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Systematic Review

Extended Reality Therapies for Anxiety Disorders: A Systematic Review of Patients' and Healthcare Professionals' Perspectives

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Abstract: (1) Background: Anxiety disorders are among the most common psychiatric conditions and have a rising prevalence. Patients with anxiety disorders can, however, be deterred from seeking treatment due to associated stigmas and medication side effects. Evidence indicates that promising digital health solutions to address those concerns reside in the growing field of extended reality (XR). The limited literature synthesis from the perspectives of patients and healthcare professionals (HCPs) regarding the experiences and effectiveness of XR-based anxiety disorder therapies motivated the undertaking of this systematic review. (2) Methods: A systematic search of the literature was conducted according to the PRISMA 2020 guidelines on the following databases: CINAHL, APA PsycNet and PubMed. The search was completed on 23 January 2024 with no restriction on the time of publication. Studies were screened based on a predetermined selection criteria relevant to the research aims. (3) Results: Five studies fulfilled the inclusion requirements. The majority investigated the use of XR tools for individual therapy and indicated that they can be as effective for patients as traditional methods and can aid in HCPs' therapeutic tasks. (4) Conclusions: XR-based anxiety disorder therapies are generally perceived as immersive and with minimal side effects by patients, while HCPs mostly consider XR tools as practical and assistive. However, refinements with the XR setup could further improve the experience. Such modalities represent potent drug-free alternatives or supplements to traditional therapy and could be considered for remote, individual care. The findings' generalisability requires further research into more conditions within the anxiety disorder group, as well as larger sample sizes.

Keywords: anxiety disorders; extended reality therapy; psychotherapy; cyberpsychology; digital health; metaverse

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1. Introduction

Following the COVID-19 pandemic, digital health approaches have experienced a surge in adoption in clinical practice [1], with researchers noting that the public health crisis might have led to a significant step toward a wider adoption of such modalities [2]. In particular, technologies with a remote component have been favoured, whether to assess confinement policies adherence or to provide continuity of care [3–5].

What also experienced a surge as a consequence of the COVID-19 pandemic was the rate of anxiety disorders [6–8]. However, even before the pandemic, anxiety disorders were among the most common psychiatric disorders, with as many as one third of the population being affected by one such condition during their lifetime [9]. Many of the people affected by anxiety disorders may not, however, be willing to seek help or receive treatment due to the associated stigma [10] and the side effects from prescribed medications [11].

Novel digital health technologies, with an adoption rate that has been on the rise in recent years, show potential to provide non-pharmacologic alternatives that can improve

convenience, provide ease of access and reduce side effects [12–15]. For anxiety disorders in particular, such technologies reside within the extended reality (XR) field, which encompass virtual reality (VR), augmented reality (AR) and mixed reality (MR) technologies [16–18]. XR technologies have also gained momentum in the general consumer industry recently, with companies such as Apple, Meta and Xreal offering XR products of different price ranges for different use cases [19]. With such interest and increasing affordability, XR devices can become more adopted [20], and there is a strong possibility that the technology could become more commonplace in healthcare practices as well.

Given the possibility that XR technology becomes an option in clinical use, it would also be important to understand how it is perceived by those who use it as well as those who administer it. Researchers further highlight the need to investigate the perceptions and experiences of patients and healthcare professionals (HCPs) when employing XR technologies in anxiety disorder treatment [21,22].

Whilst there have been reviews undertaken within this field [18,23–26], their focus has been limited to the therapy of specific conditions rather than a broader scope of anxiety disorders [25], or they have been limited to certain XR modalities [18] rather than other promising XR technologies, and they either focused on patients or HCPs but not both. Furthermore, clarification regarding the classification of anxiety disorders is unclear [18,23], which can limit clinical relevance. This indicates the need for more comprehensive investigations of XR-based treatments for anxiety disorders.

In this systematic review, the established International Classification of Diseases (ICD-11) for anxiety disorders was adopted for greater clinical significance. According to this nosology reference, anxiety disorders are classified under "Anxiety or Fear-Related Disorders" and include the following conditions: generalised anxiety disorder, panic disorder, agoraphobia, specific phobia, social anxiety disorder (SAD), separation anxiety disorder, selective mutism and some other specified anxiety or fear-related disorder [27]. The related conditions and their corresponding reference codes are tabulated in Table 1.

Table 1. List of anxiety and fear-related disorders according to the ICD-11.

ICD-11 Reference Code	Condition	ICD-11 Reference Code
6B00	Generalised Anxiety Disorder	6B00
6B01	Panic Disorder	6B01
6B02	Agoraphobia	6B02
6B03	Specific Phobia	6B03
6B04	Social Anxiety Disorder	6B04
6B05	Separation Anxiety Disorder	6B05
6B06	Selective Mutism	6B06
6B0Y	Other Specified Anxiety or Fear-Related Disorders	6B0Y

Furthermore, given the novelty of XR-based therapies in medical practice, we believe that it becomes important to clearly define them, especially in view of the persisting confusion around the similarity of the terms or other terms that bear similar acronyms [23,28]. Therefore, we aimed to provide updated definitions to avoid future confusion while not being constrained by current means to access XR elements and establish the related technologies relevant to this study. For practical and illustrative purposes, Figure 1 depicts contemporary means to access XR content and Table 2 provides concise definitions of the related terms for clarity based on classical interpretations [29–32].

Figure 1. Practical illustrations of contemporary means to access XR content ((**a**)—Meta Quest headset and controllers; (**b**)—Rokid Air AR glasses paired with a smartphone; (**c**)—Magic Leap MR headset with compu-ting unit and controller). Photographs taken by Pranavsingh Dhunnoo and shared with permission.

Table 2. Adopted definitions of XR terms in this systematic review.

Term	Definition
Virtual reality (VR)	Technology that is usually, but not exclusively, accessed through a dedicated headset that immerses the user in a virtual environment while completely blocking the visual field of the physical and surrounding environment. Figure 1a illustrates the Meta Quest VR headset and controllers which is a popular device used to access VR content.
Augmented reality (AR)	Technology that adds virtual elements to the physical world whether it is through a screen and camera combination (such as a phone) or a dedicated headset that enables the viewing of both the physical environment and virtual elements simultaneously. Figure 1b illustrates the Rokid Air AR glasses paired with a smartphone which can provide basic AR experiences.
Mixed reality (MR)	Technology that adds an additional layer of interactivity to AR through the inclusion of depth and perspective in virtual elements that are superimposed on the physical environment that is visible in tandem with the virtual elements. Figure 1c illustrates the Magic Leap MR headset along with its computing unit and controller which provide more interactions with virtual elements.
Extended reality (XR)	Spectrum that encompasses any technology that involves, but is not limited to, VR, AR or MR, and could also include other technologies that incorporate virtual elements that can be perceived through the human senses. Figure 1 illustrates the range of XR enablers.

The promising aspect of XR technologies in psychiatric care and the need for a comprehensive literature synthesis with clinical relevance, in particular from the perspectives of patients and HCPs, were motivating factors for conducting this systematic review. More specifically, this review focussed on research undertaken using XR techniques for the treatment of anxiety disorders, with a particular emphasis on studies where the experiences and perceptions of both patients and HCPs have been reported.

