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# Extended Reality and Phobia Treatments: A Systematic Literature Review

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**Abstract**

Phobias significantly impact individuals' daily lives, requiring effective treatment methods. Traditional therapies such as cognitive-behavioral therapy and in vivo exposure therapy have shown effectiveness but face several limitations that extended reality (XR) technologies can help surpass by offering innovative approaches.

This study aims to organize this field of knowledge and investigate new research avenues. A systematic literature review adhering to PRISMA guidelines was conducted to examine high-quality studies published during the last decade in Scopus and Web of Science databases, organizing the results according to the phobia types, therapeutic methodologies, technologies used, participant demographics, and treatment outcomes.

It concludes that XR technologies, particularly Virtual Reality Exposure Therapy (VRET), are effective in reducing symptoms of various phobias (e.g., acrophobia, arachnophobia, and social phobia). XR provides immersive, controlled, and repeatable environments for exposure therapy, demonstrating efficacy comparable to traditional methods and representing a transformative tool in psychological treatment for phobias.

Despite important challenges identified (e.g., high equipment costs and the need for technological proficiency among therapists), XR shows promise in enhancing the future of phobia treatment. Future research should focus on

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optimizing treatment protocols, improving accessibility, and evaluating long-term efficacy to leverage XR's potential in mental health therapy fully.


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*Keywords:* Extended reality; Virtual reality; Augmented reality; Phobia treatment; Virtual reality exposure therapy; Cognitive-behavioral therapy; Mental health therapy

## 1. Introduction

The treatment of phobias has long been a subject of interest within the psychological and medical communities due to the significant impact these conditions can have on individuals' daily lives. Traditional methods, such as cognitive-behavioral therapy (CBT) and in vivo exposure therapy, have been the cornerstone of phobia treatment [1]. Nevertheless, a significant drawback of this approach is that an individual might be reluctant to confront their source of anxiety in such a direct manner [2]. By offering innovative approaches to phobia therapy, Extended Realities (XR) – including Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) – present a unique opportunity to create and provide controlled and immersive environments where patients can confront their fears safely and gradually [3], [4] and [5]. While existing XR solutions for phobia treatment vary in effectiveness, accessibility, and user experience, they represent a significant evolution in therapeutic options [2]. Despite these technologies' promise, their integration into therapeutic practices still lacks a comprehensive understanding of their efficacy and limitations.

According to the findings of Marks [6], phobias can be categorized into several distinct subtypes, reflecting the diverse nature of anxiety disorders. These subtypes include: (i) agoraphobia, characterized by fear of open or crowded spaces; social phobia, involving anxiety in social situations; (ii) animal phobia, where specific animals trigger intense fear; and (iii) specific phobia, encompassing fears of particular objects or situations. Marks' review of anxiety literature led to increased research on these phobic subcategories, significantly shaping our understanding of phobic disorders and their distinct manifestations.

This paper aims to provide a detailed systematic literature review (SLR) encompassing the analysis of the state of XR applications in phobia treatments during the past decade (from 2013 onwards), identifying the most effective approaches and their primary limitations. The existing literature on XR-based phobia treatments is analyzed in depth to determine XR technologies' overall effectiveness, compare different XR modalities, and identify the primary challenges and limitations faced in this field. It seeks to consolidate knowledge concerning the effectiveness of XR in phobia therapy, identify gaps in the literature, and suggest future research directions, hopefully contributing to the development of more effective and optimized therapeutic interventions using XR.

The subsequent section outlines the methods adopted during the research. The article proceeds with the analysis of the findings and their discussion for clinical practices, categorizing the data by the types of phobias treated, the XR technologies used, and the outcomes achieved, highlighting the benefits and challenges of using XR in phobia treatments and comparing them to traditional therapies. It finishes by providing specific recommendations for future research to address current challenges and optimize the use of XR technologies in phobia treatment, concluding the key findings and the potential impact of XR technologies on the future of phobia therapy and clinical practice.

## 2. Methods

The conducted SLR was meticulously executed in several phases, adhering to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [7]. The identification of records was conducted on the 8th of May, 2024, by querying the Scopus and Web of Science databases using the following string: ("virtual reality"

OR "augmented reality" OR "extended reality" OR "mixed reality" OR "RV" OR "AR" OR "MR" OR "XR") AND "phobi*".

