Mobile Health Applications for Self-Management of bone disease with focus on osteoporosis and osteoarthritis: A Systematic Review

Golaleh Karbasi, Rahimah Ibrahim, Siti Anom binti Ahmad, Ghobad Moradi, Rouhollah Khodabandelou, Halimatus Sakdiah Minhat

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[1] Universiti Putra Malaysia Selangor MY
[2] Kurdistan University of Medical Sciences Sanandaj IR
[3] Sultan Qaboos University Muscat OM

Corresponding Author:
Halimatus Sakdiah Minhat

Universiti Putra Malaysia
43400 Serdang
Selangor
MY

Abstract

Background: The global aging population is rapidly increasing, with a significant proportion experiencing chronic bone diseases like osteoporosis and osteoarthritis. Mobile health applications (MHAs) have emerged as a promising tool for self-management of these conditions.

Objective: This systematic review aimed to evaluate the effectiveness of mobile health applications in self-managing bone diseases, specifically osteoporosis and osteoarthritis, by examining their impact on clinical outcomes, patient experiences, and identifying research gaps.

Methods: Following PRISMA guidelines, a comprehensive search was conducted across multiple databases, including Web of Science, Scopus, PubMed, and Google Scholar. The review included 18 studies encompassing 1,851 participants, focusing on randomized controlled trials, quasi-experimental studies, and pre-test and post-test research.

Results: The analysis revealed that mobile health applications demonstrate significant potential in managing bone diseases. Approximately 76% of studies reported improvements in pain levels, and 94% showed enhanced physical performance. However, the review identified critical gaps, including limited attention to social support (only 24% of studies) and self-efficacy (18% of studies). User perceptions were predominantly positive (55.56%), with applications like Kaia Hip and Knee Pain receiving praise for user-friendly interfaces and symptom management.

Conclusions: Mobile health applications show promising results in bone disease self-management, particularly in improving clinical outcomes. However, future research must focus on developing more holistic, user-centered approaches that address psychological and social support needs, enhance user engagement, and conduct more rigorous long-term studies to fully realize the potential of these digital health tools.

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Mobile Health Applications for Self-Management of bone disease with focus on osteoporosis and osteoarthritis: A Systematic Review

Golaleh karbasi[1], Rahimah Ibrahim1[1], Siti Anom binti Ahmad[1], Ghobad Moradi[2], Rouhollah Khodabandelou[3], Halimatus Sakdiah Minhat[4]*

[1]Malaysian Research Institute on Ageing (MyAgeingTM), university Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[2]Social Determinants of Health Research Center, Research Institute for Health Development, Kurdistan University of Medical Sciences, Sanandaj, Iran
[3]Assistant Professor Department of Instructional & Learning Technology (ILT)College of Education Sultan Qaboos University (SQU)Muscat Oman. Email:r.bandelou@squ.edu.om [4]Faculty of Medicine and Health Sciences, University Putra Malaysia, 43400 Serdang, Selangor, Malaysia.

* **Corresponding email**: halimatus@upm.edu.my

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Keywords: Mobile health applications, Osteoporosis, Osteoarthritis, Self-management, Digital health, Patient engagement

1. Introduction

With the advancement of medical research, the global population of aging individuals is growing faster than ever before, particularly in underdeveloped countries (Guner & Acarturk, 2020) . In fact, almost all countries worldwide are seeing an increase in the number and percentage of older people in their population. The number of older people worldwide is predicted to more than double over the next three decades, reaching over 1.5 billion in 2050(Wang, Liu, Liu, & health, 2020). About 20-46% of the elderly in the community live with one or more chronic diseases that cause different levels of disability and symptoms, including unrelieved pain(Abdulla et al., 2013). Musculoskeletal conditions affect approximately 1.7 billion people worldwide, among these diseases are osteoarthritis and osteoporosis, which affect millions of elderly people annually1, which cause pain, reduced physical performance, reduced mental well-being, decreased social and economic participation and are significant predictors for years of life with disability(Cieza et al., 2020).

Due to the fact that they cannot be cured, the progress of the disease and symptoms can be controlled through self-management programs (SMPs)(Safari, Jackson, & Sheffield, 2020). Typically, the treatment and control of chronic diseases such as osteoarthritis relies heavily on clinical visits and face-to-face consultations. However, with the advent of digital health technologies, there has been a significant change in the shift of this traditional practice towards new technologies, remote solutions and self-management. Digital health, especially mobile health (mHealth) applications, has emerged as a promising tool in the management of chronic conditions by enabling continuous monitoring, personalized interventions, and improved patient engagement(Mollard & Michaud, 2021; Thompson et al., 2023). To ensure high-quality integrated services and an economic and effective community-

based program, individual responsibility for health and self-management of chronic diseases is a concept that has received increasing interest in recent decade(Safdari, Alikhani, Tahmasbi, Javanmard, & Heydarian, 2020). Self-management is a highly effective factor that has the potential to promote health, which includes goal setting, motivation, self-monitoring, decision-making, problem solving, and stress Management(Alhussein & Hadjileontiadis, 2022).

Mobile health apps (apps) make it possible to provide health services through smart phones(Silva, Rodrigues, de la Torre Díez, López-Coronado, & Saleem, 2015). mHealth applications that can be implemented on smartphones have the potential to play an important role in supporting personal health management (i.e. self-management) by providing up-to-date information on health and treatment issues as well as encouraging preventive health behaviors(Brand-Miller, 2003). These programs are able to support people to self-manage their disease in their health conditions, especially chronic diseases that require a long period of monitoring, observation, care, and if they are used effectively, they can reduce costs. The solutions are to meet the needs of all stakeholders(%J, 2011).Therefore, it can be used by finding better and affordable alternatives to hospital care and health care providers or finding an organization that can support the elderly in their homes. The use of mobile applications related to health or mobile health (mHealth) has emerged as an important and useful tool to improve health outcomes in chronic diseases(Alhussein & Hadjileontiadis, 2022).The number of available programs is 8 million, of which 60% can be found in application stores. As of 2017, there are 325,000 million health apps with over 3.7 billion annual downloads (%J, 2011; Koetsier, 2020). This increase in usage and downloading is due to the increasing penetration of advanced technologies and smartphones in the field of healthcare and treatment, and on the other hand, due to the emergence of newly emerging diseases such as COVID-19 and areas that lack healthcare centers, acceptance and the use of mHealth apps is increasing (Sust et al., 2020). Therefore, it is expected that in the coming years we will face an increasing growth of smartphone ownership, especially among people over 50 years old (McKay et al., 2018). Despite this increase in the number of mHealth applications, few are dedicated to bone diseases such as osteoporosis, and this is a big challenge for the health field in all countries(Tsamlag et al., 2020). Considering that the way of providing self-management interventions is currently mostly limited to face-to-face, internet and telephone (Buchbinder, Osborne, Johnston, & Pitt, 2014) , therefore there is a need to create a suitable platform for using mHealth technologies, especially mobile applications in the field of musculoskeletal diseases as a means There is an effective way to provide an intervention to increase the effectiveness of self-management.

