Challenges and Approaches to Enhance Usability in Healthcare Applications: A Systematic Literature Review

Emanuel P. Vicente[1][a], Wilamis K. N. da Silva[1][b], Geraldo T. G. Neto[2][c] and Gustavo H. S. Alexandre[1][d]
[1]*CESAR, Recife Center for Advanced Studies and Systems, Apolo Street, Recife, Brazil*
[2]*IFMS, Federal Institute of Mato Grosso do Sul, Corumbá, Brazil*
{*epv, wkns, ghsa*}*@cesar.school, geraldo.galindo@ifms.edu.br*

Keywords: Usability, Usability Method, UCD, Usage-Centered, Medical-Hospital System, Healthcare, Medicine, Patient Safety.

Abstract: The expansion of medical-hospital applications requires increasingly more quality in their interfaces so that usability problems do not encourage errors and adverse events that could impact patient safety. The ecosystem of healthcare applications has challenges in the field of usability due to the dynamic medical environment in which these systems are designed, developed and operated, suffering interference from social and technological factors, and compliance with legislation. This research identifies the challenges faced by the healthcare applications ecosystem in order to map them. This work reports, through a literature review, which challenges software engineering has faced to guarantee the usability of applications in the healthcare context. A systematic review of the literature was carried out using a research protocol with the purpose of identifying relevant studies in the IEEE Xplore, ACM, Scopus, Science Direct and PUBMED databases, using criteria that adhere to the practices of search, critical evaluation, data extraction and synthesis of works, resulting in the obtaining of 43 relevant works. The literature search yielded 43 articles that met the study criteria. It resulted in mapping the main challenges found in the literature when applying existing approaches to increase the usability of healthcare applications and reduce the impact of violations that could result in adverse health events for patients. The study identified the challenges faced by the usability of health systems, as well as mapping which factors contribute to these challenges. Furthermore, this work aims to impact the use of approaches that guarantee better usability of the applications of this ecosystem and consequently reduce the risk of adverse events to the health of patients.

1 INTRODUCTION

In recent years, several software products aimed at the healthcare application ecosystem have emerged in the private and government markets. This explosion of solutions has directed the attention of software engineering to issues of usability of interfaces that relate to patient health care. According to Cho (Cho et al., 2022), healthcare professionals are often faced with unintended consequences related to the use of these systems, which may negatively impact patient safety. One of the main reasons for these unforeseen challenges associated with an increase in clinicians' cognitive workload, related fatigue using this systems, burnout, work inefficiency, job dissatisfaction, and intentions to leave the job arise from lack of or poor execution usability testing of these systems.

During user interaction with Health Information System (HIS), many usability problems can be identified, such as: lack of readability, feature confusion, poorly differentiated alarms or alerts, lack of design intelligent, poor feedback on the state or behavior of the system, lack of provision for online help, poor language support, among others. Also according to Adams (Adams et al., 2021), these usability problems can eventually contribute to medication errors.

For systems with usability problems, the impact of these violations significantly increases the chances of errors or adverse events that can lead to a disaster for the patient's health, as in the case of wrong medication prescription or inappropriate dosages. On

[a] https://orcid.org/0009-0008-9859-8819
[b] https://orcid.org/0000-0002-8530-5916
[c] https://orcid.org/0000-0001-7244-8822
[d] https://orcid.org/0000-0002-8347-6383

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the other hand, systems with high usability help users carry out their tasks safely, quickly, easily and with minimal mental effort.

Adams (Adams et al., 2021) highlights that systems with strong usability have the potential to significantly reduce errors and enhance patient safety.

A study carried out in 3 US hospitals on the safety of medication administration in pediatric patients showed that 36% of adverse events were related, among other problems, to the lack of feedback from the system and poor visual display of information in the Recording System. of Health(Ratwani et al., 2018b).

Usability can be considered as one of the main quality characteristics of a system, and is also defined by ease of use and the extent to which a product is used efficiently, effectively and satisfactorily by specific users in the execution of objectives (ISO 9241-11, 1998) .

The adoption of practices to guarantee a software development process must be aligned with a humanized and user-centered perspective, and thus, direct attention to end users during all phases of a software project. This view is described by Lowdermilk(Lowdermilk, 2019) as *User Centered Design* (UCD), where usability processes are focused on the end user, delivering a better quality application from the perspective of those who use the system.

This literature review analyzed studies that addressed usability methods in the context of healthcare applications to identify the main challenges faced when using approaches with the aim of understanding the problem and supporting new work in proposing more efficient processes of integration between development goodwill and usability of health systems.

2 SYSTEMATIC LITERATURE REVIEW

The literature review is composed of three phases: planning the review, conducing the review and documenting the review as Figure 1.

The Systematic Literature Review (SLR) requires an extensive process. Kitchenham et al. (Kitchenham et al., 2015) argued that the process of reviewing the literature should be highly planned and structured, thus avoiding bias on the side of researchers and providing reliability to the process.

2.1 Planning the Review

Kitchenham et al. (Kitchenham et al., 2015) refer to SRL as a project and to the importance of planning as a key step to success at the end of the study.