Therefore, the research objectives were to investigate (a) the perceptions and experiences of both patients and healthcare professionals employing XR-based therapies for anxiety disorders and (b) the perceived effectiveness of different XR approaches in anxiety disorder treatment by patients and HCPs.

2. Methods

This systematic review was conducted by following the approach highlighted in the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 guidelines [33]. The recommended Population, Intervention, Comparison, Outcomes, Study

Design, and Setting (PICOSS) framework guided the selection of relevant search terms as well as the inclusion and exclusion criteria used in the screening process [34]. To ensure the robustness of the search strategy, its underlying rationale and search terms were refined following discussion with the review team.

As this systematic review adhered to the ICD-11 classification for anxiety disorders, the anxiety disorders listed in the ICD-11 entry (Table 1) were included in the search terms, and we anticipated that the inclusion of "anxiety" would also include "generalised anxiety disorder" in the searches based on an initial pilot search while also maximising the identification of relevant publications. The term "computer simulation" was included to account for research performed with XR tools before the relevant terms were popularised; and it is a term that has also been used in a previous systematic review in the same field [35]. Abbreviations such as AR, VR, MR and XR were not included in the final search string as including these could lead to conflicting terms being identified. A pilot search was initially conducted with the abbreviations to determine whether any relevant studies would favour the use of abbreviations over full terms. As no papers were found to use solely the acronyms in the title or abstract, the use of the search string without abbreviations was applied. Abbreviations were also not included in order to have a manageable number of studies to review. This is also the reasoning for not using abbreviations such as VRET (Virtual Reality Exposure Therapy) and ARET (Augmented Reality Exposure Therapy) as the relevant terms such as "virtual reality" and "therapy" were already included in the search strategy.

The search strategy was applied to the following databases: CINAHL, APA PsycNet and PubMed, which includes MEDLINE. These databases were selected upon agreement by the authors considering that they host peer-reviewed research of clinical and psychological relevance. The databases were searched on 23 January 2024 with no restriction on the time period or language in which the studies were published. No restriction on the time period was imposed as we aimed to provide a comprehensive synthesis of the available literature from the selected databases. The following search terms were used in each of the databases: ("Virtual reality" OR "Augmented reality" OR "Mixed reality" OR "Extended reality" OR "computer simulation") AND ("Anxiety" OR "Panic disorder" OR "Agoraphobia" OR "Specific phobia" OR "Phobia" OR "Social anxiety disorder" OR "Separation anxiety disorder" OR "Selective mutism") AND ("Treatment" OR "Therapy" OR "Intervention" OR "Assessment" OR "Experience" OR "Perception").

Studies were included if they involved XR-based therapies for the treatment of an anxiety disorder listed in the ICD-11 entry (Table 1); involved patients of any age and HCPs; properly defined the XR approach used, as elaborated in Table 2; reported on the health outcomes; and reported on the perceived effectiveness of the XR method. In order to align with the objectives of this review, a mandatory requirement for studies to be included was that they had to report the experience and/or perceptions of both patients and HCPs regarding the XR therapy employed. While there are studies that report or even focus on either HCPs' perceptions [22,36] or those of patients [21,37], there are several variables across different studies that need to be accounted for. For example, the number of participants, the type of anxiety disorder under investigation and the XR setup and settings are likely to differ in different studies. These variations could prevent fair comparisons and, subsequently, meaningful conclusions from being drawn. As such, it was deemed important that the perceptions and/or experiences of both HCPs and patients should be reported in the same study to account for such variables while being relevant to the review aims. Articles were further excluded if they did not involve XR technologies that fit the provided descriptions in Table 2; did not include empirical research; or did not include patients diagnosed with an anxiety disorder listed in the ICD-11 classification. Furthermore, in order to maximise the potential of including pertinent studies, no limit on the publication dates was imposed, and papers in the English, French and Dutch languages were considered during screening. Table 3 provides an overview of the inclusion and exclusion criteria.

Table 3. Inclusion and exclusion criteria for study selection based on the PICOSS framework.

	Include	Exclude
Population	• All (children, adolescent, adults) • Patients diagnosed with anxiety disorders (including any conditions specified in Table 1) • Patients with comorbidities along with anxiety disorder(s) • HCPs involved in administering XR therapy to patients diagnosed with an anxiety disorder	• Non-human subjects • Patients with conditions other than anxiety disorders
Intervention	• Any form of properly defined XR approach used (AR, VR, MR), as elaborated in Table 2 • Computer simulation (if it relates to XR in its Methods) • Interventions used for therapeutic ends • XR used for the assessment of anxiety disorder	• Simulators • Interventions that do not relate to XR per the study methods • Interventions that are labelled as XR but do not fit the XR description provided (Table 2) • Interventions that have similar acronyms but are not XR
Comparator	• XR interventions as compared to each other or to traditional medical/therapeutic approaches or to no intervention	
Outcomes	• Experiences and perceptions of healthcare professionals and patients reported in the same study (mandatory) • All health outcomes (positive or adverse) following intervention, as identified by patients and/or professionals' reported outcomes or based on study's own criteria • Perceived effectiveness of XR method by HCPs and patients	• If no outcome is reported
Study design	• Empirical research	• Non-empirical research (opinion pieces, editorials, reviews, study protocols) • Articles where full text is not available • Non-peer reviewed publications • Studies in languages other than English, French and Dutch
Setting	• Clinical settings • Research centres	• Commercial use cases

The search results from each database were exported and uploaded to the online reference management software Rayyan (https://www.rayyan.ai/) to facilitate the screening of the titles, abstracts and full texts of each study. Two reviewers (PD and LW) performed the screening independently, corroborated the study selections and resolved any conflicts.

The data from each of the identified studies were extracted by PD and VO. Extracted details pertained to author, year of publication, country where the study was conducted, research aim(s), study sample, study design, type of XR technology employed, reported effectiveness and experiences and authors' conclusions.

The Critical Appraisal Skills Programme (CASP) appraisal checklist was adopted for the quality appraisal of the included studies [38]. A respective checklist based on each study design was used. Assessing the quality and risk of bias of the included studies was undertaken independently by two reviewers (PD and VO), which is an approach recommended to ensure accuracy while reducing bias of the critical appraisal process [39]. After their independent assessments, the reviewers corroborated their findings and resolved

any conflicts. For the bias assessment of included randomised controlled trial(s) (RCT), the Cochrane risk-of-bias tool for randomised trials (RoB 2) was employed [40,41].

3. Results

Searching the selected databases yielded a total of 3827 records. Out of these, 1058 duplicates were identified and removed. The screening of the reference lists from relevant texts and a manual search of journals yielded no additional papers. The titles and abstracts of the unique 2769 records were screened independently by each reviewer for Stage 1 screening. Any conflicts were discussed and resolved before carrying out Stage 2 screening, which involved 374 reports. The full texts of the 374 reports identified from Stage 1 screening were sought, three of which could not be obtained due to the unavailability of their full texts from available resources. The full texts of 371 reports were thus assessed based on the selection criteria (Table 3). Five papers were found to satisfy the criteria by each reviewer. Figure 2 summarises the screening process utilising the PRISMA 2020 flow diagram.