In this article, articles from different study designs such as randomized trials, cohorts and case reports that used mHealth technologies were systematically reviewed to evaluate the effectiveness of mHealth programs in controlling clinical symptoms of OA and OS as well as patient management. Limitations and problems in existing programs were evaluated.

The motivation behind this systematic review comes from the fact that, as far as we know, no other review has ever looked at mHealth programs for arthritis and constipation from this angle. This review aims to identify the current state of self-management and mHealth solutions related to these diseases reveal any lack of performance, identify challenges and barriers, and suggest recommendations for more personalized and effective remote self-management health care monitoring of osteoporosis and osteoarthritis. So that in the future, user-friendly programs with a holistic approach in the market of web-based programs will be available to the applicants. Therefore, the research questions for this systematic review were:

RQ1: What is the effectiveness of Mobile Health Applications for the Self-Management of bone disease with focus on osteoporosis and osteoarthritis?

RQ2: What gaps exist in the current literature on Mobile Health Applications for Self-Management of bone disease with focus on osteoporosis and osteoarthritis, and what areas require further research?

RQ3: What are the perceptions and experiences of individuals with osteoporosis and osteoarthritis regarding the usability and acceptability of mobile health applications for self-management?

2. Methods

2.1. Search Strategy and information sources

For this systematic review, we followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Page et al., 2021) and registered it on PROSPERO (ID: CRD42024535474). The research question formulated based on the “PICO” framework targeted the effectiveness of mobile health applications in self-management of bone diseases, specifically focusing on osteoporosis and osteoarthritis, population, intervention, comparison, and outcomes of interest **(see Table 1).** Literature searches were conducted on Web of Science, Scopus, PubMed and Google scholar databases without any publication period restrictions up to March 2024,

limited to English language clinical trials. MeSH and non-MeSH keywords such as “Mobile Apps,” “mhealth,” “Osteoporosis,” and “Osteoarthritis” were used to identify relevant studies. Additionally, searches were extended to conferences, registries, Google Scholar, and government websites, with further screening of reference lists for additional pertinent studies. The search results were imported into ENDNOTE bibliographic software.

Table 1. PICO for research questions.

concept	Description of Detail
Population	OA and osteoporosis patients
Intervention	Mobile Health Applications
Comparison	Effects of m health intervention on physical activity and sedentary behavior
Outcomes	Self-Management of bone disease

Table 2. List of search strings in different digital library.

Digital Library	Query String	Scope	Limitation
PubMed	**(Mobile Applications[mh] OR Mobile Application*[tiab] OR Mobile App*[tiab] OR Portable Software App*[tiab] OR Smartphone App*[tiab] OR Portable Electronic App*[tiab] OR** Mobile Health[tiab] OR mhealth[tiab] OR ehealth[tiab] OR digital health[tiab] OR mobile phone[tiab] OR smartphone[tiab] OR apps[tiab]**)** AND (Osteopenia*[tiab] OR Low Bone Densit*[tiab] OR Low Bone Mineral Density[tiab] OR Osteoporosis[mh] OR Osteoporoses[tiab] OR Age-Related Bone Loss*[tiab] OR Osteoarthritis[mh] OR Osteoarthrosis[tiab] OR Osteoarthroses[tiab])	Title, Abstract and keywords	without up to March 2024
WOS	TS=(**(“Mobile App*” OR “Portable Software App*” OR “Smartphone App*” OR “Portable Electronic App*” OR** “Mobile Health” OR mhealth OR ehealth OR “digital health” OR “mobile phone” OR smartphone) OR ((Mobile OR phone*) NEAR/4 (app*)**)) AND** ((Osteopenia* OR “Low Bone Densit*” OR “Low Bone Mineral Density” OR Osteoporosis OR “Age-Related Bone Loss*” OR Osteoarthritis OR Osteoarthrosis)))	Title, Abstract	
Scopus	TITLE-ABS-KEY**((“Mobile App*” OR “Portable Software App*” OR “Smartphone App*” OR “Portable Electronic App*” OR** “Mobile Health” OR mhealth OR ehealth OR “digital health” OR “mobile phone” OR smartphone OR ((Mobile OR phone*) W/4 (app*))**) AND** ((Osteopenia* OR “Low Bone Densit*” OR “Low Bone Mineral Density” OR Osteoporosis OR “Age-Related Bone Loss*” OR Osteoarthritis OR Osteoarthrosis)))	Title, Abstract and keywords	
Google scholar	result: 300 (30 first pages)	Title, Abstract and keywords	

2.2. Study Selection process

Two researchers initially reviewed the abstracts of all identified studies to identify potentially relevant articles, followed by an independent full-text evaluation of these studies by both researchers

to determine their eligibility for inclusion. Any discrepancies were resolved through discussion, with a third researcher being consulted if needed. The identified studies, if they included the inclusion criteria: randomized controlled trials (RCT), quasi-experimental and non-randomized trials, pre-test and post-test studies, focusing on the effectiveness of mobile health programs in the self-management of bone diseases in patients aged 45 and older, were considered. became Exclusion criteria included reviews, letters, editorials, retrospective studies, replications, low-quality studies, and those with a high risk of bias. Exclusion criteria involved reviews, letters, editorials, retrospective studies, duplicates, low-quality studies, and those with a high risk of bias.

