EMR by students.</td>
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<td>5. Wittels et al (Wittels et</td>
<td>Undergraduate medical</td>
<td>Emergency Medicine (EM)</td>
<td>To determine current</td>
<td>From reported data: 63% of EM clerkships allow medical</td>
</tr>
<tr>
<td>Source</td>
<td>Participants</td>
<td>Practices or perceived barriers to student documentation in EHRs on emergency medicine (EM) clerkships.</td>
<td>Students to document a patient encounter in EHRs. Most common reasons cited for not allowing students to document a patient encounter were: 1) hospital or medical school rule prohibiting student documentation (80%), 2) concern for medical liability (60%), and 3) inability of student notes to support medical billing (53%) and 38% had a lack of computer access.</td>
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<td>al., 2017)</td>
<td>students (U.S. Study)</td>
<td>clerkship directors at United States medical schools. Response Rate: High, 86% (100 unique institutional entries).</td>
<td>students to document a patient encounter in EHRs. Most common reasons cited for not allowing students to document a patient encounter were: 1) hospital or medical school rule prohibiting student documentation (80%), 2) concern for medical liability (60%), and 3) inability of student notes to support medical billing (53%) and 38% had a lack of computer access.</td>
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<td>6. white et al, (white et al., 2017)</td>
<td>Undergraduate medical students (U.S. Study)</td>
<td>Ambulatory clinic preceptors who hosted medical students during family medicine clerkships (3 U.S. based institutions). Response rate: 33% response rate (265/801).</td>
<td>To evaluate impact of EMRs on medical student education in an ambulatory setting with the goal of identifying behaviors of ambulatory family medicine preceptors in relation to EMRs and medical students. There was 33% response rate (265/801). The majority of respondents used an EMR and 91.1% provided students with access to it in some way, but only 62.2% allowed students to write electronic notes.</td>
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3.4.4.2 Curriculum development and setting competencies and frameworks

There is still a lack of curriculum development built on sound educational science in terms of EHR use in the studied population. The study of Wald et al (Wald et al., 2014) is an example of what could be done. The authors provided a useful case study of formulating a longitudinal curriculum based on educational theory. They utilized Kern’s 6-step curriculum framework to build a curriculum that incorporated narrative medicine, and reflective practice. They built six courses with defined competency goals taking into account the specific needs of “millennial learners” by adapting pedagogical methods accordingly. The narrative medicine component was especially seen as a strength to empower humanistic skills build professionalism, which can aid patient communication.

This intervention was not formally studied to look at educational outcomes. No data was provided in terms of curricular evaluation or student feedback.

McAlearney et al (McAlearney A.S, et al, 2015) also utilized a theory-driven approach as well in their qualitative methodology study which looked at EHR implantation practices in six selected organizations well known for exemplary EHR implementation. They had 12 residents amongst their study groups. They used the lenses of “social cognitive” and “adult learning theory” to develop a framework based on 5 propositions which were used to explore themes related to EHR implementation training using qualitative data collected through their informant interviews.

The analysis found evidence that training practices across the six selected organizations were consistent with the findings of their chosen theoretical framework. From this, the authors suggested 7 components of training that could help in EHR implementation based on their theory-driven propositions: 1) Obtain organizational commitment to invest in training, 2) Assess users’ skills and training needs, 3) Select appropriate training staff, 4) Match training to users’ needs, 5) Use multiple training approaches, 6) Provide training support throughout implementation, 7) Retrain and optimize. The authors also suggested that effective training programs must move beyond technical approaches and incorporate social and cultural factors to make a difference in implementation.
success.

As an example, one of their theory-driven propositions emphasized the role of a “positive role model” which was derived from social cognitive theory which stresses the concept of social persuasion. So here, when learners observe others successfully using the EHR, their efficacy expectations are increased because of their corresponding beliefs that they also have the ability to master the EHR system. This was used to formulate the third training component mentioned above “Select appropriate training staff”. I have selected examples of quotes from some of the participants, which provide further insight:

“We had champions . . . somebody that's really engaged and knowledgeable and a positive role-model.”

“Making sure that you select champions . . . your nursing champion, your super-users, and your physician champion so that you get them onboard.”

The following is a trainee quote discussing the background of their trainers:

“Some came from a clinical background and learned the technical aspect and some were technical. . . . And the mix is actually very nice because you can then target certain end users to match with certain educators.”

The role of self-efficacy advocated by this framework and the use of “EHR champions”, is also supported by Harle et al. (Harle & Gruber, 2014), and they predicted that today’s students will become future champions for this technology and they will likely facilitate EHR use and adoption.

This use of theory-driven approaches provides a fresh way to look at the challenges that come with EHR training and also to analyze the complex task of EHR implantation. Sadly, this approach still remains lacking within the literature and there is a lack of consideration of students and residents when implementing EHR systems (Wormer & Williams, 2015).

In terms of curricular guidance, both Hammoud et al (Hammoud, Dalrymple, et al., 2012) and Hersh et al (Hersh et al., 2014) EHR training recommendations, stressing on the graduated introduction of EHR-related competencies as students and learners progress in their training. Hersh et al also stress the importance of informatics to the future medical profession, as evidenced by the advent of
informatics as a new medical subspecialty, something which could help with future EHR curricular and educational development. Further details are shown in the master Table (Appendix).

Many of the studies explored in the other central themes can inform curricular design and the defining of specific competencies and standards, such as those explored under the communication theme (Crampton et al., 2016; Duke et al., 2013; Shachak & Reis, 2009). In addition to this, other examples include the work of Stephens et al (Stephens et al., 2011) in which they showcase an evaluation system, based on the “Reporter–Interpreter–Manager–Educator” (RIME) scheme, as an approach to teach and evaluate EHR clinical documentation skills in the context of the Accreditation Council for Graduate Medical Education (ACGME) core educational competencies.

3.4.4.3 Student and resident perceptions and attitudes to EHR training

Student and resident perceptions of EHR training were examined by Aaronson et al (Aaronson et al., 2001). In their survey of family medicine residents, those who perceived EHR training to be adequate and also perceived a relative ease of implementing the EMRs were more likely to perceive it to be beneficial and are more likely to choose the EMR over traditional paper records for future use.

The study by Halas et al (Halas et al., 2015) provided some qualitative understanding of how trainees and physicians can perceive EHR training. This is an example of two quotes that look at this:

. “The training was too long, very unhelpful, we couldn’t follow along with the scenarios”

. “The training should be more applied by focusing on a patient scenario, to facilitate learning how to use the system safely and efficiently during a patient visit”
3.4.4.4 Simulation training

Nine articles provided insight into the use of simulation for learner training. Simulation offers promise to provide a safe and controlled environment to allow either students or residents to safely learn how to use EHRs and also learn from them, if used for knowledge acquisition.

Simulation in medical education

A good working definition of this concept is that simulation involves: “devices, trained persons, lifelike virtual environments, and contrived social situations that mimic problems, events, or conditions that arise in professional encounters” (Issenberg, McGaghie, Petrusa, Lee Gordon, & Scalese, 2005). Simulation permits learners to learn in a safe environment that allows them to commit mistakes without compromising patient safety or privacy. It also allows for repetition and supervision and real time feedback from supervisors and teachers. This by extension provides another route for both formative and summative assessment of students (Stephenson et al 2014) (Castanelli, 2009). Due to this, some institutions, including the Institute of Medicine recommend EHR simulation training (Institute of Medicine (U.S.), 2012). Table 3.11 summarizes the studies with a simulation component.
<table>
<thead>
<tr>
<th>Reference</th>
<th>Aims</th>
<th>Population</th>
<th>Simulation</th>
<th>Finding</th>
</tr>
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<tr>
<td>1. Biagioli et al. (Biagioli et al., 2017)</td>
<td>To Assess undergraduate medical student competency in Patient Interactions whilst using a Sim-EHR, using an in-house developed EHR OSCE. The aim was to promote and provide EHR experience for students before graduation.</td>
<td>Undergraduate medical students</td>
<td>Sim-EHR built to emulate real life EHR (EPIC® based).</td>
<td>Data collected from two institutions. The OSCE scores showed students performed well in EHR-related communication tasks, but they had EHR skill deficiencies in the areas of EHR data management. E.g. medical history review, medication, and allergy reconciliation. Students' EHR skills failed to improve as year progressed, suggesting that they did not get required EHR training and experience they require to fulfill such tasks. Perceptions: Both faculty and students valued the sim EHR facilitated OSCE.</td>
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<td>2. Bloice et al. (Bloice et al., 2013)</td>
<td>A systemic review that assesses the usage of EHRs in the creation of interactive virtual patients (VPs) for teaching clinical decision-making.</td>
<td>Mix: Undergraduates students and postgraduate residents</td>
<td>Looked at virtual patient generation to assist in education</td>
<td>28 full text articles reviewed. Although VPs based on real patient data are widespread, use of unformatted EHR data is not. Many VPs examples use radiology based data (CT/MRI) vs. other data (patient reports, labs, etc.). Case studies exist for teaching/training, consultancy and assessment. Creating VPs can be costly in terms of time and money.</td>
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<td>3. March et al (March et al., 2016, p. 201)</td>
<td>To develop a high-fidelity EHR training exercise for internal medicine interns to understand patterns of EHR utilization in the generation of daily progress notes.</td>
<td>Postgraduate residents</td>
<td>EPIC® based EHR simulation</td>
<td>Simulation exercise managed to recognize training deficiencies, some of which could be potentially serious from a clinical perspective.</td>
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<td>4. March CA and Gold JA, et al 2013 (March et al., 2013)</td>
<td>To test efficacy and safety of the EHR–user interface within the intensive care unit (ICU) environment, using high-fidelity simulation training.</td>
<td>Postgraduate residents</td>
<td>EPIC® based EHR simulation</td>
<td>Simulated EHR managed to find errors in residents data extraction, despite training. Conclusion: remains significant gaps in identifying dangerous medical management issues regardless of high levels of medical training, suggesting that EHR-specific training may be beneficial. Simulation can help identify these gaps as well as promote EHR-specific training.</td>
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<tr>
<td>5. Milano et al (Milano, Hardman, Plesiu, Rdesinski, &amp; Biagioli, 2014)</td>
<td>To describe the development and implementation of a simulated EHR (Sim-EHR) curriculum, focusing on its use in a family medicine clerkship and to share preliminary findings and lessons learned from its usage</td>
<td>Mix: UG medical students and internal medicine interns. Faculty also provided feedback.</td>
<td>Sim-EHR (EPIC® based)</td>
<td>Sim-EHR described. Post curriculum trial survey’s done and feedback obtained from students, interns and faculty. Survey: For students (51%/ ~33 students) and almost all interns (92%) rated EHR sim activity as “effective” or “very effective”. Remaining ~49% of students were evenly split between “neutral” and “ineffective.”</td>
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| 6. Mohan et al (Mohan et al., 2016) | To create a consensus statement on best practices for: 1) use of EHR simulations in education and training; 2) to improve patient safety; 3) to outline a strategy for future EHR simulation work. | Study group: Informatics experts, educators, physicians, psychologist and human factor experts. | N/A | Recommendations generated according to these themes: (1) Safety, (2) Education and Training, (3) People and Organizations, (4) Usability and Design, and (5) Sociotechnical Aspects. Recommendations:  
- Simulations should be utilized to design systems & protocols explicitly to improve usability & patient safety.  
- Simulations should be considered central to clinician training and used to improve clinical team communication.  
- Simulations should be part of a sociotechnical solution involving a broad spectrum of stakeholders and organizations.  
- Simulations should be part of a comprehensive incentive program to promote patient safety. |
|---|---|---|---|---|
| 7. Neri et al (Neri et al., 2015). | To understand emergency department (ED) physicians’ use of EHR documentation so it can identify usability and workflow considerations. This is to help design future ED information system (EDIS) physician documentation modules. | Emergency medicine PG residents | In house built EHR system (EDIS) + Simulation center experts optimized simulation environment for studying EHR in an emergency room setting. | Simulation sessions managed to garner following information:  
Task Analysis: 65% of time in an ED clinical encounter is spent on documentation activities (65%), 21% of the time was spent on multiple tasks done in parallel.  
Qualitative feedback:  
* Residents report workflow varies in location and timing of documentation based on patient acuity and workload.  
* Residents report need for EHR features which support efficiency.  
* Physicians like to view patient data but struggle with the integration of clinical data from disparate systems. |
| 8. Reis et al (Reis et al., 2013). | To Compare two training programs for doctor-patient-computer communication using EHR simulation in one group vs. control. | PG-Residents (family medicine). | High-fidelity EMR system (Clicks by Roshtov and the Maccabi portal) | The experiment group received simulation based training (SBT), while the control group received traditional lecture based training. No difference was found between the experiment and control groups, except for higher satisfaction in the SBT group. |
| 9. Shachak (Shachak et al., 2015) et al | Goal of study was to pilot test prototype computer-based simulation (e-Sim) to: 1) ascertain usability /design issues, 2) inspect impact on family medicine residents’ self-reported competencies and attitudes. | Family Medicine residents | In house developed EHR simulator (EMR-Sim) | After using the simulation pilot, mean scores for competencies and attitudes improved (14.88/20 to 15.63/20 (significant) and from 22.25/30 to 23.13/30, (non significant) respectively). Mean scores for perceived usefulness and ease of use of the simulation were good. Issues identified in usability testing: preferences for a more real-life and interactive experience. |
| 10. Stephenson et al (Stephenson et al., 2014) | To determine whether participation in EHR simulation exercise improves recognition of ICU related errors. | Postgraduate residents and Fellows (Medical ICU). | Institutional EMR (not clarified further) | Two simulated cases were formulated to test the participants which were similar in difficulty. The intervention included direct educational feedback on tested case with EHR specific training on how to best recognize the errors. Of the enrolled 116 subjects, 25 subjects underwent repeat testing. The baseline performance for trainees who participated in repeat testing was the same as the cohort. For repeat testers, for both cases, recognition of safety issues was significantly higher among repeat participants vs. the first time participants. Performance improved from 39.9% to 63.6% (p = 0.0002), this is independent of the order in which the cases were used. Degree of improvement was inversely related to baseline performance. Repeat participants also showed better recognition of changes in: vitals, antibiotic mis-dosing and over-sedation vs. to first time participants. |
In the paper by Mohan et al (Mohan et al., 2016) there were several valuable insights into the use of EHR simulation to help train and assess students, residents and physicians and also improve EHR design. There was particular emphasis on how EHRs affect team-work. Some of the useful quotes from the participants:

- “The EHR is designed for a single person when really it should be designed for the team.”

- "The purpose of simulation is to train people to work together with technology in an environment."

- “…if you could change the paradigm of the simulation so that it is case-based instead of all of us…in a classroom setting. Just turn it around so that we are all part of a team and attacking the same problem, and that’s our EHR training.”

Another informative quote relates to how EHRs can be vendor designed for administrative/financial functionalities (eg. billing), vs. that of physician or health care provider focused design:

“…the vendors are not designing their systems for safety. First, they’re designing them for efficiency and billing, also we’ve got to have a huge paradigm shift that they’re not interested in at all because the people that are buying their systems are chief financial officers, not doctors.”
In summary, although there is increased educational interest in this area, barriers do still exist in relation to curriculum development. There is still a shortage of champions and advocates in the educational realm, which may contribute to the fact that there is still a lack of theory and educationally informed EHR training and integration. The vast majority of EHR student/resident training is still rooted in the “technical”. Most EHR design, training and implementation is still solely designed for clinical and financial workflows, and this is usually run by digital and technical divisions and rarely has any educational collaboration (Triola et al., 2010).

Another challenge is that of student access. There is a trend of increasing access, but there is a lack of research on how best students can be trained in an educationally safe manner, to avoid the development of learning pitfalls or EHR related habits that could be a detriment to the development of clinical reasoning skills.

Simulation and innovative, theory-driven research has promise to further understand the impact of EHRs on learners and how to best optimize learner training and use.

From the selected articles, there was also no research examining burnout and stress related to EHR use and increased information management and EHR-related workflow demands and how to train learners on how to build resilience capacity to avoid this. There also has been little research to look at contingency training for residents or students, in case of massive technical failures that can incapacitate EHR systems.

### 3.4.5 Theme 5: Knowledge Acquisition.

This theme was the fifth most represented from the selected articles, with 12 articles (14.6%). I have defined knowledge in relation to use of EHRs as that which facilitates knowledge transfer to students or residents and that aids in clinical learning (e.g. facilitates learning disease management and prevention), in addition to that of work related clinical information. The latter domain has been explored in the other central themes. I have also include publications that looked at resident tracking of former patients via the EHR as a learning exercise.
The Master Table (Appendix 2), provides a full summary of this theme’s articles, with a “KNO” theme code designation.

As noted in the simulation aspect, EHRs have promise to not only facilitate clinical workflow but simulated EHRs allow for a safe environment to practice acquisition and application of knowledge in novel ways. In a systematic review (Bloice et al., 2013), the authors looked at the use of EHRs to design virtual patients that can function as teaching aids. Of their selected papers, ~60% targeted undergraduate education, as there is restricted patient access for students as previously outlined. Their descriptive summary outlined a wide variety of applications, many of which are built on real life patient data. User feedback was deemed overall to be positive and representative of real life cases. They commented that direct raw patient information based on EHR data is rarely used, although they conclude that creating EHR-based virtual patients is useful, but it still remains costly in terms of time and money.

The use of specific documentation templates and order sets were also explored. They can prompt learners, especially students early on their training, to take better histories and guide them to entering orders in a safe manner (Keenan et al., 2006) (Rouf et al., 2007).

Computerized Clinical Decision Support Systems have also been promoted as potential educational tools, on top of their workflow and clinical safety functionalities. These systems can provide point-of-care decision aids based on evidence-based guidelines (R. H. Ellaway et al., 2013; Keenan et al., 2006), (Tierney et al., 2013), (Schenarts & Schenarts, 2012) which could help with obtaining and imparting knowledge. Further to this, a collaborative statement (Hammoud et al., 2012) recommends that students be exposed to decision aids, but questions whether meaningful knowledge acquisition actually occurs.