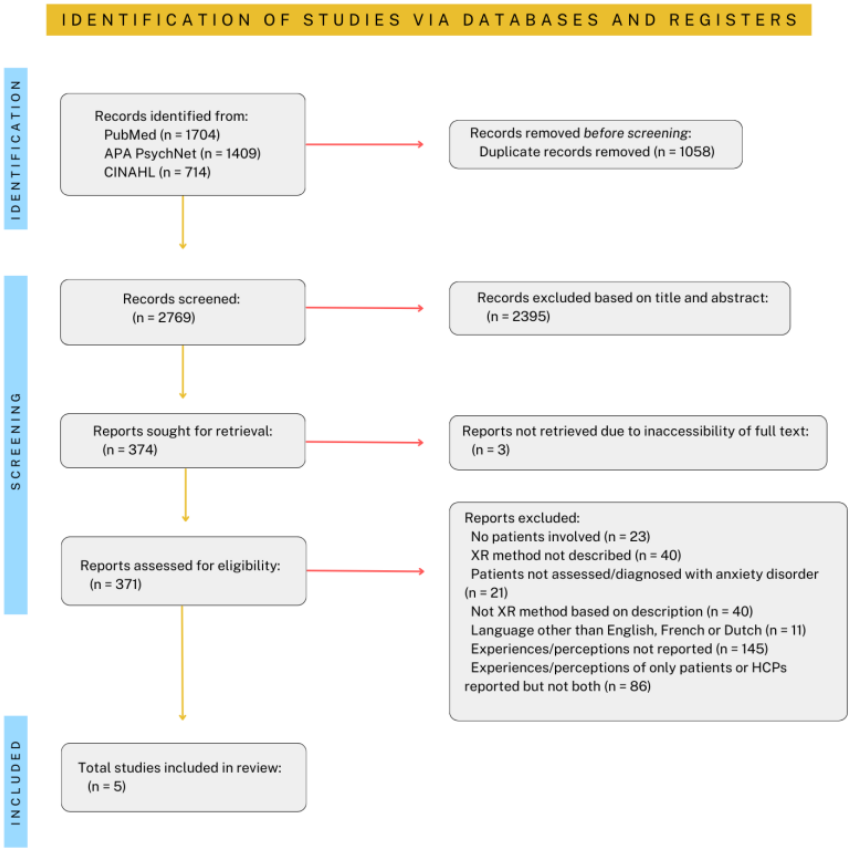

Figure 2. PRISMA 2020 flow diagram (yellow arrow indicate next filtration step; red arrow indicate exclusion). From Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ 2021;372:N71. https://doi.org/10.1136/bmj.n71 [33].

Table 4 provides a summarised version of the data extracted from each included study. Appendix A contains a more detailed version of the table.

Table 4. Summarised data extraction table.

Author/Year/ Country	Study Design and Aim(s)	XR Technology and Study Sample	Reported Effectiveness and Experiences	Authors' Conclusions
Wrzesien et al., 2010, Spain [42]	Pilot observational qualitative study conducted to analyse the collaboration between patients, therapists and the AR system in the treatment of cockroach phobia.	AR **Patients:** n = 2 **HCPs:** n = 2	**Patients:** Experienced momentary scare via phobic stimulus. **HCPs:** Some components of setup such as notes assisted them in performing therapy, but working with the setup can be uncomfortable.	Potential for AR cockroaches to create the same response as real cockroaches.
Wrzesien et al., 2012, Spain [43]	Quantitative evaluation conducted to measure and compare quality of collaboration between the client and the therapist for the treatment of phobias, with and without the mediation of technology.	AR **Patients:** n = 20; diagnosed with a specific phobia to small animals **HCPs:** n = 3	The quality of collaboration between in vivo and AR exposure therapy was found to be similar. **Patients:** Experienced lower levels of distractions with AR compared to HCPs. **HCPs:** Experienced higher levels of distraction with AR than with in vivo therapy.	Study findings can be investigated further with larger samples to validate on the Therapeutic Collaboration Scale (TCS) and data. Needs identification for comparison in different contexts such as home-based settings and different technologies such as VR or video conference exposure.
Bouchard et al., 2017, Canada [44]	RCT conducted to compare VR and in vivo exposure therapy for social anxiety disorder (SAD).	VR **Patients:** n = 59; diagnosed with SAD **HCPs:** n = 4	VR was more effective than in vivo (based on some outcome measures). **Patients:** Felt no significant increase in simulator sickness and experienced high levels of immersion and presence in VR. **HCPs:** Found VR to be significantly more practical than traditional methods.	Pairing cognitive behaviour therapy (CBT) with VR exposure was effective and found to be more practical by HCPs. CBT with VR is a viable alternative to classical, individual CBT for both acute and long-term therapy.
Arnfred et al., 2021, Denmark [45]	Qualitative study conducted to investigate the experiences of patients and therapists using virtual reality exposure (VRE) in group therapy, and identify relevant challenges.	VR **Patients:** n = 9; fulfilling social anxiety disorder and/or agoraphobia **HCPs:** n = 3	Patients found it to be challenging to engage with VRE in group therapy. **Patients:** Had complaints about lack of immersion, inability to interact with the virtual environment, quality of images and cybersickness and found that wearing a headset induces anxiety. **HCPs:** Found the experience to be time consuming and required time to familiarise with the setup.	Engagement with a virtual environment was hampered due to a lack of interaction within the virtual environment and group therapy setup. Technical issues were encountered with the VRE setup and managing patients using the technology simultaneously. Patients found VRE to be·meaningful.

Table 4. *Cont.*

Author/Year/ Country	Study Design and Aim(s)	XR Technology and Study Sample	Reported Effectiveness and Experiences	Authors' Conclusions
Mayer et al., 2022, Germany [46]	Mixed-method feasibility study conducted to test a VR app and identify potent elements required for claustrophobia VR exposure therapy	VR **Patients:** n = 15; with reported symptoms of claustrophobia and diagnosed with any anxiety disorder **HCPs:** n = 15	Feasibility and acceptability of procedure was high in both groups, but HCPs expressed a higher readiness to use the technology. **Patients:** VR environment induced direct claustrophobic symptoms; VR intervention was perceived as positive but might be tailored for specific cases. **HCP:** Found VR appealing and useful but expressed the need for more control over the situation and exposure time, considered VR an adequate starting point; some were convinced that VR intervention is appropriate for the at-home self-management training of HCPs.	Key elements of such an app should include adjustable intensity to induce presence and anxiety and can feature virtual humans for realistic scenarios. While such an app can be used alone, some patients might prefer using it in the presence of a therapist.

3.1. Study Characteristics

The five included studies were published between 2010 and 2022 [42–46] and took place in four different countries. Two were conducted in Spain [42,43], one was conducted in Canada [44], one was conducted in Denmark [45], and one was conducted in Germany [46].

Considering that they had different aims, each of the five included studies adopted different research methods. This included an observational study [42], a quantitative evaluation [43], an RCT [44], a qualitative evaluation [45] and a mixed method study design [46]. While the sample sizes varied across each study due to their differing scopes, the mean number of patients involved was 21, and the mean number of therapists was 5.4. However, the demographics of the participants were generally unclear.

