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Challenge of electronic health record interface: literature review

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Abstract. Electronic Health Record (EHR) differences from the traditional patient medical history in which everything related to the patients' past visits and records such as family history or lab results are being stored electronically. This system is supposed to innovate the world of healthcare into the next step as it intends to provide different advantages such as ensure transparency cross different medical institute and enhance quality of care. However, due to the lack of different aspects, there are some major flaws with HER. This literature review explores the challenges of EHR interface design and its impact on healthcare providers across various medical settings. The paper demonstrates through research that the significant effects of EHR usability on provider efficiency and error rates, highlighting a notable disconnect between the design of these systems and the practical needs of their users. In addition, the review reveals a critical need for user-centered EHR interfaces, emphasizing the importance of collaborative efforts among clinicians, developers, and healthcare organizations. Based on a synthesizes findings from diverse studies, this paper advocate for EHR systems that are not only technically proficient but also intuitively aligned with healthcare providers' workflows, ultimately aiming to enhance clinical outcomes and operational efficiency.

Keywords: Electronic Health Record, Design Challenges, User-Centered Design, Clinical Outcomes, Provider Efficiency.

1. Introduction

As society progresses, many industries have been incorporating some sort of artificial intelligence or machine learning algorithms into their workflows. The Electronic Health Record (EHR) is a milestone in the healthcare industry, and it benefits many individuals for different reasons. This ambitious initiative holds promise not merely to decrease patient expenditures on medical care and doctor administration but, moreover, to modernize health services by digitizing individual medical histories in a manner that could elevate both the standard and productivity of treatment. It is crucial to delivering safer, more efficient care and facilitating information sharing among healthcare providers, which can lead to more cost-effective and higher-quality patient care [1]. However, the challenge that came with this innovative tool cannot be ignored, and the scope of this paper specifically focuses on the challenges associated with the user interface design within EHR systems.

The design of EHR interfaces significantly influences the performance and cognitive load of healthcare providers, especially in high-stress environments like intensive care units [2]. Developers of EHRs and the medical practitioners who utilize EHRs on a daily basis differ vastly in the development

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and needs for EHRs. Usually, those who work on the design and development of EHRs never directly interact with the systems in a clinical setting. Because of this gap, EHR interfaces may not satisfy the practical needs of physicians and other healthcare professionals. Indeed, these interface misalignments are frequent problems that impact a variety of healthcare providers and their interactions with EHR systems; they are not uncommon oddities. But it is critical to identify and resolve this issue. EHR providers need to be aware of this discrepancy and aggressively seek feedback from medical experts. They may ensure that EHR systems are properly suited to the requirements of those who rely on them in healthcare settings by integrating this feedback and bridging the gap between the system's functionality and design.

Examining the effects of EHR interface design on healthcare professionals' performance and error rates in a range of medical contexts is the goal of this evaluation of the literature. It highlights the urgent need for user-centered interfaces by bringing to light the gap that exists between the creators of EHR systems and their users. In order to improve clinical outcomes and boost operational efficiency, the review urges physicians, EHR developers, and healthcare organizations to work together to create interfaces that are in line with the practical needs of healthcare professionals.

2. Literature review

Orfanidis, Bamidis, and Eaglestone concentrated on the national level of EHR in Greece, particularly the quality challenges of EHR [3]. In order to increase the precision and dependability of health data, it highlights the necessity of intelligent interfaces and organized data entry. According to the study, well designed user interfaces can greatly improve the caliber of data entered and kept up to date in electronic health record systems. It also discusses the more general technological difficulties in putting in place a nationwide EHR system, especially in environments with inadequate infrastructure for information and communication technologies.

Edwards et al. explore how easy it is to use a for-profit EHR system in a pediatric hospital [4]. The study used the Heuristic Walkthrough approach to find a number of usability concerns, such as navigational problems, data entry challenges, and system reaction time problems. The effectiveness and system satisfaction of healthcare professionals were impacted by these problems. The hospital revised its training materials and altered its system setup in response to these results, which addressed issues with usability. In the end, it is stressed how crucial it is to have an intuitive interface design that improves users' overall experience and productivity in a medical setting.

Next, Abramson et al. focus on the transition experience of physicians from an older to a newer EHR system by examining the impact on electronic prescribing processes [5]. The newer system is overly complex and challenging to navigate, particularly for tasks such as medication ordering and review. The increased number of steps and reliance on mouse input reduced efficiency and increased the risk of errors. Despite some advantages, like more comprehensive data displays, the study underscores the importance of considering end-user experience in EHR interface design, emphasizing that more features do not always translate to better usability.