In terms of deliberate use of EHR systems to facilitate knowledge acquisition, an elegant simulated system is described by Milano et al (Milano et al., 2014) called Sim-EHR. Third year students were asked to use this EHR during their family medicine clerkship. The researchers built several complex
chronic disease representative cases, with lengthy medical histories. The students were expected to create an evidence-based plan of care for these diseases and to incorporate prevention and management strategies, and to write orders and prescriptions. Then they reviewed their performance in small-group settings with preceptors facilitating the learning process. Their timelines working on the project were logged and also factored in for the final assessment after they submitted their cases. Student feedback indicated an appreciation for their ability to learn EHR navigation skills, but were concerned that the exercise impacted their regular examination preparation. This has more to do with curricular design than an actual negative aspect of the EHR, and could be improved by further integration of this intervention if further studies prove its success. The group did not test this on residents.

Seifan et al (Seifan et al., 2013) described an EHR with integrated knowledge management tool in which they utilized specialized software (KNOW-ET-AL), which mines in real time the clinical information from the EHR (e.g. age, ethnicity, diagnosis etc.). This was then used to search Pubmed® and pick the highest impact papers for the user to read, as well as relevant educational material. In a post-exercise survey of this software, both faculty and residents appreciated the software, with 90% of trainees stating that there is a need for better EMR tools to improve medical education, 86% of them stating that this tool would change their practice, and 84% of trainees agreeing that they can use it to answer a clinical question. Only 23% responded that they would use it for test preparation.

Another interesting aspect was that EHRs provided something not possible with traditional paper records; namely, the ability of students and residents to continue to track their patients for educational purposes electronically after their involvement in direct care has finished. Brisson et al (Brisson, Neely, Tyler, & Barnard, 2015) looked at this functionality in more detail and explored the benefits and ethical issues. They cited patient privacy concerns as the main reason against this process, and the potentially negative impact on a patient’s wellbeing. Conversely, the potential
learning opportunity offered is significant derived from tracking patients for a specified time. No current data exists to see how commonly patient tracking is practiced nor its impact on learners. The authors concluded that the benefit of patient tracking in this context outweighs the risk, but they recommended the development of guidelines to regulate this educational practice.

From the selected papers, there was no clear evidence-based approach on how EHRs can be used for knowledge acquisition purposes, nor has there been research into the best strategy to deliver knowledge and at what point in training. More research is required to understand this important aspect. This is especially important since, as previously stated, residents spend a significant amount of their time on EHRs.

3.4.6 Theme 6: Trainee assessment and Tracking.

This final theme, with 8 articles, represented 9.8% of the total selected articles. The included articles are coded as ASMT in the master table (Appendix 2).

This theme examined assessment both in terms of medical knowledge and also EHR-specific competencies. Of particular interest also within this theme was how EHRs are used to track and record medical learner experiences for assessment and educational gap identification.

Biagioli et al. (Biagioli et al., 2017) utilized an OSCE format to assess medical students on specific EHR competencies (based on the ACGME competencies*), specific to communication skills. The OSCE scores showed that students performed well in EHR-related communication tasks, but they had EHR skill deficiencies in the areas of EHR data management. However, students’ EHR skills failed to improve as the year progressed, suggesting that they did not receive the required EHR training to fulfil such tasks. On feedback, both faculty and students valued this OSCE experience.

In relation to competencies or frameworks to teach and assess specific EHR skills, Stephens et al (Stephens et al., 2011) outlined a framework based on the Reporter–Interpreter–Manager–Educator (RIME) scheme. This could also be used to teach and evaluate EMR-specific skills using the Accreditation Council for Graduate Medical Education (ACGME) core competencies*.
*Competencies are from Accreditation Council for Graduate Medical Education (ACGME) common program requirements. IV.A.5. ACGME competencies. Effective July 1, 2007. Source: http://www.acgme.org/Portals/0/PFAssets/ProgramRequirements/CPRs_07012015.pdf.

Resident tracking is an important development with EHRs and provides an opportunity for educators to obtain valuable insight into the performance of both trainees and programs. This data could be used to tailor resident training and to develop and enhance educational programs (Keenan et al., 2006). Three studies looked at EHR tracking learners to quantify and evaluate their learning. There results are summarized in table 3.12.

**Table 3.12 EHR tracking of resident’s studies.**

<table>
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<tr>
<th>Article</th>
<th>Aim</th>
<th>Population</th>
<th>Findings</th>
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<tr>
<td>Litofsky et al, 2014. (Litofsky, Farooqui, Tanaka, &amp; Norregaard, 2014)</td>
<td>Aims: Used EHRs to track continuity of care in a neurological surgery program and to assess changes in rotation requirements (Cross-sectional study).</td>
<td>Postgraduate Residents (Neurosurgery)</td>
<td>EHRs can be used to track resident continuity of care in neurological surgery. The primary operating resident saw the patient in non-operative settings, (e.g. general admission, clinic visitation, or consultation) in 20.6% of cases.</td>
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<td>Rajkomar et al, 2017. (Sequist, Singh, Pereira, Rusinak, &amp; Pearson, 2005)</td>
<td>Quantify/evaluate intern resident clinical experience with common presentations via EHR clinical documentation (Cross-sectional study).</td>
<td>IM PG-Residents (PGY1-3)</td>
<td>Over 2 year study period 53066 clinical notes were analyzed. 88% of PGY1’s spent at least 2 months on the IM service, only 3% were exposed to all of the top 10 ICD-9 diagnoses, and 31% had experience with fewer than 5 of the top 10 diagnoses. In addition, 17% of PGY-1s saw all top 10 CCS diagnoses, and 5% had exposure to fewer than 5 CCS diagnoses. Each PGY-1 saw a median of 38 different diagnostic categories. This allows resident experience documentation and educational gap identification.</td>
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<td>Sequist al, 2005. (Sequist et al., 2005)</td>
<td>To assess the outpatient educational variation (using EHR) among residents in a primary care internal</td>
<td>IM PG-Residents</td>
<td>The collected EMR data showed 2,468 patient encounters for the 8 residents. The most</td>
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There was one qualitative study within this theme, which was previously explored under the workflow theme, (Wong et al., 2012). To recap, these investigators looked at the impact of computerised provider order entry (CPOE) on the educational experiences of medical trainees. From their findings, specifically looking at the assessment perspective, the resident supervisors appreciated the ability to observe, even remotely, whether residents responded to patient parameters both in terms of choice and speed of action, which they regarded as a marker of knowledge and clinical skill. In a proof of concept study, Mohan and Gold et al, 2017 used an EHR simulation in a novel manner, to “diagnose” the reasons why residents had problems with their training performance. From their analysis of their simulation study, distinct phenotypes of learning deficits were described: 1) differentiate learners with difficulty in data processing vs. data acquisition and knowledge. 2) distinguish troubled learners who engaged in two distinctly different selective data gathering workflows which results in poor clinical decision making. These learning deficits may be resolved by guidance on data retrieval and if there was poor knowledge, educational interventions could be given based on the educational diagnosis.
Chapter 4

General Discussion

The purpose of the Scoping Review was to explore the literature for existing evidence on the role of electronic health records in undergraduate and postgraduate medical education. To the best of my knowledge, this is the first scoping review to broadly examine this topic. My study systematically maps the literature in the field and provides a broad understanding of the issues in relation to EHRs and how they impact medical students and postgraduate medical trainees.

The Results chapter explored in detail the 82 articles included in this scoping review, incorporating an initial quantities analysis and then a detailed thematic analysis of the relevant findings. In this chapter, the meaning of these results will be further analyzed, in terms of how they relate to the current literature; as well as discussion regarding knowledge gaps. Implications for practice and teaching will also be discussed in this chapter. At the end of this chapter, our study strengths and limitations will be summarized.

As a reminder, the scoping review objectives, as per methodology guidance, have been “broad and encompassing” (Arksey & O’Malley, 2005), to allow sufficient capture and mapping of the literature. Our primary objective was to map and analyze the state of the existing literature in terms of EHR use in a medical education setting at the undergraduate and postgraduate level. The secondary aims were to answer the following questions: 1) What are the research topic areas and priorities that have been studied and identified relating to EHRs and medical education? 2) What methodologies have been employed to research these topics?

I utilized a number of relevant databases to acquire the source literature described in Chapter 2. The results included a thematic analysis, which examined six representative themes that were initially formulated from the detailed review of the included studies. The vast majorities of the final 82 selected articles were from the United States and published within the last 10 years. The results will
be further analyzed and discussed in this chapter in a sequential manner, following the thematic analysis sequence presented in Chapter 3.

4.1 Workflow, efficiency and time utilization

Within this domain, the reviewed studies report resident time working on EHRs ranging from 3 to 7 hours per day, or from 30 to 50% of available time. Although resident time is quantified in these studies, research is still lacking in providing further details on how this on-screen time is actually being used. This would be useful in order to elucidate how this time has affected student learning and could also help guide future workflow modifications, software design and potentially educational interventions, with the goal of freeing up time for students and residents to pursue other educational activities. One primary question that should be asked to help with this pursuit is, “why do residents spend so much time on EHRs?” Is it a clinical or administrative requirement? Are there too many documentation requirements? Is it a software design problem, related to the way that clinical data is presented, which in turn increases processing time and thus requiring more EHR on-screen time?

Regarding documentation requirements, as example from the reviewed articles, one study (Zhang, Padman, & Levin, 2014) reported that 67.9% of residents spent in excess of 4 hours/day on this task.

4.1.1 Workflow and Documentation times

This perception of proportionally increased documentation time is not a new issue, with evidence from a New England Journal of Medicine paper from the late 1980’s (i.e., before mass EHR implementation) that residents were spending 10–20% of time “charting” and a similar percentage of time spent in direct patient care (Lurie, Rank, Parenti, Woolley, & Snoke, 1989). More up to date data shows similar patient/learner time statistics.

Despite this, there is a general perception that documentation times have increased since the advent and use of EHRs. Wormer et al (Wormer & Williams, 2015) reported doubling of EHR
documentation time compared to paper records, although this reverted to comparable timelines with paper records usage after residents became familiar and more proficient with their EHR system, highlighting that potential of EHR training in mitigating the increased time burdens of EHRs.

There is also evidence that changing administrative roles have shifted documentation requirements to residents and physicians, adding to further burdens (Halas et al). This is also supported by the general literature (Beasley, Holden, & Sullivan, 2011).

The question still remains whether resident increased “on screen” time is due to the way information is presented, which increases cognitive load and thus time utilization. Are there other undefined factors involved? The evidence is still sparse for both medical residents and student populations.

Contributions from qualitative studies were included in the review to shed light into this matter, especially in terms of providing insight on how this time is spent. Residents’ perceptions, were outlined by Varpio et al (Varpio et al., 2015) in which residents expressed annoyance towards the way data was presented, thereby requiring extra time to review on screen information. This is supported by a study (Ahmed, Chandra, Herasevich, Gajic, & Pickering, 2011) in which the interdisciplinary research team produced a novel EHR interface to improve workflow through enhanced data presentation which shows all the relevant and important clinical data in an easily accessible manner for physicians one. The result was that with the enhanced interface, there was evidence of improved task completion times, and a reduction in cognitive error and greater task load functions.

As outlined in the results section, one example of how residents deal with the extra burden of includes developing workarounds, defined by Halas et al (Halas et al., 2015) as an “alternate work flows used to get through a task”. Varpio et al (Varpio et al., 2009) described the difference between faculty and trainees, where the latter are more likely to use simple expertise when choosing a workaround, versus faculty, who tend to have adaptive expertise, one advantage of which is that they use their experience and knowledge to deal with novel challenges in an efficient manner.

As with all the studied themes, a theory-driven approach was lacking to analyze this domain. Within
the health informatics literature, there are established theoretical approaches to deal with the complexities of e-health. For example, the influence of socio-technical aspects are well-recognized in the informatics literature. Another example includes how the EHRs influence the environment, extending beyond their technical aspects as they influence the social and workflow structures surrounding them. Informaticians recognize this phenomenon and have developed frameworks related to socio-technical aspects to help elucidate and organize the approach to EHRs (Sittig & Singh, 2010). We need to learn how we can apply such approaches to improve and better design learning environments around EHRs.

4.1.2 Resident wellbeing and risk of burn out

This one of the findings that have been noted as a risk factor in relation to EHRs. Resident wellbeing is a topical and important issue that is affected by the impact of EHRs on workflow, with mounting evidence of increased information processing and documentation demands. For independent practicing physicians, there is growing evidence that EHRs significantly contribute to burnout (Downing, Bates, & Longhurst, 2018) (Gawande, 2018; Spencer, Choi, English, & Girard, 2012) (A. Jha et al., 2019). This is in the context of wider concern that burnout is reaching crisis point amongst physicians in the United States as will discussed.

From the selected articles, (Gilleland et al., 2014) screened residents who use out of hours EHR. Burnout was defined by them as having “emotional exhaustion, depersonalization, and depression”. They found no correlation between the two, with no evidence of increased burnout in their single centre survey study. There was no other specific direct data within the articles reviewed with regard to EHR-related student and resident burnout. However, a recent paper published after the target period of our review, (Domaney, Torous, & Greenberg, 2018) surveyed psychiatry residents in a single US city and found a high correlation between burnout and EHRs, suspected to be related to increased documentation times and also out of hospital access, with residents reporting average weekly EHR usage reaching 22 hours. Their findings also show that EHRs have a stronger
correlation with burnout vs. other potential burnout factors like sleep, exercise, and clinical service. With regards to medical students, this population is already prone to burnout in general (Ishak et al., 2013) thus, EHRs can potentially contribute to this risk if no preventive measures are taken, something recognized by a recent report (A. Jha et al., 2019).

In terms of what causes EHR systems to contribute to burnout, it is important to point out that the majority of EHR-related burnout reports are still from the USA. There is evidence that this is related to USA-specific EHR documentation requirements, which are designed for billing and medicolegal purposes, resulting in more complex and longer notes. Downing et al (Downing et al., 2018) discovered a distinct absence of this affect in Australia, where documentation requirements are less burdensome, resulting in shorter notes and more physicians satisfaction with EHRs.

In terms of prevention and management of such burnout, within my scoping review results, there were no reports on how burnout prevention and management is achieved. However, others have made recommendations how to best avoid and manage it, as an example, in a recent report by Jha et al (A. Jha et al., 2019), “A Crisis In Health Care: A call to action on physician burnout”, the authors recommend medical schools and residency programs actively provide sufficient staffing during off-duty hours and support self-care and counselling services for learners, as well as providing mentors who act as role models. This was also evident from earlier calls (Lown & Rodriguez, 2012) for curriculum development that focuses on learner wellbeing. They stipulated the importance of including purposeful monitoring tools to evaluate the influence of EHRs on resident wellbeing, not just learning outcomes. Off-hours access to EHRs has also been cited as a risk factor for burnout and thus such access should be monitored and regulated to promote physician/learner wellbeing (A. Jha et al., 2019). McKenna et al (McKenna et al 2016) also stressed promoting mentorship which creates a sense of community to minimize the risk of burnout. Additional measures include setting reasonable EHR documentation expectations, while prioritizing patient engagement and providing training to ensure efficient use of EHRs.
4.2 Medical student/resident documentation and note keeping

EHR-related documentation has a major influence on workflow as mentioned in the previous section. In the Results, the dominant themes were related not only to the time commitment of this task, but also the development of specific behaviours, such as the copy-paste phenomena and template usage, which are promoted for efficiency but have also caused learning, safety and ethical concerns.

4.2.1 Documentation practices

There has been a concern that allowing software to populate important clinical information may prevent students and residents from learning such skills as medication scheduling and dosing. In terms of how to mitigate these concerns, teaching strategies for better documentation practices were explored in chapter 3 in relation to our selected articles. Other literature (Gagliardi & Turner, 2016) also suggested measures such as disabling the copy-paste and auto-populate functions for learners. This would force learners to think critically about their documentation, while recognizing that this would reduce efficiency, which could be an acceptable tradeoff, especially as students are learning how to develop their critical and clinical reasoning skills.

Redundancy was also a concern due to this practice as noted by Farri et al (Farri et al., 2012). Not only is it time-consuming to review longer notes, but also potentially misleading, as it could include errors and defunct information that is no longer necessary to manage patients. Recommendations to rectify redundancy include the development of software to better highlight status changes and clinically important sections to facilitate reader navigation and comprehension and to detect potentially harmful redundancy which then be removed by the user. As an example of proposed solutions, one study (J. E. Siegler, Patel, & Dine, 2015) recommended reducing redundancies by documenting updates for hospitalized patients in a single EHR location and a single note that has input from all multidisciplinary providers. Inspired by an unpublished University of Colorado affiliated hospital practice, it was suggested that SOAP notes be rearranged to include the
assessment (A) and plan (P) at the beginning of the note, instead of the end, so learners and physicians can quickly access important information.

4.2.2 Documentation and clinical data presentation and risk of error

This section addressed how EHR notes tend to be fragmented, thus disrupting connectivity, which could lead to a disturbance in clinical reasoning and time required to process information (Varpio et al., 2015). Yudkowsky et al. (Yudkowsky et al., 2010) reported increased error rates related to retrieval problems. Additionally, March et al. (March et al., 2013) demonstrated that data presentation can affect error detection.

Evidence suggests the user interface modifications help lead to better data presentation, prioritization, and access to more meaningful and contextual information. This can support better cognitive processing, safety and workflow efficiency as shown via one study (Ahmed et al., 2011) which demonstrated that better ICU EHR system’s interface redesigns along these principles lead to a significant reduction in errors of cognition. In this study, a clinician scientist, informatics expert and a software specialist worked together to improve this ICU EHR user interface to make sure that the clinical data is presented in a practical and clinically relevant manner. This team’s findings also endorse the collaborative approach to improving EHR systems.