2.3. Quality Assessment of the Studies Included

The assessment of bias risk was conducted using the Cochrane Risk-of-Bias tool for randomized trials (RoB 2), the Joanna Briggs Institute (JBI) Checklist for Quasi-Experimental Appraisal tool, and The National Institutes of Health (NIH) quality assessment tool for before-after studies without a control group. The RoB 2 tool evaluates five domains, including randomization process, deviations from intended interventions, missing outcome data, measurement bias, and selection of reported results. The JBI checklist consists of questions for assessing the quality of quasi-experimental studies, while the NIH tool comprises 12 questions for before-after studies without a control group (Julian PT Higgins JS, 2019; NHLaBI, 2013; Tufanaru, Munn, Aromataris, Campbell, & Hopp, 2020).

2.4. Data Extraction

Two researchers independently extracted relevant data using a predefined standard form, including author, publication years, study designs, sample size, intervention details, outcomes, conclusions, and other relevant information. Data from each study included. Both reviewers one and two agreed on data extraction in more than 70% of studies. Disagreements were easily resolved by discussion and consensus with a third referee.

2.5. Synthesis method

The synthesis involved summarizing the characteristics of the included studies, details of osteoporosis and osteoarthritis self-management strategies, mobile applications used, study aims, results, and the outcomes identified in the literature were analyzed in 3 eventually, the data synthesis in meta-analysis as described further in the subsequent sections.

3. Results

3.1. Study Selection

The PRISMA flow diagram (Matthew J Page & Penny Whiting, 2021) illustrating the process of study selection is presented in Figure 1. Initially, 1,183 studies were identified through electronic database searches. Following the elimination of duplicates, the titles and abstracts of 533 studies were screened. Subsequently, 493 studies were excluded, leaving 40 articles for full-text review (two full-text articles were unavailable). Additionally, three studies were uncovered through the examination of reference lists and citations of the 38 reviewed full-text articles. **Figure 1** elaborates on the rationale for excluding 23 articles. The methodological quality of the 11 studies was evaluated using the RoB tool (**Figure 2),** while the JBI tool was applied to three studies, and the NIH tool was used for four studies. None of the studies were excluded based on the quality assessments, resulting in a total of 17studies, encompassing 1,851 participants, included in the systematic review (Table 1).

3.2. Characteristics of the included studies

The 17 included studies' characterization are described in Table 1.The PRISMA flow diagram (Matthew J Page & Penny Whiting, 2021) illustrating the process of study selection is presented in Figure 1. Initially, 1,183 studies were identified through electronic database searches. Following the elimination of duplicates, the titles and abstracts of 533 studies were screened. Subsequently, 493 studies were excluded, leaving 40 articles for full-text review (two full-text articles were unavailable). Additionally, three studies were uncovered through the examination of reference lists and citations of the 38 reviewed full-text articles. Figure 1 elaborates on the rationale for excluding 23 articles. The methodological quality of the 11 studies was evaluated using the RoB tool (Figure 2), while the JBI tool was applied to three studies, and the NIH tool was used for four studies. None

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A total of three studies were conducted in the United Kingdom (Stevenson 2024 at the University of Bath; Jakobsen 2018 at the Osteoporosis Clinic at Odense University Hospital; Ramachandran 2023 at the University of British Columbia), two in Germany (Weber 2024 and Bobrovsky 2022, both at the University of Applied Health Sciences Bochum), and two in the Netherlands (Pelle 2021 and Pelle 2020, both at the Department of Rheumatology of the Sint Maartenskliniek, Nijmegen). Additionally, three studies were carried out in the United States (Adumanu-Fintan 2023 at the University of Massachusetts Global; Martin 2023 at U.S. military academies and the Department of Physical Medicine and Rehabilitation, Uniformed Services University, Bethesda, MD; Skrepnik 2017 focusing on mobile application usage in osteoarthritis management). Two studies were conducted in Canada (Shewchuk 2021 at the University of Calgary; Ramachandran 2023 at the University of British Columbia). Additionally, one research study focused on each of the following countries: Spain (Sanchez-Laulhe 2023), Turkey (Aydogdu 2019), Norway (Stme 2019), Denmark (Jakobsen 2018), Korea (Park 2017), and Iran (Arfaei Chitkar 2021).

The table shows the publication years for the selected studies. Many studies were published in 2023, with a total of six articles (35.29%), which represents a significant peak in recent research activities in this field. It is followed by 2024, with two studies (11.76%) that show interest and a continuous, strong, and significant trend in the recent increase in research focus, and then in 2021 (n = 3; 17.65%)., 2022, and 2019, each with two studies (11.76%), which indicated a stable research interest. The years 2018, 2017, and 2020 each had one study (5.88 percent). This distribution represents a growing trend in mHealth research, particularly in the last four years, which aligns with technological advances and increased adoption of digital health solutions in clinical settings.

Five types of technology were employed to deliver exercise programs and manage symptoms for osteoarthritis and osteoporosis. Mobile apps are the most frequently used, featured in 12 out of 17 studies (approximately 70.59%), where they facilitate self-management, symptom tracking, and educational content. Web-based platforms are utilized in 5 studies (around 29.41%), offering additional support through interactive tools like exercise videos and health logs. Telephone-based interventions appear in three studies (17.65%), primarily for guiding exercises and monitoring, often augmented by other digital resources for improved patient support. Other innovative technologies, such as videoconferencing and virtual reality, are less frequently incorporated and used to maintain patient-provider communication.

RQ1: What is the effectiveness of Mobile Health Applications for the Self-Management of bone disease with focus on osteoporosis and osteoarthritis?

	Thematic analysis	Name of the paper	%
1	Physical Function (lessen risk of obesity, cardiovascular disease, diabetes)	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17	94.12%
2	pain levels	1,2,4,5,6,7,8,9,10,11,12,13,15	76.47%
3	education	1, 3, 5, 7, 9, 10, 11, 12, 14, 16	58.82 %
4	Bone Density	1, 2, 7, 10, 11, 15, 16, 17	47.06 %
5	Quality of Life, Life Expectancy	2, 4, 5, 9, 10, 13, 15	41.18%
6	Social Support	1, 2, 7, 11	23.53%
6-1	Continuity of Care (higher treatment, disease knowledge of diet, exercise, risk factors)	2, 4, 5, 7, 10, 17	35.29%
7	Improving Self-efficacy to Exercise Intervention	6, 14, 7	17.65%

The effectiveness of mobile health programs for self-management of bone diseases, including osteoporosis and arthritis, is increasing significantly. The main intention of these programs is to provide individual interventions, educational content, and tools to monitor symptoms, control pain, and improve physical performance in patients. Research has shown that mobile health applications can significantly impact clinical outcomes by providing assistance, ongoing support, and encouraging patients to participate in treatment and self-care(Ravn Jakobsen, Hermann, Søndergaard, Wiil, & Clemensen, 2018; Stevenson, Chowdhury, Lobo, Western, & Bilzon, 2024; Støme, Pripp, Kværner, & Kvaerner, 2019).

