Implementation of virtual reality in healthcare: a scoping review on the implementation process of virtual reality in various healthcare settings

Marileen Kouijzer (m.t.e.kouijzer@utwente.nl)
University of Twente Faculty of Behaviourial Management and Social sciences: Universiteit Twente Faculteit Behavioural Management and Social Sciences https://orcid.org/0000-0001-9857-9337
Hanneke Kip
University of Twente Faculty of Behaviourial Management and Social sciences: Universiteit Twente Faculteit Behavioural Management and Social Sciences
Yvonne H.A. Bouman
Department of Research, Stichting Transfore
Saskia M. Kelders
University of Twente Faculty of Behaviourial Management and Social sciences: Universiteit Twente Faculteit Behavioural Management and Social Sciences

Research Article

Keywords:

Posted Date: November 29th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-2259765/v1

Version of Record: A version of this preprint was published at Implementation Science Communications on June 16th, 2023. See the published version at https://doi.org/10.1186/s43058-023-00442-2.

Abstract

Background

Despite the potential added value of virtual reality technology in healthcare, its uptake in clinical practice is still in its infancy and challenges arise in the implementation of VR. Effective implementation could improve the adoption, uptake, and impact of VR. However, these implementation procedures still seem to be understudied in practice. This scoping review aimed to examine the current state of affairs in the implementation of VR technology in healthcare settings and to provide an overview of factors related to the implementation of VR.

Methods

To give an overview of relevant literature, a scoping review was undertaken of articles published up until February 2022, guided by the methodological framework of Arksey and O'Malley (2005). The databases Scopus, PsycINFO, and Web of Science were systematically searched to identify records that highlighted the current state of affairs regarding the implementation of virtual reality in healthcare settings. Information about each study was extracted using a structured data extraction form.

Results

Of the 5523 records identified, 29 were included in this study. Most studies focused on barriers and facilitators to implementation, that highlight similar factors related to the behavior of adopters of VR and the practical resources that the organization should arrange for. However, few studies focus on systematic implementation and on using a theoretical framework to guide implementation. Despite the recommendation of using a structured, multi-level implementation intervention to support the needs of all involved stakeholders, there was no link between the identified barriers and facilitators, and concrete implementation objectives or suitable strategies to overcome these barriers in the included articles.

Conclusion

To take the implementation of VR in healthcare to the next level, it is important to ensure that implementation is not studied in separate studies focusing on one element, e.g., caregiver-related barriers, as is common in current literature. Based on the results of this study, we recommend that the implementation of VR entails the entire process, from identifying barriers to developing and employing a coherent, multi-level implementation intervention with suitable strategies. This implementation process could be supported by implementation frameworks, and ideally focus on behavior change of stakeholders such as caregivers, patients, and managers. This in turn might result in increased uptake and use of VR technologies that are of added value for healthcare practice.

Contributions To The Literature

- Virtual reality is an innovative technology that is increasingly applied within different healthcare settings. Despite its potential to improve treatment, the adoption and uptake of VR are generally lacking.
- In this scoping review, we identified factors related to the implementation of VR that are important for successful adoption and effective use in practice. However, most often these factors are not sufficiently translated from research outcomes to healthcare practice.
- The findings of this scoping review contribute to the recognized gaps in the literature, stating recommendations for practice and future research on the systematic implementation of VR in healthcare.

Background

Virtual reality (VR) is increasingly used in healthcare settings as recent technological advancements create possibilities for diagnosis and treatment. VR is a technology that uses a headset to simulate a reality in which the user is immersed in a virtual environment, creating the impression that the user is physically present in this virtual space [1], [2]. VR offers a broad range of possibilities in which the user can interact with a virtual environment or with virtual characters. Virtual characters, also known as avatars, can provide the user with a greater sense of reality and facilitate meaningful interaction [1]. Amongst other applications, VR interventions have been piloted in healthcare and applied in treating chronic pain [3], improving balance in patients post-stroke [4], managing symptoms of depression [5], improving symptom burden in terminal cancer patients [6], and applied within treatment for forensic psychiatric patients [7]. These studies highlight the opportunities for VR as an innovative technology that could be of added value for healthcare. Nevertheless, regarding uptake in clinical practice, VR is still in its infancy [8], [9] and challenges arise in the implementation of VR. Various barriers are identified as limiting the uptake, such as a lack of time and expertise on how to use VR in treatment, a lack of personalization of some VR applications to patient needs and treatment goals, or the gap in knowledge on the added value of VR in a specific setting [8], [10].

Not only VR uptake is challenging, other eHealth technologies experience similar difficulties in implementation [11]. eHealth is known as “the use of technology to improve health, well-being, and healthcare” [11]. For years, implementation has been out of scope for many eHealth research initiatives and healthcare practices, resulting in technologies that have not surpassed the level of development [12]. For these technologies to succeed and be used as effectively as intended, they must be well integrated into current healthcare practices and connected to the needs of patients and healthcare practitioners [10]. As a result, a focus on the implementation is of added value. It has the potential to improve the adoption, uptake, and impact of technology [13]. However, implementation procedures for VR technology still seem to be understudied in both research and practice [9], [14].

One of the reasons for the lacking uptake of (eHealth) technology is the complexity of the implementation process [15], [16]. The phase between the organizational decision to adopt an eHealth technology and the caregivers actually using the technology in their routine is complex and multifaceted

[15], [16]. This highlights the importance of a systematic and structured implementation approach that fits identified barriers. The use of implementation strategies, known as the “concrete activities taken to make patients and healthcare providers start and maintain use of new evidence within the clinical setting”, can help this process by tackling the implementation barriers [17]. These strategies can be used as standalone, multifaceted, or as a combination [18]. Often, they are part of an implementation intervention, which describes what will be implemented, to whom, how, and when, with the strategies as a how-to description in the intervention [17].

While implementation interventions could help systematic implementation of VR, they are rarely used in practice. A way to stimulate systematic implementation and help develop an implementation intervention is by using an implementation model to guide this process. While a broad range of implementation models have been developed, there is still limited use of these models to structure the implementation of VR in healthcare [19]. One framework that could be used to identify important aspects of implementation is the NASSS framework, which investigates the non-adoption, abandonment, and challenges to scale up, spread, and sustainability of technology-supported change efforts in health and social healthcare [20]. The NASSS framework does not only focus on the technology itself, but includes the condition of the target group, the value proposition, the adopter system (staff, patients, and healthcare providers), the healthcare organization(s), the wider system, and the embedding and adoption of technology over time [20]. The framework is used to understand the complexity of the adoption of new technologies within organizations [21]. However, it remains unclear if and what factors of the NASSS framework, or any other implementation framework, can be found in the implementation of VR in various healthcare settings.

In summary, virtual reality interventions have the potential to improve the quality of care, but only if implemented thoroughly. As VR use becomes more prevalent, studies should expand the focus to identify factors specifically related to the implementation of this new technology [16]. It is advised to perform a needs assessment, understand potential barriers to implementation early, set implementation objectives, and identify fitting implementation strategies before testing VR interventions in practice [22]. Therefore, this scoping review aims to examine the current state of affairs in the implementation of VR technology in healthcare settings and provide an overview of factors related to the implementation of VR. This leads to the following research question: *“What is the current state of affairs regarding the implementation process of virtual reality in healthcare?”.* Within this research the following sub-questions are formulated: (1) What implementation strategies are used to implement VR in healthcare? (2) To what extent are specific implementation objectives being formulated and achieved? (3) Which barriers play a role in the implementation of VR in healthcare? (4) Which facilitators play a role in the implementation of VR in healthcare? (5) What are the recommendations for the implementation of VR in healthcare?

Methods

To address the study aims, a systematic scoping review was undertaken on the current state of affairs regarding the implementation of virtual reality in healthcare settings. Due to the broad scope of the research questions, a scoping review is most suitable to examine the breadth, depth, or

comprehensiveness of evidence in a given field [23]. As a result, scoping reviews represent an appropriate methodology for reviewing literature in a field of interest that has not previously been comprehensively reviewed [24]. This scoping review is based on the methodological framework of Arksey and O'Malley[25] including the following steps: (1) identifying the research questions, (2) identifying relevant studies, (3) study selection, (4) charting the data, and (5) collating, summarizing and reporting the results. A protocol was developed and specified the research questions, study design, data collection procedures, and analysis plan. To the authors' knowledge, no similar review had been published or was in development. This was confirmed by searching academic databases and the online platforms of organizations that register review protocols. The protocol was registered at OSF under registration DOI 10.17605/OSF.IO/5Z3MN. This scoping review adheres to the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [26].

Searches

A comprehensive, systematic electronic literature search was undertaken using three databases: Scopus, PsycINFO, and Web of Science. In each database, the same search strategy was used. Search terms were identified and included in the search strategy for three main categories relevant to the research questions; implementation, virtual reality, and healthcare. The search terms within a category were combined using the Boolean term 'OR' and the term 'AND' was used between the different categories. The search strategy was piloted to check if keywords and databases were adequate and adjustments were made whenever necessary. The full electronic search strategy can be found in Appendix 1.