In relation to the adopted diagnostic classification of patients within the included studies, the researchers generally referred to a version of either the ICD or the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders (DSM) classification. Wrzesien et al. (2010) [42] did not report whether the patients involved were initially diagnosed with an anxiety disorder listed in the ICD-11 classification (Table 1), but they were involved in therapeutic sessions for a specific phobia (fear of cockroaches in this case) for the study. In their 2012 study, Wrzesien et al. specified that patients included in the study were diagnosed and assessed based on DSM criteria for a specific phobia to small animals [43]. In their RCT, Bouchard et al. included patients who had been diagnosed with social anxiety disorder based on the DSM-V criteria for at least 2 years [44]. Arnfred et al. included patients who fulfilled the ICD-10 criteria for social anxiety disorder and/or agoraphobia [45]. In their mixed-method feasibility study, Mayer et al. [46] included patients diagnosed with any type of anxiety disorder and reported claustrophobic symptoms; however, the authors did not specify the nosology of reference for the diagnoses.

3.2. Type of XR Technology Employed

Of the included studies, two involved the use of AR technology [42,43] and three involved the use of VR technology [44–46]. The equipment used to access the XR content varied in each case.

Wrzesien et al. (2010) described their AR setup as involving a head-mounted display and AR cockroaches, while therapists could control the stimulus with a keyboard, observe what the patients saw on a computer screen and had access to notes [42]. The AR setup employed by Wrzesien et al. (2012) [43] was reported to be the same as the one employed by Juan et al. in 2005 [47], which involved a 5DT HMD to which a Creative NX-Ultra camera was attached.

VR technology was employed by Bouchard et al. in their RCT, where the researchers adopted the eMagin z800 HMD and InterSense Inertia Cube motion tracker to display virtual environments for exposure therapy and patients could interact with the environment with a wireless mouse [44]. Arnfred et al. also employed VR by means of the Oculus Go headset to display 360° videos to patients, and the researchers also used the Audio-Technica ATH-M50X as sound-blocking headphones to relay the videos' audio [45]. Mayer et al.'s VR setup involved the HTC VIVE Pro Eye headset, a pair of controllers and two base stations [46].

3.3. Reported Perceptions and Experiences

All of the included studies reported on the perceptions and/or experiences of both HCPs and patients during the XR therapy. These reports varied in each study and provided a multifaceted understanding of the views of patients and HCPs when employing the respective modality.

The patients involved in Wrzesien et al.'s (2010) study experienced a momentary scare when exposed to AR cockroaches, with the researchers concluding that this elicited a similar response to an exposure to real cockroaches [42]. As for the HCPs involved in this observational study, they found that the AR system could be uncomfortable to work with, but that some components of the setup, such as note taking, can be adequate for assisting them in therapeutic tasks.

The quantitative evaluation performed by Wrzesien et al. in 2012 reported that HCPs were more distracted when employing AR exposure therapy (ARET) than when employing in vivo therapy (exposure to the live or physical stimulus of anxiety) [43]. In contrast, patients in this study exhibited lower levels of distractions with AR than the HCPs did.

In the RCT conducted by Bouchard et al., the researchers found that VR therapy was statistically more practical for HCPs compared to the non-technology-mediated modality [44]. Based on the Simulator Sickness Questionnaire (SSQ) reports, patients did not experience notable increase in cybersickness or simulation sickness, a side effect of VR use with symptoms akin to motion sickness [48]. The Presence Questionnaire and Gatineau Presence Questionnaire results indicate that they perceived VR as providing high levels of immersion and presence.

Patients in Arnfred et al.'s qualitative study were mostly split into two groups: those who felt immersed and had their anxiety levels increased while in VR, and those who did not [45]. A lack of feeling of presence was often attributed to the inability to interact with the virtual environment, and some also attributed it to the poor quality of the VR images, which also led to simulation sickness. Patients also reported feeling self-conscious and anxious about wearing the HMD in a group therapy setting. HCPs, as well as patients, noted that virtual reality exposure (VRE) is a time-consuming process. HCPs also found that the VR setup required experience to familiarise with and to become more adept at managing multiple headsets in group therapy. Nevertheless, patients perceived VRE as being a meaningful and beneficial supplement to their therapy.

The VR environment in Mayer et al.'s feasibility study was found to be immersive by some patients while others could separate the real and virtual elements, which provided a sense of controllability [46]. However, the inclusion of virtual humans in these environ-

ments mostly elicited negative feelings. It was observed that the VR intervention might not be appropriate for every patient and could be tailored for a wider range of cases based on their needs and anxiety-inducing cues. Nevertheless, patients were open to repeat the VR intervention, particularly in the presence of a therapist. From the HCP perspective, they were more ready than patients to use the technology pre-treatment, based on the Technology Commitment Scale reports. But they expressed the need for better control over the situation and exposure time. HCPs also identified exposure through VR as comparable to in vivo exposure and adequate as a starting point. Most HCPs also favoured having an in-person therapist necessary for a successful VR intervention to minimise risks such as panic attacks while some believe it to be appropriate for at-home self-management training for HCPs themselves.

3.4. Perceived Effectiveness of the XR Method

The perceived effectiveness of the XR method employed was measured differently in each of the five included studies. Most of the studies employed validated tools to do so [43–46], while one study based this finding on the researchers' own conclusions [42]. The AR system employed by Wrzesien et al. (2010) was found to elicit feelings of tension and anxiety in patients akin to that experienced with live cockroaches, based on the authors' conclusions [42]. Wrzesien et al. (2012) found no statistical differences in the clinical outcome between patients receiving therapy through AR or traditional methods [43]. More specifically, the Behavioural Avoidance Test measure employed was found to be statistically significantly increased in both cases, meaning that the patients were less avoidant to the feared stimulus, and there was no major difference between the two groups in this aspect. The RCT conducted by Bouchard et al. demonstrated that, at post-treatment, VR therapy was more effective than in vivo therapy on the primary outcome measure, based on the Liebowitz Social Anxiety Scale-Self Reported version (LSAS-SR), and on one secondary measure, based on the Social Phobia Scale (SPS) [44]. Arnfred et al.'s study concluded that it was unclear if VRE is adequate for patients with social anxiety disorder (SAD) for group CBT [45]. The VR environment in Mayer et al.'s feasibility study elicited symptoms of claustrophobia among patients, with HCPs finding the exposure comparable to in vivo approaches [46]. Patients also observed improvements in symptoms following the intervention. Both patients and HCPs rated the VR-aided procedure with high feasibility and acceptability.

3.5. Assessment of Quality and Bias

The quality of each of the included studies were appraised with respective CASP checklists based on their individual study design. The respective appraisals can be found in Appendix B.

4. Discussion

This systematic review set out to investigate XR-based therapies for anxiety disorders from the perspectives of patients and HCPs employing such modalities. The areas of focus were as follows: (1) the perceptions and experiences of HCPs and patients utilising these technology-mediated treatment options and (2) the perceived effectiveness of different XR approaches in anxiety disorder treatment.

