Advances in Requirements Engineering for Well-Being, Aging, and Health: A Systematic Mapping Study

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ABSTRACT

Context. The increasing focus on well-being, aging, and health (WBAH) is impacting various fields, including Requirements Engineering (RE). This is particularly relevant, as RE involves defining, documenting, and managing software system requirements to ensure that developed systems effectively address user needs. However, there remains a limited understanding of how RE practices can be tailored to create WBAH-centric systems. **Aims**. This study aims to explore the current landscape of RE practices used in the development of software systems that support WBAH. **Method**. We conducted a systematic mapping study, analyzing articles from reputable conferences and journals. **Results**. Our review identified 57 articles published between 2013 and 2024 that examine RE efforts related to specifying and documenting WBAH systems. The predominant topics discussed include usability and evaluation techniques, elicitation and modeling methods, security and privacy concerns for healthcare applications, and the adaptation of RE for specific populations, such as the elderly. **Conclusion**. This study highlights significant knowledge gaps that present opportunities for further investigation by RE researchers.

KEYWORDS

software requirements engineering, well-being, aging, health, systematic mapping study

1 Introduction

The increasing global focus on well-being, aging, and health is driven by demographic shifts, advances in healthcare technologies, and a deeper societal understanding of the importance of quality of life. The World Health Organization (WHO) has identified healthy aging and well-being as key objectives for sustainable development, stressing the need for systems that not only promote physical health but also support mental and social well-being across all life stages [16]. As populations age and health challenges become more complex, software systems play a pivotal role in addressing these needs. Requirements engineering (RE) is fundamental to ensuring that such systems are user-centered, effective, and adaptive to diverse needs.

Despite the growing recognition of the importance of wellbeing, aging and health (WBAH) solutions, there remains a significant gap in understanding how RE processes can best support the development of these systems. Prior studies have indicated that traditional RE approaches may not fully address the unique challenges posed by WBAH domains, such as the need for long-term care, accessibility, personalization, and ethical considerations [3, 7]. This gap highlights the necessity of systematic research that not only consolidates existing knowledge but also identifies emerging trends and opportunities in the RE community, particularly as they relate to WBAH.

Furthermore, rapid technological advancements and the widespread adoption of digital health solutions introduce new challenges for RE, including the need for interoperable systems that can integrate data across devices and platforms while maintaining usability for populations with limited digital literacy. The COVID-19 pandemic accelerated demand for telemedicine and remote monitoring tools, exposing gaps in requirements elicitation and validation for emergency contexts [6, 11]. These factors underscore the urgency for more agile and inclusive RE methods capable of addressing the dynamic complexities of WBAH systems—from design to deployment and continuous evaluation.

This study responds to that need by conducting a systematic mapping of the current state of research in RE for WBAH systems. By analyzing 57 papers, it provides an in-depth review of existing RE practices, empirical evaluations, and gaps in the literature. Our research is structured around five key research questions (RQs) that explore the core activities and trends in RE for WBAH solutions, the types of research being conducted, and the empirical evaluations available. Additionally, the study identifies untapped research opportunities, aiming to catalyze future work that will strengthen the connection between RE methodologies and the evolving demands of well-being, aging, and health systems. Given the study's focus on the evolution of RE practices themselves, we restricted our search to premier RE venues. This focus ensures methodological consistency and enables tracing how RE researchers have approached WBAH over time.

Our results indicate that all RE activities have been utilized in the development of WBAH applications, with requirements elicitation being the most frequently employed. The primary research topics identified are Healthcare & Telemedicine and Inclusion & Accessibility, with Healthcare & Telemedicine being the most commonly addressed, especially during the requirements elicitation and analysis stages. Furthermore, solution proposals represent the

predominant type of research conducted, though there is a notable need for more studies in the areas of philosophical and opinion papers. We also found that the majority of solutions developed for WBAH have been evaluated through case studies.

We compiled all findings from this study into an evidence briefing. This resource is designed to help researchers and practitioners advance knowledge and guide future research and practices in the WBAH field.

The remainder of this paper is organized as follows: Section 2 provides background information and discusses related work on RE and WBAH systems. Section 3 outlines the overall objectives of our research, introduces our RQs, and details the data collection process and the criteria used for selecting the articles analyzed. Section 4 presents the results, further discussed in Section 5. Section 6 addresses the threats to validity. Finally, Section 7 provides conclusions of the study.

2 Requirements Engineering and Wellness, Aging, and Health Systems

WHO defines health as a state of complete physical, mental, and social well-being, rather than simply the absence of disease or infirmity [11]. Expanding on this holistic perspective, Miller [10] conducted an extensive study on well-being, examining essential factors such as physical, social, intellectual, demographic, mental, spiritual, emotional, occupational, and self-esteem in the well-being model that author proposed.

WBAH are essential concepts that play a critical role in daily life for individuals in society. Recently, there has been a notable increase in software professionals dedicated to developing advanced technological solutions for WBAH systems. These systems aim to provide personalized approaches that encourage behavior change, reduce health risk factors, and enhance the overall well-being of the population. However, despite their rising demand, many of these systems encounter significant challenges in RE, including diverse stakeholder profiles, complex requirements, and evaluation difficulties. Levy et al. [7] argued that the development of improved RE methods and tools tailored specifically for WBAH systems is crucial. Such tools can effectively address the complexity and uncertainty of requirements, ultimately enhancing the effectiveness of these systems and promoting health and well-being for individuals across all age groups [7].

In the rapidly evolving landscape of healthcare, technological advancements are crucial. Ghassemi et al. [6] emphasized that the integration of artificial intelligence (AI) into medicine has significant implications for patient care, offering substantial benefits in the years to come.