4.3 Medical student/resident and patient communication

This theme had the most methodologically sound research relative to the other themes from the quantitative aspect. Although the negative aspect of EHRs on patient/communication are often stressed, there was also evidence to show EHRs can have a positive influence, if used in the correct manner (Crampton et al., 2016). For example, Taft et al. (Taft et al., 2014) showed with proper guidance and training, the EHR can promote patient/learner communication, not hinder it.

Patient perceptions seem to be variable. If proper communication is ensured, these perceptions are likely to be more positive. There is ample evidence that patients do in fact appreciate certain aspects
of the EHR if utilized in a manner that promotes communication. This includes screen-sharing, sign-posting and proper ergonomic orientation (Shachak & Reis, 2009). This was supported by a single center, mixed methods study by Lee et al (Lee et al., 2016) where patient perceptions of resident and physician use were largely positive. An earlier systemic review by the same team (Alkureishi et al., 2016) also supported these findings, with the group concluding from their analysis of 25 studies, that there was no change in patient satisfaction or patient–doctor communication after EHRs were implemented. But this requires careful training in EHR-specific communication skills and highlights the importance of active and purposeful training for students and residents. Strategies for teaching were also outlined, including a 10-step approach (Shachak & Reis, 2009) and (LoSasso et al., 2017) demonstrated the SALTED method (a mnemonic for Set-up, Ask, Listen, Type, Exceptions, Documentation).

Unfortunately, scholarly gaps still exist in this field. As pointed out by Crampton et al (Crampton et al., 2016), there is remains a lack of common research standards for terminology, as well as a tendency to ignore computer set ups/arrangements, which is an important contributor to communication disruption. More needs to be done to see how physicians and stakeholders could be influenced to follow research informed guidance. Furthermore, they also stress that most research is focused on outpatient/ambulatory clinics not in inpatient and emergency settings, which have different dynamics and influences. More research is needed to study how inpatient EHRs impact patient/doctor communication. There is also a lack of research on how to design and better user displays that promote screen sharing with patients, especially in educational settings. Several studies (Taft et al., 2014) (Almquist et al., 2009) recommended that user interfaces should be designed to allow easier sharing of information with patients. Taft et al recommended a “discussion centric” EHR, as opposed to the “documentation centric” EHR to facilitate better patient-doctor/learner communication. Given all the other competing and complex requirements of EHRs, this needs a
multidisciplinary and collaborative approach to better design systems that further promote communication.

4.4 EHR Training and Simulation

4.4.1 Training and curricular development:

There remains a lack of evidence and theory-based curricular development and in addition to the collection of post-curricular implementation outcomes data. As with the workflow theme, there was a lack of a clear, guiding “framework” to help approach the task of creating and integrating informatics/EHR curricula. However, the health informatics community is taking an interest in this particular topic as evident by the work of Andre Kushniruk and Elizabeth Borycki (British Columbia, Canada), who have explored the integration of health informatics education (especially EHRs) and undergraduate and postgraduate medical education. In one particular study from 2009 (Kushniruk, Borycki, Armstrong, Joe, & Otto, 2009), the authors proposed a very useful framework which is described as the “loose coupling/tight coupling framework”, see Figure 4.1. This framework outlines a continuum in EHR educational integration where at end there is loose coupling where there is a weak level of integration, in which EHR training is for example, only an introductory side component (e.g. short EHR training during student/resident pre-rotation). On the other end, there tight coupling, which refers to more deliberate integration (e.g. such as the use EHRs as a teaching tool for essential aspects of health professional training). This latter tighter fit has the advantage of allowing learners to learn both clinical/medical aspects of the curriculum, using the EHR system to understand diagnosis and management, and also to familiarize themselves with the technical side of this tool. This was further explored by Borycki et al (E. Borycki, Kushniruk, Armstrong, Joe, & Otto, 2010).

The advantage of this model is it can also allow for easy designations and categorizations of institutional EHR training, thus allowing for easier communication and standardization of terminology, which could potentially aid in future research.

When looking at the challenges EHR training, there are over 80 different vendors within the USA
alone. This creates an ever-moving target, as vendors and EHRs continue to develop and modify interfaces and platforms, which could make training students and residents difficult given how these systems differ. In order to address this issue, informaticians offer some novel solutions in terms of curriculum design and implementation, one of which is suggested by Borycki et al (E. Borycki et al., 2011) who created internet-based EHR simulations that cater for a different vendor interfaces. This provides a central place where students and residents may effectively train and practice on how to use these systems.

There is also remains a concern that curriculum development is more likely to concentrate on the technical training aspect, with the risk that it may negatively impact the medical educational portion of training. Given the substantial time that learners spend on using EHRs, the question remains how to best develop curricula that enhance the educational quality of EHR usage (R. H. Ellaway, 2016). There are still no clear answers to date on this important question.

![Coupling framework](image)

**Figure 4.1** Coupling framework for integrating EHR training in health profession’s education.

Adapted from (Kushniruk et al., 2009)

### 4.4.2 Simulation

As previously stated, simulation has the benefit of providing a safe means of EHR-related training, which can facilitate not only the technical aspect of training, but also the functional aspect, especially in terms of learning how to deal with complex data in a safe manner, where error can be experienced without harm (Mohan et al., 2016). Simulation also allows valuable experience for students when real life EHR access is limited or prohibited.
In terms of the structure of simulations, examples were discussed in the results section, and in one paper, informaticians provided guidance on how best to research workflow, as there are many complex factors at play. Mohan et al (Mohan et al., 2016) outlined the importance of this when designing EHR simulations, stating that clinical care tends to rely on teamwork, and current EHRs designs are often more focused on individual interactions vs. the clinical team. Increasingly, this has become a recognized issue (Beasley et al., 2011), which has highlighted the notion of “team cognition” which are: “cognitive processes necessary to do work in teams, including communication, distributed knowledge or ‘team situation awareness,’ and coordination”.

Simulation is essential to further understand how to understand workflow patterns in a safe environment and to guide EHR development and workflow adaptations. More work needs to be done in this area and there is progress in facilitating this research. As an example of this, Borycki et al (E. M. Borycki, Kushniruk, Kuwata, & Kannry, 2006), provided a 9-step methodological framework that can help design and implement workflow simulation studies, incorporating subject selection, task selection, scenario design, required recording equipment and guidance on data collection and analysis. Mohan et al (Mohan, Scholl, & Gold, 2015) also outlined important principles that can be used for EHR simulation, including the importance of fidelity when constructing such simulations, as EHR simulations can be misrepresented and overly simplistic. They proposed three important characteristics of optimal simulated EHRs: 1) simulation cases should replicate a significant proportion of data complexity expected in direct patient care, 2) EHR training should replicate the cognitive load to which clinicians are exposed. 3) EHR training should not be just didactic and memory-based, but should also include case-based examples, so the learner can transfer what is learned into clinical practice. Simulation is also used to aid in communication skills training (Shachak et al., 2015) and educational diagnosis (Mohan, Scholl, & Gold, 2018).

4.4.3 Learning versus performance

Training tends to be performance-based, and there are increasing calls for this training to be
longitudinal, as there is risk of attrition of skills over time (Lee, Alkureishi, & Arora, 2017). How this is best accomplished is debatable. How this is best assessed is also problematic, as there are poorly defined outcomes measures to follow learners in an EHR-related context. The learning vs. performance issue is discussed in more detail in the knowledge section.

4.5 Knowledge Acquisition / Information processing / Learning

In this theme I explored how EHRs can be adapted to assist in learning. This included provision of case simulation via virtual patients, case-based teaching, and the use of the potential of computerized clinical decision support systems (CDSS) as tools to provide point of care knowledge. Although the case studies illustrated the potential for this technology, there is a lack of research that provides evidence of formal and continued implementation with this goal in mind. Hammoud et al (Hammoud, Dalrymple, et al., 2012) expressed concern whether real “learning” actually occurs with CDSS tools. These systems can deliver knowledge and specific information without considering the practitioner’s actual knowledge status, whether declarative or procedural (Wysocki, Diaz, Crutchfield, Franciosi, & Werk, 2017)

4.5.1 Learning versus Performance

This is an essential topic to cover in the relation to our fundamental goal to look at the role of EHRs in medical education; especially in the way they can influence learning. There is a long-standing debate about learning and performance (Soderstrom & Bjork, 2015). The fundamental question asks, does improvement in performance mean learning has taken place? This question is important because many of the measures related to EHR use performance as a marker of success. This is a critical issue, as EHRs have been designed with efficiency and clinical safety in mind, not education as previously outlined. In one elegant integrative review (Soderstrom & Bjork, 2015) this question was explored. The authors concluded that there is the following difference between these two entities:
“Learning is the relatively permanent changes in behaviour or knowledge that support long-term retention and transfer and performance is the temporary fluctuations in behaviour or knowledge that are observed and measured during training or instruction or immediately thereafter.”

This is an essential distinction, since students and residents can be assisted by technology, whether EHRs or other e-learning tools, to access knowledge that they can use to provide temporary working knowledge or solutions. As highlighted in the work by Bjork et al, this could lead to performance enhancements, but these are likely to be temporary. They also advise that for more permanent learning to occur, educators need to be aware of the downsides of performance-enhancing tools and to treat them with caution if learning is the primary goal, something relevant to EHR usage in an educational context. Thus educational practices are needed to ensure that learning objectives are met and regularly evaluated to establish that no knowledge or learning decay has occurred.

The following practical example highlights this importance. CDSS systems help with medication prescribing (dosing, scheduling, interaction checks etc.). If a resident with little prior prescribing experience wanted to prescribe methotrexate for rheumatoid arthritis, the system can take over much of the cognitive work associated with the medication, such as choosing the right starting dose, subsequent titration, and ensuring that follow-up bloodwork is done etc. The resident will not have the chance to learn the rationale for all these steps. The CDSS ensures the “safety and efficiency” of this step, but not that the prescriber actually “learned”. By the current performance standard, this particular prescriber may perform well, but this may mean that trainees may complete their training without “learning” adequate prescribing skills and thus will be totally reliant on these tools for future work and potentially will not achieve the right knowledge requirements and experience to deal with novel variations of such procedure, especially if the there is complete software failure.

By using the same definition that Bjork et al provides, older physicians who “learned” the traditional way about the principles of prescribing methotrexate would have acquired more “permanent” learning. Thus, even if such clinicians used the CDSS, they can benefit from its efficiency functions
without risking their learning.

Given the above discussion, especially when to introduce medical students to EHRs, there is no current evidence that comprehensively informs the best time for their introduction to such systems, especially in their current performance-driven implementations. If the timing of introduction of these tools is critical, as described in the training section in chapter 3, a graduated milestone approach to the use of EHRs could be employed as suggested by (Hersh et al., 2014), while being cognizant of prioritizing learning needs and being aware of what tools facilitate learning vs those that only facilitate performance. Further research could help sort these tools into learning or performance categories to reassure educators that students and residents can access the right tools at the right time without threatening their actual learning.

Once these drawbacks are appreciated and ideally avoided, EHRs can be used to track knowledge and learning progression. CDSS tools for example could be introduced after certain competencies are met, and once introduced, consideration should be placed on how to best design them for learners. For example, CDSS recommendation could also include educational content or prompts that facilitate student or resident learning. The content or prompts should be designed using educational and theory driven principles with aim of facilitating learning.

How EHRs can effect clinical reasoning was also discussed. The qualitative papers provided valuable insight into this aspect. Varpio et al (Varpio et al., 2015) showed how context, connectivity, bundles and narrative are important for clinical reasoning to develop and how EHRs can fragment this. This was also supported by the work of Farri et al (Farri et al., 2012) work. Additionally, the potential loss of immediate, real-time feedback can harm the acquisition of clinical reasoning (Martin & Farnan, 2017). This is because timely feedback is an important factor in developing clinical reasoning and maturation (Wong et al., 2012).

4.6 Trainee assessment and tracking

As EHRs become ubiquitous, the inevitability is that they will be increasingly used to track learners’
performance. This will likely extend to practicing physicians, with evidence that tracking can extend beyond performance measures (patient volume, adherence to clinical guidance etc.), and can also extend to actual clinical/declarative knowledge tracking (Wysocki et al., 2017).

As an example, in a novel approach to using EHRs to evaluate and diagnose potential learning problems amongst learners, Mohan et al (Mohan et al., 2018) used a simulated EHR to determine the reasons why some residents were performing badly. For example, one of their study participants who went over an EHR-simulated case was found to have issues navigating and using the EHR system but no problems with his knowledge, whereas another resident was found to have knowledge gaps that lead to his poor performance. As a result of this simulated interventions, targeted educational interventions for both cases can lead to successful outcomes.

Assessing actual learning in EHR-equipped environments is necessary to evaluate the impact of EHRs on learners. The opportunities in this area are intriguing. Although pre- and post-EHR implementation studies have been mentioned within the results section, there is still a lack of information on how learning is impacted. Further work on how to best assess such implantation is essential to understand both current impact and future interventions that could enhance learning in such environments, especially given the fact that learning could be potentially affected as discussed in section 4.5.1. We can potentially learn from assessment scholarship within medical education literature and adapt it to assess learners who are using EHR systems, either through individual and EHR-specific assessment projects or as part of a wider and encompassing program evaluations.

### 4.7 Barriers to EHR medical education integration

From the included articles, there is focus on the barriers that prevent medical students accessing EHRs, as there are still some logistical and legal restrictions on student access in some jurisdictions. Some of the causes are related to legal, privacy, and administrative concerns (Mintz et al., 2009; Welcher et al., 2018). Other overall barriers may be related to financial cost of training and provision of technical infrastructure and training staff. Another issue was the heterogeneity of EHR systems.
This is substantiated by studies (E. Borycki et al., 2011) which also provided further useful insight into these integration barriers, summarized as follows:

1) Faculty who have no functional knowledge of EHRs, 2) lack of health informatics specialists to help implement, adapt and troubleshoot EHRs, 3) poor access to different EHR systems 4) rapid pace of EHR development.

As previously mentioned, in order to tackle the issue of differing EHR systems and the lack of standards, Borycki, and Campbell (2011) recommended a web-based training simulation that incorporates different EHR interfaces to allow learners to appreciate the differences and be better prepared for the real world heterogeneity. This is certainly a common problem as previously discussed and a frequent cause of frustration for learners who often have rotate through different hospitals, all with different EHRs.

4.8 Teaching and Practice Implications

The ideal education-friendly approach could have the following characteristics, keeping in mind that further research is required to further EHR related pedagogical practice:

**Workflow:**

(i) Emphasis should be on EHR-related efficiency that reduces learner on-screen time.

(ii) Team-based, not individual documentation, should be implemented. This allows for team collaboration, communication, feedback, and better documentation habits (e.g. less redundancy) and more learning opportunities.

(iii) Technical improvements such as simpler and easily adaptable user interfaces to allow easier and time saving access to information with better presentation of data. Collaborative approaches are required to better design these interfaces.

**Documentation:**

(i) Adaptive approach to allow trainees to construct notes in a way that promotes critical thinking which ultimately contributes to the development clinical reasoning. Reduction of copy/paste
behaviour and note redundancy is an important step. This would help foster the development of clinical reasoning skills, especially if learners are provided with adequate supervision and feedback as outlined earlier in this chapter (also noted in point (ii)).

(ii) Faculty should be encouraged to provide timely feedback on trainee charting.

(iii) Less documentation requirements, to reduce the administrative and legal components by delegating to clerical staff if needed.

(iv) EHR documentation can be, and should be, used to assess learners.

(v) Technical aspects such as software that detects redundancy and provides evolving structural guidance for early learners, with preferences to integrate learning resources relevant to the content of their documentation. AI technology has future potential to assist and off-set some of the redundancy and access information related problems.

Communication:

(i) Early and purposeful EHR related communication skill requirements and training (10 step model as an example).

(ii) Technical improvement such as computer design, which allows for better information sharing with patients.

(iii) Better interfaces to allow for team based communication.

Knowledge integration:

(i) If a “tight coupling approach” to EHR is employed, EHRs can be used in simulation activities to teach in a case-based manner. This could be done via simulations or by real world EHRs after complying with ethical and privacy rules. EHRs can also be used to diagnose learner difficulties. Incorporating theory-informed instruction that promotes “long term” learning vs. short term performance gains should be the goal (Mylopoulos, Steenhof, Kaushal, & Woods, 2018).

(ii) Technical improvements such as point of care knowledge and testing tools could be built in learner adapted interfaces.
Learner supervision:

(i) Educationally sound supervision practices should be employed.

(ii) Remote supervision should be coupled with timely feedback if observations and changes are made to clinical care, and should be purposefully used as “teaching moments”. This approach of adequate and timely supervision better helps the development of clinical reasoning (Kulasegaram & Rangachari, 2018; Martin & Farnan, 2017; Reddy et al., 2010).

(iii) EHRs can also be used as a learning tracking device to ensure that learners obtain adequate clinical exposure.

Learning and performance:

(i) Educators and trainers should be able to distinguish between learning and performance.

(ii) Performance-enhancing tools such as computerized decision support system (CDSS) could lead to “short term” performance enhancements, which can be mistaken for learning.

(iii) Educators need to be aware that this does not contribute to long term and meaningful learning.

(iv) Having deliberate learning tools at hand, timely educational feedback and ongoing assessment and reinforcement are some of the strategies that can promote and reinforce learning and mitigate temporary performance gains.

EHR training:

(i) For students, training should be guided by a schedule that follows specific milestones and competencies.

(ii) Integration with other curricular activities can be achieved and with careful educational planning they could enrich not compete with other curricular requirements.

(iii) Training could follow the “loose coupling” to “tight coupling” approach as described by Kushniruk et al., 2009, with future work aimed at developing and investing in the “tight coupling” variety of EHR training.

Resident wellbeing:
(i) Active promotion and monitoring of resident well-being due to risk of burnout.

(ii) Fostering e-health professional behaviors via positive mentoring and providing adequate administrative support to reduce necessary and non-educational tasks.

(iii) Promoting self-awareness and self-compassion is another recommended element from the literature.

**Clinical Safety:**

(i) This would follow the same guidance as with independent physicians.

