Published in final edited form as:

PM R. 2018 November ; 10(11): 1237–1251.e1. doi:10.1016/j.pmrj.2018.07.004.

Barriers, Facilitators and Interventions to Support Virtual Reality Implementation in Rehabilitation: A Scoping Review

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Abstract

Virtual reality and active video games (VR/AVGs) are promising rehabilitation tools because of their potential to facilitate abundant, motivating, and feedback-rich practice. However, clinical adoption remains low despite a growing evidence base and the recent development of clinically accessible and rehabilitation-specific VR/AVG systems. Given clinicians' eagerness for resources to support VR/AVG use, a critical need exists for knowledge translation (KT) interventions to facilitate VR/AVG integration into clinical practice. KT interventions have the potential to support adoption by targeting known barriers to, and facilitators of, change. This scoping review of the VR/AVG literature uses the Theoretical Domains Framework (TDF) to (1) structure an overview of known barriers and facilitators to clinical uptake of VR/AVGs for rehabilitation; (2) identify KT strategies to target these factors to facilitate adoption; and (3) report the results of these strategies. Barriers/facilitators and evaluated or proposed KT interventions spanned all but 1 and 2 TDF domains, respectively. Most frequently cited barriers/facilitators were found in the TDF domains of Knowledge, Skills, Beliefs About Capabilities, Beliefs About Consequences, Intentions, Goals, Environmental Context and Resources, and Social Influences. Few studies empirically evaluated KT interventions to support adoption; measured change in VR/AVG use did not accompany improvements in self-reported skills, attitudes, and knowledge. Recommendations to target frequently identified barriers include technology development to meet end-user needs more effectively, competency development for end-users, and facilitated VR/AVG implementation in clinical settings. Subsequent research can address knowledge gaps in both clinical and VR/AVG implementation research, including on KT intervention effectiveness and unexamined TDF domain barriers.

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Disclosure

Disclosure: nothing to disclose

Supplementary Data

Supplementary data associated with this article can be found in the online version at <https://doi.org/10.1016/j.pmrj.2018.07.004>.

Introduction

Virtual reality and active video games (VR/AVG) are promising rehabilitation tools because of their potential to facilitate abundant, motivating, and feedback-rich practice [1,2]. A steady increase in the number of peer-reviewed articles evaluating the effects of VR/AVG interventions in many rehabilitation populations has been observed over the past 20 years. This increase reflects a growing interest in VR/AVG from the rehabilitation research and development sectors. Ideally, newly developed and empirically evaluated products and interventions that are found to be safe and effective would be quickly integrated into clinical practice. Yet what we are observing in patient care follows a more typical pattern for the adoption of evidence-based treatment techniques or tools: one of slow and variable progress [3].

Collaboration between engineers and product end-users can inform the development of useful VR/AVG technologies that meet the needs of clients and therapists. Moving VR/AVG technology into the hands of therapists allows clients to benefit from its therapeutic potential. Systematically examining the factors that impact VR/AVG adoption in rehabilitation, and the effect of knowledge translation (KT) strategies on behaviors related to their use, is critical for guiding the successful implementation of these technologies. A clear understanding of how VR/AVG is being used by clinicians, the limitations clinicians face in integrating the technologies into their daily treatment routines, and the most effective strategies for supporting clinicians in technology adoption are paramount to informing these implementation approaches.

Recent surveys of occupational and physical therapists in Canada [4], the United States (Levac et al., in preparation), and Scotland [5] on their use of VR/AVG and their learning needs related to future use of these technologies provides a foundational knowledge base about current clinical use. Nearly half of the 1071 respondents in Canada [4] and 76% of the 491 U.S. respondents (Levac et al., in preparation) had used VR/AVG clinically. However, only 12% of respondents in Canada [4], 31% in the United States (Levac et al., in preparation), and 18% of the 112 respondents in Scotland [5] reported current use. This discrepancy indicates the need for additional efforts to identify and to address existing barriers to VR/AVG use. Commercially available AVG systems were the most common systems in use in all 3 countries [4,5] (Levac et al., in preparation); the use of rehabilitation-specific VR systems by Canadian [4] and U.S. therapists (Levac et al., in preparation) was much lower (<3% of respondents for any given system).

Despite low reported daily use, VR/AVG systems were perceived by therapists to be widely relevant to rehabilitation for a number of different client populations, functional recovery goals and practice settings [4]. Sixty-one percent of respondents in Scotland reported that they would use gaming if it were available to them [5]. The majority of respondents in both Canada [4] (76.3%) and the United States (69.9%) (Levac et al., in preparation) reported low self-efficacy in using VR/AVG clinically, but were interested in learning more. Commonly reported learning needs included knowledge and skills in selecting appropriate systems and games for individual clients, grading activities, evaluating outcomes, and integrating theoretical approaches to treatment [4,6,7]. These findings suggest a strong need for

educational resources and knowledge translation (KT) supports to facilitate evidence-based technology adoption [4,6]. KT is the process of moving evidence into practice [8]. KT interventions have the potential to support adoption by targeting known barriers to change, including a lack of knowledge and skills [9].

Strong insights into the factors influencing therapists' adoption of VR/AVG have emerged only in the past 5 years. A decomposed Theory of Planned Behavior, which integrates constructs from the Technology Adoption Model and the Diffusion of Innovation theory forms the theoretical basis for the majority of this research [4,6]. The Theoretical Domains Framework (TDF) is another approach that can be used to conceptualize the evaluation of barriers and facilitators of change, including technology adoption [10]. The TDF is an implementation framework that integrates 128 theoretical constructs drawn from 33 behavior change theories into 14 barrier/facilitator domains [10]. Although the framework has not been applied yet to this body of literature, it offers a more comprehensive approach to the identification and classification of barriers and facilitators of change than a single theory or framework alone. Drawn from the KT literature, the framework can be used to structure the assessment of barriers and facilitators of change across a range of contexts, as well as the selection of interventions to target these barriers and facilitators [10].

The purpose of this scoping review was to apply the TDF to examine the extent, range, and nature of studies assessing VR/AVG barriers and facilitators and/or recommending or evaluating KT interventions to promote VR/AVG adoption in rehabilitation since 2005. Our objectives were to

1. present an overview of factors known to limit or support VR/AVG adoption for rehabilitation;
2. describe the KT strategies that have been recommended or evaluated to address these factors and to report on their effectiveness, where possible; and
3. provide recommendations for technology development, research, and clinical implementation based on these findings.

Methods

A scoping review is “a form of knowledge synthesis, which incorporate a range of study designs to comprehensively summarize and synthesize evidence with the aim of informing practice, programs, and policy and providing direction to future research priorities” [11(p1291)]. This review followed the scoping review methodology recommendations by Levac et al [12], with the exception of a formal consultation with stakeholders. The review was composed of 5 steps: (1) defining the research question; (2) identifying relevant studies; (3) selecting the studies; (4) charting the data; and (5) collating, summarizing, and reporting the results to inform practice and future research [12].