Richardson et al. [13] introduced generic requirements models tailored to distinct cohorts, emphasizing the importance of integrating human-centered elements in the development of digital healthcare software. These models enable developers to effectively meet the unique needs of specific groups, such as individuals with intellectual disabilities and older adults. The authors advocate for future research aimed at establishing generic hierarchies of requirements to identify patterns that can benefit various user groups. They acknowledge their study's deliberate emphasis on non-functional requirements and stress the critical need to explore essential aspects such as reliability, scalability, security, and privacy in greater depth [13].

To the best of our knowledge, no study has yet explored the state of RE practices for WBAH applications. In this study, we operationally define WBAH as comprehensive systems that aim to improve physical, mental, and social well-being through digital or sociotechnical interventions, particularly those that address challenges related to population aging and health contexts. This topic warrants investigation, as it could inspire new research initiatives aimed at developing software engineering techniques specifically designed to support WBAH application development. This research gap is the focus of this paper.

3 Research Method

Our primary research objective is to **characterize the application of software RE in the development of well-being, aging, and health systems**. To accomplish this, we have formulated the following RQs:

- ***RQ1****: Which RE activities have been adopted?* We aim to provide an overview of the RE activities utilized in developing WBAH solutions. To categorize these activities, we refer to the definitions outlined in the IEEE Recommended Practice for Software Requirements Specifications [1].
- ***RQ2****: What are the main research topics investigated?* Our goal is to outline the key RQs addressed in the technical literature, highlighting advancements in RE for WBAH.
- ***RQ3****: What types of research have been conducted?* To categorize the various research types, we utilize the framework proposed by Wieringa et al. [14], which includes evaluation research, solution proposals, validation research, philosophical papers, opinion papers, and experience papers.
- ***RQ4****: What types of empirical evaluations have been performed?* This question seeks to identify the empirical evaluation methods (*e.g.*, case studies, controlled experiments, and surveys) used to validate the solutions.
- ***RQ5****: What research opportunities can be identified?* Here, we aim to highlight existing research gaps in the literature to guide future research efforts in RE for WBAH.

To address the RQs, we conducted a systematic mapping study. This approach is a valuable method for secondary research, providing a structured procedure that allows for the thorough examination of various research reports and their associated results, thereby facilitating the analysis of specific RQs [12]. In this section, we outline our systematic mapping protocol, detailing the data collection and analysis procedures in accordance with the guidelines provided by Petersen et al. [12].

3.1 Data Collection

Given our interest in understanding advancements in RE for well-being, aging, and health, we focused on premier venues in the field of RE. Our study included all articles published between 2013 and 2024 in the following conferences and journals:

- IEEE International Requirements Engineering conference[1] (RE).
- International Working Conference on Requirement Engineering: Foundation for Software Quality[2] (REFSQ).
- International Workshop on Requirements Engineering for Well-Being, Aging, and Health[3] (REWBAH).
- Requirements Engineering Journal[4] (REJ).
- Workshop on Requirements Engineering [5] (WER).

Although we did not consider broader databases like Scopus or Web of Science, we opted for a venue-based approach to ensure that we covered studies that explicitly discuss RE methods. This decision provides a coherent analytical baseline for comparing practices within the RE community. As we collected all papers from the selected venues, no keyword-based search string was used. Instead, a manual inspection of all papers was conducted to ensure comprehensive coverage.

In total, we collected 1,095 articles. We then applied the inclusion criteria (ICs) and exclusion criteria (ECs) outlined in Table 1 to filter the studies.

Table 1: Inclusion and exclusion criteria

Criterion	Description
IC1	A primary study that describes how RE is applied in the development of well-being, aging, and health systems.
EC1	Articles not written in English.
EC2	Articles not published in REFSQ, RE, REWBAH, WER, or REJ.
EC3	Articles not published in research or industry tracks.
EC4	Articles published before 2013.

The study selection process involved a review of the identified articles by two researchers. Initially, each researcher independently analyzed the articles by reviewing their titles and abstracts, considering the inclusion criteria (ICs) and exclusion criteria (ECs) outlined in Table 1 to identify articles that aligned with the study's goals. Following this initial analysis, the researchers compared their findings in a consensus meeting. To assess the level of agreement between the two researchers, we calculated Cohen's Kappa coefficient [9]. This coefficient produces a value, κ, ranging from [-1, +1], with -1 indicating complete disagreement and +1 indicating complete agreement. Since the threshold for high agreement can vary by field [9], we adopted a threshold of $\kappa \geq 0.79$, as is standard in software engineering studies [8]. Our analysis yielded a κ value of +0.841, indicating a high level of agreement between the researchers. In cases where disagreements or uncertainties arose regarding the inclusion of specific articles, a third researcher was consulted to reach a consensus.

The data extraction process involved capturing various fields, including the year of publication, authors' information, and responses to each research question. An overview of the data extraction procedure is presented in Table 3, detailing how relevant data was systematically collected from each paper. After applying the inclusion and exclusion criteria, we narrowed our selection to a pool of 57 articles out of the initial 1,095. Table 2 summarizes the number of included and excluded articles by venue.

Table 2: Included and excluded articles by venue

Venue	Included articles	Excluded articles
REFSQ	3	265
REJ	3	250
REWBAH	33	2
RE	15	343
WER	3	178
Total	**57**	**1038**

Table 3: Data form extraction

Data	Description
Study metadata	Title, Authors, Venue and Year of publication
Requirements engineering activities (RQ1)	Name or short description of the activity
Research topics (RQ2)	Short description of the topic
Types of research (RQ3)	Classification based on Wieringa et al. [14]: evaluation research, solution proposal, validation research, philosophical paper, opinion paper, or experience paper.
Types of empirical evaluation (RQ4)	Empirical evaluation type: controlled experiment, case study, survey, proof of concept, or none.
Research opportunities (RQ5)	Short description of the research opportunity

3.2 Data Analysis

One researcher thoroughly reviewed all 57 articles to extract data for answering the questions. Subsequently, another researcher examined the extracted data. Any discrepancies were resolved in a consensus meeting that included a third researcher.