The search was confined to conference papers and journal articles published within the last decade (from 2013 onwards), aiming to ensure the inclusion of contemporary and relevant research in the field. The total number of articles retrieved was 142, and 55 of them were removed due to duplication. Following this, several steps were followed to determine which articles to include for analysis: (i) by reviewing the titles and abstracts, n=28 articles were excluded for not being pertinent to the research's objective; (ii) during the assessment of articles sought for retrieval (n=59), n=8 articles were excluded for their inaccessibility; and (iii) the detailed review of n=59 articles allowed evaluating their relevance and assessing whether they provided sufficient results for drawing conclusions. During this stage, n=23 articles were excluded after full-text review for the following reasons: n=12 due to lack of empirical results, n=3 because used therapies did not fully use XR technologies, n=3 for presenting systematic literature reviews, and n=2 for not involving representative users (i.e., end-users). This rigorous selection process ensured that the final set of articles included for analysis (n=28) were both relevant and of high quality, providing a solid foundation for the conducted SLR.

During this process, comprehensive data was collected from each article and organized according to: (i) types of phobias; (ii) employed therapies; (iii) used methodologies; (iv) technologies and devices used; (v) number of participants; (vi) experimental results; and (vii) suggested future research directions. This data was meticulously transferred from the tables, figures, and textual contents of the articles into a structured spreadsheet that can be accessed online[1]. Subsequently, the data was synthesized through a rigorous meta-analysis process, and its outcome was scrutinized to assess the consistencies and strengths of the findings from each study, as well as to determine the overall effect when the results from multiple studies were aggregated. This approach ensured a robust and comprehensive understanding of the data under analysis.

## 3. Results

All articles included in the systematic literature review were based on case studies, with the majority (85.7%) using Virtual Reality Exposure Therapy (VRET). No biases related to the number of sessions or sample size were considered for this research, and the success of the studies was evaluated based only on the provided results. Moreover, a total of 1068 participants were accounted for across 28 datasets. However, demographic data such as age, sex, or nationality of the participants were not considered. Additionally, it is concluded that 85.7% of the studies (n=24) used VR technologies and 14.3% (n=4) AR technology, i.e., none of them used MR approaches. Considering the used devices, it was concluded that 44.8% used head-mounted displays, 13.8% used CAVEs (Cave Automatic Virtual Environment), and 3.4% mobile devices. Additionally, 31% of the studies mentioned making use of more than one device, and 6.9% did not mention which device was used.

From the study's analysis, it was also concluded that 64.3% regard specific phobias, while 35.7% involved multiple phobias treatment. Among the specific phobias, 44.4% concerned arachnophobia, 16.7% dental phobia, 11.1% driving phobia, 5.6% katsaridaphobia, 5,6% ailurophobia, and 5.6% cynophobia, and 5.6% trypanophobia, and 5.6% blood-injections-injury. The studies encompassing multiple phobias represented two or more phobias, and included essentially arachnophobia (11.8%), cynophobia (8.8%), aviophobia (8.8%), and acrophobia (8.8%). Other combinations were also found, most of them being isolated cases.

### *3.1. Specific Phobias*

Ailurophobia

[1] All authors agreed to make the data collected from the conducted analysis available on the following link: https://tinyurl.com/3eu7rja3. The table is divided into two sections: Multiple Phobias and Specific Phobias. The names of the specific phobias are presented according to the American Psychiatric Association (APA) guidelines.

Ailurophobia concerns the irrational fear of cats, that triggers anxiety in individuals when they think about, see, hear, or encounter cats or cat-related images. A single study [18] analyzed this condition with a sample of only 5 participants by employing Augmented Reality Exposure Therapy (ARET) via Hololens technology. Initially, participants underwent cognitive interventions through one-hour sessions, three times a week. Subsequently, ARET sessions were conducted for one hour, five times per week. The study reported significant improvement in the daily lives of the participants.

Arachnophobia

Arachnophobia, the irrational fear of spiders, elicits an immediate anxiety response upon encountering spiders, whether in real life, drawings, or images. Eight studies [19] - [26] were analyzed for this specific phobia, with sample sizes ranging from 10 to 186 participants. Across all studies, the use of the technologies showed positive progress in managing phobia. Five of the eight studies (62,5%) employed VRET [19], [20], [22], [23], [24], and one study [21] used AR, while the others used VRET with live experiences [25] and realistic photo rendering [26]. A study comparing VRET and in-vivo exposure reported no significant differences in outcome, indicating the efficacy of both methods. Research [19] used exposure therapy using a headset, involving 100 participants initially exposed to real spider exposure, followed by a treatment session using the specified technology. Despite this study developed a serious game for treating the phobia, it did not report results from its use. Moreover, studies [20], [21] and [25] also used VRET and ARET, comparing them with live spider exposure. Each study focused on groups exposed to live spiders and those using VRET, concluding that both methods yielded similar results. Contrarily, [22], [23], [24] and [26] exclusively applied extended reality technologies to assess outcomes, concluding that all participants showed improvements during several temporal evaluation assessment, measuring their progress over weeks and months.