Bowman reviewed the unintended consequences of EHR systems [6]. Even though it is not directly focused on the interface discrepancy between doctors and designers, she addresses how poor design and improper use of EHR systems can lead to significant errors affecting patient safety and quality of care. The paper highlights various interface-related issues, such as confusing data displays, workflow incompatibilities, and the misplacement of critical patient information. These interface problems can lead to poor clinical decisions, delays, and data loss. She eventually suggests that interface design is a crucial factor in ensuring information integrity and calls for improved design standards in EHR systems.

Cifuentes et al. focus on the specific challenges encountered by healthcare practices integrating behavioral health with primary care in their EHR systems [7]. They identify key issues like inadequate templates for documenting behavioral health information, poor support for team communication, and limited interoperability with external devices. The study then discusses more permanent solutions, like the development of customized EHR templates and the adoption of unified EHR systems, highlighting

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the importance of adaptable and comprehensive interface designs to support integrated healthcare delivery.

Lastly, Ahmed et al. investigated the effects of EHR interface design on the performance of ICU providers [2]. The study compares a novel user interface, designed specifically for the needs of ICU providers, with a standard interface. It was more efficient in presenting relevant patient data, organized in a system-based approach, which resonated more with the workflow of ICU providers. This study underscores the significant impact of interface design on healthcare providers' efficiency and error rates, particularly in high-pressure environments like the ICU.

3. Analysis and discussion

3.1. Methodologies analysis

While Orfanidis, Bamidis, and Eaglestone offers a comprehensive view of data quality, combining theoretical discussions with practical considerations for the implementation of EHR systems in a specific national context [3]. This macro-level study provides insights into systemic challenges, including the need for intelligent interfaces and structured data entry, but may overlook the fine details of user interface interactions present in individual healthcare settings.

Edwards et. al. use the Heuristic Walkthrough (HW) method which provides a structured and detailed approach to uncovering usability issues, making the findings robust and actionable [4]. However, their method limited to one pediatric hospital system, which might affect the generalizability of the findings. Also, the focus on usability might not fully capture other dimensions of EHR interface challenges, such as adaptability to different clinical contexts.

Abramson et al. used qualitative approach, which provides in-depth insights but may limit generalizability [5]. Since it was conducted at a single institution, and the physicians' previous long-term experience with the older EHR might have influenced their perceptions of the new system which might create unintentional bias and limitation.

Bowman’s approach is to conduct a literature review which offer a comprehensive overview of existing research on EHR systems' impact on information integrity and patient safety [6]. This method synthesizes a wide range of studies, providing a broad understanding of interface-related issues, but it might not offer the depth of analysis found in primary research studies. Also, it is different from other paper which provides case study taken places in different setting.

Cifuentes et al. conducted an observational, cross-case comparative study on 11 diverse practices, including primary care clinics and community mental health centers [7]. The study involved a grounded theory approach analyzing various data sources. But their method limited by the small number of participating practices and integration experience. Additionally, these practices lacked dedicated resources for Health Information Technology (HIT) improvements, which could impact the generalizability of the findings.

Lastly, Ahmed et al. randomized crossover study and conducted with critical care physicians at an academic center [2]. They were asked to perform a structured task using either a standard electronic medical record or a novel user interface. And the primary outcome measured was task load using the NASA-task load index, with secondary outcomes including time to task completion and number of cognitive errors. They provides robust evidence of the impact of interface design on provider performance. However, the study is limited to a specific setting (ICU) and task, which may affect the generalizability comparing to the previous paper.

The diversity of methodologies across these studies enriches the understanding of EHR interface challenges from multiple angles. While some studies offer in-depth, context-specific insights, others provide broader overviews or comparative analyses. The variation in approaches highlights the complexity of EHR interface design issues, necessitating a multi-faceted exploration to fully grasp the challenges and potential solutions in different healthcare contexts.

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3.2. Gaps in Research and Future Directions

Despite the comprehensive insights provided by the studies reviewed, there remain several notable gaps in the research on EHR interface design, which might suggest directions for future exploration. As mentioned in multiple papers, many of the studies are taking place in a single setting, such as an ICU or pediatric hospital. This is a very significant gap in these studies. The future research could expand to a wider variety of medical settings, such as primary care and rural healthcare facilities.