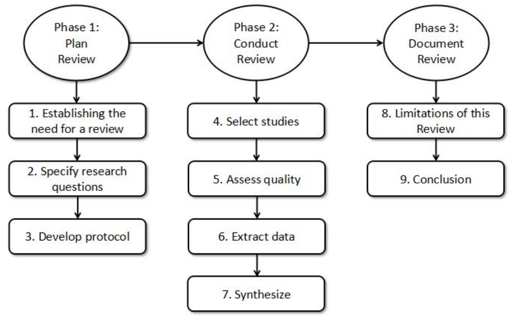

Figure 1: Planning process of the Systematic Literature Review (adapted from Kitchenham et. al. (Kitchenham et al., 2015)).

2.1.1 Establishing the Need for a Review

The authors (Kitchenham et al., 2015) emphasize the importance of checking if there is already another SRL approaching the same research topic. In his Literature Review, Carayon (Carayon and Hoonakker, 2019) identified old and new challenges of Human Factors and Usability approches for Health Information Technology. The author concludes that progress in the application of human factors methods and principles to the design of health IT is occurring, with important information provided on their actual impact on care processes and patient outcomes, and points to necessity of exam how work of health IT designers and implementers would help to develop strategies for further embedding human factors engineering in IT design processes. Also, during the initial searches on the topic of this study, we found the work (Martikainen, 2015), with a theme and research questions similar to those of our study. The author of (Martikainen, 2015) examine what factors impact the usability of Healthcare IT Systems (HITS) development in Finland to understand the reasons for poor usability.

This study brings importance to extend aim the problem to a challenges in depploing usability aprouches to enssure good results in satisfation of healthcare ecosystems aplications and mitigate adverse events on criticais interfaces.

2.1.2 Research Questions

Based on the objective of this review, the following question helps to identify primary studies that highlight the challenges faced in adopting usability approaches in the healthcare ecosystem highlighted in the literature:

- **RQ1:** *What main challenges are faced when applying approaches that aim to improve the usability of healthcare ecosystems applications?*

Based on the central question, other secondary question was raised to help understand the problem, as follows:

- **RQ2.** *What approaches are faced to mitigate these challenges in the context of the healthcare ecosystem ?*
- **RQ3.** *What are the UX artifacts most used to address usability problems and mitigate adverse patient safety events?*

The aim of her PhD research was accordingly to study what factors impact the usability of HITS as well as the user participation in HITS development in Finland and focus on User-centred design methods in order to achieve good usability. The main viewpoint of that study are "user" and how improve its involvement to solve usability issues, but this research aims to extend the problem to other perspectives, beyond the user's point of view, that's why we need to investigate challenges and deep to ensure good usability in ecosystems health.

Between summer 2013 to autumn 2015, Martikainen(Martikainen, 2015), carried a literature reviews while in this study we made searches by a systematic literature review between the year 2013 and July 2023, to identify usability challenges on healthcare ecosystens, as well, its approaches and contributions factors, and possible solutions for challenges not addressed.

2.1.3 Search Strategy

At this planning stage, a search protocol is defined to collect related primary studies that are relevant to this subject.

The main electronic databases were searched, such as: IEEE Xplore, Scopus, ACM, Science Direct and PUBMED, and were used to obtain relevant articles on the researched topic. The most relevant keywords for the topic were used together with the Boolean operator "AND" to obtain articles from different areas and the operator "OR" to expand the coverage of these areas as defined on Figure 2.

2.1.4 Study Selection Strategy

Once the works in the databases are identified, this step filters the possibly relevant works that can answer some of the research questions proposed in this study (Kitchenham et al., 2015).

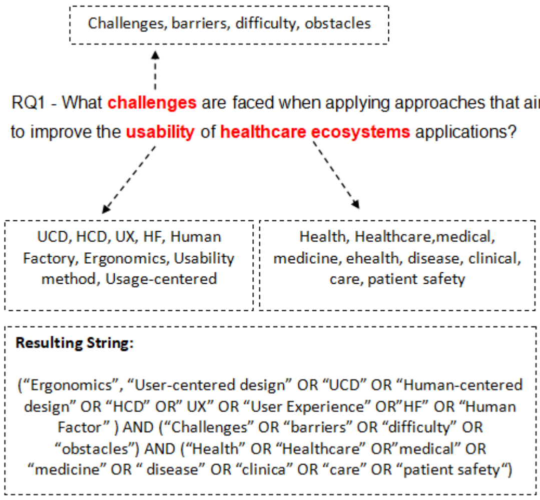

Figure 2: Search string construction (based on Silva et. al. (da Silva et al., 2014)).

Table 1: Selection process.