Research Questions

This review was guided by the questions (1) What barriers and facilitators influence VR/AVG adoption in rehabilitation? and (2) What interventions have been proposed and/or evaluated to facilitate VR/AVG adoption in rehabilitation?

Data Sources and Search Strategy

A search was undertaken in PubMed, CINAHL, Web of Science, IEEE Xplore, PsycINFO, and Embase for articles published since 2005. Keywords and subject headings related to the following concepts: VR/AVG (eg, virtual reality, video game), rehabilitation (eg, physical or occupational therapy, rehabilitation, therapists), adoption (eg, implementation, uptake, use, adoption), barriers/facilitators (eg, challenges, barriers, supports, facilitators), and KT interventions (eg, education, knowledge broker, framework, assistance). The detailed search strategy used for PubMed can be found in Appendix 1. All citations were imported into RefWorks and duplicate citations were removed manually.

Eligibility Criteria

Inclusion criteria included articles relating to using VR/AVGs for OT/PT-related rehabilitation whose primary aim was either to describe facilitators/barriers to VR adoption and/or to discuss (without the need to evaluate the extent/effectiveness of) strategies to support VR adoption (eg, education or training, clinical resources, mentoring, audit and feedback, modifying the environment) and publication in peer-reviewed journals or conference proceedings. Exclusion criteria included abstract-only publications (ie, no full-text article available) and non-English-language articles.

Study Selection

Titles and abstracts were reviewed by one investigator (D.L.) to exclude articles not meeting inclusion criteria. A second investigator (S.G.) reviewed titles/abstracts for articles that required consultation. Full-text articles were then assessed for eligibility and included or rejected based on in-depth review.

Data Charting

Data were extracted from each included article by the 2 investigators (D.L. and S.G.) with respect to the study type, rehabilitation context, VR/AVG equipment, and therapists involved, in order to describe the literature. Text pertaining to reported barriers, facilitators, as well as proposed or evaluated KT interventions was also extracted. Information on intervention effectiveness was compiled for all evaluation studies. Level of evidence based on study design was assigned for all intervention studies using the American Academy for Cerebral Palsy and Developmental Medicine (AACPDMD) level of evidence scales [13]. Authors met to review the charting framework after extracting data from 5 studies to resolve any conflicts.

Data Summary and Synthesis

Characteristics of included articles were summarized in a table. The range, extent, and nature of barriers, facilitators, and evaluated or proposed KT interventions within included

studies was summarized narratively. The extracted text relating to barriers, facilitators, and interventions was combined under value-neutral (ie, non-barrier or facilitator-specific) categories that reflected the same theme (eg, need suitable clients, and lack of appropriate clients categorized as “Appropriate clients”) and coded by S.G. in accordance with the 14 domains of the TDF based on the context provided by the study authors wherever relevant [10], and presented in tabular form. Recommendations about next steps for technology development, research, and clinical implementation were developed based on these findings.

Results

Range, Nature and Extent of Included Studies

Figure 1 provides a flow diagram of the search process. Table 1 outlines the design, population, level of evidence, and VR/AVG system of interest of the 24 included articles. The majority of articles (18/24, 75%) focused on neurologic rehabilitation (stroke, cerebral palsy, or acquired brain injury), with 3 (12.5%) focusing on geriatric patients, patients with burns, or patients with lung cancer and 3 (12.5%) not specifying a population. Six articles (25%) related to off-the-shelf AVGs, 10 (41.6%) on VR/AVGs with custom-developed software, 1 (0.04%) on VR using head-mounted displays, and 7 (29.2%) did not specify VR/AVG system type.

Barriers and Facilitators, and Interventions to Support VR/AVG Adoption

Table 2 uses the TDF [10] to summarize the full range of barriers, facilitators, and KT interventions identified across the articles included in this review. Barriers and facilitators span all TDF domains but one (Emotion), whereas proposed interventions were represented across 12 of the 14 domains (excluding Emotion and Social/Professional Role and Identity). The domain with the most barriers/facilitators was Environmental Context and Resources. Most frequently cited barriers/facilitators were found in the TDF domains of Knowledge, Skills, Beliefs About Capabilities, Beliefs About Consequences, Intentions, Goals, Environmental Context and Resources, and Social Influences. These frequent barriers and facilitators fell primarily into 3 categories: (1) Technology development (degree of match between the system and the client’s goals/needs, the ability to grade the degree of training, transfer of training to real life, perceived motivational utility); (2) Competency development for end-users (knowledge about how to operate and to apply the technology clinically, therapist self-efficacy and perceived ease of use, perceived utility); and (3) Facilitated clinical implementation (technical and treatment space issues, access to the technology, time to learn/practice and to use, support for set-up/takedown and administering treatment, client and therapist motivation). Of note was that many factors were identified both as barriers and as facilitators, within a given article, and across articles.

Of the 24 articles included in this review, only 6 articles (describing 4 studies) evaluated KT interventions to support VR/AVG adoption. Quantitative outcomes included therapist self-reported skills, knowledge, attitudes, and intention to use VR/AVG [6,14,19,20,23]. The KT interventions that have been evaluated included an online decision-making tool to support AVG use [23]; the provision of an expert clinician and assistant in a dedicated exergaming room for access by therapists [14]; a multifaceted strategy consisting of interactive

education, a clinical manual, technical and clinical support, and environmental modifications [6,22]; and a multifaceted strategy employing interactive e-learning modules, hands-on workshops, and experiential practice [19,20]. The 2 mixed-methods studies found that KT interventions improved therapists' knowledge and skills in using the technology [6,19,20], as well as their perceived ease of use of the technology and their confidence in providing VR/AVG-based treatment [6]. One study measured the impact of the KT intervention on objective measures of behavior change, including motor learning strategy use in VR implementation, and observer-rated clinical decision-making competencies about VR use [19,20], finding no changes in these outcomes following the KT intervention. In the only longitudinal study [19], no increase in VR adoption was observed in clinical practice at 6 months post KT intervention.

Discussion

Barriers and facilitators spanning almost the entirety of the TDF suggests multifaceted interventions are necessary to address the range of factors influencing adoption in any given setting. The level of evidence available in this body of literature demonstrates its emerging state with respect to the intervention studies. Qualitative, cross-sectional cohort survey, feasibility, and usability studies are valid approaches for the identification of barriers and facilitators, particularly within the specific settings in which implementation efforts are planned. The national survey studies provide a more generalized perspective of VR/AVG use and the factors influencing their adoption at a broader health system level. Repeat evaluations in different countries and practice settings, and over time, will enable comparisons to understand more clearly the dynamics of VR/AVG adoption in these differing contexts.

Based on the findings of this scoping review, we propose the following recommendations, summarized in Table 3, for developers, researchers, managers, and clinicians to facilitate the integration of VR/AVG into clinical practice and to support the evaluation of implementation efforts that employ evidence-informed KT strategies.