For primary care, EHRs are increasingly vital for enhancing public health coordination and maintaining community health. EHRs enable PCPs to effectively monitor and manage both communicable and chronic diseases by providing real-time clinical alerts and health data [8]. At the same time, as mentioned before regarding the issue of discrepancy, the enhancement of EHRs in primary care can minimize another type of discrepancy between patients and practitioners. This can allow information about the patients to be kept up to date which decreases the error rate due to the slowness of information exchange between paper documents and electronic documentation. The collaboration in EHR data exchange initiatives showcases the potential of EHRs to support the surveillance and management of communicable and chronic diseases, ultimately improving community health outcomes [8].

For rural areas where low-income populations also might come into place, EHR systems can significantly enhance healthcare delivery in those areas by providing efficient access to patient data, which is essential for effective treatment and management of health conditions. In rural areas, information and institutions might have information discrepancies due to systematic differences, and EHR might provide the possibility of reducing those differences. It makes it easier for different healthcare practitioners to coordinate and maintain patient care, which is especially helpful in rural locations where resources for healthcare may be scarce or dispersed. Nevertheless, putting all of the aforementioned advantages into practice comes with a number of difficulties. Concerns include the high initial cost of EHR adoption in remote institutions and practices run by elderly physicians. It is possible that they are unfamiliar with the new technological system and will want some time to become used to it. In addition, there's the issue of continuing maintenance and technical support costs [9].

A thorough examination of the six examined papers indicates a notable emphasis on the difficulties associated with designing EHR interfaces in particular healthcare environments, including pediatric and intensive care units, or in a broader context like national research. This focus, however, highlights a significant research vacuum concerning more diverse medical environments, especially primary care and rural healthcare facilities. In these crucial contexts, EHRs have the potential to significantly improve public health coordination and reduce inequities in healthcare delivery and access. Although studies have highlighted the advantages of EHRs in primary care for illness management and data streamlining [8], they frequently fail to consider the wider implications of EHRs in various care settings. In a similar vein, issues such as high expenses and lack of familiarity with technology in rural areas are not thoroughly investigated [9].

This analysis highlights the necessity for more thorough research in rural and primary care settings in order to properly comprehend and address the particular EHR problems that these settings provide. Future research should work to close these gaps, improving healthcare quality and accessibility for all while also assisting in the creation of more efficient and inclusive EHR systems.

3.3. Integration with Discrepancy

Edwards et al. illustrated how EHR interface design affects the performance of medical professionals in a pediatric hospital, thereby supporting the contention that interface design failures are caused by a mismatch between end users and system designers [4]. The findings on the reported usability difficulties and the ensuing improvements to the system are consistent with the necessity for developer-user collaboration and user-centered EHR interfaces in order to improve clinical outcomes and operational efficiency.

At the same time, Bowman and Ahmed et al. also provide evidence for the argument. Bowman aligns with it by illustrating the consequences of poor EHR interface design on information integrity and

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patient safety [6]. It advocates for improved design standards, which resonates with the main point and emphasizes the need for interfaces that meet healthcare providers practical needs. Ahmed et al. focus on ICU settings also provides similar evidence, but on a different level [2]. The impact of EHR interface design on provider performance and error rates is the topic of their research. The comparison of standard and novel interfaces underscores the significant improvements that can be achieved through user-centered design and collaboration among developers, clinicians, and healthcare organizations.

In contrast to the above, Cifuentes complemented the thesis in some way and demonstrated specific interface challenges in integrated healthcare settings and the solutions that emerge from collaborative efforts [7]. The study's findings on customized solutions and workarounds highlight the importance of developing EHR interfaces that cater to the unique needs of diverse medical settings.

Compared to others, Orfanidis, Bamidis, and Eaglestone indirectly provide support by highlighting the importance of intelligently designed interfaces for accurate data entry and maintenance [3]. Even though it did not specifically mention the disparity that causes interface issues, it emphasizes the broader need for user-friendly interfaces in different healthcare settings, echoing the call for user-centered design.