Based on the analysis of 17 selected studies regarding the effectiveness of mobile health programs for the self-management of bone diseases, we found that these studies mostly suggest a significant improvement in the progress of clinical results, and finally, this shows the high potential of the program. Mobile phones to encourage patient participation and continuous care. For example, when reviewing the articles, there were recurring themes, and the most frequently addressed outcomes were levels of pain and physical function. Thirteen studies (76%) (Stevenson et al., 2024; Cheng et al., 2024; Weber, 2024; Sanchez-Laulhe, 2023; Adumanu-Fintan, 2023; Martin, 2023; Ramachandran, 2023; Bobrovsky, 2022; Arfaei Chitkar, 2021; Shewchuk, 2021; Pelle, 2021; Pelle, 2020; Aydogdu, 2019; Jakobsen, 2018), making it the most addressed outcome. 16 studies (94%) showed improvements in physical performance, indicating the potential relevance of mobile apps in encouraging regular physical activity and reducing the risk of comorbidities such as obesity and cardiovascular disease. Highlights (Stevenson et al., 2024; Cheng et al., 2024; Weber, 2024;

Sanchez-Laulhe, 2023; Adumanu-Fintan, 2023; Martin, 2023; Ramachandran, 2023; Bobrovsky, 2022; Arfaei Chitkar, 2021; Shewchuk, 2021; Pelle, 2021; Pelle, 2020; Aydogdu, 2019; Skrepnik, 2017; Jakobsen, 2018; Park, 2017).On the other hand, the social support Theme received less attention in most studies and was mentioned only in four studies (24%) (Stevenson et al., 2024; Cheng et al., 2024; Weber, 2024; Sanchez-Lavale, 2023). And it has been shown that although this is an influencing factor, the social support factor may not be the main focus of mobile health apps for bone disease management. Also in comparison, only three studies (18%) focused on how to improve self-efficacy in an exercise intervention (Adomano-Fintan, 2023; Martin, 2023; Ramachandran, 2023). Overall, based on these findings, it can be said that mobile health applications can effectively affect and improve important clinical outcomes such as pain levels and physical function, but may not fully meet the holistic needs of individuals who manage bone diseases. It can be said that maybe it is because areas such as social support and self-efficacy may need more attention and development.

RQ2: What gaps exist in the current literature on Mobile Health Applications for Self-Management of bone disease with focus on osteoporosis and osteoarthritis, and what areas require further research?

Table of Challenges and Limitations:

	Challenges and Limitations	Name of Papers	Percentage
1	Lack of continuous support and long-term studies	**16** (1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17)	94.12%
2	Usability and Cost-Effectiveness Studies	**13** (1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 14, 15, 16)	76.47%
3	User Interaction and Engagement	**12** (1, 2, 3, 5, 7, 9, 10, 11, 14, 15, 16, 17)	70.59%
4	Research Gaps in mHealth Effectiveness	**13** (1, 3, 4, 5, 7, 9, 10, 11, 13, 14, 15, 16, 17)	76.47%
5	Exercise Programs and Osteoarthritis	**4** (4, 14, 16, 17)	23.53%
6	Sample Size and Study Design Issues	8 (1, 5, 6, 10, 11, 14, 15, 17)	47.06%
7	Technical Limitations and Access	**3** (3,4,11)	17.65%
8	Integration and Application of mHealth in healthcare	**3** (1,2,16)	17.65%
9	Methodological Improvements and Multi-center Studies	**6** (1, 5, 9, 10, 11, 16)	35.29%

1. Lack of continuous support and long-term studies

The lack of long-term studies and continuous support can be a good reason to emphasize the necessity of mobile health solutions as a continuous support of professional health care, which often does not exist. It is crucial to provide continual monitoring for patients to ensure they are adhering to recommended physical activity and management plans. In the research of Stevenson (2024) and

Cheng (2024), it was suggested that, in order to evaluate the sustainable impact of these programs, it is necessary to conduct long-term studies, to ensure that these programs are effective in terms of clinical results, initial improvements in bone health, and maintaining mobility.

2. Practical and economical studies

Some studies emphasize the importance of developing MHAs that are not only easy to use but also economical. Studies by Bobrovsky (2022) and Adumanu-Fintan (2023) have shown that increased usability increases patient engagement, which is directly related to improved clinical outcomes. In addition, cost-effectiveness analysis has been proposed, which justifies the implementation and widespread integration of this program in health care systems.

3. Interaction and user interaction

There is a need for MHAs to provide dynamic and entertaining interfaces with the aim of promoting increased user engagement. Research conducted by Shochuk (2021) and Martin (2023) shows that interactive components have a favorable and significant effect on compliance with treatment regimens, increasing patient participation and ultimately increasing clinical outcomes in the management of bone disease.

4. Research gaps in mHealth effectiveness

These fundamental shortcomings in existing studies, including on the sustained effectiveness of MHAs, highlight their integration into care adherence. Research by Pelle (2021) and Aydogdu (2019) suggests that more extensive studies are necessary to definitively determine the benefits and limitations of these programs.

5. Exercise Programs and Osteoarthritis

Exercise Programs and Osteoarthritis emphasizes the particular requirement for MHAs meant to promote exercise programs catered for osteoarthritis sufferers. Studies by Støme (2019) and Jakobsen (2018) show that although under-researched, the efficacy of such programs in enhancing hand dexterity and lowering joint discomfort is vital.

6. Sample Size and Study Design Issues

The issues related to sample size and study design are related to methodological problems in research, so it should be noted in current and future research that the insufficient number of samples and the absence of control groups may weaken the validity of the results. Skrepnik (2017) and Park (2015) emphasize the importance of using robust study designs in research and also highlight the need for improvement to ensure the reliability of findings.

7. Technical Limitations and Access

Constraints and Availability of Technology Explores the technological obstacles that hinder users

from fully capitalizing on MHAs. The research conducted by Ramachandran (2023) and Sanchez-Laulhe (2023) have shown that platform exclusivity and complicated interfaces might restrict access, especially for users who lack technological proficiency.