4.1. Perceptions and Experiences When Employing XR Modalities for Anxiety Disorder Treatment

Regarding the perceptions and experiences of patients and HCPs employing XR-based therapies for anxiety disorders, the XR modality employed varied in the included studies, with two utilising AR technology [42,43] and three utilising VR technology [44–46]. Considering AR technology, the findings of this systematic review suggest that, when employed for exposure therapy in phobia treatment, this technology enables patients to experience responses akin to in vivo exposure [42]. The latter has traditionally been considered the "gold standard" for treating such conditions [49]. Patients were also able to

maintain better focus on the treatment, especially when compared to HCPs, through this modality [43]. While a definitive conclusion cannot be drawn due to the limited number of reviewed studies, these findings potentially suggest that ARET could be considered an alternative to in vivo exposure in the treatment of phobias.

In the case of the perceptions and experiences of HCPs utilising AR technology for the therapy of their patients, the studies in this review provided a different perspective to that of patients'. While some components of the AR setup appear to be helpful in assisting HCPs in performing therapy [42], conducting therapy while operating the AR equipment seems to be cumbersome, with negative feedback from HCPs relating to non-ergonomic posture [42] and distraction from therapeutic tasks due to the associated AR hardware [43]. Even if few studies have investigated the perceptions and experiences of HCPs specifically employing AR technology for anxiety disorder treatment, the findings of this review echo earlier research with VR for the treatment of the fear of flying [36]. In the latter, researchers identified the technical setup as a barrier to the therapists' experience, which also hindered their focus on delivering therapy. In order to address these valid concerns, Wrzesien et al. suggested that reducing the number of associated hardware components or increasing familiarity with the setup, such as through regular use, could potentially provide a better experience with the AR system [43]. More recent consumer-oriented AR hardware could potentially address the issues identified and could be considered in new AR-based therapy research.

For the studies that employed VR treatment, patients with anxiety disorders had nuanced experiences with this modality. They generally felt immersed in the virtual environment and mostly experienced increased levels of anxiety when exposed to anxiety-inducing scenarios as they would in real-life settings, which is beneficial for their therapy [44–46]. However, a minority of patients did not share similar beneficial experiences [45,46]. While there was no significant increase in the simulator sickness reported [44,46], some patients did experience this side effect. As Arnfred et al. suggest [45], the lack of immersion and increase in cybersickness could be due to poor adjustments of the VR equipment. The VR therapy experience appears to be better overall in individual therapy contexts [44,46]; while in group therapy, patients tend to feel self-conscious and anxious about utilising an HMD [45]. A better experience could potentially be achieved by ensuring that VR enablers are properly fitted [45], limiting exposure time to reduce the risk of cybersickness [44], using wireless headsets to increase immersion [46] and preferably employing them for individual therapy.

From the perspective of HCPs, the results of this systematic review suggest that VR could be more practical than traditional exposure modalities for individual therapy and could be adequate as a starting point for treatment [44,46]. However, in a group therapy setting, managing several VR headsets is perceived as time consuming and not very convenient for HCPs [45]. Nevertheless, this might be remedied with more experience and frequent use of the VR setup, as the HCPs who employed VRE in a group context had no experience with VR prior to the study [45].

A surprising finding in a group therapy context is that, despite the issues encountered and the lack of reported immersion in VR environments, patients and HCPs identified that the technology added value to the therapy as a means to gain additional insights, to practise skills and/or provide observations for social situations [45]. This suggests that the perception of the modality could be improved with further practice sessions and familiarisation with the setup. However, further investigation would be warranted to draw more conclusive insights.

4.2. Perceived Effectiveness of XR Approaches in Anxiety Disorder Treatment

The final research objective focussed on the perceived effectiveness of different XR approaches in anxiety disorder treatment. This systematic review found that only two of the included studies involved parallel groups of participants employing in vivo exposure therapy for a comparison of outcome measures with groups adopting XR exposure [43,44].

However, no studies compared the perceived effectiveness of an XR modality with another XR modality. Therefore, we synthesised the findings from the included studies based on the XR technology used.

From the findings of this systematic review, it can be inferred that even if employing AR for specific phobia exposure can trigger tension and anxiety similar to what would be experienced during in vivo exposure [42]; there is no statistical difference between the clinical outcome of patients receiving AR exposure therapy or in vivo exposure therapy [43]. However, given the low statistical power of the analyses [43], caution is advised when drawing conclusions regarding this similarity between the modalities. Furthermore, this review focussed only on studies that reported on the perceptions and experiences of both patients and HCPs, and therefore did not take into consideration other studies that may have explored this comparison further to provide more conclusive results. Nevertheless, the findings are in agreement with those of a previous systematic review that found AR to lead to therapeutic reductions in anxiety, fear and avoidance behaviours [26]. Despite showing no significant differences in clinical outcomes with in vivo exposure, an AR alternative could potentially be more advantageous than the latter approach in that it does not require a physical phobic stimulus and can thus be better controlled while also representing lower risks [50].

Based on the findings of three of the studies that employed VR for exposure therapy [44–46], this XR modality appears to be effective in reducing anxiety symptoms. In particular, for the individual therapy of patients with SAD, VRET appears to be more effective than in vivo exposure, based on the fear and avoidance assessment scales adopted, namely the LSAS-SR and SPS [44]. Improvements were also sustained at 6-month follow-up [44]. However, no difference was found between VR and in vivo exposure based on the measures of the Social Interaction Anxiety Scale (SIAS) and Fear of Negative Evaluation (FNE) [44]. The results are consistent with the findings of the RCT conducted by Anderson et al. investigating VRE for SAD [51]. The researchers concluded that while there were no differences between VRE and in vivo exposure, the technology-mediated option can be an effective tool for social fear treatments. Emmelkamp et al.'s literature review also identified VRET as a promising option for SAD treatment but highlighted that further research is required in order to draw more robust conclusions [52].

Regarding VRE in a group therapy context, it remains unclear, based on the reviewed studies, whether VR exposure is a viable option for group CBT of patients with SAD [45]. However, since Arnfred et al.'s research was the first to investigate VRE for SAD patients in this context [45], the findings cannot be generalised. This indicates the need for further studies investigating VRE in group CBT. This is a recommendation that is also echoed by other researchers [51].

The lack of uniformity across XR tools could be a potential explanation for differences in effectiveness, as well as perceptions and experiences, across the reviewed studies. Therefore, it would be interesting to investigate more closely how the effectiveness of different XR modalities differs from each other in the same study. By way of illustration, recent studies have indicated that VRET is effective in the treatment of specific phobias [53–56] and the mixed-method study by Mayer et al. included in this review found improvements when employing VR exposure for patients with claustrophobia [46]. Giglioli et al.'s systematic review [26] as well as this present systematic review identified AR as a useful tool for specific phobia treatment. However, studies comparing the effectiveness of VR and AR, which are different technologies, in the same study for specific phobia treatment have not been identified in this review. Extrapolating findings from different studies utilising AR and VR for treating this condition remains challenging due to variables in the study characteristics. More conclusive insights could be derived if these modalities were compared in the same study with less variables. As such, this represents a potential gap in the literature that could be further investigated.