(ii) Teaching residents on how to use the built in EHR safety tools, which requires more focused and better EHR training (E. Borycki et al., 2011)

**Student/Resident engagement:**

(i) This will allow for better EHR skillset self-efficacy, and will promote better feedback that could be used to optimize their educational experience.

(ii) There is an added advantage that engagement will foster future e-Health champions.

(iii) More principles derived from educational scholarship will eventually be applied to enhance these domains as more research and collaboration occurs.

**4.9 Canadian Perspective**

Canadian Medical education scholarship and output is world renowned, and is considered the top contributor in this field according to previous research (Doja, Horsley, & Sampson, 2014). In relation to Canadian EHR educational research, only 9% were of Canadian origin (despite this, Canada was ranked 2nd overall in total number of articles). The vast majority of EHR related scholarship is American. As such, there is potential for lack of generalizability, as although there are overlapping functions in EHRs between USA and Canada, the implementation standards and approaches differ.

The USA is more billing-focused, which could contribute to their particular experience. They have a “meaningful use” measure which guides their implementation as opposed to Canada which uses different standards, depending on the province (Huang, Gibson, & Terry, 2018). The documentation
standards in the USA require longer legally and billing-oriented notes, which have been shown to
effect physician wellbeing due to the extent of documentation required, which may not be applicable
to Canada (Huang et al., 2018).

In relation to building e-Health and EHR educational and professional capacity, the CanMEDS 2015
eHealth Expert Working Group Report, which included clinical, educational and informatics
expertise was a step in the right direction. Their work resulted in the successful adaptation of the
Royal College CanMEDS framework to e-health/EHR use (Ho et al., 2014).

E-Health Competencies for undergraduate medical education were also created by the Association of
Faculties of Medicine of Canada in Partnership with Canada Health Infoway, in May 2014 (R.
Ellaway, Hayward, Ho, Hurley, & Littleford, 2014). The working group on eHealth competencies,
recommended the following to further ehealth education (including EHRs) in Canada:

- Promote Improved timelines and resourcing
- Recruit more eHealth experts.
- Engage students, residents and fellows
- Promote Inter-professional collaboration
- Recognize the need for continuing professional development for clinicians in the field.
- Involve other stakeholders: e.g. patients/ consumers.

Furthermore, a 2011 paper entitled “Information and Educational Technology in Postgraduate
Medical Education” (R. H. Ellaway, Topps, & Bahr, 2011) conveyed the following three key messages
in relation to digital and information technology education:

1. Canadian postgraduate medical education (PGME) accreditation and regulation structures ignore
digital media and methods, even though they are a growing part of healthcare.

2. Digital media research and scholarship needs to be better supported by resources. The federal
research agencies need to support innovative and critical approaches to studying and appraising the role of digital media and methods in Canadian PGME, including the ways they relate to quality-assured practice.

3. The role for education informatics leadership needs to be developed and expanded in PGME, with a need for more digitally informed leadership. This includes: “positive engagement, mentoring, development of digital competence in leaders, support for strategic initiatives and scholarship, and alignment with the growing e-health environment for Canadian healthcare”.

There exists a great opportunity to further this area of research in Canada, especially as there is such robust medical education scholarly expertise. Furthermore, more research is required outside the USA, to elucidate the difference student and resident experiences, so as to better inform local educational policy and interventions.

4.10 Summary of identified gaps in knowledge

There were a number of gaps noted in the reviewed literature related to methodology and focus of research. There was a predominance of observational methodologies, especially of the cross-sectional design, which limits defining causal relationships.

The reported survey articles also had very similar aims and conclusions, especially in terms of examining student access to EHRs. There were also few longitudinal studies to follow resident/learner progress that would allow more understanding of user maturity and how learners relate to EHRs with increased experience. These could also provide other valuable information, such as potential mechanisms of interactions. These studies would also allow the development of evidence-proven EHR-related outcomes.

In terms of experimental methods, of the 11 studies (13.6% of total) that used the “pre and post” methodology, only two of which are controlled. This type of method, also called the single-group “pre-test/post-test” design is actually the most commonly used method within medical education literature (Cook, Beckman, & Bordage, 2007). Despite the frequency of this methodology, the
uncontrolled version has significant flaws, as any observed changes could be attributed to other influences such as “maturation and co-intervention” as well as the fundamental reality that the educational intervention is being compared to “no education/training” (G. Norman & Eva, 2018), which would naturally lead to more learning occurring in the intervention group. This reasoning also extends to two of the controlled studies that employed randomization, which had “no teaching” as a control.

Most quantitative studies had a small number of participants and were from a single centre, which limits the generalizability. This is especially pertinent, as EHR vendors can provide different experiences, which could affect how we can interpret results.

Importantly, there was a lack of theory-based research. The qualitative articles provided some useful and novel theoretical insight as proof that this type of approach is needed to study such complex topics as this. This type of research should be further encouraged.

In terms of workflow-focused gaps, there was an absence of more details on how residents use their on-screen time to elucidate the main reasons for increased time utilization.

There was also a notable deficiency of trainee input in designing and implementing these systems. Involving end users has benefit (buy in) and has potential to increase user satisfaction which was also recommended by (Xie, 2015).

Despite the importance of resident wellbeing, there was no research within the selected articles that studied resident burnout and EHR use. This is a growing problem and needs to be further investigated.

The communication aspect was better studied, but contained a few gaps that were discussed in more detail previously.

Finally, but very importantly from a learning perspective, there was a notable absence of learning vs. performance differentiation and there were no studies on how to study, monitor and ensure lasting learning within EHR driven environments.
4.11 Study Strengths and limitations

To the best of my knowledge, this is the first scoping review and systematic in-depth research literature review that has explored and mapped the research relevant to the role of EHRs in medical education. The study defined in detail the main themes and topic areas related to our study aims and also provided guidance for both future research and teaching practices.

In terms of limitations, my study only looked at literature published in the English language. The review was only partly conducted by two reviewers for the “title/abstract” and full text screening” stages, part of the study selection process as detailed in the methods section. Full text data extraction and review was primarily done by the author (AO). Although O’Malley et al (Arksey & O’Malley, 2005) recommend two reviewers for each stage, for my study, the primary author (AO), reviewed the final selected articles multiple times to ensure both accurate selection and extraction. Nonetheless, there is still risk of bias and error when having a single author reviewing most of the data. Commentaries, gray literature, and proceedings were excluded, acknowledging that publications related to this area could provide very useful insights. Informatics proceedings and conference literature especially offers a rich source of material that may have been missed in this review. Future reviews, especially if well resourced in terms of number of reviewers, should seriously consider including such informatics sources.

Nursing, pharmacy and dental source materials were also excluded, while acknowledging the richness and significance of such literature. The reasons for excluding the other interprofessional EHR setups, although there are overlapping characteristics, is that EHRs for these groups tend to have different software and usability requirements which could hinder analysis for our particular research aims. The other reason is the large volume of articles would make the project unfeasible, as it would need more people to review the literature base. Future reviews and synthesis could combine all these sources for a more comprehensive and detailed look at the literature.

I did not perform the last scoping review step, of consulting relevant stakeholders, as suggested by
(Arksey & O’Malley, 2005). This could be a next step, to discuss with relevant stakeholders, which should include learners, educators and informatics specialists. This would allow for sharing of these results, and the discussions with such a group would provide further insight and avenues for further work within this topic area and could illuminate future ideas for research and educational integration of electronic health records.
Chapter 5

Future Research Directions and Conclusions

The findings of this scoping review provide an updated systematic synthesis of the effect of EHRs in medical education. This work also discusses potential avenues for further research, which is needed to understand how to optimize learning in the setting of EHRs, especially as residents spend a significant portion of their training using these systems.

Theory-based research is lacking, despite both medical education and informatics scholarship having a rich theory base that could be applied to help study and better integrate EHRs educationally. Established learning theories could be used to serve this purpose, and with further research, and new theories could be formulated to help elucidate the complex interactions that happen with these ever evolving systems.

There is also a need to study the long-term effects on learning as more performance-based tools are used, which are designed more for efficiency vs. learning. In particular, it will be important to define if and when such tools can be introduced into undergraduate medical education so as to avoid any potential harmful effects.

User maturity research is also lacking, thus longitudinal research is needed to look into how patterns of use may differ according to stage of training, but also to study student and resident satisfaction as this may be decrease due an increase documentation requirements. Longitudinal research can also help to define EHR-specific educational outcomes. EHR simulation is key in this regard, and can provide an opportunity to help answer these questions, but also to investigate how we can better optimize learner workflows (E. M. Borycki et al., 2006; Mohan et al., 2016).

With regard to workflow, further research is needed to study learner workflow and the ways to make these systems more efficient, so as to allow learners to spend more time with patients. Additionally, the information overload and burn-out risk is substantial and there may be a requirement to
intervene during training to avoid this, thus there needs to be better monitoring systems to check for such risks and despite these risks, there is still a lack of research on how EHRs effect resident/student wellbeing as more of these systems are deployed.

There are other questions related to documentation, some of which have been covered within the review, but questions remain: How do EHR-related documentation practices affect cognitive process and development of clinical reasoning skills? How do templates affect residents thinking? How do we use a theory-based, educational approach to optimize resident EHR note taking, and study the effect of such interventions? What will the role of artificial intelligence be in the future to help improve learner experience in terms of documentation and information presentation?

Learner input into EHR optimization is a potential avenue of research. Their unique feedback and experiences could help inform better EHR design and deployments. Furthermore, looking at certain EHR-related behaviors could be useful, such as the workaround phenomena that learners employ to bypass certain EHR functions. Although this is often deemed as a flaw, it could be potentially used to better design the EHR software. For example, “cow-pathing” is used by software engineers to study post software deployments to discover innovative workarounds that end users discover which in turn could be used for subsequent software enhancements (Zhang, Padman, & Levin, 2014).

There is also opportunity to determine the differences between countries and health boundaries. There is a lack of data from the Canadian perspective, the Canadian medical education community needs to be encouraged to study this topic, and there is real opportunity to impact residents’ learning outcomes and wellbeing in a Canadian context. This especially important as EHR systems and deployments can differ substantially between countries and thus questions some of the generalizability and applicability potential of outside research to Canadian context.

Another important factor is the complexity of EHR systems, thus research in multidisciplinary collaborative groups is essential. For example, informatics is an increasingly complex and maturing science and has a rich and varied literature base, which includes the use of theory to study the
complex nature of EHRs. This could further enrich medical education scholarship. Informaticians, health care providers (clinicians, nurses, pharmacists etc.) and educators need work together to optimize EHRs for learning. Vendors and computer experts also need to be involved and work closely with this collaborative, to help facilitate research and the pursuit of solutions. In terms of how much collaboration exists between these groups, data are lacking on the current levels of collaboration. We need to ask how can we facilitate this process and build bridges? Are students/residents involved in EHR related educational research, and how can we encourage them to be involved and potentially become future champions in this field?

5.1 Conclusions

This scoping review has re-affirmed some of the previous concerns and findings about this area, but has also provided new insights. There is remains a lack of research in a technology that residents can spend 30-40% of their precious educational time on.

This work described six themes acquired from the reviewed articles, which helps to define the current role of EHRs in the medical education setting. Notably, the overwhelming majority of research was from the USA, which can limit the generalizability of the findings.

Findings show that residents spend a substantial amount of time on these systems, ranging anywhere from 40 to over 50% of their time. Medical student access is increasingly being recommended and allowed and with this, there was a notable lack of research into the best learning practices in undergraduate medical education, which is concerning as EHRs are geared more towards performance improvement, rather than actual learning. More diverse educational research is needed and where available, improvement in its methodology is recommended in order to ensure better design and valid results.

There is also a lack of theory-guided scholarly work, something which could potentially help our understanding of how these complex systems impact student and resident learning. Both medical education and health informatics have an established tradition of theory-based research, and this
could be leveraged to improve research in the area. EHR simulation-based research and training looks promising in this regard as well, as it can enhance research, training and learning activities in a safe and flexible manner.

There is a need to better study the long term impact of these systems, so as to inform better educational strategies but also avoid some of the pitfalls that are becoming more evident, such as the effect on physician well-being due to increased documentation and administrative pressures that these systems have caused.

Due to the complex nature of EHR educational integration, it will require an interdisciplinary collaborative approach to help research and elucidate the best educational, training and implementation strategies. There have been multiple policy recommendations on this, but little evidence to quantify the current levels and quality of collaboration. A combined effort to tackle these challenges, including finding the right human and material resources is required.

In conclusion, as EHRs continue to develop, we should strive to ensure that they enrich future physicians learning and wellbeing not hinder it. This will require more collective effort and engagement from all relevant parties. This review augments the current evidence base related to this topic, and thus can assist in achieving this goal.
References


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Friedman, E., Sainte, M., & Fallar, R. (2010). Taking Note of the Perceived Value and Impact of Medical Student Chart Documentation on Education and Patient Care: *Academic Medicine, 85*(9), 1440–1444. https://doi.org/10.1097/ACM.0b013e3181eac1e0


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https://doi.org/10.1097/ACM.0b013e3181bf9d45


https://doi.org/10.4338/ACI-2014-08-RA-0065


Reis, S., Sagi, D., Eisenberg, O., Kuchnir, Y., Azuri, J., Shalev, V., & Ziv, A. (2013). The impact of residents’ training in Electronic Medical Record (EMR) use on their competence: Report of a


Appendices

Appendix 1 Table of article theme distribution with abbreviation key for Appendix 2 table.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Theme abbreviation Key</th>
<th>Article Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Workflow</td>
<td>WF</td>
<td>40</td>
<td>48.8</td>
</tr>
<tr>
<td>2  Medical student/resident documentation and note keeping</td>
<td>DOC</td>
<td>35</td>
<td>42.7</td>
</tr>
<tr>
<td>3  Medical student/resident and patient communication</td>
<td>COMU</td>
<td>29</td>
<td>35.4</td>
</tr>
<tr>
<td>4  EHR Training and Simulation</td>
<td>TRN/SIMM</td>
<td>34</td>
<td>41.5</td>
</tr>
<tr>
<td>5  Knowledge and Information Management</td>
<td>KNO</td>
<td>12</td>
<td>14.6</td>
</tr>
<tr>
<td>6  Trainee assessment and tracking</td>
<td>ASMT</td>
<td>8</td>
<td>9.8</td>
</tr>
</tbody>
</table>

*N=82 articles.
Appendix 2 Table summarizing all included articles (including theme categorizations). N=82 articles.