Technology Development

Taken together, the barrier assessment findings clearly identify the need for VR/AVG technologies designed to more effectively meet therapist and client needs. Engineers and game developers can build on the existing literature and work in collaboration with clinicians to design rehabilitation-centered VR/AVG applications [32]. Health professionals can share with developers the clinical reasoning processes they use to individualize the use of these technologies as a means of informing their design for rehabilitation. This perspective may support the integration of software parameters that enable the grading of the degree of physical tasks and challenge to meet the therapeutic needs and abilities of a broad range of clients. Of substantial interest is how to achieve a balance between adequate flexibility in the design of customizable software parameters while avoiding overwhelming clinicians with abundant decision-making requirements or decreased ease of use. Developing systems that group games according to functional goals, movement requirements, and client abilities are examples of efforts to achieve this balance.

Motivation for clients to participate in VR/AVG often declines over time as the novelty fades [35], or may be limited by features, such as the nature of the graphics, the variety in tasks, or the degree of challenge [17,18,22]. A greater understanding of how to design VR/AVG systems with attributes that enhance and sustain motivation and engagement over the course of treatment is needed to promote client adherence to longer-term intervention programs. Developing such systems can also enhance therapists' decision making about grading VR/AVG-based activities during treatment.

Competency Development for End Users

A common topic raised repeatedly in the barriers/facilitators' findings was that further supports for therapist competency development are needed. The development of KT resources and supports to provide information about the evidence supporting VR/AVG, the technology's utility for rehabilitation, and its operation, and to facilitate clinical use of the technology, can be used to address therapists' learning needs. Knowledge about the specific learning needs of therapists as reported in the literature [4] can be used to guide the development of clinical training resources. New VR/AVG systems should include such clinical training in their purchase packages. Managers need to make time for training and practice with new systems, and university curricula for therapy students should include clinical VR/AVG use and decision-making. Students may be engaged to support the competency development of more experienced clinicians without VR/AVG experience, and our upcoming VR/AVG competency self-evaluation tool (Glegg and Levac, in preparation) can be used to guide targeted training efforts and to monitor competency development over time. Online access to self-paced training and clinical resources can support their widespread use. More research is required to identify how best to implement and to sustain a mentoring model to facilitate VR/AVG adoption [20,22].

Facilitated Implementation in Clinical Settings

Meeting therapists' needs is paramount to facilitating technology adoption because they are the gatekeepers and decision makers of rehabilitation intervention delivery for their clients. Involving therapists in decision making about which systems will best meet their needs and those of their clients, as well as in the implementation planning process, is essential. Factors, such as perceived ease of use, perceived usefulness, and compatibility of the technology with practice preferences can be assessed or discussed as part of the decision-making process [22]. Failure to engage therapists in this way may result in discrepancies between their needs and what the technology can offer [19]. Addressing environmental and resource barriers early in the implementation process (eg, funding, treatment space requirements, location, technical and clinical personnel support, time to learn and to use) can also promote the likelihood of success [6,19]. For optimal effectiveness, KT interventions should target identified barriers and facilitators of change [36].

The use of knowledge brokers or clinical champions is an emerging KT intervention that has demonstrated promise with respect to fostering the development of knowledge and skills, promoting behavior change and supporting implementation efforts [37]. Knowledge brokers can make evidence more accessible, connect key stakeholders (eg, therapists with VR/AVG researchers and clinical experts), build capacity (eg, through mentoring or training),

facilitate implementation processes, and evaluate implementation outcomes [38]. This strategy has received substantial endorsement from therapists in one study, and may warrant future clinical piloting and empirical study [6].

Therapists' intrinsic motivation and intention to use VR/AVG can be derived from their own personal interest in these technologies, which may increase as VR/AVG becomes more mainstream, from growing evidence to support their effectiveness, from self-efficacy in using it clinically, from social influences in their work environments, or from other factors, such as characteristics of the technology, cost-benefit analysis of carrying out the intervention, adequate time to administer treatment, or requests for VR/AVG-based treatment from clients [6,22]. Context-specific research is required to determine the relative influence of these and other factors at the individual level.

Given the variability in therapists' perceptions of barriers and facilitators across individuals and health care settings, we recommend context-specific barrier assessments for any clinical site in which VR/AVG implementation is being planned. This information will enable targeting of the most significant barriers to uptake, while mobilizing existing facilitators. Tools, such as the ADOPT-VR-2 [4,22], or frameworks, such as the TDF [10], may provide structure to guide a comprehensive evaluation of the factors likely to influence use of the technologies.

Research Gaps

The findings regarding limitations in the evidence as a barrier suggests that high-quality evidence demonstrating that VR/AVG is at least equal to, if not more effective than, other treatment options is needed in order for therapists to perceive VR/AVG adoption to warrant the effort required for its successful clinical implementation [39]. This evidence base should also develop to provide guidance with respect to optimal dosage, key therapeutic ingredients, and information about safety and contraindications. Although research conducted at the body function level of the International Classification of Functioning, Disability and Health (ICF) [40] (eg, strength, range of motion outcomes) is valuable, a research gap of critical relevance to clinicians relates to outcomes at the activity and participation levels [41,42]. In particular, more research is needed to understand to what extent skills learned in a virtual environment transfer to real-life functional settings [1,41,42]. Population-specific treatment guidelines do not exist in this field to support therapists in their clinical decision making about how and with whom to use VR/AVG. Identifying methods to evaluate client progress, and offering guidance in the interpretation of system-integrated assessment features with respect to their clinical importance may also be of value [6,34]. An integrated KT approach that engages clinicians and other stakeholders throughout the research process can support the design of clinical-relevant research and technology, facilitate the piloting and implementation of VR/AVG research and technology, and promote organizational change and capacity development [43].

The examination of barriers/facilitators and interventions from the TDF domains of Optimism, Reinforcement, Emotion and Social/Professional Role and Identity would augment existing research in this field. These domains received little to no attention by the authors of the included studies and may provide additional insights into effective strategies

to support adoption. The development of a TDF-based assessment tool based on the findings of this review, or the use of existing tools employing other theoretical approaches (eg, the decomposed Theory of Planned Behavior) [4,6], may prove to be valuable for ongoing research. Other common KT strategies that have been shown to be useful in other contexts, such as audit and feedback, opinion leaders, mass media, reminders, computerized decision support, local consensus processes, and client-mediated interventions [44,45], could also be possible intervention approaches to evaluate in this context, if matched appropriately to the barriers and facilitators within a given clinical setting.

Presently, the state of the evidence on KT intervention effectiveness for VR/AVG adoption is in its infancy. Proffitt and Lange [2] remind researchers to follow a “stepwise approach” for intervention development and to clearly outline the active ingredients of their interventions to allow for carefully designed, externally valid effectiveness and efficacy trials. We recommend the Simplified Framework of KT Interventions (or “AIMD” Framework) for this purpose, which prompts researchers to state Active ingredients, Intended targets, Mechanisms of action, and Delivery modes for their proposed interventions [46]. The research findings presented here provide a foundation for designing KT intervention studies that can generate insights into the effectiveness of a range of strategies that directly target identified barriers and facilitators to promote therapists’ use of the technology in different contexts. This list is by no means comprehensive, but offers a starting point for future research and practice that comes from the perspective of therapists themselves. Further work to identify additional interventions not currently described in this body of literature may expand the toolkit available for those facilitating VR/ AVG implementation.