4.3. Characteristics of XR-Based Therapies for Anxiety Disorders

According to the ICD-11 criteria (Table 1), anxiety disorders encompass eight related conditions. However, the studies included in this review employed XR technologies for two conditions, namely social anxiety disorder and specific phobia (more specifically, fear of cockroaches and claustrophobia). Whilst focussing on studies that included the perceptions and/or experiences of both patients and HCPs limited the number of included research in this review, this relatively higher focus on specific phobias corroborates with a previous meta-analysis [57] that found most research for VR exposure therapy (VRET) to target specific phobias. However, this indicates a potential need for further investigations for XR therapies adapted to other conditions within the anxiety disorder group.

While all of the studies reviewed employed XR technology for exposure therapy, four of these [42–44,46] indicated that XR-based therapies were employed for individual treatment, while one of the studies [45] explored the use of such modalities in a group therapy context. The latter context remains underexplored [45] and, based on the reviewed publications, it remains unclear if group exposure therapy for SAD using VR is adequate. Regarding individual therapy context, recent studies show that individual treatment using VR and AR can be effective in providing exposure for the treatment of anxiety disorders [58–60]. This is in accordance with the findings of this systematic review. These results suggest that XR therapies could potentially be coupled with other digital health approaches, such as remote care, to increase access to psychotherapy. Indeed, VR-mediated psychotherapy delivered via telehealth has been proposed as an adequate treatment modality [61].

However, the findings can be challenging for generalising the feasibility of such modalities in actual clinical practice, whether in person or remotely, for individual exposure therapy. This is because the studies reviewed were generally conducted in controlled research scenarios, despite having clinical focus, and might not be totally representative of clinical practice scenarios.

While the included studies in this review adopted either a qualitative [42,45], quantitative [43], RCT [44] or mixed-method study design [46], the methodology was generally appropriate in investigating the respective research questions, even if no general consensus on data extraction methods specifically for XR therapies appears to have been followed. Nevertheless, there is an evident need for researchers to clearly state their study design, as in most cases [42,43,45], the study design was not clarified in the text. On top of being recommended academic practice for scientific integrity [62], having a clearly stated study design would allow for a (re)analysis of the study to confidently appraise and extract insights [63].

Despite the inclusion of validated tools used to collect data, the findings may be somewhat limited by the sample size and demographics. The included studies had a small sample size of total participants [43,45], particularly in the case of HCPs [42–45]. Such a limited number of participants can potentially compromise the validity of the findings [64–66] and represent underpowered studies for the reliable detection of differences between groups [67]. Low statistical power is indeed a limitation identified in Wrzesien et al.'s quantitative evaluation [43]. In addition, all but two studies were conducted in different countries where the varying cultural norms might influence the experience and perception of XR technologies. As such, this data must be interpreted with caution.

In addition, the use of self-assessment tools, such as the LSAS-SR [44], might not be ideal as they might not reflect honest responses and might not include processes that are performed unconsciously and implicitly [68]. Two proposed alternatives have been the Conditional Reasoning Problems, which assess a study participant's biases resulting from their motives, and the Implicit Association Test, which provides insights into the associative network of the self-concept [68]. This review specifically focussed on studies that reported on the perceptions and experiences of both patients and HCPs, which are subjective constructs and could be influenced by social-desirability bias. Nevertheless, the

importance of such perspectives has been highlighted as a potential benefit for positive health outcomes [69].

While one RCT was included in this systematic review [44], its risk of bias assessment resulted in some concerns (Appendix B, Table A4) and the lack of blinding in this study also indicates that these results should be interpreted with some measure of vigilance.

Attention needs to be drawn to the minority of included studies [42] that did not specify if the patients involved had been diagnosed with an anxiety disorder (Table 1), even if they followed treatments for specific phobias. Generalising the findings to phobic patients must thus be interpreted with caution.

As for generalising the findings of the effectiveness, some measure of discretion is advised as only one study investigated whether improvements were maintained in a follow-up period [44]. While the study design and scope varied across each study, follow-ups are a recommended practice in XR research to determine whether clinical outcomes are sustainable [70].

Four out of five studies reported on the XR technology and setup employed [43–46], and only one study did not specify these details [42]. As elaborated earlier, the risks of confusion and unclear references of XR tools employed are present, even in recent studies [28]. Thus, it would be important for researchers to clearly specify the tools used to access XR content. Even if a minority of included studies in this systematic review did not comprehensively report on the XR set up, this requires an additional layer of caution when interpreting the findings. In addition, while the majority of included publications described the XR setup, none provided a definition of the XR modality employed. Irregularities persist regarding these definitions [28], and providing an adopted definition, such as that provided in Table 2, could assist in deriving relevant insights.

4.4. Limitations of this Systematic Review

Several steps were adopted to ensure the robustness of this research, such as adherence to the PRISMA 2020 guidelines [33] and having two researchers independently perform the screening, quality appraisal, assessment of bias and data extraction. However, there are some limitations to this review, with the most prominent being the limited number of included studies. This represents a need for caution when drawing conclusions and extrapolating the findings of this systematic review. The limited number of included studies likely arises from the inclusion and exclusion criteria, especially with the requirement of including only studies that reported the perceptions and/or experiences of both patients and HCPs.

The search strategy also did not include terminologies of specific conditions such as claustrophobia or other prevalent disorders such as post-traumatic stress disorder. This could have omitted some study articles focusing on specific conditions. However, the search strategy was devised to ensure relevance to clinical practice and this review's research aims, which focused on the spectrum of anxiety disorders as identified by ICD-11.

Even if the number of studies included in this current systematic review is limited, it is a finding that is similar to that of the systematic review conducted by Caponnetto et al. that investigated VR therapy for SAD treatment and identified five studies relevant to their research question [71]. As the latter study and this current systematic review in the field of XR therapy for anxiety disorders both identified a limited number of relevant papers, this may indicate that the field is in its early stages and requires further research input.

4.5. Implications for Future Research and Practice

This systematic review identified several avenues for future research and practice. Considering that a small number of studies were identified that took into account the experiences and perceptions of patients as well as HCPs during the same study, it could be recommended for future investigations to explore and report on these perspectives further. Such findings may help in better understanding how those receiving and administering XR-based therapies, at the same point in time and with the same setup and view, experience

the modality. This could in turn help determine the optimal setup for both patient and HCP satisfaction.

Further work is required to establish the viability of the generalisation of this systematic review's findings through more robust research quality. As identified in this systematic review there is the need for future research to clearly specify the XR equipment employed. This will help to avoid confusion when interpreting the results and provide reproducible methodology.

A potential gap in the literature has also been identified in regard to the need to compare different XR modalities to each other. Research questions that could be asked in this regard include how AR, VR, MR and in vivo exposure therapy for anxiety disorders compare in terms of perceived effectiveness and user satisfaction, or which XR modality is preferred by patients diagnosed with anxiety disorders. Future investigations could also involve a wider pool of patients, a wider range of participant demographics and diversified study locations. Such research undertakings would aid in developing a more comprehensive picture of the impact of XR-based therapies for anxiety disorder treatment.