Scope	String
StudyContext	UCD, Usage-centered, usability, Ergonomics ,Human Factors, user,Usability method
Fields of study	Healthcare, health, medical, medicine, disease Health, clinical, care, patient safety
Study Type	Conference, Jornals
Aspect ofstudy	Challenges, difficulties, barriers, complications, obstacles,issues, failures
Source	IEEE Xplore, Scopus, ACM, PUBMED, Science Direct
Language	English

The Inclusion Criteria Are:

1. Papers published between the years 2023 and 2024
2. Papers that are related to Usability in healthcare ecosystems;
3. Papers that present, in the title or abstract, terms related to Usability in healthcare ecosystems;
4. Papers that identify approaches that may positively or negatively influence Usability in healthcare ecosystems;
5. Papers that identify methods or practices that may positively or negatively influence Usability in healthcare ecosystems.

The Exclusion Criteria Are:

1. Papers that not are related to Usability in healthcare ecosystems;
2. Papers that not present, in the title or abstract, terms related to Usability in healthcare ecosystems;
3. Papers that not identify approaches that may positively or negatively influence Usability in healthcare ecosystems;
4. Papers that not identify methods or practices that may positively or negatively influence Usability in healthcare ecosystems;
5. Incomplete papers;
6. Fulltext is not available;
7. Duplicate papers;
8. studies not published in English;
9. Studies that were not available online;
10. Studies that are not based on research and that express only official opinions from governments and experts from the area;
11. Notice of works, prefaces, conference proceedings, handouts, summaries, panels, interviews and reports.
12. Papers which do not meet the quality criteria.

2.1.5 Method to Check the Quality of the Studies

Assessing the quality of the primary studies identified in the previous step is essential to ensure that low quality studies do not reach the data synthesis stage (Kitchenham et al., 2015).

There are several methods to evaluate the quality of primary studies and checklists are commonly used for this purpose. There are several adaptations of these lists to be used in different fields of research (Kitchenham et al., 2015). Using the Critical Appraisal Skills Program (CASP) checklist, (Dybå and Dingsøyr, 2008) developed a quality list. This list has eleven questions that are presented below:

1. Is the paper based on research (or is it merely a “lessons learned” report based on expert opinion)?
2. Is there a clear statement of the aims of the research?
3. Is there an adequate description of the context in which the research was carried out?
4. Was the research design appropriate to address the aims of the research?
5. Was the recruitment strategy appropriate to the aims of the research?
6. Was there a control group with which to compare treatments?
7. Was the data collected in a way that addressed the research issue?
8. Was the data analysis sufficiently rigorous?
9. Has the relationship between researcher and participants been considered to an adequate degree?
10. Is there a clear statement of findings?
11. Is the paper of value for research or practice?

To answer the questions in the list we used annotation of 1 for yes and 0 for no. During the analysis, when the first question obtained a value of 0, the analysis of the work was interrupted, and the work did not proceed to the synthesis phase. According to (Dybå and Dingsøyr, 2008), another example that can exclude a job from the synthesis is if questions two and three get the value 0 simultaneously.

2.1.6 Strategy for Extracting Data

We first classified the types of research following the classification proposed by Wieringa et. al (Wieringa et al., 2005). Then, we classified the type of study according to Tonella et al. (Wieringa et al., 2005). Lastly, we extracted the following data: (1) Usability challenges in healthcare ecosystems; and (2) Year of publication.

2.1.7 Strategy for Synthesizing Data

The challenges found in the selected studies were categorized in a deductive way. This study was based on the systematic review carried out by Vandekerckhove et al (Vandekerckhove et al., 2020) which evaluated electronic health interventions. Research by Vandekerckhove et al (Vandekerckhove et al., 2020) identified participatory design methods in empirical eHealth studies for further development of the methodology.

We analyze the selected works following your representation. However, the categories were complemented by inductive categories that emerged from the review of the material. The categories can be termed as “factual categories” according to Kuckartz (Kuckartz and Rädiker, 2019), designating specific facts in the included studies.

3 CONDUCTING AND DOCUMENTING

3.1 Select Studies

Our study selection process comprised three activities. In the first activity, the search string defined in Figure 2, returned 1370 results.

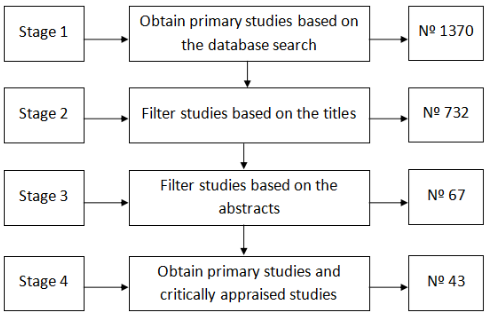

Figure 3: The filtering process of the papers (adapted from (da Silva et al., 2014) (Alves et al., 2016)).

After that, evaluating the titles and abstracts of the papers found a total of 67 studies corresponding to the inclusion criteria and thus moved to the third phase. In this phase, 43 studies were selected as answering at least one research question. The detailed list of selected studies can be found in Multimedia Appendix A. Table 2 shows the results obtained by each database.

Table 2: Summary of search results.

Database/Search engine	Search Results
Pubmed	833
IEEEXplore	211
ACM Digital	130
Science Direct	93
Scopus	63
Springer	40
Total	**1370**

3.2 Quality Assessment

Figure 4 shows the total score obtained for each question in the quality list.