8. Integration and Application of mHealth in healthcare

This study further points out the problems in the use of mobile health applications (MHAs) in current health care systems and tries to improve the implementation of effective integration of real-time monitoring capacity and the provision of individualized treatment. However, it has been emphasized in the studies conducted by Weber (2024) and Pelle (2020), this case is often problematic due to issues related to the privacy concerns of the elderly as well as problems related to interoperability.

9. Methodological Improvements and Multi-center Studies

Emphasizes the need of carrying out research involving several centers and employing rigorous techniques to improve the applicability of results. It is essential to design evidence-based procedures that can be broadly implemented, as demonstrated in research conducted by Arfaei Chitkar (2021) and Bobrovsky (2022).

These insights provide an overview of the challenges and limitations in the realm of MHAs for the management of bone diseases, and directions for future studies and their development to overcome barriers and fully exploit the possibilities of mobile health technologies. Mobile health applications (MHAs) for the management of bone diseases face many obstacles such as insufficient expert assistance, usability and cost-effectiveness issues, and the efficiency of existing research. Effective user interfaces are needed to engage the patient in new ways, and further improvements must be made in tools specifically designed for arthritis exercises. There are technical barriers in user access, which are among the reasons for the complex interfaces and exclusivity of the platform it creates. Barriers and limitations, and on the other hand, concerns about the ability to continue collaboration and privacy are another barrier to integrating care systems. The small number of samples and study designs with insufficient details and validity are among the existing methodological flaws. Therefore, in order to effectively investigate these problems, it is necessary to adopt a detailed and comprehensive strategy that is based on user-centered research methods, and the integrated integration of health care services is a priority. This study will help us to fully maximize the potential of MHAs in the management of bone disorders.

RQ3: What are the perceptions and experiences of individuals with osteoporosis and osteoarthritis regarding the usability and acceptability of mobile health applications for self-management?

NO.	Perception Category	Description	Paper ID
1	Positive	The program was effective in maintaining the level of physical activity. Significant improvements were observed in mean scores of musculoskeletal symptoms (MSK) and	1

		MSK-HQ total score. However, it does not provide detailed feedback from participants about their experiences and perceptions of the program. Qualitative data such as interviews or open-ended survey responses are required.	
2	Positive	mHealth platforms into the care continuum for osteoporosis patients can positively impact population health outcomes and reduce the burden on healthcare systems. Perceived positively for self-management, care beyond hospital settings.	2
3	Positive	Patients view MHAs positively, finding them convenient and empowering tools for managing their conditions.	3
4	Positive	mHealth applications can positively impact clinical outcomes related to pain levels and physical function in individuals. They feature a user-friendly interface, self-management recommendations, and graphical representations of exercises.	4
5	Positive/Neutral	APRNs can advocate for the adoption of these interventions in clinical settings to improve patient outcomes and reduce healthcare implications associated with knee osteoarthritis.	5
6	Neutral	Does not directly address the perceptions and experiences of individuals. It should incorporate qualitative methods such as interviews or focus groups.	6
7	Neutral	There is a gap in understanding how MHAs can best improve clinical outcomes such as bone density, pain levels, and physical function in individuals with these conditions. There is a need for qualitative studies to explore patients' attitudes, preferences, and barriers towards using MHAs for managing.	7
8	Positive	Highlights the effectiveness of the Kaia Hip and Knee Pain application in managing pain and improving the functional abilities of individuals with osteoarthritis. The study demonstrates significant clinical improvements, including reductions in pain and functional impairment, and high user satisfaction with the app’s features.	8
9	Neutral	There is no investigation into the perceptions and experiences of individuals with osteoporosis and osteoarthritis regarding the usability and acceptability of mobile health applications for self-management. Suggested qualitative studies can explore patients' attitudes, preferences, and barriers toward using mobile apps.	9
10	Positive	A qualitative report highlights positive feedback from participants regarding the app's usability and potential to motivate goal setting and self-management. Quantitative evaluation indicates mixed perceptions among healthcare providers.	10
11	Negative	The study acknowledges limitations including sample selection bias, potential Hawthorne effect, and uncertainty regarding user engagement with the mobile health application.	11
12	Neutral	Qualitative research could provide insights into factors such as user engagement, preferences for features, barriers to adoption, and overall satisfaction with these applications.	12
13	Neutral	Mobile-phone-based program not superior to brochure-based program over 3 weeks.	13
14	Neutral	Should investigate user satisfaction, usability, and acceptability of mobile health applications like Vett among individuals with osteoporosis and osteoarthritis. Qualitative research methods, such as interviews and focus groups, can provide insights into users' preferences, barriers, and facilitators to using mHealth.	14
15	Positive	Users found the app helpful in preparing for GP visits and facilitating dialogue during consultations. They appreciated having access to DXA scan results on their smartphones, which promoted engagement in self-management activities.	15
16	Positive	While the study showed positive outcomes regarding health beliefs and some physiological markers, there was no significant improvement in bone mineral density (BMD) or significant differences between the experimental and control groups in terms of lumbar BMD measured by dual-energy X-ray.	16
17	Positive	This study demonstrates high patient and physician satisfaction with the OA GO app and wearable activity monitor. It is essential to explore a broader range of patient perspectives, including those with varying levels of technological literacy and access to smartphones.	17
Total		**Positive**: 55.56% **Neutral**: 38.89% **Negative**: 5.56%	

Summary of Perceptions and Experiences:

About 55.56 percent of the reviewed studies of people with osteoporosis and arthritis have positive perceptions and experiences about the usability and acceptability of health applications for their disease and are classified in the positive category. These programs, for example, in the application Kaia Hip and Knee Pain has received attention and praise for its convenience, user-friendly interfaces, and effectiveness in managing symptoms and improving physical function, significantly reducing pain and increasing functional capabilities. Papers 1, 2, 3, 4, 8, 10, 15, 16, 17). High user satisfaction is reported for features like real-time motion correction and personalized coaching, enhancing user empowerment in managing their conditions (Papers 3, 4, 15, 17)

However, 38.89% of responses are neutral, pointing out the necessity for more comprehensive qualitative data to fully understand user engagement and the real-world applicability of these apps. The existence of a series of problems and concerns have caused gaps to fully understand the potential of mobile health applications in their effectiveness on clinical outcomes, and therefore highlight the need for in-depth qualitative studies to uncover barriers to user participation and overall satisfaction (articles 6, 7, 9, 1214 ,13و).In addition, negative perceptions regarding the effectiveness of mobile health apps, which comprise 5.56% of responses and studies, often emphasize shortcomings such as potential bias in sample selection and uncertainty about long-term engagement (Article 11).