Study inclusion and exclusion criteria

All identified records published up until February 2022, that were peer-reviewed, and written in English, Dutch or German, were included in the initial results. All references and citation details from different electronic databases were imported into the online review management system Covidence and duplicate records were removed automatically. A three-step screening approach, consisting of a title, abstract, and full-text screening, was used to select eligible studies. In the first step, two authors (MK & HK) screened all titles for assessment against the inclusion- and exclusion criteria for the scoping review. Records were included if the titles indicated that the article focused on virtual reality within a healthcare setting and that VR was used as a tool for prevention or treatment of patients. Because of the possibility of implementation not being mentioned in the title, broad criteria were used to prevent the unjust exclusion of relevant studies. Titles were included based on consensus between both authors. In the event of doubt or disagreement, the title was discussed by both authors. After screening the titles, both authors screened and assessed the abstracts using the inclusion and exclusion criteria. Abstracts were included or excluded based on consensus. In the final step, one author screened the full-text articles (MK). Records were included if they outline (parts of) the implementation process of VR technology (e.g., needs assessment, planning, execution, or lessons learned). In addition, the primary target group of the VR technology had to be patients with mental or physical disorders. If the studies focused solely on augmented reality (AR) or mixed reality (MR) and/or described a VR technology that is utilized to train

healthcare professionals, they were excluded. Additionally, studies were excluded if full texts could not be obtained or if the study design resulted in no primary data collection, such as meta-analysis, viewpoint papers, or book chapters. Reasons for excluding and any reservations about including were discussed with the other authors. The results of the search are reported in full and presented in a Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram [27] (Fig. 1).

Data extraction strategy

The data extraction of this scoping review is mostly based on the guidelines of the Cochrane Handbook for Systematic Reviews of Interventions [28]. A systematic assessment of study quality was not performed because this review focused on giving a broad overview of all factors related to the implementation of VR. This resulted in a heterogeneous sample of included study topics and designs: ranging from explorative qualitative studies to reflective quantitative studies. The data extraction process started with the creation of a detailed data extraction form based on the research questions in Microsoft Excel. This form was generated to capture the most relevant information from all obtained studies and standardize the reporting of relevant information. The extracted data included the fields as presented in Table 1. One author (MK) filled out the data extraction forms; in case of uncertainties, a second author was consulted (HK). Secondly, for each category, relevant text fragments from each study were copied from the articles into the data extraction forms.

Table 1.
Information extracted from included articles

Category	Specification
General information	General information regarding the authors, country, and year of publication
Study characteristics	Characteristics of the study; research question or goal of the study, study design, participants and method of data collection
VR technology characteristics	Description of the VR technology and its goal, target group and setting of use
Implementation characteristics	Description of implementation model and implementation stage
Implementation objectives and strategies (RQ1+2)	Description of the implementation objectives and implementation strategies
Barriers (RQ3)	Barriers to implementation: factors that hinder the implementation of VR technology in healthcare settings
Facilitators (RQ4)	Facilitators to implementation: factors that help the implementation of VR technology in healthcare settings
Recommendations (RQ5)	Recommendations or lessons learned to improve the implementation of VR technology in healthcare settings

Data synthesis and presentation

To answer the first and second research questions, the fragments from the data extraction forms were coded inductively. To answer the third and fourth research questions, fragments were first coded deductively, based on the main categories of the NASSS framework: technology, adopters, organization(s), wider system or embedding, and adaptation over time [20]. Second, within these categories, the specific barriers and facilitators were coded inductively to identify recurrent themes. The implementation recommendations were coded inductively to answer the fifth and last research question. The first author executed the coding process, which included multiple iterations and constant adaptations until data saturation was reached. During this iterative process, multiple versions of the coding scheme were discussed with all authors and adapted accordingly.

Results

Search Results

The search strategy, the number of included records, and reasons for full-text exclusion are provided in Fig. 1. The main reason for excluding full-text articles was that studies focused on the usability or effectiveness of VR, rather than on the needs assessment, planning, execution, or lessons learned from the implementation process of VR.

Study and technology characteristics

An overview of the characteristics of the 29 included records and the used VR technology is provided in Appendix 2. The following study designs were identified: qualitative (n = 13), quantitative cross-sectional (n = 10), and studies that used qualitative as well as quantitative methods (n = 6).

From the 29 included records, relatively many studies (n = 11) focused on VR use in rehabilitation clinics. Additional settings in which VR was applied are general health clinics, mental health clinics, or clinics for specific disorders e.g. eating disorder clinics or burn clinics. The goal of VR technology was often to be of added value as a treatment tool. It was used to improve movement in rehabilitation patients (n = 11) or decrease anxiety in patients with a stress-related disorder (n = 2). In addition, it was often applied to offer distraction or relaxation during medical procedures (n = 4). In addition to the variety in settings and in applications of VR, the type of technology that was applied differed as well: from immersive and interactive VR (n = 26) to (360°) videos (n = 4).

Implementation characteristics

An overview of the 29 included studies and the implementation characteristics, such as the use of an implementation model or the stage of implementation research are presented in Appendix 2. In this review, 8 of the 29 studies used a theoretical framework to structure implementation or data analysis. The Consolidated Framework for Implementation Research (CFIR) [29] was used in 3 studies and the Decomposed Theory of Planned Behavior (DTPB) [30] was also used in 3 studies. In addition, the Unified Theory of Acceptance and Use of Technology (UTAUT2) [31] was used in a single study, and the Innovation Diffusion Theory [32] was applied in one study as well.

Of the 29 included studies, the data collection of 12 studies took place before actual implementation and focused on factors, expected by stakeholders, that could influence future implementation. The data collection of the other 17 studies took place after actual implementation and reflected on existing factors related to implementation. Thus, most identified barriers, facilitators, and recommendations stated in this review were observed in studies that evaluated an existing implementation process.

Implementation strategies and objectives

To answer the first research question, an overview was created of the implementation strategies and objectives that were extracted from the included studies and is displayed in (see Appendix 2). Only in two studies, a clear implementation objective was mentioned [10], [33]. These objectives both focused on designing a knowledge translation (KT) intervention to translate knowledge about the use of VR to the caregiver. In addition, they aimed at identifying factors that influence VR adoption and caregivers' support needs.

Of the 29 included records, only 8 studies described actual implementation strategies [10], [33]–[39]. Most were mentioned in studies that collected data after implementation and reflect on existing implementation processes. In the included studies that described expected implementation factors, implementation strategies were most often not described. These studies were focused on identifying potential barriers and/or facilitators in preparation of the implementation phase and did not evaluate used strategies.

The described implementation strategies focused on multiple resources that are necessary for implementation. For example, VR equipment to be used in treatment, treatment rooms in which this VR technology can be set up and used, and time for caregivers to learn about VR and how to use it have been discussed. In addition, training and education on VR use were mentioned as important strategies. Hands-on interactive training, e-learning modules, mentorship for support and troubleshooting, and matching protocols and guidelines on how to use VR were mentioned. To set up VR treatment, an identified implementation strategy is to give support to caregivers in selecting appropriate content in VR that fits the patient's needs and give information on how to instruct the patient about VR treatment. Lastly, implementation strategies that help to increase the motivation of caregivers to use VR were mentioned. For example, having sufficient time to discuss the potential and added value of VR or having support from champions or mentors, experienced caregivers who share their experience with VR, to motivate others to integrate VR into their treatment practice were used during implementation.

Barriers to implementation

Barriers to the implementation of VR were identified based on relevant fragments from the articles. In 26 records a total of 69 different barriers were identified and divided into categories of the NASSS framework. All barriers are provided in Table 2. The barriers are explained in the accompanying text below.

Table 2
Barriers to implementation and the number of publications they were mentioned in (n)

Category	Barrier	Definition	n	References
Category 1: Condition (n = 13 barriers)				
Condition	Cognitive limitations	A decline in cognitive capabilities, such as reasoning and problem solving, could negatively affect VR use	6	[35], [36], [46]–[49]
	General decline	A decline in functional capabilities, such as mobility or communication, could negatively affect VR use	4	[36], [46]–[48]
	Distress	VR use could induce distress and anxiety	4	[35], [48]–[50]
	Fatigue	Extreme fatigue in patients could negatively affect VR experience	1	[35]
	Dissociation	Experienced disconnection from themselves and the world could negatively affect VR experience	1	[35]
	Highly medicated	Effects of medication use could negatively affect VR use and experience	1	[49]
Physical	Cybersickness	Motion- or cybersickness experienced while using VR	4	[10], [35], [49], [51]
limitations	Issues with vision/hearing	Limited vision or hearing abilities could negatively affect VR use	3	[36], [46], [49]
	Epilepsy	VR use could trigger a seizure in patients with photosensitive epilepsy	2	[51], [52]
	Poor hand dexterity	Limited ability moving fingers and hands limits the use of VR controllers	1	[46]
	Wheelchair users	The use of a wheelchair can negatively influence movement in VR	1	[33]
Socio-demographics	Reluctance due to old age	Elderly can be less technology-aware and uncomfortable to use VR	7	[35], [38], [47], [48], [53]–[55]
	Language barriers	Language can form a barrier when software is in another language	1	[47], [52]
Category 2: Technology (n = 11 barriers)				
Technical functionality	Technical issues	Technical malfunctioning of VR hardware	9	[10], [33], [37], [50], [52], [56]–[59]