To categorize the research topics, we analyzed each article's objectives and proposed contributions. We extracted the relevant sections containing this information and grouped the articles accordingly. To identify research opportunities, we followed a similar approach, focusing on the sections where the authors discussed future work in each article.

Upon examining each article's research topic and opportunities, we identified that they could be grouped into distinct categories. For instance, one paper discussing smartphone applications for older adults was categorized under Inclusion and Accessibility, while another focused on AI ethics frameworks for requirements analysis was classified as Intelligent Technology.

To uniquely identify each article, we assigned a distinctive identification code composed of the letter 'A' followed by a number, such as A1, A2, A3, and so on, up to A57.

[1] https://ieeexplore.ieee.org/xpl/conhome/1000630/all-proceedings
[2] https://link.springer.com/conference/refsq
[3] https://sites.google.com/view/rewbah2024
[4] https://www.springer.com/journal/766
[5] http://wer.inf.puc-rio.br/WERpapers/

4 Results

This section presents the results of the mapping study, derived from the information extracted from a total of 57 selected articles, which can be accessed in our complementary material [2].

4.1 Overview

Figure 1 illustrates the results and distribution of selected articles published between 2013 and 2024. The concentration of research in this domain has notably increased in recent years, with a significant surge in published articles occurring in 2020 and 2023. This increase coincides with the launch of the International Workshop on RE for Well-Being, Aging, and Health (REWBAH) in 2020.

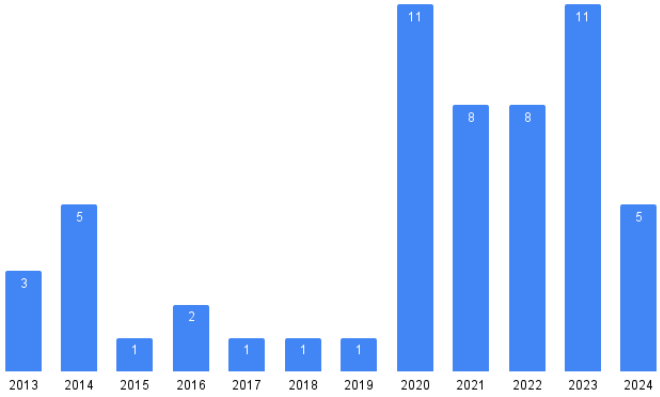

Figure 1: Distribution of papers per year

4.2 RQ1: Which RE Activities Have Been Adopted?

To address this question, we employed the IEEE Recommended Practice for Software Requirements Specifications [1] as a framework, categorizing each article according to the relevant RE activities. We acknowledged that an article could be classified into multiple categories of activities. Table 4 presents the distribution of articles across these RE activities.

From the table 4, it is evident that **requirements elicitation** and **requirements analysis** were the most commonly used activities in the development of WBAH solutions, followed by **requirements specification**, **requirements validation**, and **requirements evaluation**.

We also noted that fourteen papers addressed more than one activity, with their identifiers highlighted in bold in Table 4. For example, A49 focused on both *Requirements Elicitation* and *Requirements Analysis*, while A44 covered *Requirements Elicitation*, *Requirements Analysis*, and *Requirements Validation*.

> **Key finding 1.** We found evidence that all RE activities have been utilized in the development of WBAH applications, with *requirements elicitation* being the most frequently employed to date.

Table 4: RE activities identified in the articles. Articles' identification in bold indicate that they approached more than one activity.

Activity	Quantity of articles	Articles' identification
Requirements Elicitation	35	A3, A4, **A5**, **A6**, A8, A11, **A12**, A13, A18, A19, A22, A23, A24, **A26**, A27, A29, **A31**, A33, A36, **A38**, A40, A41, A42, **A44**, **A45**, A46, A47, **A49**, A50, **A51**, **A52**, A53, **A54**, **A55**, A56
Requirements Analysis	26	A1, A2, **A5**, **A6**, A9, A10, **A12**, A14, A20, A21, **A26**, A28, A30, **A31**, A32, A37, **A38**, A39, A43, **A44**, **A45**, A48, **A49**, **A51** **A55**, **A57**
Requirements Specification	13	**A5**, **A6**, A7, **A12**, A15, A16, **A26**, **A31**, A34, **A38**, **A45**, **A52**, **A57**
Requirements Validation	11	**A5**, **A6**, **A12**, A25, **A26**, **A31**, A35, **A38**, **A44**, **A45**, **A54**
Requirements Evaluation	8	**A5**, **A6**, **A12**, A17, **A26**, **A31**, **A38**, **A45**

4.3 RQ2: What Are The Main Research Topics Investigated?

To address this question, we determined the research topic of each article based on its objectives. After extracting these topics, we organized similar ones into the following broader categories:

- **Healthcare and Telemedicine**: This category includes 16 articles (A11, A16, A23, A24, A28, A29, A30, A32, A33, A34, A35, A39, A41, A42, A44, A54) that primarily focus on systems utilized in healthcare, as well as mobile applications designed to support patients and their treatments.
- **Inclusion and Accessibility**: Comprising 13 articles (A3, A4, A14, A15, A17, A18, A31, A36, A37, A48, A50, A55, A56), this category highlights accessible and inclusive software and systems designed for various demographics, including the elderly and people with disabilities.
- **Intelligent Technology**: Encompassing ten studies (A2, A6, A7, A25, A26, A45, A47, A49, A53, A57), this category explores the integration of machine learning, the Internet of Things, and intelligent assistants in the contexts of health, wellness, and aging.
- **Mental and Emotional Health**: This group consists of five articles (A10, A13, A22, A40, A52) that focus on mental and emotional well-being.
- **Human Interaction and Medical Communication**: Featuring six articles (A5, A19, A20, A21, A46, A51), this category emphasizes human interactions within healthcare and the well-being of healthcare professionals and individuals in other fields.
- **Patient Support and Follow-up**: This category aggregates seven studies (A1, A8, A9, A12, A27, A38, A43) that present solutions aimed at clinical follow-up and support for patients.