The criteria of objectives, context of the research, conclusions and value of the research obtained a maximum grade in the evaluation.

However, forty three studies justified the selection of the research public cause having obtained answer 1 on question one and seven studies were eliminated after having obtained answer 0 in question one (Middleton et al., 2013),(Hettinger et al., 2021),(Alon and Torous, 2023),(Carayon and Salwei, 2021),(Catchpole et al., 2021),(Schumacher and Jerch, 2012),(Lowry et al., 2012). Full metadata Quality Assessment from selected studies can be found in Multimedia Appendix B.

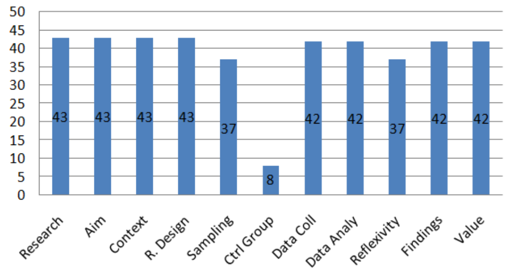

Figure 4: Total obtained by quality questions (based on (Dybå and Dingsøyr, 2008)).

3.3 Extract Data

We started our data extraction by classifying the selected primary studies, according to Wieringa et. al. (Wieringa et al., 2005). In our analysis, there was a predominance of studies that propose a solution technique with eleven studies. According to (Wieringa et al., 2005), these studies should propose a technical solution and justify its relevance through validation or a good set of references. Then came the studies of validation research with five studies, evaluation research with four, philosophical and experience papers each one with two studies. Finally, one paper to experience papers, as show in Table 3.

Table 3: Types of research (based on Wieringa et. al. (Wieringa et al., 2005)).

Method	Result
Case Study	13/43 (30.23%)
Observational Study	13/43 (30.23%)
Action Research	12/43 (27.91%)
Cross-Sectional	2/43 (4.65%)
Experience report	1/43 (2.33%)
Comparative	1/43 (2.33%)
Not Specified	1/43 (2.33%)

Following our extraction protocol, we consolidate the demographic information of the studies according to Tonella et. al. (Tonella et al., 2007). We grouped Case Study and Observational Study totaling 30,23% each one. Action Research totaling 27,91% of studies. Other methods together represent 11,64% of studies, according to the (Tonella et al., 2007) approach.

In our study we analyzed studies from 2014 to december of 2024, with the distribution of studies throughout years presented in Table 4.

Table 4: Distribution of studies by year.

Year	Number	Percent
2024	11	26%
2023	7	16%
2022	6	14%
2021	6	14%
2020	4	9%
2019	2	5%
2018	3	7%
2017	2	5%
2015	2	5%
Total	43	100%

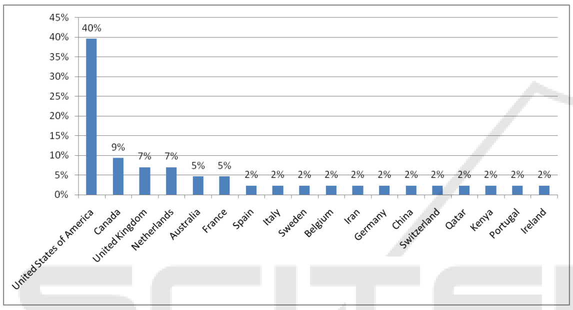

Figure 5: Distribution of studies per country.

We observed in the year 2021 had the highest incidence of studies with 22% related to this research topic. Also, there was at least one qualifying study each year.

3.4 Synthesis Protocol

To answer RQ1, we conducted a thematic analysis. We followed the process described by Braun and Clarke (Braun and Clarke, 2006) as detailed below:

1. **Familiarising Yourself with Your Data.** Braun and Clarke (Braun and Clarke, 2006) introduce two important concepts: data corpus and data set. Data corpus refers to all data used for an analysis; And the data set may correspond to a particular topic of interest within the data corpus; in our case, the studies to include Usability challenges.
2. **Generating Initial Codes.** After an initial reading of the primary studies, the first codes emerged. We analysed the studies in two rounds. First, all the studies were analysed, generating a list of 231 codes. Second, another reading was performed. Finally, 122 codes were generated in this step
3. **Searching for Themes.** At this stage, the codes generated in the previous step were refined and duplicate items and items from the same context were removed, resulting in a list of 122 challenges. These challenges were analyzed again and grouped into 21 themes.

   All selected code faced challenges in application approaches that aim to improve usability of healthcare ecosystem applications. The present study identified 122 challenges and for a better presentation of them, we grouped them into 21 main challenges themes.
4. **Reviewing Themes.** According to Braun and Clarke(Braun and Clarke, 2006), the themes identified in the previous step should be refined in two levels. First, perform an analysis of all the codes within each theme, checking if the codes should belong to that theme. In addition, one must analyse whether the codes generate a coherent pattern for the construction of a theme.