Category	Barrier	Definition	n	References
	Lack of client safety	Lack of client safety due to unforeseen movement of patient in the treatment room while using VR	6	[10], [35], [38], [39], [60], [61]
	No reliable Wi-Fi	No reliable network connection which is necessary to use VR	4	[37], [53], [54], [57]
	Infection control issues	Difficult to control contaminations when using VR with multiple patients	3	[48], [49], [59]
	Data privacy and security	Lack of data privacy and security when using patient data in VR	2	[38], [58]
	System not charged	Battery of VR system is not charged and VR cannot be used	1	[57]
Usability	Lack of patient comfort	The use of VR headset and headphones could be uncomfortable	4	[35], [38], [59], [62]
	Usability issues	Issues with the usability and user-friendliness of VR	3	[35], [39], [61]
	Additional effort	The use of VR adds additional steps for caregivers during treatment	2	[10], [57]
Effect of VR on treatment	Isolation from contact	The VR headset can isolate patients from human contact	6	[50], [51], [53]–[55], [62]
	Lack of realism	Lack of realism and immersion experienced by patients in VR	4	[10], [50], [51], [63]
Category 3: Value proposition (n = 8 barriers)				
Influencing treatment	Lack of personalization	Lack of personalization to treatment goals and patients' needs	6	[10], [38], [57], [58], [64], [65]
	Distract from goals	The fun and gamification aspects of VR could distract from treatment goals	1	[37]
	Disinterest therapeutic activities	The preference for VR treatment could cause disinterest in other therapeutic activities	1	[37]
	No translation into real-world improvement	Treatment improvements in VR do not directly translate into real-world improvements outside of the treatment room	1	[58]
	Avoid in-vivo exposure	The use of VR can be a way to avoid in-vivo exposure	1	[50]

Category	Barrier	Definition	n	References
	Biased attention in group therapy	When VR is used in group therapy, the attention of the caregiver is focused on one patient and not on the other participants	1	[57]
Practical resources	Financial costs	Costs of purchasing and time for maintaining VR	9	[35], [38], [39], [48], [51]–[54], [58]
	Time for maintaining	Lack of time for the maintenance and updating of VR software	3	[10], [38], [52]
Category 4: Adopter system (n = 18 barriers)				
Factors that Influence	Lack of research	Perceived lack of research and evidence on the added value of VR	10	[10], [33], [35], [38], [47]–[49], [51], [54], [64]
Opinion towards VR	Lack of experience	Perceived lack of experience in working with VR	7	[33], [36], [38], [50], [53], [54], [56]
- caregivers	Lack of suitable patients	Perceived lack of appropriate patients that can be referred to VR treatment or perceived lack of support in referring patients	3	[10], [33], [34]
	Lack of support	Perceived lack of support from management in using VR	3	[23], [33], [34]
	Dissatisfaction with VR	Not satisfied with the use of VR hardware or software	2	[48], [56]
	No interest in VR use	Not interested in using VR technology in treatment	1	[64]
	Negative patient response	Expected negative patient response towards VR	1	[54]
	Resistance to new treatment	A general resistance towards new therapeutic approaches	1	[35]
Factors that influence	Low patient motivation	Patient motivation is low for VR treatment	5	[10], [33], [36], [58], [64]
opinion towards VR	Stress inducing	The new aspects of VR technology could be stress inducing because patients are exposed to a new form of treatment and new reality	2	[36], [55]

Category	Barrier	Definition	n	References
- patients	Disorientation during VR	Patient could experience disorientation when present in VR scenario	1	[59]
	Mistrust in new treatment	Patient mistrust in new or experimental treatment options	1	[38]
	No support caregiver	Patient does not feel supported in VR use by caregiver	1	[57]
Integrating VR in routines	Difficulty combining VR with existing treatment	Perceived difficulty combining VR with existing treatments and integrating VR in existing protocols	2	[37], [46]
Knowledge and skills of	Lack of time to learn and use VR	Lack of perceived time and opportunities to learn how to use VR and integrate VR in treatment	8	[10], [37], [48], [52]–[54], [57], [64]
caregivers	Lack of knowledge/skills	Lack of knowledge and skills to feel confident using VR	5	[35], [38], [39], [54], [59]
	Difficulty explaining VR	Difficulty explaining the VR system to patients during treatment	2	[33], [47]
	Difficult to learn VR	Difficult to learn how to use VR in treatment with patients	1	[50]
Category 5: Organization (n = 13 barriers)				
Readiness to innovate	Other goals taking priority	Other goals that do not focus on VR taking priority within the organizational policy	1	[33]
	Negative culture towards innovation	Negative organizational culture towards innovation and new technology	1	[38]
Introducing VR to caregivers	No opportunity to try VR	Not giving an opportunity to caregivers to try out VR for themselves	8	[10], [35], [37], [47], [48], [55], [57], [60]
	Lack of education	Not organizing enough educational opportunities to learn how to use VR	2	[10], [47]
	Lack of training courses	Not offering enough standardized training courses to caregivers	2	[[48], [51]
Providing support	Lack of time to learn VR	Not making enough time available for caregivers to learn how to use VR	13	[10], [33], [37]–[39], [47], [48], [52]–[54], [57], [64], [65]

Category	Barrier	Definition	n	References
for caregivers	Lack of technical support	Not offering technical support to help set up the VR system or help fix hardware or software malfunctions	12	[10], [33]–[35], [38], [39], [48], [52]–[54], [57], [64]
	Lack of rooms	Not having enough rooms available for VR treatment	8	[10], [36]–[38], [47], [48], [57], [64]
	Insufficient VR systems	Not having enough VR systems available for VR treatment	3	[10], [36], [48]
	No official channels to report performance issues	Not creating official channels to report performance issues experienced during VR treatment	1	[57]
Integrating VR in workflow	Lack of guidelines on patient suitability	Lack of guidelines on suitability of patients and medical indication for VR treatment	3	[35], [38], [57]
Providing conditions for	Lack of treatment protocols	Lack of validated treatment protocols on how to use VR in treatment	2	[51], [52]
use	Integration of VR	Not integrating VR in existing workflows and traditional treatment	1	[38]
Category 6: Wider system (n = 3 barriers)				
Societal development	Not innovation minded	Opinion leaders are not innovation-minded and do not support VR	2	[38], [54]
	Focus on well-being over treatment for specific conditions	Health industry's focus on creating VR for general wellbeing over developing VR treatments for specific conditions	1	[38]
Regulatory/legal issues	Ethical or legal concerns	Ethical or legal concerns around the use of VR in treatment, such as cybersecurity, privacy and regulations	1	[58]
Category 7: Embedding and adoption over time (n = 3 barriers)				
Challenge to scale up	Lack of insurance reimbursement	Lack of insurance reimbursement to compensate costs of VR use	2	[38], [39]
	Sustainability	VR use is not sustainable over a longer period of time, because risk of hardware quickly becoming obsolete	2	[51], [65]

Category	Barrier	Definition	n	References
	Lack of technical support	Lack of technical support to maintain hardware limits upscale of VR use	1	[52]

A variety of barriers that were mentioned in the included studies are displayed in Table 2. A broad range of barriers was relevant to the implementation of VR in healthcare. Most identified barriers were related to the organization category of the NASSS framework. These are mainly focused on the lack of practical resources for caregivers to use VR. For example, the organization does not schedule sufficient time for caregivers to learn how to use VR and how to integrate VR into practice. In addition to a lack of time, not enough technical support, treatment rooms for VR, and VR equipment to treat patients were mentioned as organizational barriers.

Frequently mentioned barriers related to the adopters are factors that negatively influence caregivers' opinions of VR. First, a lack of research and evidence on the added value of VR was often mentioned as a barrier. Second, a perceived lack of experience in working with VR was said to cause a lack of confidence and self-efficacy in caregivers to work with VR during treatment. The perceived lack of time and limited opportunities to learn how to use VR contributes to this feeling.

Furthermore, technical barriers were often identified to hinder VR implementation. Functional issues, such as technical malfunctioning of VR hardware or software, or a lack of client safety while wearing a VR headset in the limited space of the treatment room that limits freedom of movement were most frequently mentioned as barriers. Related to the VR headset, a lack of physical comfort for the patient when wearing the VR headset and the feeling of isolation while wearing the headset were frequently mentioned as barriers.

Lastly, barriers related to the condition, value proposition, wider system, and embedding and adoption over time categories of the NASSS framework were less frequently identified. The conditions and physical limitations of patients that could negatively influence VR use, such as several cognitive limitations, distress, or cybersickness during VR, were frequently mentioned as barriers. Related to the value proposition, barriers such as high costs to purchase VR equipment or the lack of time for maintaining the VR hardware were mentioned occasionally. In addition, the lack of personalization to patients’ needs and treatment goals was frequently mentioned as a barrier. The barriers related to the wider system and adoption over time, such as organizations not being innovation-minded or the lack of insurance reimbursement to compensate for costs of VR use were mentioned less frequently.

Facilitators to implementation

Besides barriers, a total of 53 different facilitators to the implementation of VR in healthcare was identified in 26 records. Facilitators were identified based on relevant fragments from the articles and are

divided into categories of the NASSS framework. They are mentioned and explained in Table 3 and the accompanying text below.