Most of the analyzed articles were categorized under *Healthcare & Telemedicine*, totaling 16 entries. This was followed by the *Inclusion & Accessibility* category, which included 13 papers. *Intelligent Technology* featured ten articles, while *Patient Support & Follow-up* had seven. The category of *Human Interaction & Medical Communication* contained six articles, and *Mental & Emotional Health* had the fewest entries, with only five articles.

Key finding 2. Healthcare & Telemedicine and Inclusion & Accessibility have emerged as the primary topics of investigation in RE for WBAH applications.

We also examined the relationship between requirements activities and the identified research topics. Figure 2 presents a Sankey diagram illustrating these connections. It is evident that *Requirements Elicitation* is the most strongly associated activity, engaging with nearly all topics, particularly with greater intensity in *Healthcare & Telemedicine* and *Inclusion & Accessibility*. Additionally, *Requirements Analysis* shows a strong connection to several topics, especially in *Healthcare & Telemedicine*, *Intelligent Technology*, and *Patient Support & Follow-up*.

A44 exemplifies the integration of RE activities with prevalent research topics in the development of a health monitoring application by analyzing similar applications. The article highlights requirements elicitation, using data from application descriptions, user reviews, and source code to gather domain knowledge; Requirements analysis, building a domain feature model (DFM) to compare features, identify gaps, and evaluate solutions; and Requirements validation, using the DFM to engage stakeholders, verify features, and prioritize them based on user needs and feasibility.

Key finding 3. The most frequently addressed research topic has been Healthcare & Telemedicine, especially during the stages of Requirements Elicitation and Requirements Analysis.

4.4 RQ3: What Types of Research Has Been Conducted?

Wieringa et al. [14] proposed a classification schema for research conducted in RE, as outlined below:

- **Evaluation Research**: This involves investigating a problem in RE practice or implementing a specific RE technique.
- **Solution Proposal**: This category presents a new or significantly improved solution technique and argues for its relevance, although it may not yet be fully validated.
- **Validation Research**: This type examines the properties of a proposed solution that has not yet been implemented in practice.
- **Philosophical Papers**: These papers introduce a new conceptual framework or perspective, with evaluation criteria focusing on originality, soundness, and insightfulness.
- **Opinion Papers**: This category expresses the author's views on what is beneficial or problematic, including suggestions for improvement. Criteria for evaluation include the soundness of the argument, its potential to spark discussion, and whether the opinion is thought-provoking.
- **Personal Experience Papers**: These emphasize the "what" rather than the "why" and are often derived from the author's personal experiences with one or more projects.

Table 5 provides a detailed overview of the articles categorized by research type. With the exception of *philosophical papers*, we found evidence for nearly all types defined by Wieringa et al. [14]. The majority of articles presented *solution proposals*, followed by those that conducted *validation research* and *evaluation research*. Notably, papers A47 and A53 fall into the *Solution Proposal* and *Validation Research* categories, and therefore, it has been classified accordingly.

Key finding 4. The most common research type identified is Solution Proposal. However, the distribution of paper types does not necessarily need to be balanced. For impact and validity, a stronger presence of evaluation and validation studies, as well as a smaller number of philosophical or opinion papers, may be more desirable.

We also analyzed the relationship between research topics and research types, as illustrated in Figure 3. The *Solution Proposal* research type emerges as the most strongly connected, spanning a diverse range of areas with a total of 32 connections. It prominently focuses on all topics, particularly *Healthcare & Telemedicine*, *Inclusion & Accessibility*, and *Intelligent Technology*. Following this, *Validation Research* and *Evaluation Research* also demonstrate a significant presence in relation to these topics.

A24 illustrates a Solution Proposal in the realm of Healthcare and Telemedicine, employing a tailored applied cognitive task analysis approach to craft a novel emergency care device. Through the integration of digital workshops and expert interviews, the researchers pinpointed user requirements and obstacles, shaping an intuitive interface design. This iterative process demonstrated how customized methodologies can efficiently address limitations in emergency medical settings, promoting integrated solutions within the field.

Table 5: Articles organized by research type. Articles' identifications in bold indicate that they considered more than one research type

Type	Quantity of articles	Articles' identification
Solution Proposal	32	A1, A2, A4, A5, A6, A11, A12, A13, A14, A19, A20, A22, A24, A28, A29, A31, A33, A35, A36, A40, A41, A42, A43, A45, **A47**, A49, A50, A51, A52, **A53**, A54, A57
Validation Research	14	A8, A16, A18, A21, A25, A26, A32, A37, A38, A39, A46, **A47**, A48, **A53**
Evaluation Research	9	A3, A7, A9, A10, A15, A17, A44, A55, A56
Experience Paper	3	A23, A27, A34
Opinion Paper	1	A30