   In the second level of analysis, Braun and Clarke (Braun and Clarke, 2006) define that “at this level, you consider the validity of individual themes in relation to the data set, but also whether your candidate thematic map “accurately” reflects the meanings evident in the data set as a whole”. From our initial list of themes defined in the stage three, we observed a strong relationship between two themes, “lack of academic studies on this topic”, and “lack of secondary study on the topic”. In this way, we grouped the two themes. The theme “Lack of academic research on the topic” has emerged.
5. **Producing the Report.** The identified themes are presented in the section 4.2.

4 RESULTS

In this section, we first provide an overview of the studies included in this work. We finish the section presenting the results of this SLR, according to our three research questions.

4.1 Overview

The initial search was done using a general search string as show on Figure 2 in every relevant base and resulted in a total of 1370 hits (PubMed:n=833, 61%; IEEEXplore:n=211, 15%; ACM Digital:n=130, 9%; Science Direct:n=93, 6.70%); Scopus:n=63, 5%); Springer :n=40, 3%). From the 43 primary studies analyzed, 26% 11/43) of them were published in 2024, 16% (7/43) in 2023, 14% (6/43) in the year 2023, as show in Table 4.

Regarding the type of venue, 91% (39/43) were published in journals, and 9% (4/43) were published in conferences.

4.2 RQ1: What Main Challenges Are Faced when Applying Approaches that Aim to Improve the Usability of Healthcare Ecosystems Applications?

After applying the thematic analysis process presented in synthesis protocol 3.4 session, twenty-one themes representing challenges in healthcare ecosystems applications studies have emerged.

To answer RQ1, our study identified three large thematic areas with the greatest number of challenges: **Usability Process and Integration**, **technical Issues** and **Knowledge and Conceptual Gaps** , concentrating 37.70% of the challenges that need to be addressed, as as shown in table 5.

Also, 13 challenges were identified related to the lack of **Knowledge and Conceptual Gaps** about usability evaluation in healthcare projects, also related to the understanding of nomenclatures and processes in the healthcare application ecosystem

The **Usability Process and Integration**, which addresses problems in applying usability methods and approaches, point to 19 challenges that need to be addressed. Another major thematic area with challenges is related to **technical issues**, which highlights challenges in product artefact that point to usability errors, which highlights 14 challenges.

All other thematic areas and their respective challenges can be found in Appendix C of this work.

4.3 RQ2:What Approaches Are Faced to Mitigate These Challenges in the Context of the Healthcare Ecosystem?

In our research, many works addressed the solution of usability challenges such as those of Gettinger and Zayas (Gettinger and Zayas-Cabán, 2021) , which proposes including UCD processes to address usability challenges *"fund research to examine the effectiveness of usability policies including UCD processes employed by health IT developers"*.

Also, Ratwani et al, propose to address usability challenges for a user-centric approach(Ratwani et al., 2018a) *"Use of user-centered design approach"*.

Table 5: Number of challenges by themes.

Themes	Challenges
USABILITY PROCESS AND INTEGRATION	19
TECHNICAL ISSUES	14
KNOWLEDGE AND CONCEPTUAL GAPS	13
WORKFLOW SIMPLIFICATION	8
TRAINING AND AWARENESS	7
RESEARCH LACK	5
RESOURCE LIMITATIONS	5
SYSTEM AND IMPLEMENTATION CHALLENGES	5
ACCESSIBILITY	5
NEW APPROACH ADOPTIONS	5
LACK OF USABILITY APPROACHES	5
DOCUMENTATION	5
REGULATORY COMPLIANCE AND CERTIFICATION	5
RISK MANAGEMENT	4
USABILITY MEASUREMENT	4
COMMUNICATION AND COLLABORATION	4
ENVIRONMENTAL LIMITATIONS	3
ETHICAL AND DATA PRIVACY	2
LEADERSHIP AND ORGANIZATIONAL SUPPORT	2
LACK OF TRANSPARENCY	1
CONSISTENCY	1
Total	**122**

In table 6 we list the most used approaches in the papers selected by this literature review. The User-Centered Design (UCD) approach was the most used among the studies, showing that 60% of the studies adopt the culture of user-centered design as the main method to improve the usability and UX of healthcare applications.

Table 6: approaches must used to address UX challenges in healthcare context.

Approuches	Ocorrences
User-Centered Design (UCD)	26/43 (60%)
Usability Evaluation	13/43 (30%)
Iterative Design Processes	11/43 (26%)
Think-Aloud Protocol	10/43 (23%)
Human-Centered Design (HCD)	9/43 (21%)
Participatory Design	9/43 (21%)
Heuristic Evaluation	9/43 (21%)
Human Factors Engineering (HFE)	3/43 (7%)
Cognitive Walkthrough	2/43 (5%)
Feedback Mechanisms	2/43 (5%)
Risk-Based Usability Testing	1/43 (2%)
Scenario-based Evaluations	1/43 (2%)
SEIPS Model	1/43 (2%)
Workflow-Based Design	1/43 (2%)
DEMIGNED Principles	1/43 (2%)
Cognitive Systems Engineering	1/43 (2%)
Remote Testing and User Conferences	1/43 (2%)
Formative and Summative Testing	1/43 (2%)
Sociotechnical Framework	1/43 (2%)

In this paper all themes that categorize usability challenges in healthcare systems expands the surface area of the technical-social issues of usability and UX within the healthcare applications ecosystem, not just technical usability issues. It is also worth highlighting that the scope of issues that impact usability is wide and can be affected by processes, interpersonal relationships, compliance and privacy, risk management, accessibility and so one, as categorized in table 6.