<table>
<thead>
<tr>
<th>Ng</th>
<th>Study Authors/year of publication</th>
<th>Title (Ti) and Aim(s) of Study</th>
<th>Population/Participants</th>
<th>Study design</th>
<th>Main findings</th>
<th>Represented theme(s)</th>
<th>Gaps/ Main limitations</th>
</tr>
</thead>
</table>
| 1  | Aaronson, J. W.; Murphy-Cullen, C. J.; Chop, W. M.; Frey, R. D. 2001 | **Ti**: Electronic Medical Records: The Family Practitioner's Perspective  
**Aims**: 1) To determine residents’ perceptions of EMR in a longitudinal clinic.  
2) How EMR training and previous computer background influence residents’ perception of difficulty in EMR implementation. | Postgraduate residents (PG) (PGY1-PGY6) | Survey | -Overall ambivalence and frustration toward EMR system  
-EMR training can influence ease of EMR implementation & attitudes regarding how EMR usefulness.  
Residents who perceived adequacy of EMR training and ease of EMR implementation (easier and less lengthy training) were more likely to perceive the EMR to be beneficial and were more likely to choose EMR over traditional paper records for future use. | TRN/SIMM | -Incomplete survey response rate and failure to survey all family practice residency programs nationally (USA) limited the findings of study.  
-Not enough statistical power to study correlation between type of EMR vs. resident experience with EMR. |
| 2  | Asan, Onur; Kushner, Kenneth; Montague, Enid. 2015 | **Ti**: Exploring Residents' Interactions With Electronic Health Records in Primary Care Encounters  
**Aims**: 1) Investigate/compare residents interaction with EHRs during primary care encounters.  
2) To explore if these interactions/behaviors differ by residency year level. | Family Medicine Residents (PGY1 – PGY3) | Cross-sectional | 3rd year residents had highest percentage of visit time looking at EHR screens vs. 1st- and 2nd-year residents.  
3rd-year residents spent more time typing or inputting information into the records during the clinical visit vs. 1st- and 2nd-year residents. | COMU, WF | - Cross-sectional study: residents not followed as they progressed through the program.  
- Small sample size = lower statistical power. - One ergonomic setup was used for EHR systems making generalization uncertain for other arrangements |
| 3  | Aruater, Amber R.; Rudd, Mariah; Brown, Audrey; Wiener, John S.; Benjamin, Robert; Lee, W. Robert; Rosdahl, Julia A. 2016. | **Ti**: Developing Teaching Strategies in the EHR Era: A Survey of GME Experts.  
**Aims**: Survey education experts to ask:  
-Does EHR impact graduate medical education (GME)?  
Goal of question to develop strategies/tools to enhance GME teaching/learning within EHR environment. | Physician educators | Survey (Delphi) | Identified effective Strategies:  
-**Chart Review**  
-Review notes with trainee  
Compare amended note to initial note  
Provide feedback on the trainee's notes and ability to edit the trainee's note  
-Review imaging with the team/trainee  
Create a shared list of interesting cases for the team  
-Faculty model to trainees on how to use the electronic health record (EHR)  
-**Templates**  
Use of common templates  
Use templates as teaching tools (for billing)  
Leverage the templates, order sets, and smart phrases  
**Ineffective Strategies** (examples):  
- Relying on the EHR instead of direct verbal communication  
- Using templates for procedure notes vs. direct to step-by-step description  
- Classroom instruction on use of the EHR not as effective as real/direct learning  
**Templates**  
| COMU | - The study used an abbreviated Delphi design (2 rounds not 3 rounds)  
- Participants only used EPIC EHR systems, may result in reduced generalizability. |
| 4  | Aylor, Megan; Campbell, Emily M.; Winter, Christiane; Phillipi, Carrie A. 2017. | **Ti**: Resident Notes in an Electronic Health Record: A Mixed-Methods Study Using a Standardized Intervention With Qualitative Analysis | Pediatric Residents | Mixed Methods (Quantitative/ qualitative data before/after) | - Shorter note length with new templates.  
-Survey response: 89% liked the new note templates, 78% indicated new templates facilitated note completion. | WF, DOC | - 34% more notes were available for analysis in the post-intervention year than the pre-intervention year. This most likely reflects an increase in the patient census |
<table>
<thead>
<tr>
<th>ID</th>
<th>Title</th>
<th>Authors</th>
<th>Aims</th>
<th>Methods</th>
<th>Results</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>The Electronic Health Record Objective Structured Clinical Examination (OSCE): Assessing Student Competency in Patient Interactions While Using the Electronic Health Record.</td>
<td>Undergraduate medical students</td>
<td>Data collected from two institutions. The OSCE scores showed students performed well in EHR-related communication tasks, but they had EHR skill deficiencies in the areas of EHR data management. For example, students had difficulty navigating the EHR, assessing patient progress notes, and identifying the best patient interactions.</td>
<td>-The resident focus group revealed ambivalence toward the EHR's contribution to note writing.</td>
<td>on the hospitalist service and increase in number of notes written without a change in resident coverage. Residents started and filed their notes earlier in the day prior to the intervention, but a few notes were filed after the hospital shift ended.</td>
<td>observational study, RCT would provide more robust data.</td>
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<tr>
<td>6</td>
<td>In the Wake of the 2003 and 2011 Duty Hours Regulations, How Do Internal Medicine Interns Spend Their Time?</td>
<td>Internal medicine interns (PGY1)</td>
<td>Interns directly observed for 873 hours in 2 sites. Computer use occupied 40% of interns' time. They spent 12% of their time in direct patient care, 64% in indirect patient care, 15% in educational activities, and 9% in miscellaneous activities. No significant difference in time between two sites.</td>
<td>-Lack of evidence based EHR standards to use as an assessment tool.</td>
<td>observational study, RCT would provide more robust data.</td>
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<tr>
<td>7</td>
<td>On the usage of health records for the design of virtual patients (VPs): a systematic review.</td>
<td>Mix: Undergraduates students and postgraduate residents</td>
<td>They reviewed 28 full text articles. Although VPs based on real patient data are widespread, use of unformatted EHR data is not. Many VPs examples use radiology based data (CT/MRI) vs. other data (patient reports, labs, etc.). Case studies exist for teaching/learning, consultancy and assessment. Creating VPs can be costly in terms of time and money.</td>
<td>-single centre study. Small sample size (72 overall, of which only 24 residents)</td>
<td>-limited to internal medicine residents only (19 PGY1's in a single hospital)</td>
<td>limited to internal medicine residents only (19 PGY1's in a single hospital)</td>
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<td>8</td>
<td>Faculty, Resident, and Clinic Staff's Evaluation of the Effects of EHR Implementation.</td>
<td>Mix: Postgraduate residents and independent physicians and non clinical staff</td>
<td>Survey: 8 then 12 after implementation</td>
<td>-Overall negative perception related to EHR implementation amongst residents and physicians. Physicians and residents were very dissatisfied with time required for EHR documentation. Other studied domains also scored very low and did not change within studied time.</td>
<td>single centre study. Longer study time may be required to better evaluate for significant changes related to EHR use.</td>
<td>observational study, RCT would provide more robust data.</td>
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<tr>
<td>ID</td>
<td>Author(s)</td>
<td>Title</td>
<td>Aims</td>
<td>Authors</td>
<td>Conclusion</td>
<td>WF</td>
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<tr>
<td>9</td>
<td>Brisson G, Neely K, Tyler P. D, Bamard C</td>
<td>Should Medical Students Track Former Patients in the Electronic Health Record? An Emerging Ethical Conflict.</td>
<td>To explore if medical Students should track former patients via EHRs.</td>
<td>Authors provide arguments for both sides and debate the potential ethical conflicts, especially related to patient privacy. They argue that tracking improves training and so benefits society (distributive justice).</td>
<td>Students should be permitted to track patients for educational purposes, but with patient permission and with well defined limits to safeguard patient autonomy and defined educational purpose.</td>
<td>WF</td>
</tr>
<tr>
<td>10</td>
<td>Campbell, Joyce K; Ortiz, Michael V.; Otrolni, Mary C.; Birch, Sarah; Agarwal, Dewesh</td>
<td>Personal Digital Assistant-Based Self-Work Sampling Study of Pediatric Interns Quantifies Workday and Educational Value.</td>
<td>To investigate how interns utilize their time on inpatient rotations &amp; perceived educational value of workday activities.</td>
<td>Time spent using EHRs took up 33% of intern time. Other activities: communicating with the health care team 23%, educational activities 17%, and time with patients and families 12%. Time with patients and families was perceived to be the most educational part of clinical service. Time used for EHR was perceived as least educational (3.4 hrs/day). Writing discharge summaries (41 mins/day). Other: Interns perceived clinical service as excellent or good 37% of the time, while planned educational activities were perceived as excellent or good 81% of the time.</td>
<td></td>
<td>WF</td>
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<tr>
<td>11</td>
<td>Chen, Lu; Guo, U.; Blipparambol, Lijo C.; Netertors, Matt D.; Sheshadri, Bhairavi; Kara, Eric; Peterson, Stephen J.; Mehta, Parag H</td>
<td>Racing Against the Clock: Internal Medicine Residents’ Time Spent On Electronic Health Records Quantifies Workday and Educational Value.</td>
<td>To quantify the time actually spent using the EHR by first-year internal medicine residents in a single program</td>
<td>Within this group, Interns spent substantial time actively using the EHR. Each intern spent average 112 hours / month over 206 EHR encounters. Interns spent more time in July compared to January (41 minutes versus 30 minutes per EHR encounter, P , .001). Equates to average 7 hours/day in July, 5 hours/day in January. Redacel time in January may reflect greater experience with the EHR, growing EHR efficiencies.</td>
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<td>WF</td>
</tr>
<tr>
<td>12</td>
<td>Chi, Jeffrey; Kugler, John; Chu, Isabella M.; Lofts, Pooja D.; Evans, Kambrta H; Osokrsky, Tomiloy; Basavith, Preetha; Braddock, Clarence H</td>
<td>Medical Students and the Electronic Health Record: ‘An Epic Use of Time’.</td>
<td>To quantify amount of medical student time spent on EHR use and to examine potential benefits of student EHR use on education outcomes.</td>
<td>Medical students are exposed to large amounts of screen time during clerkship years. EHR usage does not correlate with performance as based on formal examination scores and student evaluations. EHR screen time differs according to specialty, with internal medicine rotations having the highest screen time (.619 -IM)</td>
<td></td>
<td>WF</td>
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<tr>
<td>ID</td>
<td>Author(s)</td>
<td>Title</td>
<td>Methods</td>
<td>Results</td>
<td>Implications</td>
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<tr>
<td>13</td>
<td>Crampton, Noah H.; Reis, Shmuel; Shachak, Aviv</td>
<td>Ti: Computers in the clinical encounter: a scoping review and thematic analysis</td>
<td>Mix: PG Residents/practicing physicians Systematic synthesis (scoping review)</td>
<td>Broad results that HIT (EHRs) impact patient/physician in multiple and complex ways (eye contact/gaze, information sharing, building relationships, and conversation). Perceptions of this impact depends on multiple factors including physical setting, clinician style (e.g. typing methods, screen gaze, screen sharing habits etc.). Evidence shows that interactions can be positive if right approach is utilized giving opportunities for optimizing educational interventions to improve HIT related communication skills.</td>
<td>Quality of included studies not assessed, but methodology is not suited for quality assessment in any case. Studies included only assessed direct face-to-face encounters and did not look at other more modern HIT options such as rich media, video encounters and electronic communication.</td>
<td></td>
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<tr>
<td>14</td>
<td>Dean, Shanton M.; Eickhoff, Jens C.; Bakel, Leigh Anne</td>
<td>Ti: The Effectiveness of a Bundled Intervention to Improve Resident Progress Notes in an Electronic Health Record (EPIC EHR).</td>
<td>Pediatric PG Residents Before and After Study (retrospective pre/post intervention)</td>
<td>Intervention lead to significant impact on reducing vital sign clutter (4% pre-intervention vs. 84% post-intervention, ( p &lt; 0.0001 ) and other visual clutter within the note (0% pre-intervention vs. 28% post-intervention, ( p = 0.0035 )). No significant impact on the reduction of input/output or lab clutter. No significant difference observed in the inclusion of the medication list. No significant improvements related to copy-paste phenomenon.</td>
<td>Small sample size Did not evaluate same group of interns for pre/post intervention, which may affect result. Short study period, thus improvements over longer period not assessed. Audit instrument requires expertise to help evaluate the notes More work is required re. the intervention to improve inappropriate copy/paste &amp; to improve note clinical narrative.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Deaño, Roderick Corro; DeKosky, Allison; Appasimauri, Anoop; Doll, Jacob; Georgitis, Emily; Potts, Steven; Arora, Vineet</td>
<td>Ti: Resident Time Spent in Clinical and Educational Activities at Home: Implications for Duty Hours</td>
<td>IM PG Residents Survey</td>
<td>EHRs have allowed residents to take their work home. 93% of residents checked lab work from home at least once, with 45% doing so frequently, 2/3 of whom doing this after a call day. 70% of residents order lab studies from home, 37% do so after a call day.</td>
<td>Sample size. Self reported data may limit accuracy</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Duke, Pamela; Frankel, Richard M.; Reis, Shmuel</td>
<td>Ti: How to Integrate the Electronic Health Record and Patient-Centered Communication Into the Medical Visit: A Skills-Based Approach</td>
<td>Mix: PG/UG and PG directors/teachers Narrative Review</td>
<td>- Review of literature pertaining to patient centred and relationship care as well as examination room computing and communication research which guided/informed their detailed 7-step model for EHR communication teaching.</td>
<td>Non-systematic synthesis. Some of the evidence they used is based on expert opinion, not on higher quality evidence.</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Ellaway, Rachel H.; Graves, Lisa; Greene, Peter S.</td>
<td>Ti: Medical education in an electronic health record- mediated world.</td>
<td>Mix: UG/PG Narrative, thematic review</td>
<td>Discussed how HIT/EHR’s impact following themes: learners &amp; teachers; educational environment; responsiveness of HIT systems, policy/leadership and research. Main findings: Literature outlines many challenges, with no evidence of viable connections between EHRs and education yet with deficiencies outlined in all the above mentioned themes.</td>
<td>Non-systematic synthesis.</td>
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<tr>
<td>ID</td>
<td>Author(s)</td>
<td>Title</td>
<td>Brief Description</td>
<td>Aims</td>
<td>Qualitative (think-a-load protocol)</td>
<td>Controls</td>
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<td>18</td>
<td>Fallar, Laura; Yan, Donglin; Conigliaro, Rosemarie, 2016.</td>
<td>Taking Note of the Perceived Value and Impact of Medical Student Chart Documentation on Education and Patient Care.</td>
<td>To study the impact of medical student chart documentation on education and patient care.</td>
<td>To assess the extent of restrictions to medical student documentation and their impact on medical student education as well as patient care.</td>
<td>Most 90% believe student notes belong in medical records. Only 42% had a policy to support thin. 93% believed without student notes, student education would be negatively affected, (56%) indicated patient care would be negatively affected. Most (&gt;90%) believe limiting students' notes would negatively affect other issues (e.g. team bonding, internship preparation etc.). 52% reported that fourth-year students could place notes in paper charts at “all” affiliated hospital. Among 57 responses about the EMR, significantly fewer reported that “all” (33%) or “most” (21%) affiliated hospitals allowed student notes in the EMR. Reasons inc. concern about billing, co-signing, note quality/safety and liability.</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Farr O, Pieckiewicz D, Rahman A, Adam T, Pakhomov S, Melton G, 2012</td>
<td>Document Synthesis by Clinicians: The goal is to understand medical intern's cognitive processes and barriers when they synthesize patient clinical documents in an EHR system with the aim of accomplishing routine clinical tasks.</td>
<td>To determine extent of restrictions to medical student documentation and individual feedback. Out of 40 scored notes, educational quality improvement project did not improve the quality of clinical documentation as measured by PDQ-9.</td>
<td>To assess impact of training on synthesis of documentation.</td>
<td>Analysis concluded that correlated with implications of patient documentation sections, 2) highlighting status changes, 3) Glossary to explain specialized terms. Other: Cognitive load theory applied to documentation, poor organization=difficulty obtaining data, which leads to poor motivation which could lead to increased chances of inaccurate clinical judgment.</td>
<td></td>
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<tr>
<td>20</td>
<td>Fogarty, Colleen T; Winter, Paul; Farah, Subrina, 2016.</td>
<td>Improving patient-centered communication while using an electronic health record: Report from a curriculum evaluation.</td>
<td>To assess the impact of training workshop pertaining to EHR related “patient-physician” clinical communication skills (via 11 self-reported behaviors).</td>
<td>Mix (PG/Independent Physicians). Nurses also included. Before and after study.</td>
<td>Post-intervention survey, showed 2 statistically significant changes in the 11 self-reported behaviors: improvement in telling patients about EHR screen use, and a reduction in study participant introduction to patients.</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Friedman, Erica; Saini, Michelle; Fallar, Robert, 2010.</td>
<td>Ti: A Qualitative Analysis of EHR Clinical Document Synthesis by Physicians.</td>
<td>The goal is to understand medical intern’s cognitive processes and barriers when they synthesize patient clinical documents in an EHR system with the aim of accomplishing routine clinical tasks.</td>
<td>Internal Medicine (Interns)</td>
<td>Analysis concluded that correlated with implications of patient documentation sections, 2) highlighting status changes, 3) Glossary to explain specialized terms. Other: Cognitive load theory applied to documentation, poor organization=difficulty obtaining data, which leads to poor motivation which could lead to increased chances of inaccurate clinical judgment.</td>
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</table>