Limitations

This article provides an overview of the barriers, facilitators, and intervention strategies related to VR/AVG adoption by therapists. The search strategy employed may have resulted in the omission of relevant articles or resources (eg, gray literature, articles in non-English languages, publications prior to 2005). Individual interpretation of the data extracted from included articles during the categorization of barriers/facilitators and interventions according to TDF domains may have produced results that might differ from an alternative coder’s analysis. This limitation is particularly pertinent to the classification of the interventions because of the general lack of explicit linkage between barriers/facilitators and intervention components reported by the articles’ authors. Further research is warranted to explore the relevance and validity of these and of alternative TDF domain classifications through qualitative methods. Given that primary studies were not appraised for methodological quality, we were not able to make conclusions about the reliability or validity of effectiveness findings of the evaluated KT strategies.

The focus of this review with respect to barriers and facilitators was on therapist perspectives; as such, the perceptions of clients have not been addressed. A thorough understanding of the client perspective is also critical to support engagement and adherence to VR/AVG-based rehabilitation, but was beyond the scope of this work. With the exception of the national survey studies [4,5], (Levac et al., in preparation) the findings discussed here were necessarily drawn from small-scale research because of the current state of the

evidence, and in the case of barriers/facilitators, the nature of the research question. Larger samples from multisite randomized controlled trials in a variety of practice settings would offer the strongest evidence for the effectiveness of different KT interventions across health care contexts.

Finally, the recommendations do not address all of the barriers/facilitators and research gaps identified in this review. Researchers and those supporting VR/AVG development and implementation must undertake a more comprehensive context-specific analysis of these findings in order to avoid overlooking important directions of value.

Conclusion

This review identified an extensive range of barriers and facilitators spanning nearly the entire range of the TDF domains. Prominent categories identified in the literature related to technology development, end-user competency development, and facilitating clinical implementation. Few studies empirically evaluated KT interventions to support adoption, and gaps exist in proposed strategies to target identified barriers. Recommendations for technology development, competency development, and facilitated clinical implementation can be applied by VR/AVG developers, researchers, health administrators, and clinicians to facilitate VR/AVG adoption. Further to the need for additional high-quality VR/AVG effectiveness studies, a significant demand exists for targeted VR development and implementation research. This research should engage clinicians throughout the development, testing, and implementation processes; examine the role of barriers and facilitators, particularly within uncharted TDF domains; and further evaluate the effectiveness of the various KT interventions compiled here, as well as those KT interventions shown to be effective in other implementation contexts.

Acknowledgments

The authors thank Andrea Ryce for her assistance developing the search strategy, and Marta Samokishyn and Silhouette Renteria for their assistance running the literature search.

This work was not supported by a specific research grant. Stephanie Glegg is supported by a Vanier Canada Graduate Scholarship, a Canadian Child Health Clinician Scientist Program Career Enhancement Award, a UBC Public Scholars Award and a Four-Year Fellowship. Danielle Levac is supported by a Mentored Research Scientist Career Development Award (K01HD093838) from the National Institutes of Health.

Appendix 1 Detailed PubMed Search Strategy

Concept	Keywords
VR/active video games (AVG)	virtual real* OR virtual technolog* OR virtual gam* OR virtual environment OR video gam* OR computer gam* OR electronic gam* OR MeSH terms: Video games OR Computer simulation OR User-computer interface
Barriers/facilitators	barrier* OR facilitat* OR support* or challeng*
Adoption of VR/AVG	adopt* OR implement* OR uptake or use
Rehabilitation	rehabilitation OR physical therapy OR occupational therapy OR physiotherapy OR clinical
Therapists	Physical therapist* OR physiotherapist* OR occupational therapist* OR clinician*

Concept	Keywords
KT Intervention	Education OR training or tool* or resource* OR e-learning* or online module* OR tutorial* or workshop* OR mentor* OR evidence or decision-making framework OR support OR environment* OR personnel or assistance OR knowledge broker* OR champion OR template* OR protocol

References

1. Levin M, Weiss P, Keshner E. Emergence of virtual reality as a tool for upper limb rehabilitation: Incorporation of motor control and motor learning principles. *Phys Ther* 2015;95: 415–426. [PubMed: 25212522]
2. Proffitt R, Lange B. Considerations in the efficacy and effectiveness of virtual reality interventions for stroke rehabilitation: Moving the field forward. *Phys Ther* 2015;95:441–448. [PubMed: 25343960]
3. Grimshaw JM, Eccles MP, Lavis JN, Hill SJ, Squires JE. Knowledge translation of research findings. *Implement Sci* 2012;7:50. [PubMed: 22651257]
4. Levac D, Glegg S, Colquhoun H, Miller P, Noubary F. Virtual reality and active videogame-based practice, learning needs, and preferences: A cross-Canada survey of physical therapists and occupational therapists. *Games Health J* 2017;6:217–228. [PubMed: 28816511]
5. Thomson K, Pollock A, Bugge C, Brady MC. Commercial gaming devices for stroke upper limb rehabilitation: A survey of current practice. *Disabil Rehabil Assist Technol* 2016;11: 454–461. [PubMed: 25634339]
6. Glegg S, Holsti L, Stanton S, et al. Evaluating change in virtual reality adoption for brain injury rehabilitation: A knowledge translation study. *Disabil Rehabil Assist Technol* 2017;12: 217–226. [PubMed: 28508725]
7. Levac D, Miller P, Missiuna C. Usual and virtual reality video game-based physiotherapy for children and youth with acquired brain injuries. *Phys Occup Ther Pediatr* 2012;32:180–195. [PubMed: 21942894]
8. Canadian Institutes of Health Research. Knowledge translation at CIHR. Available at <http://www.cihr-irsc.gc.ca/e/29418.html>. Accessed October 12, 2016.
9. Glegg SMN, Holsti L, Stanton S, et al. Using virtual reality in clinical practice: A multi-site exploratory study. *NeuroRehabilitation* 2014; 35:563–577. [PubMed: 25238866]
10. Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implement Sci* 2012;7:37. [PubMed: 22530986]
11. Colquhoun HL, Levac D, O'Brien KK, et al. Scoping reviews: Time for clarity in definition, methods, and reporting. *J Clin Epidemiol* 2014;67:1291–1294. [PubMed: 25034198]
12. Levac D, Colquhoun H, O'Brien KK. Scoping studies: Advancing the methodology. *Implement Sci* 2010;5:69. [PubMed: 20854677]
13. Darrah J, Hickman R, O'Donnell M, Vogtle L, Wiart L. AACPD Methodology to Develop Systematic Reviews of Treatment Interventions (Revision 1.2). <https://www.aacpdm.org/UserFiles/file/systematic-review-methodology.pdf>. Published 2018.
14. Nguyen AV, Ong YLA, Luo CX, et al. Virtual reality exergaming as adjunctive therapy in a sub-acute stroke rehabilitation setting: Facilitators and barriers. *Disabil Rehabil Assist Technol* 2018:1–8.
15. Valdés BA, Glegg SMN, Lambert-Shirzad N, et al. Application of commercial games for home-based rehabilitation for people with hemiparesis: Challenges and lessons learned. *Games Health J* 2018;7:g4h.2017.0137.
16. Ogourtsova T, Archambault PS, Lamontagne A. Exploring barriers and facilitators to the clinical use of virtual reality for post-stroke unilateral spatial neglect assessment. *Disabil Rehabil* 2017;7:1–9.
17. Glegg S Virtual rehabilitation with children: Challenges for clinical adoption from the field. *IEEE Pulse* 2017;8:3–5. [PubMed: 29155369]