In our study, we assessed in which phases of the software development life cycle (SDLC) healthcare product usability issues were addressed first.

4.4 RQ3:What Are the UX Artifacts Most Used to Address Usability Problems and Mitigate Adverse Patient Safety Events?

We identified that 53% of the papers used the "Think-Aloud Protocols" tool to evaluate their healthcare software products em improve usability to mitigate patient hazards as demonstrate on table 7.

Table 7: UX artifact occurrences.

UX artifact	Ocorrences
Think-Aloud Protocols	23/43 (53%)
System Usability Scale (SUS)	20/43 (47%)
Feedback Summaries	20/43 (47%)
Heuristic Evaluation Reports	19/43 (44%)
Prototypes	17/43 (40%)
Task Analysis	16/43 (37%)
Usability Test Reports	13/43 (30%)
Wireframes	3/43 (7%)
Personas	3/43 (7%)
Interviews	2/43 (5%)
User Flows	2/43 (5%)
Satisfaction Questionnaires	1/43 (2%)
Computer System Usability Questionnaire (CSUQ)	1/43 (2%)
Design Workshops	1/43 (2%)
Mockups	1/43 (2%)
Use Cases	1/43 (2%)
Logic Models	1/43 (2%)
Focus Groups	1/43 (2%)
Scenarios	1/43 (2%)
Research Reports	1/43 (2%)
User Experience Questionnaire (UEQ)	1/43 (2%)
Card Sorting	1/43 (2%)
Delphi Questionnaires	1/43 (2%)

Also, "System Usability Scale (SUS)" and "Feedback Summaries" have a significant participation in the improvement of healthcare software products with 47% each one.

All other tools and their occurrences on selected academic works can be consulted in table 7.

5 DISCUSSION

This systematic review highlighted Challenges and Approaches to Enhance Usability in Healthcare Applications.

Ratwani (Ratwani et al., 2018b) explores usability-related challenges in Electronic Health Records (EHRs) within pediatric settings and their impact on patient safety. By analyzing 9,000 patient safety event reports from three healthcare institutions, the study identifies key usability issues contributing to medication errors and adverse events in pediatric care.

This study highlights the importance of usability to mitigate adverse events and increase patient safety against harm to their health.

They identified usability challenges in EHR systems in pediatric healthcare and determined how these challenges contribute to medication errors and adverse events. Also propose strategies to address usability challenges to improve patient safety.

They grouped the challenges into 4 themes: systems feedback, visual display, data entry and workflow support.

Ratwani (Ratwani et al., 2018b) main findings point out that system feedback issues were responsible for 82.4% of reported usability challenges. Other challenges included visual display issues (9.7%), data entry difficulties (6.2%), and workflow integration issues (1.7%). Furthermore, inadequate dosage errors represented 84.5% of medication errors. 18.8% of events related to usability reached the patient; 3.3% caused temporary damage or required monitoring.

Below we will discuss the main findings. To do this, we will consider the 4 most relevant groups/themes of challenges.

5.1 Challenges in Usability Process and Integration

We identified 19 challenges related to the difficulty in executing processes and integration between different approaches that guarantee good usability in health systems.

Ratwani (Ratwani et al., 2015), investigates the usability challenges of electronic health records (EHRs) and evaluates the user-centered design (UCD) processes employed by vendors. It categorizes vendors based on their UCD practices and identifies barriers to implementing effective UCD methodologies.

Ratwani (Ratwani et al., 2015), mention out the challenges in conducting detailed clinical workflow studies, highlighting the **difficulty for healthcare solution providers in understanding the flow of livestock activities in the healthcare ecosystem**, when he says: *"Vendors in this category overwhelmingly described the difficulties to conduct detailed, contextually rich research. workflow studies across different subspecialty clinical disciplines"*. He also points out challenges in recruiting participants for usability studies, *"specific resource challenges include difficulties recruiting participants ("it is a real challenge to get participants")*".

It also makes reference to the challenge of including expert personnel in the usability process, which in many healthcare application providers is neglected as says: *"Vendors in this group typically employ a few usability experts, but the usability personnel face specific challenges that will need to be overcome in order for a more rigorous UCD process to be employed"* and *"These vendors generally do not have usability experts on staff, and the leadership of these vendors often lacks an appreciation for UCD"*.

Lloyd, (Lloyd et al., 2023), examines the usability of electronic medical records (EMRs) in Australian hospitals. The article explores physicians' and nurses' perspectives on EMR implementation, highlighting usability challenges and their impact on clinical workflows, communication, and patient care.