**Notes:**
- **DOC:** Document
- **COMU:** Concern about respondents may not be actual deans but someone else delegated to respond.
- **WF:** Workforce
- **Self reporting.** 28 % post intervention survey response (risk of type-2 error/false negative). Limited sample size with no subgroup analysis.
- **Short timeline for study.** Small sample size, thus no adjustment for resident seniority.
- **No note template specification was made.** Note feedback providers not trained.
- **Only interns studied, thus more mature physicians may exhibit different thought processes.** One EHR vendor trialed. Thus their interface may affect results differently to other vendor interfaces. Single Centre study.
<table>
<thead>
<tr>
<th>#</th>
<th>Title</th>
<th>Authors</th>
<th>Methods</th>
<th>Findings/Results</th>
<th>Implications/Conclusions</th>
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<tr>
<td>22</td>
<td>Resident Duty Hours in the Outpatient Electronic Health Record Era: Inaccuracies and Implications</td>
<td>Fischer, Jonathan; Fischer, Shira H.; Katherine; Christner, Jennifer G.; Hammoud, Maya M.; Imran I.; Briscoe, Gregory W.; Margo, Katherine; Ali, Stewart, Robyn A.; Fisher, Carol; Katz, Alan</td>
<td>Internal medicine Residents Observatio nal Cohort</td>
<td>Resident EHR use estimates not accurate. Residents reported 3.03 hours/week EHR after-hours usage vs. actual recorded usage, found to be at mean of 1.20 hours/week. There was no association between after-hours EHR use and resident burnout.</td>
<td>Small sample size, Single Centre Log in/out EHR data, may not reflect what residents were actually doing at the time they were logged on. EHR burnout survey internally created and not validated.</td>
</tr>
<tr>
<td>23</td>
<td>New conceptual model of EMR implementation in interprofessional academic family medicine clinics.</td>
<td>Halas, Gayle; Singer, Alexander; Styles, Carol; Katz, Alan.</td>
<td>Mix: Family medicine residents, faculty (and support staff) Qualitative</td>
<td>Findings informed conceptual model which consists of the 1) EHR infrastructure (system design/EHR training), 2) Interface and usage (Work-flow, communication, information management, continuity). Participant feedback were outlined for each of these major domains.</td>
<td>Data collected from single training program (although distributed amongst 3 sites). Study did not look at affect of passage of time after implementation.</td>
</tr>
<tr>
<td>24</td>
<td>Medical Student Documentation in Electronic Health Records: A Collaborative Statement From the Alliance for Clinical Education.</td>
<td>Hammond, Maya M.; Dalrymple, John L.; Christner, Jennifer G.; Stewart, Robyn A.; Fisher, Jonathan; Margo, Katherine; Ali, Imam I., Briscoe, Gregory W.; Pangaro, Louis N.</td>
<td>PG deans/teachers. Undergraduate Medical Student (target population but not directly studied). Statement/ proposal</td>
<td>ACE recommends medical schools develop clear set of competencies related to student documentation in the EHR which students must achieve prior to graduation. Summary of recommendations: (a) Students must document in patients chart &amp; their notes should be reviewed for content and format, (b) students must have chance to practice EHR order entry prior to graduation, (c) students should be exposed to decision aids that accompany EHRs, (d) schools must develop set of student competencies related to EHR charting and an accompanying assessment plan.</td>
<td>- Opinion/proposal, some of statements need to be further studied and proven by research.</td>
</tr>
<tr>
<td>25</td>
<td>Opportunities and Challenges in Integrating Electronic Health Records Into Undergraduate Medical Education: A National Survey of Clerkship Directors.</td>
<td>Hammond, Maya M.; Margo, Katherine; Christner, Jennifer G.; Fisher, Jonathan; Fischer, Shira H.; Pangaro, Louis N.</td>
<td>Clerkship directors (undergraduate medical education) Survey (quantitativ e and qualitative responses collected)</td>
<td>64% of programs currently allow student use of EHRs, of this two thirds allowed students to write notes within EHRs. Overall, clerkship directors' opinions on the effects of EHRs on medical student education were neutral, they acknowledging advantages of EHRs, but also many concerns regarding their use in education (copy/paste problem, time utilization of EHRs, communication, lack of student EHR privileges). Another reported challenge is that more than 80 different EHR systems were reported as used by various institutions, but 4 software programs represented ~50% of total systems in use.</td>
<td>DOC, WF, COMU, TRN/SIMM, KNO - Self report data, which may or may not reflect actual student usage patterns etc.</td>
</tr>
<tr>
<td>26</td>
<td>Factors in Medical Student Beliefs about Electronic Health Record Use.</td>
<td>Hart, Christopher A; Gruber, Laura A; Dewar, Marvin A.</td>
<td>UG Medical students. Cross-Sectional study (via survey)</td>
<td>Males reported a higher average, ease-of-use scores vs. women's. Computer self-efficacy related to higher expectations of EHR ease of use and usefulness. EHR ease of use and usefulness were also associated with.</td>
<td>TRN/SIMM Single Centre study Cross sectional design (risk of confounding) Study done at time of initial EHR training, thus may not reflect real-life EHR usage.</td>
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<td>ID</td>
<td>Authors</td>
<td>Title</td>
<td>Methods</td>
<td>Results</td>
<td>Risk of bias</td>
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<td>27</td>
<td>Heimann, Heather L; Rastinski, Sonya; Bierman, Jennifer A; Evans, Daniel B; Kinner, Kathryn G; Stamos, Julie; Martinovich, Zoran; McGaghie, William C, 2014.</td>
<td>Medical Students’ Observations, Practices, and Attitudes Regarding Electronic Health Record Documentation</td>
<td>UG Medical Students.</td>
<td>80% report at least sometimes seeing residents copying data from other providers’ notes and 60% reported observing attending physicians doing this. Most students (95%) reported copying from their own previous notes, and 22% reported copying from residents. Only 10% indicated that copying from other providers is acceptable, whereas 83% believe copying from their own notes is acceptable. Most students use templates and auto-inserted data.</td>
<td>Single Centre study, Cross-sectional Survey (can’t study cause/effect). Self reported, data not confirmed by more objective methods.</td>
</tr>
<tr>
<td>28</td>
<td>Henning, Daniel; Horng, Steven; Sanchez, Leon, 2013</td>
<td>Evaluating how electronic charting affects resident productivity.</td>
<td>1st year emergency medicine residents. Before and after study</td>
<td>Both uni-variate and multivariate analysis did not show that the EMR affected resident productivity.</td>
<td>Single Centre study Limited to PGY1’s only</td>
</tr>
<tr>
<td>29</td>
<td>Hersh, William R; Gorman, Paul; Biagioli, Frances; Mohan, Vishnu; Gold, Jeffrey; Mejicano, George, 2014.</td>
<td>Beyond information retrieval and electronic health record use: competencies in clinical informatics for medical education</td>
<td>Undergraduate (i.e., informatics specialists)</td>
<td>Qualitative</td>
<td>Expert opinion, not higher level evidence.</td>
</tr>
<tr>
<td>30</td>
<td>Huer, Daniel B; Rothschild, Adam; LeMaistre, Anne; Keeler, Joy, 2004.</td>
<td>Differing Faculty and House staff Acceptance of an Electronic Health Record One-Year After Implementation.</td>
<td>Mix PG residents/Faculty/teachers.</td>
<td>Survey</td>
<td>Qualitative</td>
</tr>
<tr>
<td>32</td>
<td>Lanier, Cédric; Dominique Dao, Melissa; Hudleston, Patricia; Cerutti, Bernard; Junod Perron, Noëlle, 2017.</td>
<td>Learning to use EHRs: can we stay patient-centered? A pre-post intervention study with family medicine residents.</td>
<td>PG Residents (family medicine)</td>
<td>Before and After Study</td>
<td>No control group. Comparisons to no training, means improvement can happen regardless. Residents being observed could lead to Hawthorne effect.</td>
</tr>
</tbody>
</table>
33 Litofsky, N. Scott; Fanoosi, Ali; Tanaka, Tomoko; Norregaard, Thor, 2014.

**Title**: Use of the Electronic Health Record to Track Continuity of Care in Neurological Surgery Residency.

**Aims**: Use EHRs to track continuity of care in a neurological surgery program and to assess changes in rotation requirements.

**Methods**: Postgraduate Residents (Neurosurgery)

**Design**: Cross-sectional

**Findings**: The EHR can be used to track resident continuity of care in neurological surgery. The primary operating resident saw the patient in non-operative settings, such as general admission, clinic visitation, or consultation in 26.0% of cases.

**Conclusion**: ASMT Single centre Small resident population

34 Lobasso, Alisa Alfonsi; Lamberton, Courtney E.; Sammon, Mary; Berg, Katherine T.; Garuo, John W.; Cass, Jonathan; Hojat, Mohammadreza, T.; Caruso, John W.; Cass, Sammon, Mary; Berg, Katherine T.; Garuo, John W.; Cass, Jonathan; Hojat, Mohammadreza, T.; Caruso, John W., 2014.

**Title**: Enhancing Student Empathetic Engagement, History-Taking, and Communication Skills During Electronic Medical Record Use in Patient Care.

**Aims**: To examine whether an intervention on proper use of electronic medical records (EMRs) in patient care could help improve medical students’ empathic engagement, and to test the hypothesis that the training would reduce communication hurdles in clinical encounters.

**Methods**: Undergraduate medical students

**Design**: RCT

**Findings**: Faculty mean ratings on the DPPEP (Perceptions of Physician Empathy), history-taking skills, and communication skills were significantly higher for the intervention group than the control group. SP mean ratings on history taking skills were significantly higher for the intervention group than the control group. Both groups’ JSE mean scores increased pre-test to post-test, but the changes were not significant.

**Conclusion**: COMU Single Centre


**Title**: Use of simulation to assess electronic health record safety in the intensive care unit: a pilot study

**Aims**: To test efficacy and safety of the EHR-user interface within the intensive care unit (ICU) environment, using high-fidelity simulation training.

**Methods**: Postgraduate residents (ICU)

**Design**: Observational cohort

**Findings**: Simulated EHR case with medical errors: ICU residents, blinded to these. Residents given 10 minutes to review and present case to attending. Participants include interns (I), residents (R) and fellows (F). Mean error recognition rate= 41% (6–73%), increased slightly with training (55% I, 41% R and 50% F). Over-sedation was least recognized error (16%); poor glycemic control was most often recognized (68%). Only 32% of the participants recognized inappropriate antibiotic dosing, thus despite comprehensive EHRs, there remain significant gaps in identifying dangerous medical management issues regardless of high levels of medical training, suggesting that EHR-specific training may be beneficial. Simulation can help identify these gaps as well as promote EHR-specific training.

**Conclusion**: TRN/SIMM, WF, KNO, DOC

36 March, Christopher A.; Scholl, Gretchen; Deversdal, Renee K.; Richards, Matthew; Wilson, Leah M.; Mohan, Vishnu; Gold, Jeffrey A, 2016.

**Title**: Use of Electronic Health Record Simulation to Understand the Accuracy of Intern Progress Notes.

**Aims**: To develop a high-fidelity EHR training exercise for internal medicine interns to understand patterns of EHR utilization in the generation of daily progress notes.

**Methods**: Postgraduate residents

**Design**: Observational cohort

**Findings**: Three-quarters of notes contained either copy-paste elements or the elimination of active medical problems from the prior day’s notes. The study showed a significant number of quality related issues, including failure to recognize absence of deep vein thrombosis prophylaxis, medications that were stopped on admission, and issues in a prior discharge summary. The study outlines the inadequacies of EHR specific skillsets in the early part of internship, which may point towards the lack of training or access during residents medical school and may suggest

**Conclusion**: TRN/SIMM, DOC

Only interns sampled. Simulation did not include real or simulated patient component which could add to fidelity of exercise No information regarding intern experience prior to this exercise.
<table>
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<tr>
<th>Ref</th>
<th>Authors</th>
<th>Title</th>
<th>Method</th>
<th>Findings Related to EHR Implementation/Usability</th>
<th>Recommendations/Implications</th>
</tr>
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<tr>
<td>37</td>
<td>McKeeney, Ann Scheck; Robbins, Julie; Kowalczyk, Nina; Claisen, Deena J.; Song, Paula H.</td>
<td>Ti: The Role of Cognitive and Learning Theories in Supporting Successful EHR System Implementation Training: A Qualitative Study.</td>
<td>Mix: PG residents (12), attending doctors (22), other clinicians (7) and other stakeholders/non-clinical, administrative and IT personal (36). A qualitative approach was used to interview physicians (including 12 residents), and various other stakeholder. A theory driven conceptual framework was applied to analyze the interview content. Using the lenses of social cognitive and adult learning theories, 5 propositions were developed and these were used to explore themes related to EHR implementation training using qualitative data collected through 43 key informant interviews and 6 physician focus groups. The results showed found consistent evidence that training practices across the six selected organizations known for exemplary implementations were consistent with the findings of these theoretical frameworks. From this, the authors suggested 7 training components that could help in EHR implementation: 1) Obtain organizational commitment to invest in training, 2) Assess users’ skills and training needs, 3) Select appropriate training staff, 4) Match training to users’ needs, 5) Use multiple training approaches, 6) Provide training support throughout implementation, 7) Retrain and optimize. The authors also suggest that effective training programs must move beyond technical approaches and incorporate social and cultural factors to make a difference in implementation success.</td>
<td>TRN/SIMM Risk of recall bias from interviewees. Only studied centre’s known to have successfully implemented EHRs, thus insights may not be generalizable.</td>
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<tr>
<td>38</td>
<td>Milano, Christina E.; Hardman, Joseph A.; Plessiu, Adeline; Rdeinski, Rebecca E.; Biagioli, Frances F.</td>
<td>Ti: Simulated Electronic Health Record (Sim-EHR) Curriculum: Teaching EHR Skills and Use of the EHR for Disease Management and Prevention</td>
<td>Mix: UG medical students and IM interns. Faculty also provided feedback. Proposal/Sim-EHR described. Post curriculum trial survey’s done and feedback obtained from students, interns and faculty. Survey: For students (51%/~33 students) and almost all interns (92%) rated EHR sim activity as “effective” or “very effective”. Remaining ~49% of students were evenly split between “neutral” and “ineffective.”</td>
<td>KNO, WF, TRN/SIMM Limited number of students and interns, in a single centre. Single centre</td>
<td></td>
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<tr>
<td>39</td>
<td>Mintz M, Narvarte HJ, O'Brien KE, Papp KK, Thomas M, Dunning SJ.</td>
<td>Ti: Use of Electronic Medical Records by Physicians and Students in Academic Internal Medicine Settings</td>
<td>Clerkship Directors in Internal Medicine institutional members at U.S. and Canadian academic health centers. Survey In ambulatory setting, only 44% of schools had policies regarding medical student documentation of progress notes in the EMR during the ambulatory internal medicine (IM) clerkship. Schools were dichotomously split; 48% required and 52% prohibited allowing students to document in the EMR. The programs</td>
<td>DOC, TRN/SIMM Only IM directors surveyed - Self reported data and opinions, not actual practice reporting/evidence, which may differ. - Absence of student opinion</td>
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<td>40</td>
<td>Mohan, Vinhne, Woodcock, Deborah; McGrath, Karess; Scholl, Gretchen; Pranat, Robert; Doberte, Julie W.; Chase, Dian A.; Gold, Jeffrey A.; Ash, Joan S.</td>
<td>Ti: Using Simulations to Improve Electronic Health Record Use, Clinician Training and Patient Safety Recommendations From A Consensus Conference.</td>
<td>Extended population: Mix (UG/PG) education. Study group: Informatics Qualitative Recommendations generated according to these themes: (1) Safety, (2) Education and Training, (3) People and Organizations, (4) Usability and Design, and (5) Sociotechnical Aspects. Recommendations: -Simulations should be utilized to design</td>
<td>WF, TRN/SIMM Findings based on opinions - No involvements of learners/students, all qualified informatics experts or physicians</td>
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<td>ID</td>
<td>First Author</td>
<td>Year</td>
<td>Title</td>
<td>Study Design</td>
<td>Sample Size</td>
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<td>41</td>
<td>Mohan V. Scholl G, Gold JA.</td>
<td>2017</td>
<td>Use of EHR-based simulation to diagnose aetiology of information gathering issues in struggling learners: a proof of concept study.</td>
<td>Mixed</td>
<td>Postgraduate Residents (IM, Neurology)</td>
</tr>
<tr>
<td>42</td>
<td>Morrow, Jay B; Dobbie, Alison E; Jenkins, Celia; Long, Rosita; Mihalic, Angela; Wagner, James.</td>
<td>2009</td>
<td>First-year Medical Students Can Demonstrate EHR-specific Communication Skills: A Control-group Study.</td>
<td>RCT</td>
<td>1st year Medical Students</td>
</tr>
<tr>
<td>43</td>
<td>Neri, P.M.; Redden, L.; Poole, S.; Poumer, C.N.; Horisky, J.; Raja, A.S.; Poon, E.; Schiff, G.; Landman, A.</td>
<td>2015</td>
<td>Emergency Medicine Resident Physicians’ Perceptions of Electronic Documentation and Workflow.</td>
<td>Mixed methods (Task analysis and Qualitative)</td>
<td>ED PG residents</td>
</tr>
<tr>
<td>44</td>
<td>Nuovo, Jim; Hutchinson, David; Bahnbach, Thomas; Keenan, Craig.</td>
<td>2013</td>
<td>Establishing Electronic Health Record Competency Testing for First-Year Residents.</td>
<td>Ambulatory workflow skills: 70%–100% were competent. Three skills which interns needed the most assistance were: 1) Generating and routing a result note (25%), 2) deleting or changing a medication dose (reconciling)</td>
<td>1st-year residents (IM, pediatrics, surgery, family medicine, psychiatry)</td>
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</table>
designed EHR training. community medicine) medications) (15%), (5) locating results for past 90 days (15%). For inpatient workflow skills: 63%–100% showed competence. Three skills in which interns required most help were (1) creating a referral order at discharge (34%), (2) finding patient temperature on a flow sheet and accessing trending data (21%), and (3) generating a discharge summary, getting it reviewed, and then forwarding it to patient’s primary care doctor (21%).


**Ti:** Take Note(s): Differential EHR Satisfaction with Two Implementations under One Roof

**Aims:** To compare EHR user satisfaction between pediatrics residents and internal medicine residents in an academic practice.

**Pediatric and internal medicine residents**

**Survey**

Although satisfaction with the EHR implementation was high for both groups, internal medicine residents were significantly less likely to be satisfied with the EHR implementation, less likely to believe that their colleagues were satisfied with it and less likely to believe that templates can improve efficiency. They were also more likely to believe the system was designed to improve billing.

**COMU, WF, DOC**

IM residents had experience with previous EHR which could have influenced their preference. Population studied (pediatric and IM residents), thus results may not be applicable to independent practicing physicians or different specialties. At the time of the study, the population was young and likely grew up using computers which can influence results/outcomes. Nature of IM clinic/care in study setting could be less suited for template based notes, other IM settings (preventive care) could be more suited for template based notes, thus likely to receive more positive feedback.


**Ti:** Physicians’ attitudes towards copy and pasting in electronic note writing

**Aims:** Study aimed to: 1) find out physicians’ copy-paste function (CPF) use, 2) how residents and faculty perceive its impact on notes and patient care, 3) opinions on its future use.

**Mix: PG residents and faculty (IM and pediatrics)**

**Survey**

315 physicians responded to the survey (response rate of 70%). 97% of residents were electronic note writers vs. 61% of faculty. 90% of electronic writers report using CPF in daily notes, 78% of whom are high CPF users, 78% of whom are high CPF users vs. faculty. CPF users frequently copied notes written by other doctors (81%) and notes written during past visits/admissions (72%). 47% percent of CPF users at Hospital B with the copy forward function and 69% at Hospital A copied either the entire note or part of the note, including the physical exam. Inconsistencies and outdated information frequently noted due to CPF (71%), even though, few physicians felt CPF had a negative impact on patient documentation (19%) or led to mistakes in patient care (24%). 80% of participants wanted to continue this function.

**DOC**

Self reported data can be subject to bias. Both sites had similar computer systems which could affect generalizability to other settings, however the CPF were significantly different between the two sites.

47 Ouyang, David; Chen, Jonathan H.; Hom, Jason; Chi, Jeffrey, 2016.

**Ti:** Internal Medicine Resident Computer Usage: An Electronic Audit of an Inpatient Service.

**Aims:** to describe how internal medicine IM PG residents

**Observational Cohort**

House staff worked a median of 69 hours each week. A total working time of 4.2 hours/day (50%) was spent using the EHR. Medical chart review accounted for most.