Blood-injections-injury

Blood injection phobia pertains to the fear and anxiety associated with injections and medical procedures involving blood, encompassing both visual and tactile stimuli. One study examined the use of XR technologies for treating this phobia [27], employing VRET with a Samsung Gear VR headset and a Samsung Galaxy S7. It involved 43 participants and was divided into three phases: an initial session with medical professionals, a follow-up session after one week of treatment, and a third session three months later. One participant withdrew from the study, but the remaining participants showed improvement after the treatment.

Cynophobia

Cynophobia, the overwhelming fear of dogs, causes intense anxiety and fear in individuals when they think about, see, or encounter dogs. In severe cases, this phobia can lead individuals to avoid places where dogs might be present.

To conclude about the effects of XR in helping to treat this phobia, research [28] applied VRET with a 360º camera and Oculus Rift with a sample of 8 participants. Therapy sessions were conducted over 2, 3, and 4 weeks, with outcome evaluations occurring one month after the final treatment. The authors mention results were consistent with the literature, concluding it significantly improved participants from pre-treatment to post-treatment.

Dental Phobia

A significant portion of the population suffers from dental fear, leading to fewer dental visits and poor oral health, as advocated by [29], [30], and [31]. Researchers employed VRET to treat dental phobia for these cases, involving 9, 2, and 30 participants, respectively. In [29], heart rates were measured 16 times over 14 weeks and again during a follow-up after 6 months. This study recorded that 66,7% of participants were free of the phobia after the 6-month follow-up, indicating significant improvements in treating the phobia. Study [30] subjected participants to a behavioral test, concluding that none met the criteria for phobia according to the study's checklist in the 6-month follow-up. Additionally, [31] mentioned participants used a VR simulator, with another group controlling the stimuli, during a therapy involving five scenarios, where heart rates were monitored by the researchers. The results showed positive evidence supporting the use of VR technology for treating this specific phobia.

Driving Phobia

Driving phobia is characterized by an intense, persistent fear of driving, which escalates as a person anticipates or is exposed to driving stimuli. Two studies [32] and [33] involving a similar number of participants (30 and 31, respectively) concluded similar results, showing a significant reduction in this specific phobia. Study [32], in its turn, required participants to drive for 5 minutes in a virtual environment using VRET with headsets, a steering wheel, and biosensors. After exposure, most of the participants mentioned they wanted to continue and increase the difficulty and stimuli in the virtual environment (pedestrians, cars, etc.). Additionally, research [33] also used VRET with headsets, a steering wheel, and biosensors. Similarly, the results were positive, concluding that VR induces anxiety levels comparable to real-life experiences.

Katsaridaphobia

Katsaridaphobia regards the fear of cockroaches. Individuals with this phobia go to great lengths to prevent a cockroach from entering their homes and feel that their safety is compromised by these animals. One study [34] encompassing a sample size of just 4 participants used ARET, utilizing a projector. The project was developed according to the recommendations and criteria presented by various authors cited within the study, and it was observed that all participants experienced significant improvements in combating their phobia.

Trypanophobia

Trypanophobia, or needle phobia, is a common disorder found among individuals who experience anxiety symptoms at the sight or thought of needles or similar objects. The only study analyzed within this scope [35] employed VRET using headsets and VR videos with a single participant, concluding that the participant showed increased adherence to environments involving needles, and that this improvement persisted over time.