Paper show challenges to integration providers and clinical workflows needs, *"The current systems require the clinician to change his [or] her workflow/practice/ processes to accommodate the system, rather than the system accommodating the user"*

Goerss, (Goerss et al., 2024) examines the feasibility and value of involving people with dementia in the user-centered design (UCD) of a smartwatch-based intervention. The study focuses on usability, user preferences, and the effectiveness of involving people with mild cognitive impairment or dementia in the design process. Through iterative feedback, the research identifies design improvements and highlights challenges in usability for this population. In that paper, he finds challenges in understanding tasks when participants occasionally had difficulty understanding instructions, requiring clearer guidance and design refinements. *"We found that incomplete or irregular fulfillment of tasks was not recognized by the concerned participants"* and *"Some participants struggled with the Likert scale, which might be avoided by guiding them or modifying the questionnaire"* .

Harte, (Harte et al., 2017) presents a structured Human-Centered Design (HCD) approach for developing a smartphone app in a connected health system targeting older adults. The app integrates with wireless insoles to assess fall risks and detect falls. Through iterative phases of usability evaluation and redesign, the study emphasizes optimizing the interface for older adults, addressing usability challenges, and improving user satisfaction and system performance.

Harte points to a challenge of user-centered design processes. *"HCD is a multi-stage process that allows for various iterations of a design and subsequent update to the requirements. The importance* *of involving end users in the design process of health products is recognized, and different approaches have been demonstrated in literature"*.

5.2 Challenges in Technical Issues

We identified 14 challenges involves to moderating sessions, observing user behavior, collecting feedback, and handling technical issues.

Kato (Kato et al., 2024) presents the implementation and evaluation of a 5-type Health Information Technology (HIT) safety classification framework by the Veterans Health Administration (VHA). The study focuses on categorizing HIT patient safety concerns and improving risk mitigation strategies. By analyzing 140 patient safety issues from the VHA's Informatics Patient Safety (IPS) database, the classification system demonstrates its utility in standardizing safety issue identification, enabling actionable responses, and supporting organizational learning in a high-reliability healthcare organization (HRO). This paper cite **Challenges with hybrid medical record systems** - *"Issues included notification problems and functional defects such as duplicate orders"*.

Goerss (Goerss et al., 2024) examines the feasibility and value of involving people with dementia in the user-centered design (UCD) of a smartwatch-based intervention. The study focuses on usability, user preferences, and the effectiveness of involving people with mild cognitive impairment or dementia in the design process. Through iterative feedback, the research identifies design improvements and highlights challenges in usability for this population. This paper cite **"Issues with notifications and account management"** - *"Participants showed a wish for less obtrusive notifications and dislike toward a watch that was very conspicuous but also stated a wish for speech output"*.

Meidani (Meidani et al., 2024) evaluates the usability and quality of the "Head Computed Tomography Scan Appropriateness Criteria (HAC)" mobile application, designed to assist physicians in ordering head CT scans. The evaluation uses a mixed-methods approach, incorporating usability testing, the Mobile Apps Rating Scale (MARS), and debriefing sessions to identify strengths and usability issues. This papar points to challenges to **Touch interaction** - *"Some participants expected more predictive capabilities..."*.

McMullan (McMullan et al., 2023) examines the development and usability testing of the PROmicsR ePRO system designed for patients with inflammatory diseases, focusing on its application in the POLARISE clinical trial. The research highlights technical and usability challenges encountered during testing, evaluates the system's feasibility for clinical deployment, and incorporates feedback to refine the system for subsequent trials. That paper mention **Hardware and technical limitations** - *"Two participants failed at the outset due to an outdated operating system and compatibility issues"*.

5.3 Challenges in Knowledge and Conceptual Gaps

Some findings, 13 in total, are related to knowledge challenges and conceptual gaps in how to apply usability or UX methods and practices, these challenges involve training deficiencies, lack of learning capacity, guideline limitations and so on.

Lloyd, (Lloyd et al., 2023), mention **Issues with design and learnability** - *"Non-intuitive. So many steps to complete one task"*.

Ghorayeb, (Ghorayeb et al., 2023) focuses on developing and validating a new usability scale specifically tailored for clinical decision support systems (CDSS). The HSUS aims to address usability challenges unique to clinical contexts, enabling the early identification of potential issues that may impact patient safety and workflow integration.

Usability metrics and guidelines limitations - *"The SUS and existent scales are not reflective of the usability in the real world as it does not consider the context of use"*.

For McMullan (McMullan et al., 2023), there is a **Limited reliance on training materials during usability testing** - *"Participants preferred consulting researchers rather than using the provided training manual"*.

Pruitt, (Pruitt et al., 2023) investigates usability challenges in the design of an electronic medication administration record (eMAR) system. Using scenario-based evaluations and qualitative thematic analysis, the researchers identified critical usability issues impacting nurse workflows and patient safety. The study underscores the need for iterative usability evaluations and process improvements to align eMAR functionalities with real-world nursing tasks.