**WF**

Study limited to a single specialty Single centre study
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<th>Ti:</th>
<th>Survey/Design</th>
<th>Aims</th>
<th>Total Population</th>
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<tr>
<td>48</td>
<td>Oxentenko AS, West CP, Popkave C, Weinberger SE, Kolars JC, 2010.</td>
<td>Time Spent on Clinical Documentation: A Survey of Internal Medicine Residents and Program Directors.</td>
<td>To understand internal medicine residents perspectives regarding time devoted to documentation and direct patient care, and perceived frequency and importance of feedback on patient-related documentation.</td>
<td>Total of 16402 trainees (85.9% response rate) and 235 PDs (61.7%).</td>
<td>Majority of residents (56.5%) and program directors (63.0%) believed feedback on documentation happens less than 50% of time. PDs were more likely than residents to view feedback on documentation as highly important (73.2% vs 58.6%; P &lt; .001).</td>
</tr>
<tr>
<td>49</td>
<td>Prazeres, Filipe, 2014.</td>
<td>How do GPs versus GP trainees adapt to electronic health records? A Portuguese pilot study.</td>
<td>To compare general practitioners (GPs) and general practice trainees (GPTs) on how they adapted to the EHR and how they perceive its impact on medical consultations.</td>
<td>Both GPs and trainees expressed overall satisfaction with their EHR systems (80.4% and 75% satisfaction rates for GPT's and GP's respectively).</td>
<td>Single centre study with limited sample size (147 physicians). Single specialty (general practice), may not be generalizable to other settings. Self reported data may not reflect real life objective data.</td>
</tr>
<tr>
<td>50</td>
<td>Rajkomar, Alvin; Ranji, Sumant R.; Sharpe, Bradley, 2017.</td>
<td>Using the Electronic Health Record to Identify Educational Gaps for Internal Medicine Interns.</td>
<td>To quantify/evaluate intern residents clinical experience with common presentations via EHR clinical documentation.</td>
<td>Over study period (2 years), 53066 clinical notes were analyzed, covering 10 022 hospitalizations with 1436 different International Classification of Diseases 9 (ICD-9) diagnoses spanning 217 Clinical Classifications Software (CCS) diagnostic categories. The 10 most common ICD-9 diagnoses accounted for 23% of diagnosis-days, while the 10 most common CCS groupings accounted for more than 40% of the diagnosis-days. 88% of PGY1's spent at least 2 months on the IM service, only 3% were exposed to all of the top 10 ICD-9 diagnoses, and 31% had experience with fewer than 5 of the top 10 diagnoses. In addition, 17% of PGY-1s saw all top 10 CCS diagnoses, and 5% had exposure to fewer than 5 CCS diagnoses. Each PGY-1 saw a median of 38 different diagnostic categories.</td>
<td>Only billing/coding information was used to determine diagnosis which may exclude other secondary diagnoses. Residents experience could be missed: residents can obtain experience but not write a note, thus risk of underestimating resident overall experience.</td>
</tr>
<tr>
<td>51</td>
<td>Reddy, Siddharta G.; Babbott, Stewart F.; Beasley, Brent W.;</td>
<td>Prevalence and Functionality of Electronic Health Records in Internal Medicine.</td>
<td>Resident ambulatory clinics (teaching/academic programs) seem to have</td>
<td></td>
<td>Relied on program directors to provide clinic directors information, thus risk of</td>
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<td>Author(s)</td>
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<td>Dobbi D. Alison</td>
<td>Medicine Continuity Clinics</td>
<td>Aims: To determine the current roles and functions that health information technology (HIT)/EHRs in ambulatory clinic settings of internal medicine (IM) residents.</td>
<td>greater adoption of HIT/EHRs when compared to practicing physicians’ ambulatory offices. 221 directors (62%) completed the survey, representing ~50% of the accredited programs. According to these, in 56% of the clinics, residents had access to EHRs. Of these clinics, 67% of residents used electronic data systems (practice management), with 28% of them using to generate patient lists, with bigger programs more likely to have them then smaller ones (67% vs. 53%), electronic prescription writers, were also more likely in bigger programs (57% vs. 42%) and also EHRs (60% vs. 45%).</td>
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<td>Rouf, Emran; Chumley, Heidi; and Na; Schwartz, Mark D</td>
<td>The impact of residents' training in Electronic Medical Record (EMR) use on their competence: Report of a pragmatic trial.</td>
<td>Aims: To Compare two training programs for doctor–patient–computer communication.</td>
<td>The experiment group received simulation based training (SBT), while the control group received traditional lecture based training. No difference was found between the experiment and control groups, except for higher satisfaction in the SBT group.</td>
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<td>Rouf, Emran; Whittle, Jeff; Lu, Na; Schwartz, Mark D</td>
<td>Computers in the Exam Room: Differences in Physician–Patient Interaction May Be Due to Physician Experience.</td>
<td>Aims: To determine whether physician experience modifies the impact of exam room computers on the physician–patient interaction.</td>
<td>Patients reported that if seen by residents, computers reduced the amount of interpersonal engagement vs. faculty. They also agreed that computers adversely affected the amount of time doctors spent on the following: talking (34% vs. 15%), looking at them (45% vs. 24%), and examining (32% vs. 13%) and the visits are more likely to be less personal (20% vs. 5%). Only a few patients thought computers intruded with their relationship with their doctors (8% vs. 8%). Residents were more likely vs. faculty to report these adverse effects, but the difference was small.</td>
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<td>Roaf, Emran; Chumley, Heidi, and Dobbi D. Alison</td>
<td>Electronic health records in outpatient clinics: Perspectives of third year medical students</td>
<td>Aims: This study aims to report third year medical students' attitudes towards clinical learning using the EHR in ambulatory primary care setting (single centre/University of Kansas Medical Center, USA).</td>
<td>3rd year UG-Medical Students</td>
<td>Survey</td>
<td>Third-year medical students within this school had generally positive attitudes. Explored 6 themes: 1) Organization of information, 2) access to online resources, 3) prompts from the EHR, 4) personal performance (charting and presenting), 5) communication with patients and preceptors and 6) impact on student and patient follow-up. 1) Majority of students liked EHR’s ability to organize information: 70% of respondents felt that “essential information” easier to find via EHR. 2) 36% and 33% of students reported accessing online patient information and clinical guidelines more often when using the EHR vs. using paper charts. 3) Majority of students (72%) asked more “history”</td>
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<td>Nadkarni, Mohan M.; Gernter, Eric J.; Holmboe, Eric S</td>
<td>University of Kansas Medical Center, USA).</td>
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<td>non-response bias. Significant non-response rate, ~50% of programs did not respond. Residents not directly involved in providing information about their HIT/EHR usage.</td>
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| 53 | Schenarts, Paul J.; Schenarts, Kimberly D, 2012.  
**Title:** Educational Impact of the Electronic Medical Record.  
**Aims:** Objective of this review is to obtain more information about the impact of EMR on graduate medical education.  
**Methods:** UG medical students and PG residents  
**Systematic synthesis:** Total articles analyzed 47. Main themes discussed:  
1) Impact on Teacher–Learner Interactions.  
2) Impact of Excessive Data, Auto-filling, Prompts, and Copy and Paste on Clinical Reasoning.  
3) Impact on Resident Workflow.  
4) Impact on Medical Student Education.  
5) Impact on patient outcomes.  
The explored themes showed mixed results with the authors conclusion that, overall, the EMR has a negative effect on teacher and learner interactions, clinical reasoning, and mixed/ inconsistent impact on resident workflow. Data on impact of EMR on patient safety, quality of care, and medical finances are also mixed.  
**Conclusion:** COMU, KNO, MF, DOC  
Systemic review did not follow specific protocol/guidelines (e.g. Cochrane, PRISM guidelines etc).  
Inclusion/exclusion criteria not described in detail. |
**Title:** Can my electronic health record teach me something? A multi-institutional pilot study.  
**Aims:** To examine the utility of EHRs with integrated knowledge management system that provides case (patient) specific medical information for clinicians/trainees.  
**Methods:** Faculty and PG residents (Neurology and internal medicine). Observatio nal Cohort (with survey). Multicentre.  
**Results:** More than 80% of unique respondents agreed that there is a need for EHR tools to improve medical education and continuing medical education, as well as to inform clinical decision-making. The authors state that they findings suggest that information technology tools should be integrated, with protected time, into graduate and continuing medical education. 77% stating that it could change practice. For residents, only 23% would use this technology for examination/test preparation. For respondent preference for knowledge/education resources, the majority prefer access to clinical guidelines and peer reviewed research. For access preferences, 51% would prefer to access this resource in real time whilst seeing patients (residents). 47% of residents were concerned that too much information could be presented.  
**Conclusion:** KNO, DOC  
Survey tool not validated  
Low response rate (only 18% response from those initially emailed). |
| 57 | Sequist, Thomas D.; Singh, Surya; Pereira, Anne G.; Rusiniak, Donna; Pearson, Steven D, 2005.  
**Title:** Use of an Electronic Medical Record to Profile the Continuity Clinic Experiences of Primary Care Residents.  
**Aims:** To assess the outpatient educational variation (using EHR) among residents in a PG Residents (IM)  
**Observatio nal cohort:** For assessing program and trainee learner experience, extracting data from an EMR represents a feasible and practical method to help curricular development and adjustments and can help with ensuring residents get ASMT  
Only included the primary care component, were not able to capture other experiences. Study used diagnostic codes, thus some other clinical data could be missed. |
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<th>Authors</th>
<th>Title</th>
<th>Methods</th>
<th>Participants</th>
<th>Findings</th>
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<tr>
<td>Shachak, Sharon, Domb, Elizabeth, Borycki, Nancy, Fong, Alison, Skyrme, Andre; Koshitrui; Shmuel, Reis; Amitai, Ziv, 2015</td>
<td>Ti: A Pilot Study of Computer-Based Simulation Training for Enhancing Family Medicine Residents’ Competence in Computerized Settings.</td>
<td>Aims: Goal of study was to pilot test prototype computer-based simulation (e-Sim) to: 1) ascertain usability/design issues, 2) inspect impact on family medicine residents' self-reported competencies and attitudes related to using the EMR in medical consultation, 3) assess acceptability of simulation to family medicine residents.</td>
<td>Mixed Methods (Before and after testing + Qualitative – Think aloud observatories and free text comments).</td>
<td>After using the simulation pilot, mean scores for competencies and attitudes improved (14.88/20 to 15.63/20 (significant) and from 22.25/30 to 23.13/30, (non significant) respectively). Mean scores for perceived usefulness and ease of use of the simulation were good. Issues identified in usability testing: preferences for a more real-life &amp; interactive EMR simulation &amp; more options for shared decision making. Useful to use early on in the residency.</td>
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<td>Shachak, Aviv; Reis, Reis, Shmuel, 2009.</td>
<td>Ti: The Impact of Electronic Medical Records on Patient–Doctor Communication during Consultation: a Narrative Literature Review.</td>
<td>Aims: to review the literature on EMR effect on Patient-Doctor-Communication (PDC), especially to: 1) identify recurring themes, and to 2) offer preliminary guidelines and future directions for medical education and research.</td>
<td>Narrative Review (UG/PG)</td>
<td>14 articles included in final review. From review, mixed findings. EMR can often provide positive impact on information exchange, but also can exert negative influence on patient-doctor communication. Negative consequences can be mitigated by computer skill and behavioural style. Computer and communication training can improve patient/doctor interaction in context of EHR usage.</td>
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<td>Shriner, A.R.; Webber, L.C, 2014.</td>
<td>Ti: Attitudes and Perceptions of Pediatric Residents on Transitioning to Computer Provider Order Entry (CPOE).</td>
<td>Aims: To investigate attitudes and perceptions of residents related to implementation of CPOE and clinical decision support (CDS).</td>
<td>PG Residents (Pediatric)</td>
<td>Survey (pre and post EMR implementation).</td>
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Small sample of residents (8 only) in one specialty.

Small convenience sample (16 students). Not an RCT. Relied on self-reported measures. Type 1 errors cannot be excluded. Short intervention with only two simulation prototypes. Sim-EHR prototypes, meant to be an easy to develop and maintain system, however some feedback that it is not representative of real life EMR.

14 papers included in final analysis, thus theoretical saturation for analysis not met as per author report. The recommended/suggested tips on better patient/doctor communication not validated by post implementation research. I.e. what are the potential negative aspects of screen shaning and risks of causing stress or information overwhelm etc.

Small sample, single institution. Surveyed residents over the 2 year period for pre, and post implementation, were not the same. Self reported information from residents was not backed up by direct observation (risk of bias).
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<th>Methodology</th>
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<td>61</td>
<td>Silverman, Howard; Ho, Yun-Xian; Kaib, Susan; Ellis, Wendy; Danto, Moffitt; Matticka, P.; Chen, Qingsia; Nian, Hui; Gadd, Cynthia S.</td>
<td>A Novel Approach to Supporting Relationship-Centered Care Through Electronic Health Record Ergonomic Training in Pre-clerkship Medical Education.</td>
<td>To determine how medical student EHR ergonomics training can be used to enhance relationship centered care.</td>
<td>Undergraduate medical students (pre-clerkship)</td>
<td>Students’ relationship-centered EHR use showed significant positive effect due to EHR ergonomics skills training on (P &lt; .005). Minimum of 3 ergonomic training sessions needed to see an overall improvement in EHR use. Students who got training reported following: 1) Can use EHR to engage with patients more effectively, 2) better articulate benefits of using the EHR, 3) better address patient concerns, 4) appropriately position the EHR device, 5) more effectively integrate the EHR into patient encounters. Students’ self-assessments substantiated by simulated patients and faculty assessments.</td>
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<td>62</td>
<td>Solarte, Ivan; Könings, Karen D.</td>
<td>Discrepancies between perceptions of students and deans regarding the consequences of restricting students’ use of electronic medical records on quality of medical education.</td>
<td>To investigate Colombian medical student and medical school deans perspectives in relation to EMR use by students, especially in terms of quality of education and patient care and to also determine any concerns.</td>
<td>Undergraduate medical students, postgraduate residents, medical school deans in Colombia</td>
<td>About~50% medical schools had learning programs and policies about the use of EMR by students. Perceptions of EMR usage and student access differed between deans and students, signifying real life student usage which was not officially recognized or managed. According to students/learners and deans, limiting students use of EMR has negative consequences on medical education, with deans expressing more concern, with both citing following consequences that could be negatively affected: Student involvement in patient care, assessment of competences, feeling part of the team, development of communication written skills, and groundwork to be a doctor. Billing issues and liability aspects were their major concerns. In terms of what could justify restriction of students accessing or using EMRs, deans and students especially were concerned about medical liability, as indicated by 85% of both students and deans.</td>
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<td>63</td>
<td>Spencer, David C.; Choi, Dongseok; English, Clea; Girard, Donald</td>
<td>The Effects of Electronic Health Record Implementation on Medical Student Educators.</td>
<td>To determine effects of EHR implementation on medical student educators.</td>
<td>Clinical Faculty at a single educational centre (Oregon Health &amp; Science University, USA)</td>
<td>Overall, there was a trend towards a negative opinions in terms of the impact of EHRs on the educational process as per respondents answers. Approximately half (48.2%) of the faculty</td>
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TRN/SIMM COMU