As identified in this review, all of the included studies employed XR for exposure therapy. Further research should be undertaken to investigate the impact of XR modalities beyond exposure therapy for the treatment of anxiety disorders such as mindfulness and relaxation [72–74]. This could help in determining the effectiveness of XR approaches other than exposure therapy based on patients' individual needs and preferences.

Finally, no studies were identified, based on the inclusion criteria, that employed mixed reality for anxiety disorder treatment. This could indicate another avenue for future research in this particular XR modality.

5. Conclusions

This systematic review provided important insights into the perceptions and experiences of patients and HCPs utilising XR-based therapies for anxiety disorder treatment. The results of this review indicate a nuanced landscape regarding patient experiences. While patients in the reviewed studies generally perceive XR modalities as immersive and with minimal side effects, others might not share similar experiences. However, this discrepancy could be attributed to poorly fitted XR equipment, and despite complaints about the lack of immersion and cybersickness, virtual environments are perceived as a beneficial tool by patients. HCPs as well find XR tools as practical, assistive in performing therapeutic tasks and as a potential aid for their own at-home training, although some ergonomic aspects of the XR equipment and setup can be improved.

In addition, this systematic review suggests that XR-based therapies could have the potential to positively impact the treatment of anxiety disorders; however, further research would be required. XR therapies could be considered viable non-pharmacologic treatments to supplement traditional approaches for individual therapy, with minimal side effects to patients. Nevertheless, the benefits of XR in group exposure therapy context remains unclear, indicating the need for further investigation.

Future research in the use of XR for anxiety disorder treatment would need to investigate both patient and HCP perspectives in order to provide a comprehensive understanding of their experiences. In addition, comparative studies across different XR modalities are needed to identify the optimal XR approach for individual anxiety conditions. Such research endeavours would not only provide important insights aimed at improving current XR-based therapies but also hold potential in developing novel and impactful interventions in anxiety disorder treatment.

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Disclaimer: This study is based on the re-analysis of existing data, which is openly available, extracted and reported by other literature. Full details listed under references.

Appendix A

Detailed data extraction table.

Author/Year/ Country	Aim(s)	Study Sample	Study Design	Type of XR Technology Employed	Results	Authors' Conclusions
Wrzesien et al., 2010, Spain [42]	To analyse the collaboration between patients, therapists and the AR system in the treatment of cockroach phobia.	**Patients:** n = 2 **HCPs:** n = 2	Pilot observational qualitative study with video coding of interactions.	AR: HMD, AR cockroach, swatter, a computer screen, keyboard, notes	Areas of improvement for system and setup identified. Hesitancy from therapist in coding process due to equipment setup and unrealistic number of cockroaches. Some indication of response from patients in both therapeutic sessions. **Perceptions and experiences reported:** **Patients:** Momentary scare by phobic stimulus. **HCPs:** Some components of setup such as notes assist them in performing therapy; working with the setup can be uncomfortable.	Potential for AR cockroaches to elicit the same response as real cockroaches. Further work required to address setup issues.
Wrzesien et al., 2012, Spain [43]	To measure and compare the quality of collaboration between the client and the therapist for the treatment of phobias, with and without the mediation of technology.	**Patients:** n = 20; M = 26.40 years old; all female with specific phobias to small animals (DSM-IV). **HCPs:** n = 3	Quantitative evaluation (1) Between-subject comparison of two types of therapeutic sessions (in vivo exposure and AR) (2) Quality of collaboration using Therapeutic Collaboration Scale (TCS)	AR: 5DT HMD with a Creative NX-Ultra camera attached	Similar qualities of collaboration between in vivo and AR exposure therapy. Some significant differences between groups for cooperation orientation dimension of TCS but low power calculations. **Perceptions and experiences reported:** **Patients:** Lower levels of distractions with AR compared to HCPs. **HCPs:** Higher levels of distraction with AR than with in vivo therapy.	Preliminary findings; study can be improved through larger samples to validate TCS and data. Need to apply TCS in using different technologies such as VR or video conference exposure. Need for comparison of different contexts such as home-based settings.

Author/Year/ Country	Aim(s)	Study Sample	Study Design	Type of XR Technology Employed	Results	Authors' Conclusions
Bouchard et al., 2017, Canada [44]	To compare VR and in vivo exposure therapy for social anxiety disorder (SAD).	**Patients:** *n* = 59; aged 18–65 (M = 34.50 years old) diagnosed with SAD (DSM-V) **HCPs:** *n* = 4	Randomised controlled trial involving patients with SAD and VR and in vivo therapy comparison. Measurements: (1) Clinical outcomes: Fear and avoidance assessment on Liebowitz Social Anxiety Scale—Self Reported version (LSAS-SR) scale, social phobia scales: Social Phobia Scale (SPS); Social Interaction Anxiety Scale (SIAS); and Fear of Negative Evaluation (FNE), Beck Depression Inventory (BDI-II) for depressive symptoms (2) Therapists assessed on Specific Work for Exposure Applied in Therapy (SWEAT) scale for relevant practical and financial resource requirements (3) VR side-effects measured with Simulator Sickness Questionnaire (SSQ) (4) Feeling of presence with Presence Questionnaire and Gatineau Presence Questionnaire	VR: eMagin z800 head-mounted display and InterSense Inertia Cube motion tracker	VR more effective than in vivo on primary outcome measure and on one secondary measure at post-treatment. **Perceptions and experiences reported:** **Patients:** No significant increase in simulator sickness; high levels of immersion and presence in VR. **HCPs:** VR is significantly more practical than traditional methods.	Pairing cognitive behaviour therapy (CBT) with VR exposure is effective and found to be more practical by HCPs. CBT with VR is a viable alternative to classical individual CBT for both acute and long term therapy. Need to replicate study with larger sample size and monitoring of physiological parameters.
Arnfred et al., 2021, Denmark [45]	To investigate the experiences of patients and therapists using virtual reality exposure (VRE) in group therapy and identify relevant challenges.	**Patients:** *n* = 9 (6 females, 3 males); aged 18–75 (M = 25.40 years old); fulfilling social anxiety disorder and/or agoraphobia (ICD-10); **HCPs:** *n* = 3 (1 female, 2 males); all involved in delivering the treatment	Qualitative study using individual semi-structured interviews with SAD patients and HCPs.	VR: Oculus Go HMD with sound-blocking headphones	Patients found it challenging to engage with the VRE in group therapy. **Perceptions and experiences reported:** **Patients:** Some did not feel immersed; some felt immersed, and their anxiety levels increased: complaints about inability to interact with the virtual environment, quality of images, cybersickness, wearing HMD inducing anxiety. **HCPs:** Time consuming; requires experience to familiarise with the setup.	Engagement with virtual environment hampered due to lack of interaction within virtual environment and group therapy setup. Technical issues encountered with VRE setup and managing patients using the technology simultaneously. Patients found VRE to be meaningful.