18. Schmid L, Glässel A, Schuster-Amft C. Therapists' perspective on virtual reality training in patients after stroke: A qualitative study reporting focus group results from three hospitals. *Stroke Res Treat* 2016;2016:6210508. [PubMed: 28058130]
19. Levac D, Glegg SMN, Sveistrup H, et al. A knowledge translation intervention to enhance clinical application of a virtual reality system in stroke rehabilitation. *BMC Health Serv Res* 2016;16:557. [PubMed: 27716179]
20. Levac DE, Glegg SMN, Sveistrup H, et al. Promoting therapists' use of motor learning strategies within virtual reality-based stroke rehabilitation. *PLoS One* 2016;11:e0168311. [PubMed: 27992492]
21. Hoffman AJ, Brintnall RA, Cooper J. Merging technology and clinical research for optimized post-surgical rehabilitation of lung cancer patients. *Ann Transl Med* 2016;4:28. [PubMed: 26889481]
22. Glegg SMN, Holsti L, Velikonja D, Ansley B, Brum C, Sartor D. Factors influencing therapists' adoption of virtual reality for brain injury rehabilitation. *Cyberpsychol Behav Soc Netw* 2013;16:385–401. [PubMed: 23713844]
23. Levac D, Espy D, Fox E, Pradhan S, Deutsch JE. "Kinect-ing" with clinicians: A knowledge translation resource to support decision making about video game use in rehabilitation. *Phys Ther* 2015;95: 426–440. [PubMed: 25256741]
24. Ferche O-M, Moldoveanu A, Moldoveanu F, Voinea A, Asavei V, Negoii I. Challenges and issues for successfully applying virtual reality in medical rehabilitation. Paper presented at: 11th International Scientific Conference eLearning and Software for Education; Bucharest; April 24–25, 2015 10.12753/2066-026X-13-131.
25. Tatla SK, Shirzad N, Lohse KR, et al. Therapists' perceptions of social media and video game technologies in upper limb rehabilitation. *JMIR Serious Games* 2015;3:e2. [PubMed: 25759148]
26. Valdés BA, Hilderman CGE, Hung CT, Shirzad N, Van der Loos HFM. Usability testing of gaming and social media applications for stroke and cerebral palsy upper limb rehabilitation. *Annu Int Conf IEEE Eng Med Biol Soc* 2014;2014:3602–3605.
27. Kiselev J, Haesner M, Gövercin M, Steinhagen-Thiessen E. Implementation of a home-based interactive training system for fall prevention: Requirements and challenges. *J Gerontol Nurs* 2015; 41:14–19.
28. Levac DE, Miller PA. Integrating virtual reality video games into practice: Clinicians' experiences. *Physiother Theory Pract* 2013; 29:504–512. [PubMed: 23362843]
29. Levac DE, Galvin J. When is virtual reality "therapy"? *Arch Phys Med Rehabil* 2013;94:795–798. [PubMed: 23124132]
30. Hochstenbach-Waelen A, Seelen HAM. Embracing change: Practical and theoretical considerations for successful implementation of technology assisting upper limb training in stroke. *J Neuroeng Rehabil* 2012;9:1. [PubMed: 22244362]
31. McCullagh PJ, Mountain GA, Black ND, et al. Knowledge transfer for technology based interventions: Collaboration, development and evaluation. *Technol Disabil* 2012;24: 233–243.
32. Laver K, George S, Ratcliffe J, Crotty M. Virtual reality stroke rehabilitation—hype or hope? *Aust Occup Ther J* 2011;58: 215–219. [PubMed: 21599688]
33. Markus LA, Willems KE, Maruna CC, et al. Virtual reality: Feasibility of implementation in a regional burn center. *Burns* 2009;35: 967–969. [PubMed: 19447555]
34. Glegg SMN, Hung C-T, Valdes Benavides BA, Kim BDG, Van der Loos HFM. Kinecting the Moves: The kinematic potential of rehabilitation-specific gaming to inform treatment for hemiparesis. *Int J Child Health Hum Dev* 2016;9:351–360.
35. James S, Ziviani J, King G, Boyd RN. Understanding engagement in home-based interactive computer play: Perspectives of children with unilateral cerebral palsy and their caregivers. *Phys Occup Ther Pediatr* 2016;36:343–358. [PubMed: 26606419]
36. Colquhoun H, Grimshaw J, Wensing M. Mapping KT interventions to barriers and facilitators In: Straus S, Tetroe J, Graham ID, eds. *Knowledge Translation in Health Care: Moving from Evidence to Practice*. 2nd ed. Chichester, UK: Wiley Blackwell BMJ Books; 2013:137–149.
37. Bornbaum CC, Kornas K, Peirson L, Rosella LC. Exploring the function and effectiveness of knowledge brokers as facilitators of knowledge translation in health-related settings: A systematic review and thematic analysis. *Implement Sci* 2015; 10:162. [PubMed: 26589972]

38. Glegg SMN, Hoens AM. The role domains of knowledge brokering: A model for the healthcare setting. *J Neurol Phys Ther* 2016;40: 115–123. [PubMed: 26937654]
39. Laver K, Ratcliffe J, George S, Lester L, Crotty M. Preferences for rehabilitation service delivery: A comparison of the views of patients, occupational therapists and other rehabilitation clinicians using a discrete choice experiment. *Aust Occup Ther J* 2013;60:93–100. [PubMed: 23551002]
40. World Health Organization. The International Classification of Functioning, Disability and Health. Geneva: World Health Organization; 2001.
41. Glegg SMN, Tatla SK, Holsti L. The GestureTek virtual reality system in rehabilitation: A scoping review. *Disabil Rehabil Assist Technol* 2014;9:89–111. [PubMed: 23713408]
42. Laver K, Lange B, George S, Deutsch J, Saposnik G, Crotty M. Virtual reality for stroke rehabilitation. *Cochrane Database Syst Rev* 2017;11:CD008349. [PubMed: 29156493]
43. Gagliardi AR, Berta W, Kothari A, Boyko J, Urquhart R. Integrated knowledge translation (iKT) in health care: A scoping review. *Implement Sci* 2016;11:38. [PubMed: 26988000]
44. Grimshaw JM, Shirran L, Thomas R, et al. Changing provider behavior: An overview of systematic reviews of interventions. *Med Care* 2001;39(8) (suppl 2):I12–I45.
45. Canadian Agency for Drugs and Technologies in Health. Rx for Change database. Available at <https://www.cadth.ca/rx-change>. Published 2014.
46. Colquhoun H, Leeman J, Michie S, et al. Towards a common terminology: A simplified framework of interventions to promote and integrate evidence into health practices, systems, and policies. *Implement Sci* 2014;9:51. [PubMed: 24885553]

Figure 1.
Flow diagram of search strategy and screening results.