Table 3
Facilitators to implementation and the number of publications they were mentioned in (n)

Category	Facilitator	Definition	n	References
Category 1: Condition (n = 1 facilitator)				
Socio-demographics	Young age	Younger people may be more open to new technology and feel comfortable to use VR during treatment	2	[35], [48]
Category 2: Technology (n = 5 facilitators)				
Technical functionality	Client safety	Client is physically safe in treatment room while using VR hardware	6	[10], [35], [38], [39], [60], [61]
	Reliability	VR hardware is reliable and stable while in use	1	[61]
Usability	Patient comfort	The patient is comfortable while using VR hardware and software	4	[35], [38], [59], [62]
	Easy to use	The VR hardware and software is easy to use by end-users	3	[35], [39], [61]
Effect of VR on treatment	Realism and immersion	VR is able to induce feelings of realism and immersion	4	[10], [50], [51], [63]
Category 3: Value proposition (n = 8 facilitators)				
Influencing treatment	Safe and controlled environment	Having a virtual environment that is controlled by the caregiver and therefore offers a safe space to practice behavior	5	[49]–[51], [53], [58]
	Different reality	Practice behavior in a virtual environment of choice, while physically in the treatment room	4	[37], [38], [51], [58]
	Personalizing treatment	VR can be adapted to fit patient needs and treatment goals	3	[58], [60], [61]
	Facilitate human interaction	VR could facilitate human contact by practicing virtual roleplays, which other technologies can not	3	[49], [53], [55]
	Control and self-efficacy	VR could increase behavioral control and self-efficacy in patients	2	[51], [58]
	Insight into behavior and experiences	VR could increase insight of caregiver into behavior of patients and their experiences	1	[35]
Practical resources	Financial viability	VR demonstrates financial viability and has a strong business case	1	[35]

Category	Facilitator	Definition	n	References
	Time and resource efficient	VR is time and resource efficient to use compared to other treatment forms	1	[50]
Category 4: Adopter system (n = 18 facilitators)				
Factors that influence opinion	Evidence of VR value	Availability of validated evidence on the value of VR for treatment	10	[10], [33], [35], [38], [47]–[49], [51], [54], [64]
towards VR **-** caregivers	Experience with technology	Having experience with technology in general and/or with VR	7	[33], [36], [38], [50], [53], [54], [56]
	Added value of VR	Being aware of the benefits of VR for patients and treatment	4	[35], [37], [46], [54]
	Improvement in patients	Perception of improvement in patients' health and treatment goals	2	[47], [57]
	Satisfaction with VR	Being satisfied with the usability of VR hardware and software	2	[48], [56]
	Support from management	Perceived support from management to use VR	2	[33], [64]
	Innovativeness	Being intrigued by the innovativeness of VR in existing treatment	1	[53]
Attitude towards VR - patients	Patient motivation	VR could enhance patient motivation and engagement in treatment	11	[10], [33], [35]–[37], [39], [50], [57], [58], [63]–[65]
	Positive	VR is perceived as positive, fun and engaging by patients	1	[57]
	Less stressful	Exposure in VR is less stressful than in-vivo exposure	1	[58]
	Encouraged by caregiver	Patient feels encouraged and supported by caregiver to use VR	1	[57]
Attitude towards VR – colleagues	Positive social influence	Positive opinion of VR of colleagues causes a 'domino effect'	1	[47]
Integrating VR in routines	Combine and integrate VR	The capacity to combine and integrate VR in existing treatment	2	[37], [46]

Category	Facilitator	Definition	n	References
Knowledge and skills needed to use	Training	Offering training on how to use VR hardware and software	8	[35]–[37], [47], [49], [53], [54], [57]
VR	Knowledge and skills	Developing sufficient knowledge and skills to feel confident and comfortable using VR	5	[35], [38], [39], [54], [59]
	Intervision	The possibility of frequent contact with colleagues on VR for support, troubleshooting and reviewing VR use	2	[10], [53]
	Protocols	Having protocols or guides available on how to use VR	2	[34], [54]
	Technological capabilities	The use of VR may increase technological capabilities and vice versa	1	[53]
Category 5: Organization (n = 18 facilitators)				
Readiness to	Innovative culture	Having an innovative culture within the organization	2	[35], [38]
innovate	Champions	Strategic recruitment of champions to promote VR uptake and credibility	2	[35], [38]
	Willingness to invest	Organization is willing to invest time and money in VR	1	[64]
Introducing VR to caregivers	Try out VR	Giving the opportunity and time to caregivers to try out VR for themselves	8	[10], [35], [37], [47], [48], [55], [57], [60]
	Educational materials	Creating access for caregivers to educational materials on VR	5	[33], [34], [54], [60], [64]
	E-mail updates	Sending e-mail updates on VR use and added value of VR to keep caregivers informed on VR progress in the organization	2	[10], [34]
	Staff meetings	Introduce VR and opportunities of VR during staff meetings	1	[35]
Providing support	Time to learn VR	Offering enough time for caregivers to learn how to use VR	13	[10], [33]–[35], [38], [39], [48], [52]–[54], [57], [64]

Category	Facilitator	Definition	n	References
for caregivers	Technical system support	Offering technical system support to caregivers who work with VR	12	[10], [33]–[35], [38], [39], [48], [52]–[54], [57], [64]
	Rooms availability	Having enough rooms available for VR use	8	[10], [36]–[38], [47], [48], [57], [64]
	Support staff	Having support staff available that helps set up the VR system	6	[33], [36], [46], [47], [53], [64]
	VR systems	Sufficient VR systems to use in treatment	5	[10], [33], [36], [48], [62]
	Staff who operate VR	Having selected caregivers available who operate VR for multiple patients, instead of training all staff on VR	4	[36], [46], [47], [64]
	Staff who supervise VR	Having technical support staff available who supervise VR sessions and help caregivers	4	[39], [47], [48], [53]
	Training on patient suitability	Organizing training in determining patient suitability for VR	4	[35], [36], [49], [65]
	Train-the-trainer	A learning model in which colleagues who have experience with VR train colleagues that are new to VR	1	[65]
Integrating VR in	Fit current protocols	VR should fit with current treatment protocols	2	[38], [52]
organizational structure and workflow	Reinforcement from management	Reinforcement from management to refer clients to VR treatment	2	[36], [47]
Category 6: Wider system (n = 2 facilitators)				
Societal	Innovation minded	Opinion leaders being innovation minded and open towards VR	2	[38], [54]
development	Opinion of society	General positive opinion of society on VR	1	[51], [54]
Category 7: Embedding and adoption over time (n = 1 facilitator)				
Challenge to scale up	Commonplace and affordable	VR becomes more commonplace and affordable, making it easier to scale up VR use	1	[51]

In comparison to the barriers, facilitators to implementation are mentioned less frequently in the included studies. Similar to the barriers, most facilitators were related to the organization category of the NASSS framework. Providing support from the organization to caregivers to learn and use VR was mentioned most frequently as a facilitator. More specifically, an organization should schedule sufficient time for caregivers to learn how to use VR and allow them to try out and experiment with VR themselves. In addition, technical system support, available treatment rooms with VR equipment, and support staff during VR treatment were mentioned as important facilitators for successful VR implementation.

In multiple studies, it was mentioned that adopters of VR technology need training and education on how to use and integrate VR in treatment. Specific facilitators that are frequently identified are; training in hardware and software, intervision with colleagues that are trained in VR use, and protocols or guidelines to support VR use. Caregivers want to increase their knowledge, skills, and experience with VR to feel confident and increase self-efficacy in using VR in treatment with patients. Besides, as a facilitator in the adopter's category, it is mentioned that having access to evidence on the value of VR for treatment is a major facilitator in VR implementation because caregivers feel the use of VR is validated within treatment.

Lastly, facilitators in the condition, technology, value proposition, wider system, and embedding and adoption over time category of the NASSS framework were identified less frequently. For example, when looking at the sociodemographics of patients, the young age of patients was identified as a facilitator since these people tend to be more open to new technology and treatments and feel more comfortable using VR. Related to technology, ensuring client safety is mentioned as a facilitator, that is creating a physically safe space in the treatment room for patients to use VR. This safe and controlled environment is also identified in the value proposition category. Meaning that caregivers can create a safe space for patients to practice challenging behavior. Lastly, being innovation-minded as an organization and VR becoming more and more commonplace and affordable to scale up, are both mentioned as facilitators in the wider system category and the adoption over time category of the NASSS framework.

Recommendations for implementation

In Table 4, a total of 51 different recommendations for the implementation of VR in healthcare are provided in 20 records. These recommendations are inductively coded and divided into seven categories: 1) Increase understanding of patient suitability, 2) Improve knowledge and skills on VR use, 3) Improve caregivers’ engagement with VR, 4) Have support staff available, 5) Points of attention for developing VR treatment, 6) Support functionality of VR hardware and software, and 7) Design and development of implementation.