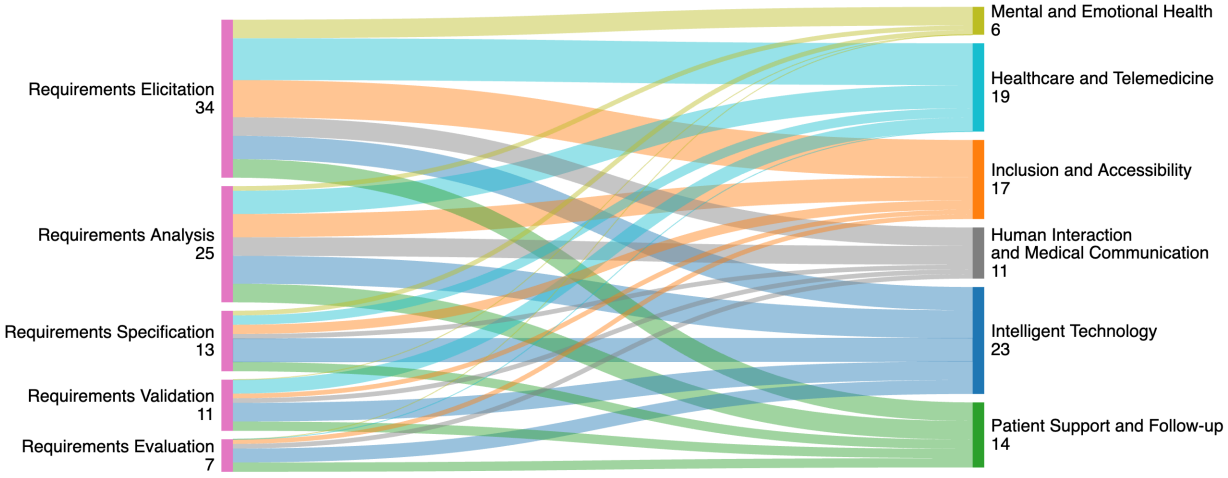

Figure 2: Relationship between RE activity and the research topics

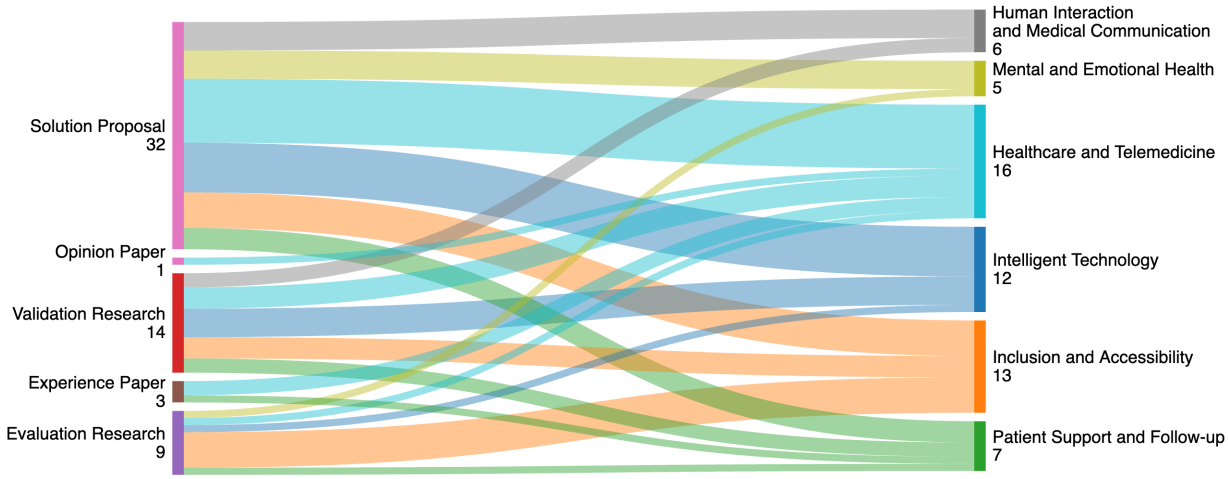

Figure 3: Relationship between research topics and research types

4.5 RQ4: What Types of Empirical Evaluation Have Been Performed?

Figure 4 illustrates the distribution of articles based on empirical evaluations. We identified empirical evaluations in 31 articles. Case studies were the most frequently employed method, appearing alone in 22 articles. Additionally, four studies combined case studies with other methods: two with a proof of concept, one with a survey, and one with interviews. Surveys were used as the sole method in two articles and were combined with interviews in one. Other methods included a standalone proof of concept, validation research, and standalone interviews, each reported in one article.

Key finding 5. The majority of solutions for WBAH have been evaluated through case studies.

4.6 RQ5: What Research Opportunities Can Be Identified?

We identified a range of research opportunities, which we have organized into the following categories:

- **Security and Privacy** (A1, A25, A35). A1 outlines three primary directions for future research: expanding the proposed protocol to address new hazards, conducting a more comprehensive evaluation with additional requirements engineers, and replicating the case study in other safety-critical domains, such as automotive and aeronautical systems. A25 investigates how intermediate feedback on safety issues in requirements can enhance overall software security through an industrial case study. Meanwhile, A35 suggests applying the SBE+Security approach to medical devices during the development phase to assess its effectiveness in defining safety requirements. These findings highlight a growing

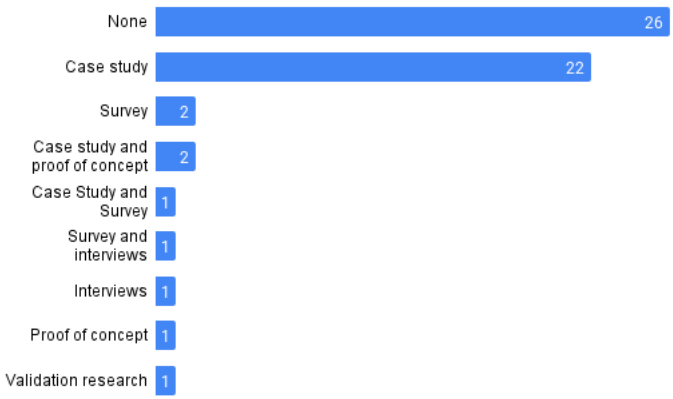

Figure 4: Distribution of Empirical Evaluations

need for integrating security and privacy requirements from the earliest stages of software development, particularly in healthcare systems where sensitive personal and clinical data are involved. Building on these findings, future research could explore the integration of security and privacy considerations throughout the software lifecycle, encompassing requirements elicitation, implementation, and evaluation.