Table 1

Summary of Included Articles

First Author, Year [Reference Number]	Study Design (Level of Evidence [14]) *	Population	Clinicians	VR/AVG Interface/ System Type	KT Intervention Evaluated	Evaluation Findings
Nguyen, 2018 [14]	Qualitative case study (V)	Stroke	OT, PT	Motion capture and body- worn sensor, custom software	Expert clinician and assistant available to develop client treatment programs	Expert clinician-related facilitator themes included client safety, practicality, and reliability; communication was both a facilitator and a barrier
Valdes, 2018 [15]	Qualitative findings from mixed- methods randomized cross-over intervention study	Pediatric and adult hemiplegia	OT, PT	Motion capture, custom software		N/A
Ogourtsova, 2017 [16]	Qualitative barrier/facilitator assessment	Stroke	OT	Nonspecific		N/A
Glegg, 2017 [17]	Perspective	Pediatric	Not specified	Nonspecific		N/A
Levac, 2017 [4]	Cross-sectional survey (assessment of barriers/facilitators, VR/AVG usage habits and learning needs)	Nonspecific	OT, PT	Nonspecific		N/A
Schmid, 2016 [18]	Qualitative study of barriers/facilitators and experiences using VR	Stroke	OT, PT	Sensor glove, custom software		N/A
Levac, 2016 [19]	Mixed-methods pre/post evaluation of a KT intervention (IV)	Stroke	OT, PT	Motion capture, custom software	Interactive e- learning modules, hands-on workshops, experiential practice	Improved perceived behavioral control, self-efficacy and facilitating conditions/barriers ratings; no change in intention to use VR (high at baseline) or in frequency of perceived barriers; increase in knowledge and skills, retained at 6 mo
Levac, 2016 [20]						Improved self-confidence about using motor learning strategies with VR; No change in competencies for motor learning strategy use or in use of motor learning strategies
Hoffman, 2016 [21]	Descriptive account of the authors’ experience conducting a clinical AVG trial	Lung cancer	Nurses (overseeing balance training program)	Handheld sensor, off-the- shelf AVG		N/A
Glegg, 2017 [6]	Mixed-methods pre/post evaluation of a KT intervention (IV)	Pediatric and adult brain injury	OT, PT, RT	Motion capture, custom software I	Interactive education, clinical manual, charting template, technical and clinical support, environmental modifications	Increased perceived ease of use and self-efficacy; No change in intention to use VR (high at baseline); Decreased frequency of reported barriers

First Author, Year [Reference Number]	Study Design (Level of Evidence [14])*	Population	Clinicians	VR/AVG Interface/ System Type	KT Intervention Evaluated	Evaluation Findings
Glegg, 2013 [22]	Cross-sectional survey (baseline barrier/facilitator assessment)					N/A
Thomson, 2016 [5]	Cross-sectional survey (assessment of opinions and use of AVG)	Stroke	OT, PT	Off-the-shelf AVG		N/A
Levac, 2015 [23]	Qualitative study of the usability of a KT resource to support clinical AVG use (V)	Nonspecific	PT	Motion capture, off-the-shelf AVG	Usefulness and usability of the resource; suggestions for improvement	Need a decision-making algorithm, clear, descriptive category names and more content on game use with people with disabilities; videos helpful to illustrate game play
Ferche, 2015 [24]	Narrative review of considerations for using VR	Nonspecific	Not specified	Nonspecific		N/A
Tatla, 2015 [25]	Qualitative study of perceptions and barriers of AVG use	Stroke; cerebral palsy	OT, PT	Motion capture, off-the-shelf AVG		N/A
Valdes, 2014 [26]	Usability study assessing ease of use, barriers/facilitators and changes required to the technology	Stroke; cerebral palsy	OT, PT	Motion capture, custom software		N/A
Kiselev, 2014 [27]	Mixed-methods user acceptance and usability study	Geriatrics	PT	Motion capture and worn sensor, custom software		N/A
Levac, 2013 [28]	Qualitative study of observations about clinical AVG integration	Pediatric brain injury	PT	Handheld sensor, off-the-shelf AVG		N/A
Levac, 2013 [29]	Perspective	Pediatric	OT, PT	Nonspecific		N/A
Levac, 2012 [7]	Qualitative study of therapists' descriptions of their motor-based interventions	Pediatric brain injury	PT	Handheld sensor, off-the-shelf AVG		N/A
Hochstenbach-Waelen, 2012 [30]	Literature search and qualitative interviews to identify criteria/conditions of technology to facilitate its adoption	Stroke	OT, PT	Nonspecific		N/A
McCullagh, 2012 [31]	Descriptive account of the authors' experience developing and evaluating technology prototypes	Stroke	Various	Nonspecific telerehabilitation		N/A
Laver, 2011 [32]	Perspective	Stroke	OT	Nonspecific		N/A
Markus, 2009 [33]	VR implementation feasibility study to determine resource requirements	Burn	OT, PT	Head-mounted display, custom software		N/A

VR = virtual reality; AVG = active video game; KT = knowledge translation; OT = occupational therapists; PT = physiotherapists; N/A = not applicable; RN = registered nurses; RT = rehabilitation therapists.

* Level of evidence is provided only for intervention study designs.