Table 4
Recommendations on implementation and the number of publications they were mentioned in (n)

Category	Code	Specification	n	References
Category 1: Increase understanding of patient suitability (n = 3 recommendations)				
Understanding patient suitability	Understanding suitability	Determining for which patients VR treatment is fitting	6	[33], [35], [48], [59], [60], [64]
	Functional limitations	Take patients' functional limitations into account, such as mobility or communication skills, before referring patients to VR	2	[33], [60]
	Not mandatory	Consider that not all patients want to use VR; it should not be mandatory to use	1	[66]
Category 2: Improve knowledge and skills on VR use (n = 17 recommendations)				
Learning how to use VR	Training programs	Offer training programs on technical skills for caregivers	7	[35]–[37], [48], [49], [53], [58]
	Educational resources	Develop and disseminate quality educational and training activities and materials	5	[34], [35], [37], [49], [53]
	Mentorship	Offer mentorship by colleagues experienced in VR use	4	[37], [48], [60], [65]
	Multi-phased	Develop multi-phased strategies to address caregivers needs as they progress from novice to experienced VR users	3	[33], [34], [48]
	Decision-making	Develop training on clinical decision-making and application competences of when to use VR and for whom	3	[33], [37], [48]
	Frequently reassess	Frequently reassess multi-phased strategies to see if the strategies fit with the needs of caregivers and patients	3	[33], [36], [37]
	Different formats	Use different formats in training (e.g. written documentation, video, online activities)	2	[10], [48]
	Online vs. real-life	Combine online and real-life training on VR use for caregivers	2	[10], [48]
	Individual vs. group	Combine individual and group learning on VR use for caregivers	2	[10], [48]
	Train-the-trainer	Use the train-the-trainer model in which colleagues who have experience with VR train colleagues that are new to VR	2	[33], [46]

Category	Code	Specification	n	References
	Comfortable	Make caregivers comfortable with VR use by letting them try out VR and experiment with colleagues	2	[34], [57]
	Refresher sessions	Include refresher sessions between initial skills training and caregivers first use of VR with patients	1	[10]
Information provision on VR	Knowledge gaps	Address caregivers' knowledge gaps and misconceptions about VR and address the added value of VR	2	[35], [37]
	Acceptability	Address acceptability and feasibility to aid adoption and sustained uptake	1	[35]
	Theoretical background	Provide theoretical background on VR use and effect on treatment outcomes	1	[49]
	Protocols	Develop guidelines and treatment protocols	1	[35]
Available time	Support time	Management should support time for training, use and maintenance of VR	1	[37]
Category 3: Improve caregivers' engagement with VR (n = 4 recommendations)				
Awareness and information on	Benefits	Communicate possible benefits and the importance of VR and its possible contributions to treatment to caregivers and patients	4	[46], [56]–[58]
added value of VR	Evidence	Use example cases and supporting evidence of added value of VR from research	2	[46], [59]
	Experience	Let caregivers experience VR to see the potential and increase motivation for use	1	[46]
	Purpose	Inform about purpose of using VR	1	[53]
Category 4: Have support staff available (n = 3 recommendations)				
Support staff	Staff support	Hire staff to support VR use and maintenance	4	[38], [46], [56], [59]
	Champions	Use other experienced caregivers or mentors to promote uptake and increase self-efficacy	3	[35], [48], [65]
Motivation	Encouragement	Organization should provide encouragement to caregivers with regard to using VR and motivate them to expanding their skills	1	[56]
Category 5: Points of attention for developing VR treatment (n = 11 recommendations)				

Category	Code	Specification	n	References
Treatment	Frequency of use	Use of VR in treatment ranging from daily to once a week	2	[52], [60]
considerations	When to use	Introduce VR early in treatment, but not at the first appointment, because the use of VR can be overwhelming	2	[52], [66]
	Establish goals	Establish measurable goals for VR treatment	1	[33]
	Match patient needs	VR treatment should match patient needs	1	[64]
	Become familiar	Patients should spend sufficient time with VR technology before treatment starts to become familiar with the system	1	[49]
	Step by step	Start step by step and slowly navigate within the virtual environment	1	[49]
Safety	Freedom of movement	Treatment room should offer sufficient freedom of movement to keep risk of falling as low as possible	1	[60]
	Switch off	VR systems should be able to switch off immediately, e.g. in case of dizziness	1	[60]
	Infection control	Consider hygienic measures before implementing VR in practice	1	[59]
Integration into	Part of treatment	Offer VR as part of existing treatment	2	[37], [60]
workflow	Knowledge Translation intervention	Support clinical integration of VR by knowledge translation intervention	1	[48]
Category 6: Support functionality of VR hardware and software (n = 9 recommendations)				
Functionality	Clarify needs	Clarify functional needs of VR technology that are necessary in use according to caregivers	1	[46]
	Works as intended	Check if technology works as intended	1	[46]
Technical issues	Channels to report	Make sure that caregivers are aware of the official channels that they can use to report technical issues	1	[57]
Software	Patient-appropriate	Create patient-appropriate content for VR software that fits patient needs	3	[33], [49], [59]
	Setting-appropriate	Create setting-appropriate content for VR software that fits the setting	2	[59], [66]

Category	Code	Specification	n	References
	Age-appropriate	Create age-appropriate content that fits patient age	1	[66]
Hardware	Interaction	Interaction between caregiver and patient should still be possible with headset on	1	[66]
	Relocatable	System has to be practical to set up in a treatment room and easy to relocate if necessary	1	[57]
	Adaptable	System has to be able to adapt for limited mobility of patients	1	[66]
Category 7: Design and development of implementation (n = 4 recommendations)				
Using a theoretical framework	Guide development	Use a theoretical framework to guide development of relevant implementation strategies to enhance uptake	1	[35]
Implementation intervention	Intervention	Use a multi-model and active implementation intervention to support needs of stakeholders and address barriers to VR use	2	[48]
Engaging stakeholders	Key stakeholders	Engage key stakeholders during the design and development process of implementation	4	[35], [46], [57], [65]
Integration of VR in workflow	Understanding needs	Understand clinical reasoning processes and treatment needs as means of informing features and functionality of VR systems that support integration in practice	2	[48], [65]

The first recommendation is to increase the understanding of patient suitability. In other words, it should be clear for caregivers how they can determine for which patients VR treatment is a fitting option. One way to determine patient suitability is to take into account the functional limitations of patients, such as level of mobility or communication skills, before referring patients to VR treatment. Next to functional limitations, one should take into account cognitive limitations and any sensitivity to cybersickness. Patient suitability can be dependent on the goal of VR treatment, as some functional or cognitive limitations are not always a barrier for VR use.

The second recommendation is to improve the knowledge and skills of caregivers on VR use. Training programs and other educational resources, such as training days, online meetings, or videos, that should be developed and disseminated to caregivers were often mentioned as key elements to improving knowledge and skills.

The third recommendation is to improve caregivers' engagement with VR. To accomplish this, the benefits of VR use and its possible contributions to treatment should be communicated to caregivers and patients. The use of successful example cases or disseminating supportive evidence of the added value of VR were mentioned as options to increase the engagement of caregivers with VR.

The fourth recommendation is to have sufficient support staff available to support VR use during treatment and maintain VR equipment. In addition, champions or mentors, caregivers experienced in VR treatment, were mentioned to promote uptake and increase the self-efficacy of caregivers in VR use.

The fifth recommendation is related to developing VR treatment. The included studies give some inconsistent suggestions on the frequency of use, from daily to once a week. Important aspects of developing a VR treatment are to set clear treatment goals, let the patient become familiar and comfortable with the VR equipment and software, and increase the treatment difficulty step by step.

The sixth recommendation is to support the functionality of VR hardware and software and ensure that it fits the user. Software should be appropriate for the patient's needs, and age, and should fit the treatment setting. The hardware needs to be adaptable for the limited mobility of patients, for example, patients that are wheelchair-bound. In addition, the VR hardware should still give the possibility for caregivers and patients to interact during the use of VR. The patient needs to be able to hear the voice of the caregiver.

The seventh and last recommendation is related to the design and development of the implementation of VR in practice. In multiple studies, it was advised that healthcare organizations use a structured, multi-model implementation intervention to support the needs of stakeholders and address barriers to VR use. The key stakeholders should be engaged during the development process of implementation interventions. It was recommended to use a theoretical framework, such as the Consolidated Framework for Implementation Research (CFIR) [58] or the Decomposed Theory of Planned Behavior (DTPB) [59] to guide the development of relevant implementation strategies to enhance the uptake of VR in healthcare practice.

Discussion

Principal findings

This scoping review was conducted to provide insight into the current state of affairs regarding the implementation process of virtual reality in healthcare and to identify recommendations to improve implementation research and practice in this area. This review has resulted in an overview of current implementation practice. A broad range of study designs was identified: from qualitative studies that described expected factors of implementation, to quantitative methods that summarized observed factors. From the included studies, it can be concluded that the main focus of the implementation of VR is on practical barriers and facilitators and less attention is paid to creating a systematic implementation plan, including concrete implementation objectives and suitable implementation strategies to overcome these barriers. Only two studies described objectives for implementation and the practical strategies that were used to reach these objectives. Most implementation strategies that were described were related to practical resources and organizational support to create time and room for caregivers to learn about VR and use it in treatment. Despite differences in the type of VR technology, healthcare settings, and study designs, many studies identified the same type of barriers and facilitators. Most identified barriers and

facilitators focused on the adopter system and organization categories of the NASSS framework [20], e.g., the needs of caregivers related to VR use and the organizational support during the implementation of VR. The most frequently mentioned barriers were a lack of practical resources, such as time and treatment room, a lack of validated evidence on the added value of VR, and a perceived lack of experience in working with VR. This review showed that facilitators were studied less than barriers. However, similar themes related to practical resources, organizational support, and providing evidence of the added value of VR were found between identified barriers and facilitators. The content of the recommendations for the implementation of VR fits with the foregoing.