In conclusion, although there is a very favorable view of mobile health applications in the management of osteoarthritis and osteoporosis, which could reflect their potential to facilitate effective self-management, a series of studies have highlighted the importance of addressing user feedback. Emphasizes data security and research development. To ensure that these tools are effective in meeting the various needs of patients and also fill the gaps in the field of user experience and performance of the designed programs.

5. discussion

Main findings

This section discusses the answers to the research questions based on related studies, this systematic review has pointed out the potential benefits of using mobile health applications in the self-management of bone diseases, especially osteoporosis and osteoarthritis. Mostly on the role of several key findings of these programs in the improvement of clinical results, promotion of regular physical activity and positive and significant effect that points to the reduction of pain level and improvement of physical performance in patients, as well as reducing the risk of co-morbidities such as obesity and cardiovascular diseases. will be and importantly, a study by Bobrovsky, 2022 found that mobile health applications have significant potential to reduce healthcare costs by minimizing

the need for in-person visits.

On the other hand, several gaps can be pointed out in this review, including the issue of social support, which was considered in only four studies (24%) and was not the main focus of mobile health programs for the management of bone diseases (Stevenson et al., 2024; Cheng et al., 2024; Sánchez-Laval, 2023) (1,2,4)But in many other studies, the family factor and social support play a key role in overcoming obstacles and are vital in facilitating the use of electronic health services among the elderly (Wäsche et al. 2021). There are two main reasons for the limited focus on social support in the program. Mobile health applications for self-management of bone diseases. First, most programs prioritize technical functions and immediate clinical outcomes, physical function, and pain management, and social support features often require more complexity and resources, so they are not feasible for developers focused on direct clinical needs. For example, Weber (2024) and Sanchez-Lavale (2023) highlighted their emphasis on improving physical performance and pain levels through structured training and exercise programs. Secondly, these programs emphasize individual care and self-management strategies and unintentionally marginalize social support mechanisms. Ramachandran (2023) emphasized the benefits of personal involvement and adherence to treatment plans through regular monitoring and feedback that ensures appropriate care for each patient. This individual approach can lead to less attention to the collective aspects of social support that require a broader and community-focused strategy.

The next factor is the effect of self-efficacy on the acceptance of health programs, which compared to other studies, only three studies (18%) focused on how to improve self-efficacy in an exercise intervention (14,6,7) (Adomano-Fintan, 2023; Martin, 2023; Ramachandran, 2023). while many studies have pointed out the great impact of this item. One study showed that self-efficacy, people's belief in their ability to use digital health services, significantly affects the willingness of the elderly to accept these services. Affect. Older people with higher self-efficacy are more likely to use these services, which indicates that they must see the value and believe in their competence to use them effectively (Jokisch, Schmidt, & Doh, 2022). Providers and designers often prioritize features that lead directly to measurable clinical outcomes, such as physical function and pain reduction, over psychological factors such as self-efficacy. Easier to quantify and demonstrate effectiveness of clinical outcomes. For example, Stevenson et al. (2024) and Cheng et al. (2024) emphasized significant improvements in physical function and pain management, with less focus on self-efficacy, as these outcomes are more easily measured through clinical trials. Second, investigating self-efficacy improvements is complex and requires a detailed understanding of behavioral psychology, which may not be the core expertise of app developers. Adumanu-Fintan (2023) stressed that

although improving self-efficacy is crucial for sports interventions, it requires tailored and interactive features that support behavior change, which can be challenging to develop and implement effectively.Overall, based on these findings, it can be said that mobile health applications can effectively affect clinical outcomes that are measurable and easier to demonstrate effectiveness, such as pain levels and physical performance. In addition, the complexity of integrating features that address social support and self-efficacy. But they may not fully meet the holistic needs of people managing bone disease. It can be said that perhaps it is because areas such as social support and self-efficacy may need more attention and development and require a deeper understanding of behavioral psychology and more resources, so it often leads developers to emphasize simpler clinical interventions.

In general, in this systematic review, three important views on the usability and acceptability of mobile phone health programs for self-management of osteoporosis and osteoarthritis were evaluated. In the most important and general point of view, it has been well received so that a significant part of the studies (55.56%) reported a positive user perception and the reasons for this were issues such as ease, user-friendly interfaces and effectiveness in managing symptoms and improving physical performance. For example, applications such as Kaia Hip and Knee Pain application have been noticed and welcomed due to their ability to reduce pain and increase functional capabilities. But from one direction, one can find studies that had neutral (38.89%) and negative (5.56%) perceptions, and this can indicate the need to shift research towards comprehensive qualitative studies such as interviews and focus groups, to investigate attitudes, preferences and barriers to use. Also, to investigate issues such as sample selection bias and uncertainty about long-term interaction to find the needs of users in the real world and how to increase the acceptability of these programs to ensure that the programs are designed in a way that effectively meets the concerns and diverse needs of users. that manage chronic bone diseases.

Challenges and Limitations:

Accordingly, based on SLR, several research gaps were identified. As illustrated in the diagram several critical challenges and limitations in the current literature. According to the most important challenge (94.12) mentioned in most studies, this gap emphasizes the necessity of continuous monitoring and long-term evaluations to evaluate stable clinical results and ensure patients' adherence to physical activity and recommended management programs over time. Usability and cost-effectiveness is another important factor that has caused users' concern because it has a direct relationship with patient participation and the wider implementation of MHAs in health care systems, so the programs should be designed in such a way that they are user-friendly and be cost-effective so

that their effectiveness and acceptance are maximized. Another important factor is to pay attention to the complete understanding of user interaction by conducting comprehensive qualitative studies in order to significantly increase the patient's compliance with treatment regimens according to their results. Gives