Table 2

Reported Barriers/Facilitators of, and KT Interventions to Support Adoption

TDF Domain Descriptions [11]	Barriers/Facilitators	Interventions
<i>Knowledge:</i> An awareness of the existence of something	<ul style="list-style-type: none"> • Knowledge about the differences between VR and conventional therapy (including benefits) [30] • Knowledge of disadvantages of different systems [30] • Awareness of usefulness of the technology [30] • Knowledge to operate the technology [4,16,17,22,28,30] • Familiarity with games/tasks [14,22] • Knowledge to apply the technology clinically [4,5,16,17,19,22,28] • Familiarity of clients with technology [14,15,21,32] 	<ul style="list-style-type: none"> • Clinical resources, including manual [6,19,20,22,30]: <ul style="list-style-type: none"> ○ Overview of technical operation ○ Information about differences between VR/AVG and conventional therapy • Information about benefits of VR/AVG <ul style="list-style-type: none"> ○ Overview of games matched to functional goal areas ○ Software parameter setting guidelines for different functional levels ○ Activity grading tips ○ Sample goals/support to structure measurable goals ○ Clinical forms for documentation • Guide for supporting clients with multiple impairments and varying levels of consciousness <ul style="list-style-type: none"> ○ Instructions on managing technical issues • Self-paced e-learning modules [6,17,19,20] <ul style="list-style-type: none"> ○ Embedded video clips ○ Interactive learning activities ○ Knowledge checks to demonstrate learning • Evidence syntheses [6] • Task analysis of games to facilitate matching to client goals and functional abilities [6,15,22]
<i>Skills:</i> An ability or proficiency acquired through practice	<ul style="list-style-type: none"> • Therapist experience with the system [4,14,18,22] • Client experience with the system [30] • Skills to optimize patient outcomes [17] • Opportunity for practice [7,14,15,19,30,32] 	<ul style="list-style-type: none"> • Interactive education/training for hands-on learning [5,6,17,19,20,29,30] • Use of case examples [6] • Video tutorials targeting specific learning needs [19,20] • Individualized 1:1 clinical mentoring [6,22] • Online support strategies [4,6] • Competency development framework to guide self-evaluation and development of competencies required for clinical VR use [6,22,29]
<i>Social/professional role and identity:</i> A coherent set of behaviors and displayed personal qualities of an individual in a social or work setting	<ul style="list-style-type: none"> • Attitude of therapist toward the technology [4,6,7,22,30] • Attitude of patient toward the technology [7,19,21] • Reconciling therapist role in gaming context [7,25] • Being tech-savvy (clients and therapists) [4,14,22] • Compatibility with treatment preferences needs [4,6,7,19,22] • Keeping up with rapid technological advances [32] 	Not addressed
<i>Beliefs about capabilities:</i> Acceptance of the truth, reality, or validity about an ability, talent, or facility that a person can put to constructive use	<ul style="list-style-type: none"> • Self-perceptions of being generally tech-savvy [22] • Availability of education opportunities [4,6,19,22] • Perceived ease of use of the technology (for both clinicians and patients) [4,6,7,14,16,19,22,24] • Self-efficacy in clinical use of the technology [4,7,19,22,32] 	<ul style="list-style-type: none"> • Practice opportunities with the equipment outside of clinical time to support skill development and self-efficacy [15,19,20,24,30] • Graded/multistage training approach (general knowledge, then specific operational, then clinical skills) [6,19]
<i>Optimism:</i> The confidence that things will happen for the best or that desired goals will be attained	<ul style="list-style-type: none"> • Therapists have to take responsibility to use it well [28] • Skepticism about its benefits [4,6,22,27] 	<ul style="list-style-type: none"> • Experience/use of the technology [27]
<i>Beliefs about consequences:</i> Acceptance of the truth, reality, or validity about outcomes of a behavior in a given situation	<ul style="list-style-type: none"> • Perceived therapeutic benefit to clients [4,6,14,16,19,22,27] • Perceived match to client's goals/needs [4,6,7,14,17,19,22,25,30,31] • Perceived match to therapist's needs [4,6,22,30,31] • Perceived motivational utility [4,6,7,19,22,28] • Concerns about screen time [6,17] 	<ul style="list-style-type: none"> • Evidence syntheses to raise awareness of the potential benefits of VR use [6,29] • Demonstrate clinical utility in the clinical setting [30] • Implement clinical outcome measurement for VR/AVG use [6]

TDF Domain Descriptions [11]	Barriers/Facilitators	Interventions
<p><i>Reinforcement:</i> Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus</p> <p><i>Intentions:</i> A conscious decision to perform a behavior or a resolve to act in a certain way</p> <p><i>Goals:</i> Mental representations of outcomes or end states that an individual wants to achieve</p> <p><i>Memory, attention, and decision processes:</i> The ability to retain information, focus selectively on aspects of the environment, and choose between 2 or more alternatives</p> <p><i>Environmental context and resources:</i> Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behavior</p>	<ul style="list-style-type: none"> • Transfer of training to real life [4,16,18,20,22,24,25,32] • Privacy concerns of social media use/confidentiality of data [25] • Potential for physical fatigue [26] • Confidence in expert clinician/mentor [14] • Ethical issues [24] • Legal issues [24] • Relative advantage over other options [4,6,22,25,30] • Being reminded to use the system [14] <p>• Therapist's motivation/interest in using VR/video games with clients [4,6,7,16–18,22,30]</p> <p>• Therapist's interest in learning more about clinical VR/AVG use [4,17]</p> <ul style="list-style-type: none"> • Fun and meaningful [5] • Degree of client motivation [4,6,7,18,19,22] • Ability to use for home-based treatment [15,27,28] • Integrates physical and cognitive tasks [28] • Targets fine-motor goals [19] • Potential to target a range of goals [14] • Opportunity for client self-practice [5] • Opportunity for additional practice outside of regular therapy sessions [14] • Opportunity for social interaction [5] • Opportunity for competition [4] • Degree of system/game's match to client's needs/goals [4,6,7,14,19,22] <ul style="list-style-type: none"> • Competing technologies [4,6,17,22] • Competing treatments [4,6,17,22] • Multiple goals [22] • Ease of identifying ways in which to target different goals [28] • Applying evidence (research and clinical) related to VR effectiveness [30] • Determining appropriate timing of VR introduction [6,22] <p><i>Technology-specific factors:</i></p> <ul style="list-style-type: none"> • Technical issues [4–6,14,15,18,19,22] • Appropriateness of instructions and feedback provided by the system (eg, complexity, clarity, negative vs positive) [7,14] • Sensory feedback provided [4,18] • Age appropriateness of use [16,17,25,34] • Ecological validity of the virtual environment/tasks [18,32] • Equipment/interface sized/calibrated for client/patient [17] • Robustness/precision of device tracking capabilities [14,26] • Task specificity [14] 	<ul style="list-style-type: none"> • Engage therapists in a needs assessment to match available VR/AVG systems with specific client and practice setting needs [19] • Collaboration between therapists, game designers, and researchers to develop virtual environments/systems [30,32] <ul style="list-style-type: none"> • Email reminders [14] <ul style="list-style-type: none"> • Target theory-based determinants of intention (attitudes, perceived ease of use, perceived usefulness, compatibility, social influences, perceived behavioral control, self-efficacy, facilitating conditions and barriers) [6,22] • Share evidence on effectiveness [30] • Engage clinicians in research [22] • Identifying direct links between functional goals, activity grading, and outcome measurement [6] <ul style="list-style-type: none"> • Clinical decision-making framework to guide selection of VR systems based on therapeutically relevant characteristics [17,28,30] • Clinical decision-making resources—for activity selection, task grading, and medical documentation [6,17,27,28] • Support for determining client appropriateness for VR-based therapy [6,22,28] • Feedback about the use of a theoretical approach to VR-based treatment to promote reflection about therapist's performance in clinical VR use [20] • Step-by-step guide for system operation [22,26] • Providing time for therapist to make clinical observations of clients using VR/AVG [15] • Make disadvantages of systems clear to therapists [30] <p><i>Technology-specific:</i></p> <ul style="list-style-type: none"> • Technical support (on-site) [6,17,22,29,33] • Incorporate principles of human computer interaction [31] • Establish permanent or standardized setup configuration to minimize technical issues [6,22] • Support to interpret system-embedded evaluation metrics [17] • User-centered design, evaluation, and implementation processes [17]