Comparison with prior work

As stated above, the review identified a lack of studies that highlight implementation objectives and specific strategies. Despite the importance of concrete strategies to successfully implement VR [17], there is a lack of research on this systematic implementation approach and on theoretical frameworks or guidelines on which specific strategies are useful in which phase or level of implementation. In this review, only a few studies used a framework to structure implementation or data analysis. Frameworks that were mentioned most often were the Consolidated Framework for Implementation Research (CFIR) [29], and the Decomposed Theory of Planned Behavior (DTPB) [30]. However, none of the studies that mention the use of these models describe an explicit link between the separate strategies, barriers, or facilitators and the integrated systematic implementation process. This illustrates the gap in research between identifying factors that influence implementation and linking them to practical strategies to form a coherent implementation intervention. Only two studies, included in this review, used a form of systematic implementation in creating a knowledge translation (KT) intervention that focuses on the needs and behavior of clinicians. A KT intervention could be an option to structure the implementation process and bridge the gap between knowledge on the use of VR to actual uptake in practice [40]. KT interventions are aimed at promoting clinician behavior change to support implementation and improving patient care [40]. However, from implementation frameworks, such as the NASSS framework [20] or the CFIR [29], it is clear that the focus should lie on a coherent multilevel implementation intervention that focuses on all involved stakeholders and end-users, not only on one stakeholder.

The importance of focusing on the behavior change of all involved stakeholders, such as caregivers, patients, support staff, and managers, is reflected in the results of this review. Most barriers, facilitators, strategies, and recommendations are related to stakeholders within the healthcare organization that need to change their behavior in order to support implementation. For example, caregivers are expected to learn new skills to use VR and organizational management needs to make time and room available to support caregivers in their new learning needs and actual VR use during treatment. This highlights the importance of focusing on strategies that target concrete behavior of stakeholders for successful implementation. Identifying concrete behavior that is targeted in an implementation intervention can help describe who needs to do what differently, identify modifiable barriers and facilitators, develop specific strategies, and ultimately provide an indicator of what to measure to evaluate an intervention's effect on behavior change [41]. The focus on behavior in implementation is not new, it is an important point of attention in

the implementation of other eHealth technology [11]. However, based on the results of this scoping review, this focus is lacking in research on VR implementation.

To design implementation interventions that focus on behavior change of stakeholders and select suitable implementation strategies, existing intervention development frameworks can be used. An example is Intervention Mapping (IM). Intervention Mapping is a protocol that guides the design of multi-level health promotion interventions and implementation strategies [42], [43]. It uses a participatory development process to create an implementation intervention that fits with the implementation needs of all involved stakeholders [42]. Therefore, a key feature of Intervention Mapping has been its usefulness in developing strategies to enhance the implementation, adoption, and maintenance of clinical guidelines and enhance the effectiveness of evidence-based interventions [42], [44]. IM can provide guidance on overcoming barriers by applying implementation strategies based on behavioral determinants and suitable behavior change techniques [42]. For example, when reflecting on the implementation strategies described in this review, feedback as a behavior change method can be used during the education or training on VR use to support the learning needs of caregivers. In addition, providing opportunities for social support could be seen as the behavior change technique behind the need for support and discussion of VR use during intervision groups with other caregivers.

Implications for practice and future research

The results from this review provide various points of departure for future implementation research and implications for practice. An important implication for both is the need for a systematic approach to the implementation process. Most studies identified in this review focused only on barriers or facilitators to implementation, ignoring the systematic process of developing an implementation intervention that specifies implementation objectives and describes suitable strategies that fit with these barriers and facilitators to result in successful implementation. The development of an implementation intervention should preferably be supported by theoretical implementation frameworks. The current review identified a lack of studies that applied implementation frameworks, such as the Consolidated Framework of Implementation Research [29], or the NASSS framework [20]. In this review, all implementation factors could be coded with and analyzed within the categories of the NASSS framework. Indicating its usefulness in structuring implementation research. Future research could focus on applying and evaluating such implementation frameworks to the implementation of VR in healthcare, specifying factors related to the implementation of VR focusing on all phases and levels of implementation.

In addition, it could be valuable to focus on existing intervention development frameworks, such as Intervention Mapping, to guide the design of a complete implementation intervention. Future research could apply these existing frameworks in an implementation context and reflect on the similarity in working mechanisms and evaluate their influence on the implementation process and the behavior change of the involved stakeholders. This way, a first step in identifying the added value of systematic implementation intervention development can be made.

Strengths & Limitations

This review set out to give an overview of factors that are related to the implementation practice of VR in healthcare. A strength of this study is that it used the NASSS framework to structure the analysis and review process. The use of an implementation framework contributed to systematic data collection and analysis, which can increase the credibility of the findings [45]. However, the use of the NASSS framework also revealed some drawbacks. Although all implementation factors were categorized within the categories of the NASSS framework, this coding was limited by the description of these categories and the overlap between some categories. For example, most barriers and facilitators that were categorized under organization, adopters, or technology, were relevant for sustainable embedding and thus could fit in the category 'embedding and adaptation over time' as well. In addition, the description of the category 'condition', the illness of the patient, and possible comorbidities, which are often influenced by biomedical and epidemiological factors [20], is too limited to describe all factors related to patient suitability for VR. The condition of a patient within mental healthcare is often related to other aspects, such as sociodemographic factors like age, or technical skills, and feeling comfortable using new technology. All these factors could influence patient suitability for VR. Besides, in most included studies, the barriers or facilitators were not described in great detail, which made the coding process within the NASSS categories more difficult.

Furthermore, when titles of screened records did not focus on the implementation process of VR, e.g., studies that only focused on usability or effectiveness, they were excluded. Since usability studies could still partly focus on implementation, this may have caused us to miss publications that could provide interesting insights on implementation but whose main focus was other than that. We tried to overcome this limitation by selecting detailed inclusion and exclusion criteria for the literature search and abstract screening. Only when there was no indication of a link between usability and implementation, the study was excluded.

Furthermore, because this scoping review aimed to provide an overview of the current state of affairs related to the implementation of VR in healthcare, all available studies were included, regardless of their quality and type of results. This is in line with the general aim of scoping reviews, which is to present a broad overview of the evidence on a topic. Since a quality assessment was not conducted, not all results of included studies might be valid or reliable. In addition, most of the barriers, facilitators, and recommendations stated in this review are observed studies that took place after actual implementation. However, some of these factors were mentioned as potential factors related to implementation in studies that collected data before actual implementation. These factors were described as expected factors by involved stakeholders, but not observed. Therefore, these findings should be interpreted with care.

Conclusion

This scoping review has resulted in an initial overview of the current state of affairs regarding the implementation of VR in healthcare. It can be concluded that in the included publications, a clear focus on types of barriers and facilitators to the implementation of VR has been identified. Most factors are related to organizational support of the needs of caregivers during the implementation of VR. Practical

resources, such as time to use and learn VR, room for VR sets, and technical support during use were identified frequently. In addition, the importance of validated evidence on the added value of VR to support implementation became clear. However, there is a lack of studies using implementation frameworks and specifying concrete implementation strategies. To take the implementation of VR in healthcare to the next level, it is important to ensure that implementation is not studied in separate studies focusing on one element, e.g. therapist-related barriers, but that it entails the entire process, from identifying barriers to developing and employing a coherent, multi-level implementation intervention with suitable strategies. This implementation process should be supported by implementation frameworks, and ideally focus on behavior change of stakeholders such as caregivers, patients, and managers. This in turn might result in increased uptake and use of VR technologies that are of added value for healthcare practice.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

All dataset(s) supporting the conclusions of this article are available in the included primary studies.

Competing interests

All authors declare that they have no competing interests.

Funding

Funding for this study was provided by Stichting Vrienden van Oldenkotte. They had no role in the study design, collection, analysis, or interpretation of the data, writing the manuscript, or decision to submit the paper for publication.

Author Contributions

MK, HK and SK designed the study and wrote the protocol. MK conducted literature searches. MK and HK screened the titles and abstracts. MK analyzed the data and wrote the first draft of the manuscript. HK, SK, and YB contributed to and have approved the final manuscript.

Acknowledgements

Not applicable.

References

1. Kim M, Jeon C, Kim J. “A Study on Immersion and Presence of a Portable Hand Haptic System for Immersive Virtual Reality,” Sensors, 17, 5, May 2017, doi:10.3390/S17051141.
2. Pillai AS, Mathew PS. “Impact of Virtual Reality in Healthcare,” Virtual and Augmented Reality in Mental Health Treatment, vol. 17, 2018.
3. Li A, Montaño Z, Chen VJ, Gold JI, “Virtual reality and pain management: current trends and future directions,” *Pain Management*, vol. 1, no. 2, pp. 147–157, Mar. 2011, doi: 10.2217/pmt.10.15.
4. de Rooij IJM, van de Port IGL, Meijer J-WG, “Effect of Virtual Reality Training on Balance and Gait Ability in Patients With Stroke: Systematic Review and Meta-Analysis,” *Physical Therapy*, vol. 96, no. 12, pp. 1905–1918, Dec. 2016, doi: 10.2522/ptj.20160054.
5. Falconer CJ, et al. Embodying self-compassion within virtual reality and its effects on patients with depression. BJPsych Open. Jan. 2016;2(1):74–80. doi:10.1192/bjpo.bp.115.002147. “,”, , .
6. Niki K, et al., “A Novel Palliative Care Approach Using Virtual Reality for Improving Various Symptoms of Terminal Cancer Patients: A Preliminary Prospective, Multicenter Study,” *Journal of Palliative Medicine*, vol. 22, no. 6, pp. 702–707, Jun. 2019, doi: 10.1089/jpm.2018.0527.
7. Kip H, Bouman YHA, “Van denken en praten naar doen en ervaren: op zoek naar de toegevoegde waarde van technologie voor de forensische psychiatrie,” 2020.
8. Smith V, et al., “The Effectiveness of Virtual Reality in Managing Acute Pain and Anxiety for Medical Inpatients: Systematic Review,” *Journal of Medical Internet Research*, vol. 22, no. 11. JMIR Publications Inc., Nov. 01, 2020. doi: 10.2196/17980.
9. Garrett B, Taverner T, Gromala D, Tao G, Cordingley E, Sun C, “Virtual reality clinical research: Promises and challenges,” *JMIR Serious Games*, vol. 6, no. 4. JMIR Publications Inc., Oct. 01, 2018. doi: 10.2196/10839.
10. Levac DE, Miller PA, “Integrating virtual reality video games into practice: Clinicians’ experiences,” *Physiotherapy Theory and Practice*, vol. 29, no. 7, pp. 504–512, Oct. 2013, doi: 10.3109/09593985.2012.762078.
11. van Gemert-Pijnen L, Kelders S, Kip H, Sanderman R. eHealth research, theory and development. Oxford: Routledge; 2018.
12. Pieterse M, Kip H, Cruz-Martínez RR, “The complexity of eHealth Implementation: A theoretical and practical perspective,” 2018.
13. van Gemert-Pijnen JEWC, et al., “A holistic framework to improve the uptake and impact of ehealth technologies,” *Journal of Medical Internet Research*, vol. 13, no. 4. JMIR Publications Inc., Oct. 01, 2011. doi: 10.2196/jmir.1672.
14. Brassel S, Power E, Campbell A, Brunner M, Togher L. “Recommendations for the Design and Implementation of Virtual Reality for Acquired Brain Injury Rehabilitation: Systematic Review,” Journal of medical Internet research, vol. 23, no. 7, 2021.