The effectiveness of mHealth, identified by 76.47% of studies, emphasizes the need for extensive research to definitively determine the benefits and limitations of these programs. Similarly, issues related to sample size and study design (47.06%) point to methodological weaknesses that should be addressed to improve validity and reliability of research findings. mHealth effectiveness, usability and cost-effectiveness are also prominent concerns that 76.47% of studies have mentioned. The importance of these factors is because

directly affect patient participation and wider acceptance of MHAs in health care systems, therefore, it is necessary to conduct more extensive studies to find out the advantages and limitations, and that in a larger sample size to improve the validity and reliability of the research findings and address the weaknesses. Cognitive methodology is better. Among other very important issues in the integration and application of mHealth in healthcare, technical and access limitations have been identified that hinder the effectiveness and widespread adoption of mobile health applications (MHAs), including the design of specific platforms that limit the access of users with different devices and This lack of compatibility between the platform and complex and unintuitive user interfaces can discourage users, especially those who are not tech-savvy, so simplifying the design and improving the user experience is necessary to increase usability and patient adherence. Limited access to technology and levels Different digital literacy among users can be the next important thing that has a significant impact on the effectiveness of MHAs, the availability of programs and providing the necessary training can help solve this problem and encourage the elderly. Weber (2024) and Paul (2020) stated that privacy and security issues are particularly important when dealing with sensitive health data and if users are concerned about data breaches or misuse of their personal information, it is possible are unwilling to use MHA

In general, considering that the evidence shows the significant effect of MHAs in the management of osteoporosis and osteoarthritis, therefore, addressing these key challenges and limitations to optimize their design and effectiveness is very important and helpful in order to be able to the potential of MHAs in the management of chronic disease, comprehensive, long-term development and user-centered development approaches were fully utilized.

Key Achievements) Strengths (of Mobile Health Applications in Chronic Disease Management:

In the evaluation of the studied research, several important achievements of mobile health

applications (MHAs) were found in the management of the condition of people with chronic diseases such as osteoporosis and osteoarthritis. These achievements can indicate the high potential of these apps in caring for and improving health outcomes. For patients, MHAs have a patient-centered approach by providing tools that promote independence, empowerment and active participation in the management of patients' health, and most of the responsibility for care is placed on the patient. Second, these programs significantly increase patient engagement by promoting interactive features that increase levels of cooperation and better adherence to treatment plans and improve health outcomes in their health management. Third, MHAs provide care outside of traditional hospital settings. They provide the possibility of continuous monitoring and support, especially for chronic disease management where continuous care is very important. Fourth, educational programs provide reliable and valid information and increase the probability of patients using educational content and better managing their health. Fifth, the convenience of using MHAs at any time and place can lead to higher usage rates and better adherence to these new tools in health management. Sixth, MHAs are associated with higher acceptance by healthcare providers, as nurses find these tools useful in managing patient care and ultimately leading to better patient outcomes. Seventh, MHAs help to improve patients' quality of life, which is one of the important indicators in the overall effectiveness of health interventions. Eighth, it increases patient awareness and knowledge in health and management conditions, and as a result, patients with better information are more likely to adopt positive health behaviors. MHAs motivate behavior change and increase technology mastery and can lead to more successful health outcomes and ultimately, increase quality of life. These achievements underscore the critical role of MHAs in improving patient care, engagement and outcomes in the management of chronic conditions such as osteoporosis and osteoarthritis**.**

recommendations for future studies

The researchers in these studies have suggestions to reduce the existing gap, barriers can be overcome if future research on conducting long-term follow-up, evaluating the sustainable effects of self-care interventions in mobile health applications (MHAs) and conducting cost-effectiveness analyzes to evaluate outcomes. Economically, they should prioritize and focus. Identifying effective patient engagement strategies and conducting comparative studies to determine the most effective and scalable care models are also essential. Research should focus on confirming the clinical effectiveness of MHAs in different settings and populations, generating broader findings to improve study robustness, and conducting adequately powered larger-scale randomized control trials. It should also consider the need to examine the usability and acceptability of these programs and incorporate the diverse perspectives of patients and health care providers. In addition, future studies

should establish clearer definitions and operationalize the intended use of eHealth technologies, develop standardized evaluation methods.

On the other hand, future research should evaluate the effectiveness of MHAs in the real world, use interactive technology as alternative approaches, focus on technology-based tools to promote, change behavior and increase adherence to methods, and measure direct physiological variables to improve bone health. is Finally, the goal of future research should be to examine the impact of MHAs on clinical outcomes such as bone density, pain levels, and physical function, as well as their role more specifically in the practical aspects of incorporating therapeutic paradigms to improve mobility in patients with osteoarthritis and knee osteoarthritis in mobile health applications. To investigate the effect of mobile applications and wearable activity monitors on mobility parameters and pain reduction. These recommendations provide a comprehensive guide for future research directions that address various aspects of mobile health applications and their impact on patient care.

CONCLUSIONS

The aim of this systematic study is to investigate the significant role of mobile health applications (MHAs) in increasing the effectiveness of self-management of bone diseases such as osteoporosis and arthritis. Overall, these studies pointed to positive clinical outcomes that MHAs have had in reducing pain, improving physical function, and increasing overall quality of life. By promoting a patient-centered approach, these digital tools and programs help people take an active role in managing their health and expand the range of care from traditional methods to beyond borders using new technology.

On the other hand, this review also reveals significant gaps that must be addressed to fully realize the potential of MHAs in assisting individuals with positive self-care. It is noteworthy that the factor of social support, which is a key component in the management of chronic diseases, has been emphasized by few studies and has not been fully investigated. In addition, the role of self-efficacy, which is essential for effective adoption and use of digital health tools, has not been sufficiently explored. Not integrated into current MHA programs. Thus, these gaps suggest that while MHAs are effective in improving measurable clinical outcomes, they may fall short in addressing the holistic needs of patients, particularly in areas requiring psychological and social support.However, this study has some obstacles and limitations, including the lack of long-term studies, along with issues related to the usability and cost-effectiveness of this tool, the need for studies in larger samples and more detailed and comprehensive methodological research. For future studies, they should focus on developing MHAs that are not only clinically effective, but also user-friendly, accessible, and supportive of patients' broader psychosocial needs.

As a result, while today's research shows the great impact of using digital technology in various fields, especially MHAs, they promise a significant part to improve the management of osteoporosis and osteoarthritis, future research should prioritize the integration of comprehensive support systems in these programs. Do something yourself. By addressing the identified gaps and challenges, MHAs can be better positioned to improve patient care, promote sustainable partnerships, and contribute to the overall well-being of people managing chronic bone diseases.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest involved in the study.