Self-reported data susceptible to bias and there is no directly observed data to confirm findings.
| 64 | Stephens M, Gimbel R, Pangarol., 2011. | **Title:** The RIME/EMR Scheme: An Educational Approach to Clinical Documentation in Electronic Medical Records  
**Aims:** To discuss EHR educational issues, and to present the Reporters–Interpreters–Managers–Educators (RIME) scheme as an approach to teach and evaluate clinical documentation skills using EMRs in context of ACGME core educational competencies.  
**Methodology:** Mix (undergraduate/postgraduate)  
**Statement/Proposal:** RIME/EMR framework presented and used in context of ACGME competencies. The framework is also used to showcase training guidance as learners progress in their training from students up to independent physicians. | DOC, TRN/SIMM, ASMT | Research required to validate this approach. |
| 65 | Stephenson, Laurel S; Gorsuch, Adriel; Hersh, William R; Mohan, Vishnu; Gold, Jeffrey A, 2014 | **Title:** Participation in EHR based simulation improves recognition of patient safety issues.  
**Aims:** To determine whether participation in EHR simulation exercise improves recognition of ICU related errors.  
**Methodology:** Postgraduate residents and fellows (medical ICU).  
**Before and After Study:** Two simulated cases were formulated to test the participants which were similar in difficulty. The intervention included direct educational feedback on tested case with EHR specific training on how to best recognize the errors. Of the enrolled 116 subjects, 25 subjects underwent repeat testing. The baseline performance for trainees who participated in repeat testing was the same as the cohort. For repeat testers, for both cases, recognition of safety issues was significantly higher among repeat participants vs. the first time participants. Performance improved from 39.9% to 63.6% (p = 0.0002), this is independent of the order in which the cases were used. The improvement was inversely related to baseline performance. Repeat participants also showed better recognition of changes in: vital signs, antibiotic mis-dosing and over-sedation vs. to first time participants.  
**Conclusion:** Not clear if improvement in performance related to better cognition or better EHR usage (technical). This is very important to help better understand process for better future refinement of EHR related educational activities. Simulation, although conducted in an ICU workstation to help stimulate real-life environment, it was done in isolation of a full ICU team as would be the case in real life, where teams can also act in tandem to detect errors and influence clinical performance. Also, as it was done in an ICU, distraction could influence performance. Study done in the afternoon where there is more risk of trainee fatigue which could influence clinical performance and results. Electronic templates not used as would be the case in real life. Participants wrote on paper to present findings, this ritual could influence and stimulate a different cognitive process which could obscure the simulation vs. real life. | TRN/SIMM | No accompanying student opinion sought. |
| 66 | Stewart, Elizabeth; Kahn, Daniel; Lee, Edward; Simon, Wendy; Duncan, Mark; Mosher, Hilary; Harris, Katherine; Bell, John; El-Farra, Neveen; Sharpe, Bradley, 2015 | **Title:** Internal Medicine Progress Note Writing Attitudes and Practices in an Electronic Health Record.  
**Aims:** To evaluate the perceptions of internal medicine housestaff and attendings on EHR based inpatient progress note  
**Methodology:** Mix: PG IM residents and faculty (attendings)  
**Cross-sectional survey:** The majority of housestaff responded that the quality of notes was “unchanged” or “better” (50% unchanged, 34% better, only 9% felt it was worse) following the implementation of an EHR, whereas attendings believed note quality was improved. The most enthusiastic teachers seemed to be those most negatively affected by EHR implementation. Faculty felt that EHRs reduced quality of time spent with patients and students alike as their use takes up time. Comments included also the lack of specific training to help educators integrate EHRs in teaching process.  
**Conclusion:** Survey’s (self report) are at risk of bias. Despite 4 centres participating, all used the same type of EHR (EPIC), thus results may not be applicable to other types of vendors. Actual note quality was not measured, only | DOC | No accompanying student opinion sought. |
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<th>Conclusion</th>
<th>Study Design</th>
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<td>67</td>
<td>Sutter, Mary Beth; Magee, Susanna R.</td>
<td>Resident education through electronic medical record counselling prompts.</td>
<td>To evaluate perceptions of family medicine residents regarding an EHR integrated patient counselling tool which provides detailed patient counselling prompts/information that the residents can use to advise their patients.</td>
<td>PG family medicine residents (PGY-2 and 3). Survey and before and after testing. Majority of residents (88%) used electronic sources to find medical information. However, some residents (30%) reported that information was not readily available to them during patient encounters. Residents reported using the studied EMR prompts tool during most patient visits and rated its effectiveness as high. Residents had average higher confidence levels and average higher test scores after prompt use, but these were not significant enough in the before and after comparison.</td>
<td>COMU</td>
<td>Population: small sample (n=23). Rated PGY 2/3 whom usually have higher knowledge which may account for the lack of significant difference in pre/post testing. Inclusion of more junior residents to compare results would be beneficial. No patient feedback data included, reported scores are resident based and are subject to bias.</td>
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<td>68</td>
<td>Taft, T.; Lens, L.; Sakaguchi, F.; Stoddard, G.; Milne, C.</td>
<td>Effects of electronic health record use on the exam room communication skills of resident physicians: a randomized within-subjects study.</td>
<td>To evaluate the effects of EHR use compared with paper chart use, on novice physicians’ communication skills.</td>
<td>First-year internal medicine residents RCT</td>
<td>The overall average communication score was better when using an EHR vs. the paper chart.</td>
<td>COMU</td>
<td>This study was conducted using first-year residents in simulated patients at a single institution. Population size (32 per each group) This young cohort of students has excellent computer usability skills which can be a factor that influenced the results (e.g. fast touch typing skills). Study used a laptop, not desktop PC, which can bias results, as laptops more maneuverable.</td>
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<td>69</td>
<td>Thornton, J. Daryl; Schold, Jesse D.; Venkatesh, Lokesh; Lander, Bradley.</td>
<td>Prevalence of copied information by attendings and residents in critical care progress notes.</td>
<td>To determine prevalence and mechanism of copying among intensive care (ICU) physicians using an electronic medical record.</td>
<td>Postgraduate residents and attendings. Retrospective cohort study.</td>
<td>Copying among attendings and residents was common, with residents copying more frequently but attendings copying more information per note. Of the studied cohort, 82% of all resident and 74% of all attending notes contained ≥20% copied information. Residents copied less information between notes than attendings (53% vs. 61%, p &lt; .001). Following ≥1 day off, residents copied less often from their own prior notes compared to attendings (66% vs. 94%, p &lt; .001). However, some residents (30%) reported less information was not readily available to them during patient encounters. Residents reported using the studied EMR prompts tool during most patient visits and rated its effectiveness as high. Residents had average higher confidence levels and average higher test scores after prompt use, but these were not significant enough in the before and after comparison.</td>
<td>DOC</td>
<td>Single centre study Single EHR vendor (Epicare) Physicians not directly observed to study this behaviour and it’s influences and they were not questioned on their reasoning.</td>
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<td>70</td>
<td>Tiemey, Michael J.; Pagelet, Natalie M.; Kahana, Madelyn; Pantaleoni, Julie L.; Longhurst, Christopher A.</td>
<td>Medical Education in the Electronic Medical Record (EMR) Era: Benefits, Challenges, and Future Directions.</td>
<td>A narrative review that looks at medical education in the EMR era, using the lens of the Accreditation Council for Graduate Medical Education’s six core competencies.</td>
<td>Mix: UG medical students and PG residents education. Narrative Review.</td>
<td>The review summarized how at the time of publication EMR’s affected medical education, especially how it affects medical knowledge, Practice-Based Learning and Improvement, Patient Care, Interpersonal and Communication Skills, Professionalism and Systems-Based Practice. They describe</td>
<td>COMU, KNO, - Non Systematic review.</td>
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<td>71</td>
<td>Tiemey, W. M.; Overhage, J. M.; McDonald, C. J.; Wolinsky, F. D., 1994.</td>
<td>Electronic patient record (EPR)</td>
<td>Survey</td>
<td>Overall, opinions were positive but the positivity was maximum amongst junior students and declined towards seniority: where it was lower amongst residents, with the latter reporting this system consumes more time vs. paper based orders.</td>
<td>WF, DOC</td>
<td>Single centre study. Survey methodology prone to reporter based bias. This was done in 1994 (oldest paper in this review), the technology then may not represent current day EHR systems.</td>
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<td>72</td>
<td>Varpio, Lara; Day, Kathy; Lillator-Miller, Pat; King, James W; Kazienksy, Craig; Parush, Avi; Roffey, Tyson; Rashotte, Judy, 2015</td>
<td>The impact of adopting EHRs: how losing connectivity affects clinical reasoning</td>
<td>Qualitative (grounded theory approach)</td>
<td>The interviews provided detailed insights on how physicians and co-workers reacted to EHR implementation, especially when compared to paper records. In the paper flowsheet, doctors documented and viewed patient data organized in a chronological manner, which emphasized data interconnections. Conversely, EHR flowsheets recorded such data in a manner that leaves it chronologically and contextually isolated. This resulted in physicians: 1) not knowing patient's evolving status; 2) increased cognitive load and 3) loss of clinical reasoning mechanisms. Interestingly, medical students/junior residents had a favourable response vs. senior doctors. Educators, leaders &amp; vendors should focus on countering these challenges.</td>
<td>DOC, WF</td>
<td>Comprehensive study with detailed descriptions of participants and the methodology. However, not much more detail in terms of how students and residents felt about the studied system.</td>
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<td>73</td>
<td>Varpio, Lara; Schilder, Catherine F; Lingard, Lorelei, 2009</td>
<td>Routine and adaptive expert strategies for resolving ICT mediated communication problems in the team setting</td>
<td>Qualitative (grounded theory approach)</td>
<td>From authors' approach: 3 interprofessional communication strategies were identified: (i) all participants routinely formulated ‘workarounds’ to circumvent problematic EPR-mediated communications; (ii) workarounds were classifiable as instances of Abandoning, Forcing or Submitting to the EPR, and (iii) novices learned workaround strategies through an informal curriculum, but they did not learn to manage the interprofessional effects of these workarounds. Staff members, use adaptive expertise to develop these workarounds as part of a broader network of colleagues and communication tools. This process of “adaptive” expertise which attendings possess and more senior residence eventually develop is not clearly understood in terms of how it is acquired in this setting. More research is needed to clarify this to trainees can be assisted to develop this skill.</td>
<td>WF, COMU</td>
<td>From authors' approach: 3 interprofessional communication strategies were identified: (i) all participants routinely formulated ‘workarounds’ to circumvent problematic EPR-mediated communications; (ii) workarounds were classifiable as instances of Abandoning, Forcing or Submitting to the EPR, and (iii) novices learned workaround strategies through an informal curriculum, but they did not learn to manage the interprofessional effects of these workarounds. Staff members, use adaptive expertise to develop these workarounds as part of a broader network of colleagues and communication tools. This process of “adaptive” expertise which attendings possess and more senior residence eventually develop is not clearly understood in terms of how it is acquired in this setting. More research is needed to clarify this to trainees can be assisted to develop this skill.</td>
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<td>74</td>
<td>Victores, Andrew J.; Coggins, Kenneth; Takashima, Mas, 2015.</td>
<td>Electronic Health Records and Resident Workflow: A Time-Motion Study of Otolaryngology Residents.</td>
<td>Before and After Study</td>
<td>When compared to data collected prior to use of EHRs, overall, time was spent similarly. However, residents post- EHR implementation, devoted significantly more time to indirect patient care on clinic days</td>
<td>WF</td>
<td>Single Centre study. Direct observation of residents may lead to Hawthorne/observer effect. PGY 2/4 studied, more junior residents may exhibit different behaviours/results.</td>
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<td>75</td>
<td>Electronic Health Record Training in Undergraduate Medical Education:</td>
<td>Wald H, George P, Rea S, Taylor J. S, 2014</td>
<td>TRN/SIMM</td>
<td>- Useful summary of considerations regarding curriculum design and implementation in EHR setting but would require educationally minded researchers to confirm or test some of the recommendations.</td>
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<td>Bridging Theory to Practice With Curricula for Empowering Patient-</td>
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<td>and Relationship-Centered Care in the Computerized Setting.</td>
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<td>Aims: How can medical educators meet needs of UG Medical learners</td>
<td>UG medical Residents (UG medical Education)</td>
<td>Statement/ Proposal</td>
<td>They propose these general guiding principles of curriculum design for EHR training in undergraduate medical education:</td>
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<td>while integrating EHRs into medical education and practice? How can</td>
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<td>- Kern and colleagues six-step curriculum design framework (problem identification and needs assessment; targeted needs assessment; goals and objectives; educational strategies; implementation; evaluation and feedback),</td>
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<td>they help learners foster good communication skills while using</td>
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<td>- Reflective learning and practice</td>
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<td>EHRs? How can UG medical curricula be devised for skilled use of EHRs</td>
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<td>- Spiral longitudinal developmental curriculum</td>
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<td>to enhance rather than hinder provision of effective, humanistic</td>
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<td>- Narrative medicine</td>
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<td>health care?</td>
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<td>- Adapting pedagogy to needs of millennial learners.</td>
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<td>76</td>
<td>Barriers to Medical Students' Electronic Health Record Access Can</td>
<td>Welcher, Catherine M., Hersh, William; Takesue, Blaine; Nagy Elliott,</td>
<td>DOC, TRN/SIMM</td>
<td>- Opinion/narrative review article that summarizes important issues.</td>
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<td></td>
<td>Impede Their Preparedness for Practice.</td>
<td>Victoria; Hawkins, Richard E, Online: 2017 (2018-print)</td>
<td></td>
<td>- Review of literature does not employ systematic methodology,</td>
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<td>Aims: Article aims to discuss medical students' current state in</td>
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<td>terms of access to EHRs and explore current issues related to this</td>
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<td>and proposed policies, and possible solutions with regard to student</td>
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<td>EHR access and training.</td>
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<td>77</td>
<td>Electronic Medical Records, Medical Students, and Ambulatory Family</td>
<td>White, Jordan; Anthony, David; WinklerPrins, Vince; Roskos, Steven,</td>
<td>DOC, TRN/SIMM</td>
<td>Low response rate (33%). Lack of details about preceptors in terms of number of students they have per time unit and how much time they dedicate to them.</td>
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<td>Aims: To evaluate impact of EMRs on medical student education in</td>
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<td>- Review of literature does not employ systematic methodology,</td>
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<td>an ambulatory setting with the goal of identifying behaviors of</td>
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<td>ambulatory family medicine preceptors in relation to EMRs and</td>
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<td>medical students.</td>
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<td>Ambulatory clinic preceptors who hosted medical students during</td>
<td>Ambulatory clinic preceptors who hosted medical students during family medicine clerkships (3 USA based institutions).</td>
<td>Survey</td>
<td>There was 33% response rate (265/801). The majority of respondents used an EMR and 91.1% provided students with access to it in some way, but only 62.2% allowed students to write electronic notes. In terms of feedback on EMRs and student progress notes, 30.5% of subjects stated that the EMR made no difference, 40.9% reported that the EMR made providing feedback somewhat easier or a lot easier. Of those preceptors, who allowed students electronic access, one-third did so by logging students in under their own (the preceptor’s) credentials, either by telling the students their log-in information (30.9%) or by logging in for the student without divulging their passwords (21.3%). This outlines that preceptors have sometimes</td>
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<td>family medicine clerkships (3 USA based institutions).</td>
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<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Type</th>
<th>Methodology</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>Medical Student Documentation in the Electronic Medical Record:</td>
<td>Wittels, Kathleen; Wallenstein, Joshua; Patwan, Rahul;</td>
<td>Survey</td>
<td></td>
<td>- High response rate 86% (100 unique institutional entries). From the</td>
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<tr>
<td>Patterns of Use and Barriers.</td>
<td>Patel, Sundip, 2017</td>
<td></td>
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<td>data, 63% of EM clerkships allow medical students to document a patient</td>
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<td>encounter in EHRs. Most common reasons cited for not allowing students</td>
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<td>to document a patient encounter were: 1) hospital or medical school</td>
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<td>rule prohibiting student documentation (80%), 2) concern for medical</td>
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<td>liability (60%), and 3) inability of student notes to support medical</td>
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<td>billing (53%) and 38% had a lack of computer access. Nearly 95% of</td>
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<td>students are given feedback on their documentation as per responders</td>
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<td>reports, with supervising faculty being the most common group to give</td>
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<td>feedback (92%), and then residents by (64%).</td>
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<td>Computerised provider order entry and residency education in an</td>
<td>Wong, Brian; Kuper, Ayelet; Robinson, Nicole; Morra,</td>
<td>Qualitative (grounded theory)</td>
<td></td>
<td>- Five aspects of postgraduate training were formulated from the</td>
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<td>academic medical centre.</td>
<td>Dante; Etchells, Edward; Wu, Robert; Shojaia, Kaveh,</td>
<td></td>
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<td>analysis, CPOE had both positive and negative impacts on: (1)</td>
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<td>2012.</td>
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<td>learning (e.g., better for medication interactions and availability of</td>
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<td>learning resources; worse for memorization medication doses); (2)</td>
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<td>teaching (e.g. more medication information available to stimulate case</td>
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<td>discussions; but negative aspect is that fewer face-to-face teaching</td>
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<td>opportunities happen); (3) feedback (e.g. improved ability to observe</td>
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<td>medication ordering behaviours to inform feedback; but due to remote</td>
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<td>access option, chance of less provision of direct feedback); (4)</td>
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<td>clinical supervision (e.g. enables efficient and safe supervision from</td>
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<td>a far, but this may impede trainee independence as attendings can</td>
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<td>easily order things instead of residents), and (5) trainee assessment</td>
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<td>(e.g. increased opportunities to assess clinical decision making and</td>
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<td>organizational skills by following EHR/electronic orders etc.). A</td>
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<td>developed conceptual framework also discussed that could facilitate</td>
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<td>identifying educational opportunities whilst safeguarding safety of</td>
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<td>medical trainees.</td>
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<td>Impact of Implementing an Electronic</td>
<td>Wormer B, Coitavita P, Yokeley W, 2012.</td>
<td>Survey</td>
<td></td>
<td>- Medical students not included. Involve one specialty (internal</td>
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<td>Postgraduate</td>
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<td>medicine), thus findings may not be generalizable to other specialties</td>
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<td>which may have different work flow. Data gathered from interviews, not</td>
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<td>via direct observation. CPOE findings of this particular groups system,</td>
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<td>may not be applicable to other systems.</td>
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<tr>
<td>Study Authors/year of publication</td>
<td>Title (Ti) and Aim(s) of Study</td>
<td>Population/Participants</td>
<td>Study design</td>
<td>Main findings</td>
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<td>Bradley J, Williams K, Walters A, Green J, Heniford B, 2015.</td>
<td>Health Record on Surgical Resident Work Flow, Duty Hours, and Operative Experience. <strong>Aims:</strong> To assess the effect of implementing an EHR on surgical resident work flow, duty hours, and operative experience at a large teaching hospital.</td>
<td>Surgical residents from 15 surgical residents at all time intervals. Survey looked at: resident time to complete patient documentation, average call/duty hours, and operative experience before EHR and afterward (at 1, 4, 6, 8, and 24 weeks). Results showed that EHR implementation leads to an initial doubling of resident documentation time of almost all note types; however, over six months it returns to baseline of paper charting with exceptions of operative notes &amp; discharge summaries. Surgical residents kept similar duty hours and similar operative experience during the transition to EHR. Of concern, a majority of residents (74%) reported a concern for increased risk of committing medical errors with the implementation of the EHR.</td>
<td>TRN/SIMM, DOC, COMU</td>
<td>Especially as there is no direct observational data. Small population (15 residents) Single centre</td>
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<td>Yudkowsky R, Galanter W, Jackson R, 2010</td>
<td>Ti: Students overlook information in the electronic health record <strong>Aims:</strong> This pilot study aimed to determine whether medical students who had undergone routine EHR training and were familiar with the EHR would: (1) successfully retrieve critical information embedded in the EHR, (2) maintain a patient-centred approach to communication in the presence of an EHR, in context of a simulated patient (SP) encounter.</td>
<td>Medical Students All 197 students participated and accessed EHR. Results: 174 (88%) explained to the patient why they were using the computer. Only 18% asked the patient about prior MI. In the post-encounter note, 19% students documented prior history of an MI and 23% noted thrombocytopenia. Only 6% documented both thrombocytopenia and MI. Mean patient-centred communication score was 84%, equivalent to scores on other simulated patient stations. Medical students with 12 months of EHR experience maintained patient-centred communication while using the EHR, but unsuccessful in identifying embedded critical clinical info.</td>
<td>TRN/SIMM, DOC, COMU</td>
<td>Did not characterize the form of EHR training and control for it.</td>
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<td>Zelnick CJ, Nelson DA, 2002</td>
<td>Ti: A medical informatics curriculum for 21st century family practice residencies <strong>Aims:</strong> To measure if introduction of new informatics curriculum improved residents' informatics skills and computer knowledge. The curriculum integrated the following: evidence-based medicine, communication and behavioural sciences, patient education, and computer skills.</td>
<td>Family medicine residents The curriculum improved residents' self-ratings of informatics knowledge and computer skills, but the objective test did not show a significant difference between programs (vs. other programs that did not use the curriculum). An objective measurement of knowledge that tests the participants on the taught informatics curriculum did not demonstrate the benefit of curriculum compared to other programs. Conclusion: Providing didactic-based instruction on EHRs does not seem to lead students to transfer their knowledge to practice. This may outline that didactic transfer of EHR/informatics knowledge may not be enough.</td>
<td>TRN/SIMM</td>
<td>Small sample (n=24) Survey subject to bias. Control groups in other institutions and they did not detail what form of EHR training or exposure they had.</td>
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</table>

No Study Authors/year of publication.

Title (Ti) and Aim(s) of Study

Population/Participants

Study design

Main findings

Represented theme(s)

Gaps/ Main limitations

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