15. Varsi C, Ekstedt M, Gammon D, Ruland CM, “Using the consolidated framework for implementation research to identify barriers and facilitators for the implementation of an internet-based patient-provider communication service in five settings: A qualitative study,” *Journal of Medical Internet Research*, vol. 17, no. 11, Nov. 2015, doi: 10.2196/jmir.5091.
16. Ross J, Stevenson F, Lau R, Murray E, “Factors that influence the implementation of e-health: A systematic review of systematic reviews (an update),” *Implementation Science*, vol. 11, no. 1. BioMed Central Ltd., Oct. 26, 2016. doi: 10.1186/s13012-016-0510-7.
17. Waltz TJ, et al., “Use of concept mapping to characterize relationships among implementation strategies and assess their feasibility and importance: Results from the Expert Recommendations for Implementing Change (ERIC) study,” Implement Sci, 10, 1, Aug. 2015, doi:10.1186/s13012-015-0295-0.
18. Powell BJ, et al., “Enhancing the impact of implementation strategies in healthcare: A research agenda,” *Frontiers in Public Health*, vol. 7, no. JAN, 2019, doi: 10.3389/fpubh.2019.00003.
19. Ritchie MJ, et al., “Using implementation facilitation to improve care in Veterans Health Administration (version 2),” *Veterans Health Administration, Quality Enhancement Research Initiative (QUERI) for Team-Based Behavioral Health*, 2017.
20. Greenhalgh T, Abimbola S, “The NASSS Framework A Synthesis of Multiple Theories of Technology Implementation,” *Studies in Health Technology and Informatics*, vol. 263, pp. 193–204, 2019, doi: 10.3233/SHTI190123.
21. Thach KS, Lederman R, Waycott J. “Virtual Reality in Residential Aged Care: a study of adoption and system complexity.”.
22. Birckhead B, et al., “Recommendations for methodology of virtual reality clinical trials in health care by an international working group: Iterative study,” *JMIR Mental Health*, vol. 6, no. 1. JMIR Publications Inc., Jan. 01, 2019. doi: 10.2196/11973.
23. Kip H. “The added value of ehealth in treatment of offenders: Improving the development, implementation and evaluation of technology in forensic mental healthcare,” 2021.
24. Davis K, Drey N, Gould D. “What are scoping studies? A review of the nursing literature,” Int J Nurs Stud, 46, no. 10. 1386–400, Oct. 2009. doi:10.1016/j.ijnurstu.2009.02.010.
25. Levac D, Colquhoun H, O’Brien KK. “Scoping studies: Advancing the methodology,” Implement Sci, 5, 1, Sep. 2010, doi:10.1186/1748-5908-5-69.
26. Arksey H, O’Malley L, “Scoping studies: Towards a methodological framework,” *International Journal of Social Research Methodology: Theory and Practice*, vol. 8, no. 1, pp. 19–32, Feb. 2005, doi: 10.1080/1364557032000119616.
27. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. J Clin Epidemiol. Oct. 2009;62(10):1006–12. doi:10.1016/j.jclinepi.2009.06.005. “,”, , .
28. Higgins JPT, (Sally S, Green E, and Cochrane Collaboration., *Cochrane handbook for systematic reviews of interventions*. Wiley-Blackwell, 2008.

29. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. “Fostering implementation of health services research findings into practice: A consolidated framework for advancing implementation science,” Implement Sci, 4, 1, 2009, doi:10.1186/1748-5908-4-50.
30. Taylor S, Todd P. “Marketing Decomposition and crossover effects in the theory of planned behavior. A study of consumer adoption intentions; 1995. &#8221.
31. Venkatesh V, Thong JYL, Xu X, “Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology,” 2012.
32. Rogers E, *Diffusion of Innovations*. 1995.
33. Glegg SMN, et al., “Evaluating change in virtual reality adoption for brain injury rehabilitation following knowledge translation,” *Disability and Rehabilitation: Assistive Technology*, vol. 12, no. 3, pp. 217–226, Apr. 2017, doi: 10.3109/17483107.2015.1111944.
34. Banerjee-Guénette P, Bigford S, Glegg SMN, “Facilitating the Implementation of Virtual Reality-Based Therapies in Pediatric Rehabilitation,” *Physical and Occupational Therapy in Pediatrics*, vol. 40, no. 2, pp. 201–216, Mar. 2020, doi: 10.1080/01942638.2019.1650867.
35. Chung OS, et al., “Implementation of Therapeutic Virtual Reality Into Psychiatric Care: Clinicians’ and Service Managers’ Perspectives,” Front Psychiatry, 12, Jan. 2022, doi:10.3389/fpsyt.2021.791123.
36. Demers M, et al., “Exergaming for stroke rehabilitation: Lessons learned for future implementation strategies,” 2019.
37. Levac DE, et al., “A comparison of virtual reality and active video game usage, attitudes and learning needs among therapists in Canada and the US,” *2019 International Conference on Virtual Rehabilitation (ICVR)*, pp. 1–7, 2019.
38. Sarkar U, Lee JE, Nguyen KH, Lisker S, Lyles CR, “Barriers and facilitators to the implementation of virtual reality as a pain management modality in academic, community, and safety-net settings: Qualitative analysis,” *Journal of Medical Internet Research*, vol. 23, no. 9, Sep. 2021, doi: 10.2196/26623.
39. Vincent C, Eberts M, Naik T, Gulick V, O’Hayer CV, “Provider experiences of virtual reality in clinical treatment,” *PLoS ONE*, vol. 16, no. 10 October, Oct. 2021, doi: 10.1371/journal.pone.0259364.
40. Cavenett W, et al., “Deploying new technology in residential aged care: Staff members’ perspectives,” in *ACM International Conference Proceeding Series*, Dec. 2018, pp. 200–204. doi: 10.1145/3292147.3292214.
41. Nguyen AV, et al. Virtual reality exergaming as adjunctive therapy in a sub-acute stroke rehabilitation setting: facilitators and barriers. Disabil Rehabilitation: Assist Technol. May 2019;14(4):317–24. doi:10.1080/17483107.2018.1447608. “,”, , .
42. Ogourtsova T, Archambault PS, Lamontagne A, “Exploring barriers and facilitators to the clinical use of virtual reality for post-stroke unilateral spatial neglect assessment,” *Disability and Rehabilitation*, vol. 41, no. 3, pp. 284–292, Jan. 2019, doi: 10.1080/09638288.2017.1387292.
43. Stamou G, Garcia-Palacios A, Botella C, “The combination of cognitive-behavioural therapy with virtual reality for the treatment of post-natal depression,” in *ACM International Conference*

Proceeding Series, Dec. 2019, pp. 599–603. doi: 10.1145/3369457.3369541.