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Supplementary Files

Figures

Identification of studies via databases, registers and other methods.

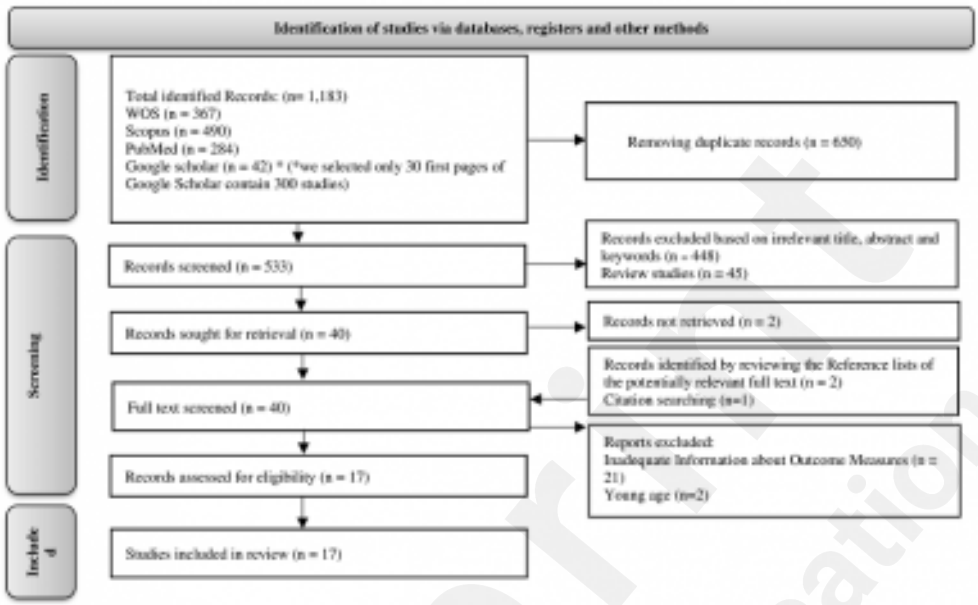
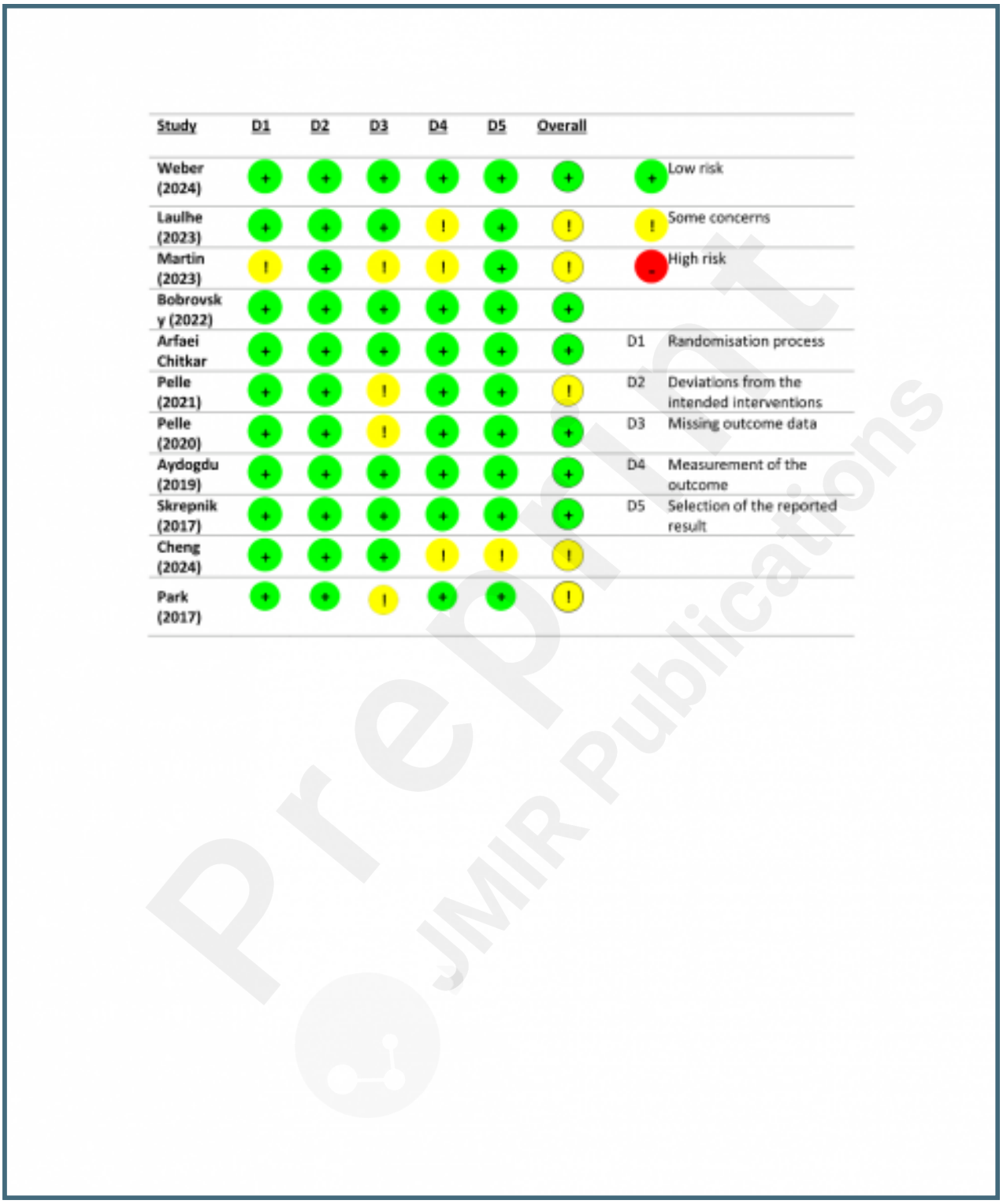


Figure 1: PRISMA flow diagram showing the selection process of qualified articles

Quality Appraisal RoB.



Multimedia Appendixes

Untitled.
URL: http://asset.jmir.pub/assets/cae39bf642f2074afcec07f89cd969d7.rar

Related publication(s) - for reviewers eyes onlies

Untitled.
URL: http://asset.jmir.pub/assets/7b0903d1cf453b9c9047a0fe2adcd4d5.pdf