Last but not least, Abramson's research emphasizes the mismatch by demonstrating how EHR interfaces created with little user needs consideration can result in lower productivity and higher error rates [5]. This research connects to the thesis by reiterating how important it is to have interfaces that naturally fit the workflows of healthcare providers. One of the main conclusions from his research is that doctors thought the more recent EHR system was too complicated and difficult to use, even though it was technologically sophisticated. Tasks that are essential to the primary care process, such as ordering and reviewing medications, were particularly complicated. This emphasizes how important it is for EHR developers to work closely with medical professionals throughout the design phase to guarantee that the interfaces of the EHRs are clear and easy to use.

4. Synthesis

Overall themes and patterns in EHR interface design and their effects on healthcare delivery and performance are shown by a comprehensive analysis of the research. The substantial impact of interface usability on healthcare provider efficiency and error rates has been noted as a consistent theme in the research conducted by Edwards et al. and Abramson et al. [4-5], and less productivity and more error-proneness can result from interfaces that are not intuitively built for end users. Orfanidis, Bamidis, and Eaglestone are consistent with their emphasis on the significance of user-friendly interfaces for accurate data administration, particularly in the context of broad healthcare frameworks similar to those in Greece [3]. Furthermore, Bowman emphasizes the crucial role that interface design plays in maintaining patient safety and information integrity, reinforcing the necessity for interfaces that meet the real-world requirements of healthcare professionals [6]. The problem was thoroughly examined by Cifuentes et al. in their paper. The need for flexible and all-inclusive interface designs to accommodate the distinct requirements of diverse medical contexts is further demonstrated by the integration of behavioral health and primary care [7]. Finally, Ahmed et al. highlight the advantages of interfaces customized to particular provider requirements by showing through their comparative study in ICU settings that user-centered interface design may greatly enhance operational efficiency and reduce cognitive errors [2]. All of these studies support the idea that improved clinical outcomes and operational efficiency in a variety of healthcare settings depend on thoughtfully created, user-centered EHR interfaces.

The review of the literature on EHR interface design reveals several inconsistencies that have significant implications for the field. Firstly, there is a noticeable lack of research focusing on the long-term effects of EHR interface usability on healthcare provider performance. While Edwards et al., and Abramson et al. provide insights into immediate usability challenges, the long-term impacts remain underexplored [4-5]. Furthermore, the degree to which diverse medical environments are reflected in said research seems to lack congruence and can potentially be improved for more well-rounded insights. As highlighted by Orfanidis et al. and Kruse et al., studies predominantly focus on specific settings, such as ICUs and pediatric hospitals, with less attention given to primary care and rural healthcare facilities [3, 9]. This skew in research focus could lead to the development of EHR systems that are not fully

attuned to the diverse needs of various healthcare environments. Furthermore, they reveal a gap in understanding the specific needs and challenges faced by different user groups within healthcare settings, such as nurses, administrative staff, and various specialties of physicians. The implications of these gaps are significant. They suggest that future research should strive for a more comprehensive approach, encompassing a wider variety of healthcare settings and user groups.

5. Conclusion

This literature review explored EHR interface design in a variety of studies, and the clear message from the literature is that EHR interfaces affect healthcare provider performance, with a greater impact on error rates and performance in certain medical settings. While the reviewed studies provide a comprehensive understanding of the current state of EHR interface design, they also unveil gaps and opportunities for future research. Addressing these gaps requires a concerted effort from all stakeholders in the healthcare ecosystem, aimed at developing EHR systems that enhance operational efficiency, reduce error rates, and ultimately improve the quality of patient care across the healthcare spectrum.

This review faces certain limitations that should be acknowledged. The scope of references used is somewhat restrained, which may affect the comprehensiveness of the analysis. At the same time, the absence of field research means that the conclusions drawn are primarily based on secondary data and it could be beneficial if research is done from direct observational studies or primary data collection in future work.

With subsequent enrollment in a Master of Engineering in Biomedical Engineering at Johns Hopkins University, the research focus will expand into innovative healthcare technologies with the potential to integrate cutting-edge engineering solutions into EHR systems. This education will allow for enhanced the technical and analytical skills that might contribute to the design of more effective and intuitive EHR interfaces. Advances in academia progression offer the possibility to further explore data integration techniques and usability strategies that can be directly applied to enhance EHR systems, leading to a whole better outcome.

In conclusion, while this review has laid a solid foundation for understanding the impact of EHR interface design on healthcare providers, it also sets the stage for a deeper investigation enriched by further academic and practical experiences. The knowledge and skills acquired during my graduate studies will provide valuable insights into optimizing EHR systems.

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