44. Rimer E, Husby LV, Solem S, “Virtual Reality Exposure Therapy for Fear of Heights: Clinicians’ Attitudes Become More Positive After Trying VRET,” *Frontiers in Psychology*, vol. 12, Jul. 2021, doi: 10.3389/fpsyg.2021.671871.
45. Ma L, et al. Integrating virtual realities and psychotherapy: SWOT analysis on VR and MR based treatments of anxiety and stress-related disorders. Cogn Behav Ther. 2021;50(6):509–26. doi:10.1080/16506073.2021.1939410. “,”, , .
46. Langlet BS, Odegi D, Zandian M, Nolstam J, Södersten P, Bergh C. “Virtual reality app for treating eating behavior in eating disorders: Development and usability study,” JMIR Serious Games, 9, 2, Apr. 2021, doi:10.2196/24998.
47. Bryant L, et al. “Opportunities for Immersive Virtual Reality in Rehabilitation. Focus on Communication Disability; 2020. &#8221.
48. Kramer TL, Pyne JM, Kimbrell TA, Savary PE, Smith JL, Jegley SM. Clinician perceptions of virtual reality to assess and treat returning veterans. Psychiatric Serv. 2010;61(11):1153–6. “,”, .
49. Üstel P, et al. Acceptability and Feasibility of Peer Specialist-Delivered Virtual Reality Job Interview Training for Individuals with Serious Mental Illness: A Qualitative Study. J Technol Hum Serv. 2021;39(3):219–31. doi:10.1080/15228835.2021.1915924. “,”, , .
50. Algahtani M, Altameem A, Baig AR. An Extended UTAUT2 model to Explain the Adoption of Virtual Reality Technology in Health Centers_ An Empirical Study Based in Riyadh. Int J Comput Sci Netw Secur. 2021;21(3):219–28. “,”, .
51. Høeg ER, Scully CFR, Bruun-Pedersen JR, Serafin S, “The reality of implementing virtual reality: A case study on the challenges of integrating vr-based rehabilitation,” in *Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST*, 2020, vol. 328 LNICST, pp. 749–759. doi: 10.1007/978-3-030-53294-9_58.
52. Lindner P, Miloff A, Zetterlund E, Reuterskiöld L, Andersson G, Carlbring P, “Attitudes toward and familiarity with virtual reality therapy among practicing cognitive behavior therapists: A cross-sectional survey study in the era of consumer VR platforms,” *Frontiers in Psychology*, vol. 10, no. FEB, Feb. 2019, doi: 10.3389/fpsyg.2019.00176.
53. Nwosu AC, Mills M, Roughneen S, Stanley S, Chapman L, Mason SR. Virtual reality in specialist palliative care: a feasibility study to enable clinical practice adoption. BMJ Supportive and Palliative Care. 2021. doi:10.1136/bmjspcare-2020-002327. “,” .
54. Dahms R, Stamm O, Müller-Werden U, “Developing a VR Training Program for Geriatric Patient with Chronic Back Pain,” 2019. [Online]. Available: http://www.springer.com/series/7409.
55. Tennant M, McGillivray J, Youssef GJ, McCarthy MC, Clark TJ, “Feasibility, Acceptability, and Clinical Implementation of an Immersive Virtual Reality Intervention to Address Psychological Well-Being in Children and Adolescents With Cancer,” *J Pediatr Oncol Nurs*, vol. 37, no. 4, pp. 265–277, Jul. 2020, doi: 10.1177/1043454220917859.

56. Ford CG, Manegold EM, Randall CL, Aballay AM, Duncan CL. Assessing the feasibility of implementing low-cost virtual reality therapy during routine burn care. Burns. Jun. 2018;44(4):886–95. doi:10.1016/j.burns.2017.11.020. “,”, , .
57. Demers M, Chan Chun D, Kong, Levin MF. Feasibility of incorporating functionally relevant virtual rehabilitation in sub-acute stroke care: perception of patients and clinicians. Disabil Rehabilitation: Assist Technol. May 2019;14(4):361–7. doi:10.1080/17483107.2018.1449019. “,”, , .
58. Levac D, et al. A knowledge translation intervention to enhance clinical application of a virtual reality system in stroke rehabilitation. BMC Health Serv Res. Oct. 2016;16(1):1–11. doi:10.1186/s12913-016-1807-6. “,”, , .
59. Proffitt R, Glegg S, Levac D, Lange B, “End-user involvement in rehabilitation virtual reality implementation research,” *Journal of Enabling Technologies*, vol. 13, no. 2, pp. 92–100, Aug. 2019, doi: 10.1108/JET-10-2018-0050.
60. Easterlin MC, et al., “Child and Parent Perspectives on the Acceptability of Virtual Reality to Mitigate Medical Trauma in an Infusion Center,” *Maternal and Child Health Journal*, vol. 24, no. 8, pp. 986–997, Aug. 2020, doi: 10.1007/s10995-020-02955-x.
61. Levac D, Glegg SM, Camden C, Rivard LM, Missiuna C. Best Practice Recommendations for the Development, Implementation, and Evaluation of Online Knowledge Translation Resources in Rehabilitation. Phys Ther. 2015;95(4):648–62. “,”, .
62. Presseau J, McCleary N, Lorencatto F, Patey AM, Grimshaw JM, Francis JJ. “Action, actor, context, target, time (AACTT): A framework for specifying behaviour,” Implement Sci, 14, 1, Dec. 2019, doi:10.1186/s13012-019-0951-x.
63. Eldredge LKB, Markham CM, Ruiter RA, Fernández ME, Kok G, Parcel GS. Planning health promotion programs: an intervention mappinga pproach. John Wiley & Sons; 2016.
64. Proctor EK, Powell BJ, Mcmillen JC, “Implementation strategies: recommendations for specifying and reporting,” *Implementation Science*, vol. 8, 2013, [Online]. Available: http://www.implementationscience.com/content/8/1/139.
65. Donaldson A, Lloyd DG, Gabbe BJ, Cook J, Finch CF, “We have the Programme, what next? Planning the implementation of an injury prevention programme,” *Injury Prevention*, vol. 23, no. 4, pp. 273–280, Aug. 2017, doi: 10.1136/injuryprev-2015-041737.
66. Lincoln YS, Guba EG, “But is it rigorous? Trustworthiness and authenticity in naturalistic evaluation,” *New Directions for Program Evaluation*, vol. 1986, no. 30, pp. 73–84, 1986, doi: 10.1002/ev.1427.

Figures

Figure 1. ***Search strategy and results***

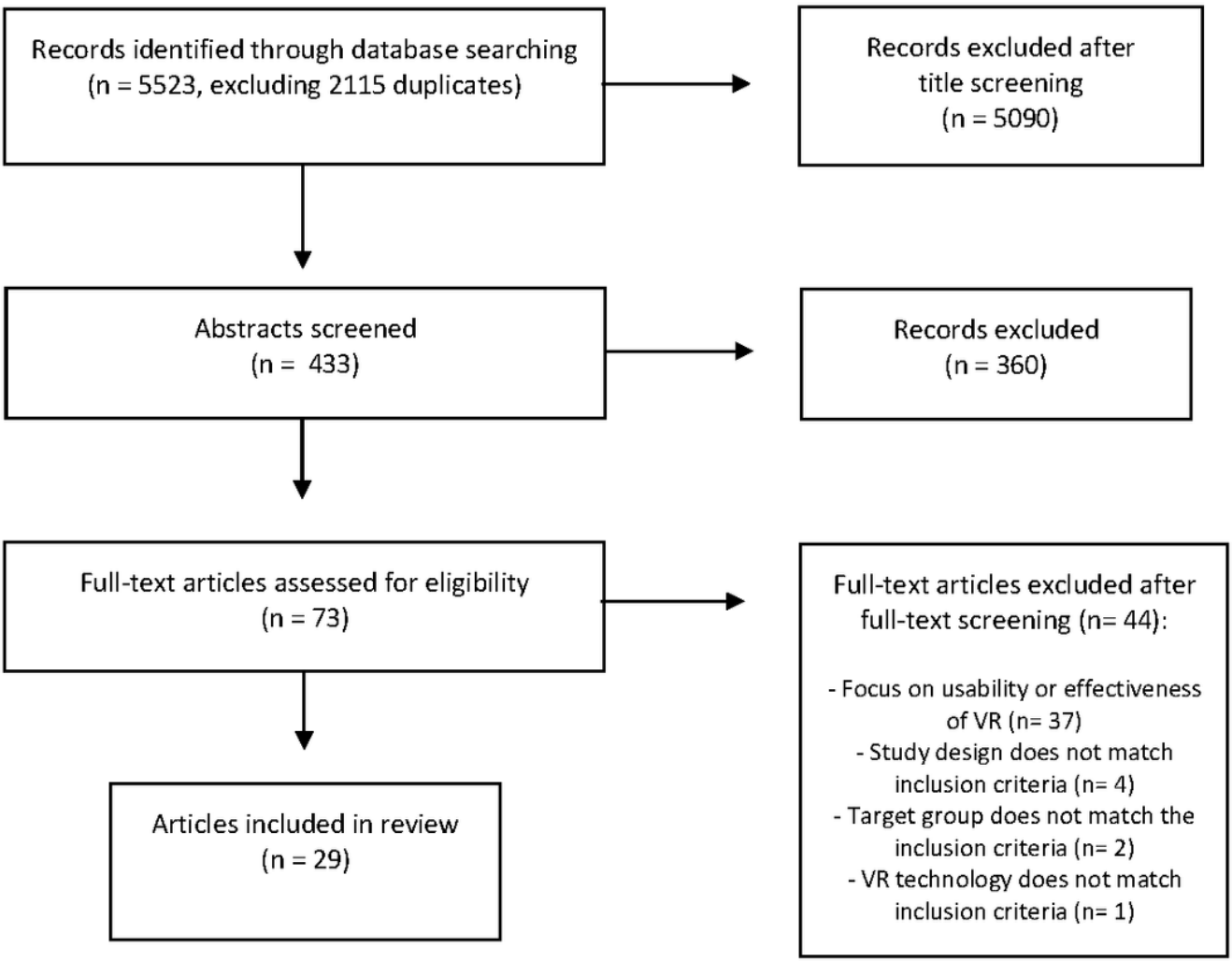

Figure 1

Search strategy and results

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Appendix.docx
- AdditionalfilePRISMAScRFillableChecklist.pdf