- **Machine Learning and Data-Driven Approaches** (A30, A29, A43, A26, A53, A57). A30 advocates for establishing a dedicated area of focus on data-driven RE, emphasizing the automation of requirements extraction and alignment with strategic goals. A29 aims to enhance the requirements generation process by employing pruning techniques to minimize the number of generated executions. A43 presents a questionnaire-based approach to online patient monitoring that dynamically tailors interactions based on individual patterns. A26 explores various methodological approaches for applying modeling frameworks effectively. A53 details a comprehensive RE methodology for developing a LLM to automate the triage of digital medical inquiries. A57 proposes a tailored NFR framework to assess the health of software ecosystems through the extraction and evaluation of quantitative metrics from code repositories, reinforcing the role of data-driven methods in supporting decision-making. Future research can focus on advancing data-driven techniques to automate and streamline RE tasks while aligning them with strategic objectives in WBAH contexts. Moreover, leveraging AI and ML tools could enable real-time adaptation of requirements models based on continuous data from healthcare systems, improving responsiveness and personalization. Furthermore, the application of Large Language Models presents opportunities that can enable automated analysis of large datasets, user-centric requirements generation, and improved adaptability to the evolving needs of healthcare systems, presenting a promising area for innovation.
- **User Experience** (A19, A41). A19 seeks to develop a solution for online consultations that benefits both physicians and patients, alleviating stress for healthcare professionals while enhancing the quality of medical care. Additionally, A41 proposes creating a taxonomy of emotions to better capture users' reactions during software interactions and explores strategies for conducting emotional analysis. These studies emphasize the importance of emotional well-being in digital health systems, highlighting how stress, anxiety, and satisfaction impact both clinical outcomes and system usability. These studies suggest that future research could develop comprehensive solutions for improving user interactions in healthcare systems, particularly by addressing emotional responses and stress management in user experiences. New frameworks and evaluation methods could be designed to systematically measure emotional engagement and its influence on decision-making processes in digital health environments.
- **Usability and Evaluation** (A7, A8, A10, A13, **A3**, A56). A7 proposes to evaluate the usability of the proposed method in additional projects involving risk consultants. A8 aims to conduct a pilot study with 200 real users to explore new design requirements and clinical content. A10 is focused on developing and testing SAMS software, assessing its acceptance prior to a longitudinal study implementation. A13 suggests creating a comprehensive application to assess its impact over time. A3 examines the transformation of recommendations into design patterns tailored for companies, with an emphasis on developing applications for the elderly. A56 reports a case study where a self-assessment tool was used within an organization to evaluate and improve its maturity in handling accessibility requirements and the study demonstrates the applicability and impact of structured evaluation tools in real-world software processes. Overall, the opportunities identified in this category indicate that future research could concentrate on specific methodologies for evaluating the effectiveness and usability of technological solutions in real-world settings. Moreover, future work could develop standardized evaluation frameworks and multi-dimensional assessment tools capable of capturing not only usability but also clinical safety, emotional experience, and long-term system impact on users' quality of life.
- **Elicitation and Modeling Techniques** (**A3**, A23, A11, A33, A40, A49, A55). A3 investigates how to transform recommendations into design patterns for creating applications tailored to the elderly. A23 addresses the challenges of crowdsourcing requirements from experts in the field. A11 concentrates on translating refined flowcharts into a semiformal language suitable for medical decision support. A33 examines the applicability of the elicitation and modeling methodology across various healthcare domains. A40 intends to develop an interface for game developers that emphasizes therapeutic requirements. A49 proposes enhancements to User Stories by adding insights from patients' emotional experiences. Finally, A55 explores developers' perspectives on accessibility practices and requirements, uncovering gaps in education, training, and collaboration that impact how accessibility is elicited, documented, and implemented. Research in this category highlights the need for innovative

approaches to eliciting and modeling requirements, particularly in healthcare contexts, while integrating patient and user perspectives more deeply into the process. Emerging techniques such as conversational agents, virtual stakeholders, and AI-supported elicitation tools could be explored as new means of capturing more nuanced, contextualized, and emotion-sensitive requirements from diverse healthcare users and professionals.