Author/Year/ Country	Aim(s)	Study Sample	Study Design	Type of XR Technology Employed	Results	Authors' Conclusions
Mayer et al., 2022, Germany [46]	To test a VR app and identify potent elements required for claustrophobia VR exposure therapy	**Patients:** *n* = 15 (7 females, 8 males); aged 20–72 (M = 46.07); with reported symptoms of claustrophobia and diagnosed with any anxiety disorder **HCPs:** *n* = 15 (6 females, 9 males); aged 26–41 (M = 33.79)	Mixed-method non-randomised feasibility study including qualitative semi-structured interviews and think-aloud method, and quantitative evaluations conducted to explore self-reported presence with the with the Igroup Presence Questionnaire (IPQ) and Likert-scaled evaluation items	VR: HTC VIVE Pro Eye headset with 2 base stations and 2 controllers	Patients with higher pre-treatment anxiety experienced lower presence than HCPs based on IPQ scores. Feasibility and acceptability of procedure was high in both groups, but HCPs expressed higher readiness to use technology than patients, and financial/technical barriers for adoption were expressed. Improvements in symptoms were reported following the intervention, but the physical presence of a therapist was deemed important for successful VRET. **Perceptions and experiences reported:** **Patients:** VR environment induced direct claustrophobic symptoms; some felt immersed in VR while others were aware of difference between real and virtual environments; VR intervention perceived as positive but might be tailored in specific cases (individual trigger cues, elderly, past trauma). **HCP:** Assessed VR as appealing and useful but expressed the need for more control over situation and exposure time; considered VR an adequate starting point; some were convinced VR intervention is appropriate for at-home self-management training of HCPs.	The use of a VR app developed for exposure therapy in the case of claustrophobia is feasible. Key elements of such an app should include adjustable intensity to induce presence and anxiety, and feature virtual humans for realistic scenarios. While such an app can be used alone, some patients might prefer using it in the presence of a therapist.

Appendix B

The quality of each of the included studies was appraised with respective CASP checklists based on their study design. As the mixed-method research by Mayer et al. included both qualitative and quantitative investigations [46], it was assessed with both qualitative and quantitative checklists where appropriate. Given the qualitative nature of the research undertaken by Wrzesien et al. (2010) [42] and Arnfred et al. (2021) [45] in the list of included studies, the CASP Qualitative Studies Checklist was employed to assess these. The qualitative aspects of Mayer et al.'s mixed-method study was also assessed with this checklist. The results are displayed in Table A1.

Table A1. CASP Qualitative Studies Checklist results for included qualitative studies.

Question	Assessment		
	Wrzesien et al. (2010) [42]	**Arnfred et al. (2021) [45]**	**Mayer et al. (2022) [46]**
1. Was there a clear statement of the aims of the research?	Yes	Yes	Yes
2. Is a qualitative methodology appropriate?	Yes	Yes	Yes
3. Was the research design appropriate to address the aims of the research?	Yes	Yes	Yes
4. Was the recruitment strategy appropriate to the aims of the research?	Can't tell	Yes	Yes
5. Was the data collected in a way that addressed the research issue?	Yes	Yes	Yes
6. Has the relationship between researcher and participants been adequately considered?	No	Yes	No
7. Have ethical issues been taken into consideration?	Yes	Yes	Yes
8. Was the data analysis sufficiently rigorous?	No	Yes	Yes
9. Is there a clear statement of findings?	Yes	Yes	Yes
10. How valuable is the research?	Potentially the first study to investigate Human Computer Interaction in the AR exposure therapy field	Provides insights about VR exposure for social anxiety disorder in a group therapy context and how relevant challenges can be alleviated	Potentially the first study exploring the experiences of patients with anxiety disorder with a VR exposure app for claustrophobia that includes virtual humans

The quantitative evaluation of Wrzesien et al.'s research (2012) [43] as well as the quantitative segments of Mayer et al.'s mixed-method study (2022) [46] were appraised using the CASP Case Control Study checklist. The results of this appraisal are shown in Table A2.

Table A2. CASP Case Control Study Checklist results for Wrzesien et al.'s quantitative evaluation.

Question	Assessment	
	Wrzesien et al. (2012) [43]	**Mayer et al. (2022) [46]**
1. Are the results of the trial valid?	Yes	Yes
2. Did the authors use an appropriate method to answer their question?	Yes	Yes
3. Were the cases recruited in an acceptable way?	Yes	Yes
4. Were the controls selected in an acceptable way?	Yes	No
5. Was the exposure accurately measured to minimise bias?	No	No

Table A2. *Cont.*

Question	Assessment	
	Wrzesien et al. (2012) [43]	**Mayer et al. (2022) [46]**
6. (a) Aside from the experimental intervention, were the groups treated equally?	• Comorbidities of patients not accounted for. • Experience and familiarity of patients with XR technology prior to intervention not considered.	• Experience and familiarity of patients with XR technology prior to intervention not considered. • No assessment of technology commitment post treatment.
6. (b) Have the authors taken account of the potential confounding factors in the design and/or in their analysis?	Yes	No
7. How large was the treatment effect?	• Highlights the need for the evaluation of new approaches for phobia treatment. • Low statistical power indicates the need for caution when drawing conclusions.	
8. How precise was the estimate of the treatment effect?	• Involved 2 judges with high agreement rates on the reliability test.	• Pre-treatment, HCPs scored higher than patients on technology commitment. • Post-treatment, both groups evaluated high immersion based on the IPQ scores.
9. Do you believe the results?	Yes	Yes
10. Can the results be applied to the local population?	Yes	Yes
11. Do the results of this study fit with other available evidence?	Yes	Yes

As Bouchard et al.'s study was a randomised controlled trial [44], the CASP RCT checklist was adopted for its appraisal and the results are shown in Table A3.

Table A3. CASP RCT checklist results of Bouchard et al.'s study.

Question	Assessment
1. Did the study address a clearly focused research question?	Yes
2. Was the assignment of participants to interventions randomised?	Yes
3. Were all participants who entered the study accounted for at its conclusion?	No
4. • Were the participants 'blind' to the intervention they were given? • Were the investigators 'blind' to the intervention they were giving to participants? • Were the people assessing/analysing outcome/s 'blinded'?	No No No
5. Were the study groups similar at the start of the randomised controlled trial?	Yes
6. Apart from the experimental intervention, did each study group receive the same level of care (that is, were they treated equally)?	Yes

Table A3. *Cont.*

Question	Assessment
7. Were the effects of intervention reported comprehensively?	Yes
8. Was the precision of the estimate of the intervention or treatment effect reported?	No
9. Do the benefits of the experimental intervention outweigh the harms and costs?	Yes
10. Can the results be applied to your local population/in your context?	Yes
11. Would the experimental intervention provide greater value to the people in your care than any of the existing interventions?	Yes

Given that Bouchard et al.'s study was the only randomised controlled trial that fulfilled the inclusion criteria of this systematic review, it was the only one where the RoB 2 tool could be used to assess for bias. The results of this assessment are shown in Table A4.

Table A4. Risk-of-bias assessment results of Bouchard et al.'s RCT.

Domain	Risk-of-Bias Judgement Score
Domain 1: Risk of bias arising from the randomisation process	Low
Domain 2: Risk of bias due to deviations from the intended interventions (*effect of adhering to intervention*)	High
Domain 3: Missing outcome data	Low
Domain 4: Risk of bias in measurement of the outcome	Some concerns
Domain 5: Risk of bias in selection of the reported result	High
Overall risk of bias	Some concerns

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