For Pruitt, (Pruitt et al., 2023) there is a **Inability to document home medications** - *"Nurses lacked a mechanism to document medications not pre-listed in the eMAR"*.

For Harte, (Harte et al., 2017), there is a **Older adults struggle with modern touchscreen interfaces due to unfamiliarity and cognitive challenges** - *"The acquisition and comprehension of information from interfaces become more difficult as a person progresses into older age"*.

5.4 Challenges in Workflow Simplification

Workflow simplification specifies challenges related to interface navigation, presentation issues, and cognitive overload of healthcare professionals while operating the systems. This work found 8 challenges related to workflow simplification.

Heitkemper (Heitkemper et al., 2024) evaluates the usability of SHAREdash, a Tableau-based health equity dashboard developed for rural public health practitioners in the Northwestern United States. The usability evaluation, conducted in the third stage of the System Development Lifecycle (SDLC), assessed efficiency, satisfaction, and validity through think-aloud tasks and interviews with public health professionals.

Heitkemper **Lack of basic usability functions** - *"Users described navigating filters as cumbersome, particularly when searching for specific counties"*

Engelsma (Engelsma et al., 2024) examines the usability of digital health technologies (DHTs) designed for individuals living with dementia. It evaluates the DEMIGNED principles, which are tailored design guidelines for dementia-specific DHTs, using heuristic evaluation and think-aloud user testing on a mobile website for the Alzheimer Center Amsterdam. The study reveals gaps in usability evaluations and proposes refinements to the DEMIGNED principles based on user feedback.

In his exam, a challenge of **cognitive overload** was identified - *"A former excessive amount of information on a single page and in the menu (e.g. the number of subpages to choose from) not only can it burden users who live with cognitive problems problems, making it a challenge to process and re- content member, but also impair decision-making skills, hindering the ability to effectively filter the relevant information"*.

Kene (Kenei and Opiyo, 2022), explores the use of a classification and visualization model to support the review of clinical narrative texts in electronic health records (EHRs). By addressing the challenges of unstructured data in EHRs, the study presents a two-step approach: classification of clinical narrative texts into structured sections and visualization of these sections as a cluster map. The solution aims to improve information retrieval, support clinical decision-making, and reduce cognitive overload on healthcare providers.

In that paper **cognitive overload** is a great challenges as Engelsma, also points.

For Kene (Kenei and Opiyo, 2022), there is a **Cognitive Overload** due *"clinical notes that are stored in EHRs, present special challenges to analyzing them due to their unstructured nature"* and *"Although, clinical notes provide detailed information about the patient's condition, using them is a challenge"*.

Due to page limitations in this paper, all other challenges grouped by themes listed in the table 5 can be consulted in appendix C of this work.

5.5 Limitations

The focus of this research was on selected studies focusing on usability challenges faced in the healthcare product ecosystem.

The search process was performed using a limited set of keywords with the aim of providing an overview of usability challenges in healthcare. This research focused on publications for a finite period from 2014 to 2024. However, it explores several challenges faced by Usability/UCD/UX approaches used during all stages of software development.

5.6 Future Works

The conduction of SLR studies is at an early stage of research. We developed a research agenda that can be followed by the empirical community of SE. We believe that conducting such research may assist the process of conducting SLR studies.

5.7 Threats to Validity

We classified the threats of this study using the study proposed by Ampatzoglou et al. (Ampatzoglou et al., 2019) that provides a set of validity threats in review studies in the context of SE. Regarding the selection process of the studies, we used the guideline proposed by Kitchenham et al. (Kitchenham et al., 2015) to define our research protocol. Our search string was defined based on the definitions of primary studies based on Silva et. al. (da Silva et al., 2014), we would identify all published studies, which can be considered a limitation to the study. Selection of articles more specifically related to criteria of inclusion and exclusion, a threat of this study may be the establishment of criteria defined by only one researcher. However, its application was conducted by two researchers, and a third researcher mediated the conflicts. We observed that 80% of the studies analysed were published in important venues of SE, such as Journal of the American Medical Informatics Association, Journal of healthcare engineering, International journal for quality in healthcare, International Conference on e-Health Networking, Applications and Services and International Conference on Medical and

Health Informatics.

6 CONCLUSION

In this paper we conducted short SLR to identify main usability challenges in heathcare applications. We analysed a total of 43 primary studies published between 2014 and April 2024. We observed that the main challenges are related to usability process adoption and technical issues. There were others challenges related do **Research lack** as mentioned by Broekhuis et al (Broekhuis et al., 2021) *"In contrast, much research has been conducted to create generic instruments to obtain a rapid and very general assessment of the status of usability of systems, regardless of the system domain or context"*. Our study also addressed solutions to usability challenges in healthcare ecosystem products.

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APPENDIX

Multimedia Appendix A

Metadata of the included studies.
[PDF File , 106 KB-Multimedia Appendix A]

Multimedia Appendix B

Metadate of Quality Assessment.
[PDF File , 76 KB-Multimedia Appendix B]

Multimedia Appendix C

Metadate of Codes.
[PDF File , 257 KB-Multimedia Appendix C]