- **Ethical and Human-Centric Considerations** (A12, A14, A15, A4, A18, A51, A52, A54). A12 focuses on designing accessible interfaces for older adults, while A14 explores how emotional goals link personal and organizational values, emphasizing inclusion. A15 proposes models capturing human aspects in software design. A4 serves as a foundational resource for ethical design tools that inform stakeholders about the ethical considerations essential in the design, development, and use of devices. A18 seeks to improve User Stories, ensuring they are more comprehensive and aligned with acceptance criteria. A51 introduces the first steps toward building a dictionary of emotional requirements specifically for healthcare and well-being systems, addressing the lack of standardized terminology and proposing a structured vocabulary to improve elicitation and stakeholder communication. A52 explores mental health professionals' perspectives on digital anxiety solutions in the UAE and proposes a conceptual framework that emphasizes cultural appropriateness, safety, accessibility, and user-centered features grounded in professional practice. A54 investigates user needs for a personalized medication platform aimed at preventing adverse drug reactions, revealing ethical concerns regarding data use, privacy, and personalization in health systems. The authors propose design guidelines that prioritize user agency and safety while anticipating the future integration of AI-based features. Together, these papers highlight the need for future research on the ethical and human values integral to software design and emerging technologies. Further studies could address conflicts between ethical principles and practical constraints in healthcare systems, propose decision-making frameworks that prioritize human dignity, and expand emotionally intelligent systems by integrating culturally-sensitive, safe, and inclusive design strategies supported by interdisciplinary collaboration.
- **Technology for Older Adults** (A17, A36). A17 highlights the necessity of adapting requirements validation and elicitation techniques to meet the needs and technological characteristics of older adults. A36 proposes investigating the motivations and psychological barriers older adults face in digital transformation activities to identify strategies that can help them feel more comfortable engaging with technology, while considering factors such as education and professional history. These studies suggest future research should make technology more accessible and motivating for older adults, respecting their limitations and barriers. In particular, inclusive design approaches, co-creation methodologies, and age-adaptive interfaces could be investigated to foster digital confidence and long-term engagement in this demographic.
- **RE for Mobile Applications** (A44). A44 suggests the development of a tool to incorporate user evaluations into the RE process for health monitoring applications. The initial focus will be on constructing the Domain Feature Model (DFM) and automatically identifying the relationships between application features. Future work could focus on tools and methods to better incorporate user feedback into the RE process for health monitoring applications, emphasizing the automatic identification of feature relationships. Additionally, future research could explore real-time feedback mechanisms integrated into mobile health applications, allowing continuous requirement refinement and adaptation based on users' contextual needs, preferences, and health conditions.

Key finding 6. The research opportunities cover key areas such as security & privacy, machine learning & data-driven approaches, user experience, usability & evaluation, elicitation & modeling techniques, ethical & human-centric considerations, technology for older adults, and RE for mobile applications.

5 Discussion

This systematic mapping study uncovers insights and opportunities for RE research focused on WBAH. While all RE activities have been examined in the context of developing WBAH applications, our findings indicate that requirements elicitation is the most extensively explored phase. This suggests a significant opportunity for future research to delve deeper into other phases, particularly requirements validation and evaluation.

Additionally, Health & Telemedicine and Inclusion & Accessibility are the most researched topics; however, emerging issues such as security and privacy, data-driven approaches and machine learning, and ethical and human-centered considerations need further exploration.

Another observation is that most studies focus on proposed solutions, such as specific software systems, algorithms, or design principles, which creates an opportunity for more theoretical discussions and reflections, including philosophical or opinion pieces. These contributions could offer a critical and comprehensive perspective on the ethical and social challenges associated with developing solutions for WBAH. Additionally, the prevalence of case studies in evaluating these solutions indicates a need for greater methodological diversity, including controlled experiments and long-term empirical studies, to validate and strengthen the findings.

To organize the key findings from this study, we created an evidence briefing, as outlined by [4]. This one-page document succinctly summarizes the results of systematic studies, following the template provided by [4]. Figure 5 shows the complete version of the defined evidence briefing. It can be downloaded from our complementary material [2]. The evidence briefing is organized into three columns: a brief overview of the mapping study, the main findings, and detailed information on the study's methodology. By consulting the evidence briefing, researchers and practitioners can quickly identify key insights, such as: "We found evidence that

ADVANCES IN REQUIREMENTS ENGINEERING FOR WELL-BEING, AGING, AND HEALTH

This briefing reports scientific evidence on advances in requirements engineering for well-being, aging, and health.

To obtain the findings, we conducted a systematic mapping study considering the following premier venues of Requirements Engineering:

- **International Working Conference on Requirement Engineering: Foundation for Software Quality (REFSQ).**
- **IEEE International Requirements Engineering conference (RE).**
- **International Workshop on Requirements Engineering for Well-Being, Aging, and Health (REWBAH).**
- **Workshop on Requirements Engineering (WER).**
- **Requirements Engineering Journal (REJ).**

FINDINGS

We found evidence that all requirements engineering activities have been used to develop well-being, aging, and health applications, but requirements elicitation has been the most used to date.

The main research topics investigated are:

- **Healthcare and Telemedicine**: it has primary focus on systems used for healthcare, as well as mobile applications dedicated to supporting patients and their treatments.
- **Intelligent Technology**: it introduces elements of machine learning, the Internet of Things, and intelligent assistants for health, wellness, and aging.
- **Human Interaction and Medical Communication**: it focuses on human interactions and the health of healthcare professionals, and individuals in other fields.
- **Mental and Emotional Health**: it focuses on mental and emotional aspects.
- **Inclusion and Accessibility**: it addresses accessible and inclusive software and systems for various situations, such as the elderly or people with disabilities.
- **Patient Support and Follow-up**: it presents solutions and focuses on clinical follow-up of patients.

The most frequently addressed research topic has been Healthcare & Telemedicine, particularly in the stages of Requirements Elicitation and Requirements Analysis.

The most common research type is Solution Proposal, but more studies are needed in the Philosophical and Opinion Paper categories.

Most of the solutions for WBAH have been evaluated by case studies.

The Solution Proposal research type is by far the most related to topics. It strongly focuses on all topics, especially Healthcare & Telemedicine, Inclusion & Accessibility, and Intelligent Technology. They are followed by Validation Research and Evaluation Research, which also have a significant presence.