TDF Domain Descriptions [11]	Barriers/Facilitators	Interventions
	<ul style="list-style-type: none"> • Socioemotional features, eg, opportunities for social connection [5,25] • Variety of games/tasks [14,15,22,32] • Appropriateness of level of challenge/ability to grade challenge [4–7,14,17,19,22,25,28,32] • Ability to trial the technology [8] • Time for client to accommodate to VR/AVG room or to being in VR environment [14,24] • Accessible to clients eg, compatibility with mobility equipment, cognitive impairment [6,14,17,22,32] • Compatibility of applications across devices [24] • Degree of risk of motion sickness [24,32] • Potential for compensation and overuse injuries [15,26] • Safety concerns [21] • Privacy concerns for online platforms [17,25] • Pop-up ads and in-app purchases [15,17] • Graphics offered by the system [17,18,22] 	
	<p><i>Environmental factors:</i></p> <ul style="list-style-type: none"> • Treatment space issues (eg, dedicated; proximity to typical treatment areas, getting patients to room) [4–6,14,17,19,22] • Scheduling process [6,14] • Organizational support [16,30] • Different environments that affect system functioning, eg, home [14,21,27] • Standard procedures congruent with the technology's use, eg, treatment of multiple clients concurrently [19] • Client length of stay [6,19] • Length of therapy sessions [14] • Appropriate clients/patient acceptance [4,6,16,22] • VR research participation [6,17,22] 	<p><i>Environment-specific:</i></p> <ul style="list-style-type: none"> • Increased availability and accessibility of the room [14,22,30] • Dedicated VR treatment space [5,6,17,22] • Moving VR equipment closer to regular treatment space [19] • Scheduling [6] • Do extensive pretesting of the technology in new environments [27] • Participation in research to enhance its clinical relevance and facilitate implementation [17,22]
	<p><i>Resource-related factors:</i></p> <ul style="list-style-type: none"> • Cost [24,32] • Technical support [4,6,17,22,33] • Availability of/access to the technology [4,6,14,16,17,22,25,30] • Time to set up and clean [6,22,33] • Support for equipment set-up/take-down and to administer treatment programs [4,6,14,16,22,33] • Need to supervise treatment [14,15,24,29] • Access to evidence [4,6,17,22,31] • Quality of evidence [4–6,17,22] • Availability of evidence [5,24,32] • Familiarity with/awareness of evidence [4,6,17,22] • Availability of clinical tools/required resources [4,6,22] • Access to education [4,6,22] • Time to learn how to use [4–7,14–17,19,22,33] • Time to use VR [4–7,19,22] • Therapist mentor providing clinical instruction/feedback [6,22] • Management support [4,6,22] • Staff scheduling issues [6] 	<p><i>Resource-specific:</i></p> <ul style="list-style-type: none"> • Funding [4,5] • Technical support (on-site) [6,17,22,29,33] • Support staff assistance with equipment set-up/take-down [6,22] • Rehabilitation support personnel to administer treatment program [6,22,29] • Purchasing multiple VR systems to reduce scheduling conflicts [6,22] • Protected time to practice using the systems [17] • Supervisor support [17] • Identifying peer mentors, knowledge brokers, or champions to support competency development, access to evidence and adoption [17] • Expert clinician to deliver treatment [14] • Dedicated personnel to set up/take down equipment [22,33] • User-centered design, evaluation, and implementation processes [17] • Centralized cleaning process [33] • Organization to provide required resources [14] • Education opportunities [4,22] • Management support, eg, for physical resources and time to practice [28] • Repeated assessment of barriers/facilitators to guide KT interventions over time as therapist needs change [6,19]
<p><i>Social influences:</i> Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviors</p>	<ul style="list-style-type: none"> • Client motivation and/or engagement [4,6,7,14,17,19,22,24,33] • Client fear of the technology [21] • Colleagues with interest/experience in VR [22] • Therapists' social connections [22] • Peer influence [4,6,17,22] 	<ul style="list-style-type: none"> • Engaging therapists in research [6,22] • Engaging a site "champion" or knowledge broker to model VR use and to support implementation [6,17,22] • Facilitating communication between expert clinician and therapists [14]

TDF Domain Descriptions [11]	Barriers/Facilitators	Interventions
	<ul style="list-style-type: none"> • Peer mentors/knowledge brokers/champions/experts [14,17,22] • Communication among staff [14] • Supervisor support [4,6,17,22] <p>Not addressed</p>	<ul style="list-style-type: none"> • Information exchange between researchers, device suppliers, device engineers, therapists, and users [18] <p>Not addressed</p>
<p><i>Emotion:</i> A complex reaction pattern, involving experiential, behavioral, and physiological elements, by which the individual attempts to deal with a personally significant matter or event</p> <p><i>Behavioral regulation:</i> Anything aimed at managing or changing objectively observed or measured actions</p>	<ul style="list-style-type: none"> • Training in system operation and clinical best practices [4,6,18,22] • Scheduling clients [6] • Integrating the technology into existing practices [30] • Referral process [14] • Action plan detailing conditions to be fulfilled for ongoing use of the technology [30] 	<ul style="list-style-type: none"> • Training in system operation and clinical best practices [6,22,29] • Medical documentation templates to facilitate regular charting of patients' VR sessions [6] • Support to integrate system-embedded evaluation metrics into clinical evaluation processes [17] • Integrate technology into existing practices [30] • Protocol documents to prompt therapists in carrying out procedures, eg, technical operation [6] • Implement an easy-to-use referral system [14] • Provide step-by-step guidance process for ongoing use of the technology [14,30] • Develop implementation intervention, eg, training methods and materials, based on evidence-informed knowledge translation strategies [16,29]

KT = knowledge translation; TDF = Theoretical Domains Framework; VR = virtual reality; AVG = active video games.

Table 3

Summary of Recommendations

Recommendation	Technology Development	Competency Development for End Users	Facilitated Implementation in Clinical Settings	Research Gaps
Enhance collaboration	Engineers and developers should work with clinicians and other end-users throughout the technology development process	Managers should work with clinicians to facilitate time for learning; students can share knowledge with clinicians; explore a mentoring model	Engage clinicians in decisions about which systems to acquire; explore the effectiveness of knowledge brokers for VR/AVG implementation	Use an integrated KT approach by engaging therapists throughout the research/KT processes; work with KT scientists to explore implementation strategies that have been effective in other contexts
Ensure KT interventions are system- and context-specific	Include tailored clinical training packages	Undertake a site-specific learning needs and barrier/facilitator assessment prior to selecting/implementing a VR/AVG system	Address site-specific institutional barriers to technology use, eg, adequate resources, personnel, environmental setup, etc	Explore the role of potential barriers/facilitators in uncharted TDF domains; evaluate which KT approach is best suited to different facilitators and barriers across varying VR/AVG systems
Optimize VR/AVG effectiveness through an evidence-based approach	Design VR systems to exploit their evidence-based, scalable attributes (eg, feedback); apply evidence on client motivation to inform system design and therapeutic approach (eg, grading activities, game selection)	Develop training and clinical tools based on best practices in education and KT, and documented learning needs	Design implementation strategies that target known barriers and facilitators, as well as KT best practices	Expand the clinical evidence base by which clinicians can inform their work; researchers should clearly outline the proposed active ingredients of their KT interventions [46]

VR/AVG = virtual reality/active video games; KT = knowledge translation; TDF = Theoretical Domains Framework.