The primary research opportunities are:

- **Security and privacy**: Future research may investigate the continuous integration of security and privacy considerations throughout the software life cycle, from requirements elicitation to implementation and evaluation.
- **Machine learning and data-driven approaches**: This research opportunity delves into the potential for innovation in requirements engineering by examining various strategies to optimize and adapt processes. Specifically, it focuses on integrating machine learning techniques into the day-to-day operations of WBAH systems to improve efficiency and decision-making processes.
- **User experience**: Future research could develop comprehensive solutions for improving user interactions in healthcare systems, particularly by addressing emotional responses and stress management in user experiences.
- **Usability and evaluation**: Future work could develop standardized evaluation frameworks and multi-dimensional assessment tools capable of capturing not only usability but also clinical safety, emotional experience, and long-term system impact on users' quality of life.
- **Elicitation and modeling techniques**: Research on elicitation and modeling techniques opens up several possibilities in health and technology. It is possible to explore design patterns for the development of applications aimed at older adults, and there is also room for research focused on medical decision support systems.
- **Ethical and human-centric considerations**: The articles in this category show how future research should explore ethical and human values that are practically embedded in software design processes and emerging technologies.
- **Technology for older adults**: These studies suggest that future research can explore ways to make technology more accessible and motivating for older adults while respecting their limitations and psychological barriers.
- **Requirements engineering for mobile applications**: Research in mobile applications, particularly in health monitoring, can improve requirements engineering in WBAH systems. For instance, developing tools that integrate user feedback into the requirements engineering process can lead to more accurate adaptation to user needs.

Who is this briefing for?

Software engineering practitioners who want to make decisions about how to develop well-being, aging, and health applications.

Where the findings come from?

All findings of this briefing were extracted from the mapping study conducted by Camila Almeida, Sávio Freire, Manoel Mendonça e Rodrigo Spínola.

What is included in this briefing?

The main findings of the original systematic mapping review, and brief contextual information about the context of the findings

What is not included in this briefing?

Additional information not supported by the findings of the original systematic mapping review as well as descriptions about the research method or details about the primary studies analyzed in the original systematic mapping review.

For additional information about our research groups:

- ***Systems and Software Engineering Laboratory (Labes[2]): https://sites.google.com/view/labes2/home***
- ***Technical Debt Research Team: https://www.tdresearchteam.com/home***

Figure 5: Evidence briefing summarizing our results

all RE activities have been used to develop of well-being, aging, and health applications, but requirements elicitation has been the most used to date." It also highlights the main research topics and primary research opportunities.

Moving forward, these findings underscore the need for a more balanced research agenda that addresses both technical and human-centric aspects of WBAH systems. Future work should focus on developing integrated RE frameworks that combine robust validation methods with ethical guidelines, particularly for vulnerable populations. Additionally, establishing partnerships between academia and healthcare institutions could facilitate large-scale evaluations of RE techniques in real-world settings, ultimately leading to more effective and inclusive WBAH solutions. By addressing these gaps, the RE community can play a pivotal role in shaping technologies that truly enhance well-being and quality of life for aging populations.

6 Threats to Validity

As with any empirical study, there may be threats and/or limits to our methods and findings [15].

External validity: A potential threat arises from the selection of data sources used to compile the pool of articles. While we did not include all data sources typically used in systematic studies, we mitigated this threat by focusing on the premier venues in the RE field. However, we acknowledge that the multidisciplinary nature of the topic—spanning health and RE—may result in relevant articles being published in journals outside the RE and software engineering domains. Another threat is related to gray literature[6]. Given that WBAH is a socially impactful and application-driven domain, substantial innovation and evaluation may occur outside peer-reviewed venues. As we did not include this kind of literature, it could lead to an incomplete understanding of actual RE practices in real-world settings. Future work could address this by expanding the selection criteria to incorporate relevant sources from other fields as well as gray literature.

Internal validity: A key threat is associated with the study selection process, specifically how we determined whether an article met the acceptance criteria. To mitigate this threat, two researchers independently reviewed the titles and abstracts of the articles and compared their assessments to reach a consensus. We also measured the level of agreement, achieving a Cohen's Kappa coefficient (κ) of +0.841, indicating a high level of agreement between the researchers. Another potential threat was identified during the data extraction process. To address it, one researcher collected the data according to the form shown in Table 3, while another researcher reviewed all extracted data to ensure accuracy and consistency.

Conclusion validity: We identified a threat in the coding and grouping process used to summarize the data from the articles. To minimize it, one researcher conducted these processes, which were then thoroughly reviewed by another researcher. Any divergences were addressed and resolved in a collaborative meeting.

[6]Gray literature includes unpublished materials not found in traditional channels such as peer-reviewed academic journals [5].

7 Conclusion

This systematic mapping study examines advancements in RE for WBAH, analyzing 57 papers published between 2013 and 2024. Our findings show that requirements elicitation is the most extensively explored activity, reflecting the focus on understanding user needs in WBAH systems. However, other critical activities such as validation and evaluation have received less attention, indicating a significant gap that future research could address to improve the overall quality and effectiveness of these systems.

While Healthcare & Telemedicine and Inclusion & Accessibility are the most researched areas, emerging challenges related to security, privacy, and ethical considerations are underrepresented. With increasing reliance on technology in health and aging, addressing these issues will be crucial for developing systems that are both secure and user-centered. The need for more empirical research, beyond case studies, is also evident, as varied evaluation methods can provide more robust validation of RE practices.

In addition, the predominance of solution proposals highlights an opportunity for more theoretical and reflective work in the field, such as philosophical or opinion pieces. These contributions could explore broader societal and ethical implications of WBAH systems. Overall, this study identifies critical gaps and presents opportunities for future research to advance RE practices in the evolving landscape of well-being, aging, and health.

This mapping serves as a foundation for both academia and industry. For researchers, it emphasizes the importance of conducting diverse empirical studies and engaging in theoretical reflections on ethical and social aspects. For practitioners, it identifies specific areas, such as usability, inclusion, and privacy, where RE methods can directly improve the quality of healthcare systems. Future research could expand this study to other areas of SE and HCI and incorporate gray literature to capture industry perspectives.

ARTIFACT AVAILABILITY

All data supporting this study are openly available through our complementary material [2], ensuring transparency, replicability, and accessibility in regard to our study.

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