### *3.2. Multiple Phobias*

Study [8] used VRET supported by Blue Room CAVE technology to treat multiple phobias: Cynophobia (D), Amaxophobia (CP), School Main Door (SMD), Nyctophobia (DK), Making Requests (MR), Igniterroremophobia (FA), and Astraphobia (T&L). The results indicated functional improvement concerning the phobia of four participants, with no improvement in three participants, and one participant was unable to complete the treatment. Study [9] employed the same therapy and technology to treat a wide range of phobias including Bananas (B), Cynophobia (D), Spheksophobia (W&B), Aerophobia (FL), Open Spaces (OS), Chronophobia (SCT), Acrophobia (LH&GE), Nyctophobia (DK), Astraphobia (T&L), Entomophobia (IS), Making Requests (MR), Scopophobia (BLA), Masklophobia (MTS), Changes in Weather (CW), Automated Toys (AuT), Deipnophobia (EIFOP), Globophobia (BLL), Amaxophobia (TITC), Pediophobia (DLL), Toiletphobia (WC), and Chiroptophobia (BTS). After participants undergoing treatment over four sessions – the initial session, the second after 2 weeks, the third after 6 months, and the fourth after 12 months – the treatment led to improvements in 10 patients and worsening in 3. Similarly, research [10] utilized VRET but supported by Blue Room VRE (Virtual Reality Environment) to treat Ornithophobia (P) and Enochlophobia (C), involving nine participants, each receiving four 20-30-minute sessions in the Blue Room VRE. Eight participants completed the treatment, with only four showing improvements. On the other hand, [11] employed VRET and biofeedback with Oculus Quest 2 technology to treat Acrophobia (H), Claustrophobia (CLB), and Glossophobia (GL). This study involved 19 participants, and average values of electrodermal activity and heart rate variability were calculated during each test session. Participants and psychotherapists provided positive feedback regarding the system's effectiveness.

Additionally, [12] used ARET supported by AR 5DT and Vuzix VR Goggles to treat Arachnophobia (A) and Katsaridaphobia (K) and involved 63 participants, concluding that a high percentage of participants were classified as recovered or improved post-treatment and at 3 and 6-month follow-ups. Study [13] employed VRET, Cognitive Behavior Therapy (CBT), and Systemic Desensitization with support from Android platform technologies to treat Agyrophobia (AGP) and Glossophobia (GL). Ten participants could select a specific phobia for a CBT section, followed by a VRET, or watch exercise videos that followed their progress. After the treatment concluded, the application was evaluated, receiving predominantly positive feedback regarding its design, functionality, and effectiveness in learning. Other researchers [14] also used CBT in Virtual Reality with support from an unspecified Head Mounted Display (HMD) and a CAVE technology to treat Social Phobia (SP), Acrophobia (H), and Aerophobia

(FL), involving a sample of 16 participants. The treatment consisted of a non-VR CBT intervention and a VR intervention. post-treatment results indicated no significant improvements for acrophobia patients, but those with other phobias showed significant improvements. Study [15] combined VRET with CBT, using a smartphone and headset technology to treat Acrophobia (H), Aerophobia (FL), Arachnophobia (A), Cynophobia (D), and Trypophobia (T). The 126 participants used a self-guided application comprising six modules developed by a clinical psychologist (psychoeducation, relaxation, mindfulness, cognitive techniques, VR exposure, and relapse prevention), and the results showed reduced severity of symptoms across the five specific phobias, with treatment effects persisting for six weeks post-treatment. Moreover, [16] combined CBT in Virtual Reality with the Blue Room to treat Social phobia (SP), Open spaces (OS), Entamaphobia (ETP), Arachnophobia (A), Pedophobia (PDP), Ornithophobia (P), Entomophobia (IS), and Enochlophobia (C). A sample of 8 participants, received two sessions of 20 to 30 minutes each, and 5 improved their ability to manage their phobias in daily life, with four of these five experiencing no impact from the phobia.

Finally, [17] combined CBT, VRET, and exposure to real images, to treat Arachnophobia (A), Katsaridaphobia (K), and Herpetophobia (LIZ), involving a sample of 31 participants: 14 receiving CBT and VRET, and 17 receiving CBT and exposure to real images. Both groups showed a significant reduction in anxiety and phobia levels post-therapy, which were maintained at follow-up, but there were no significant differences between the two groups.

## 4. Future Research Directions Based on a Systematic Literature Review

Based on the performed SLR, several future research themes and research questions (RQ) were identified to advance this field of knowledge, suggesting key areas and challenges crucial to be addressed in the near future.

### *4.1. Training Programs*

Comprehensive training programs should be implemented for therapists to utilize XR technologies in the practice effectively. These programs should cover the technical aspects of XR and therapeutic techniques specific to XR environments. Certification programs and ongoing professional development can ensure therapists are well-equipped to use these technologies, potentially including simulation-based training modules. RQ1: What are the most effective training programs for therapists to learn how to use XR technologies? RQ2: How can certification programs and ongoing professional development be designed to ensure therapists are proficient in both the technical and therapeutic aspects of XR environments?

### *4.2. Longitudinal Studies*

Conducting longitudinal studies to assess the long-term efficacy of XR-based phobia treatments and identify potential relapse patterns was another gap identified. These studies should track patients over several years to determine the sustainability of treatment outcomes and any necessary follow-up interventions. RQ1: What are the long-term effects of XR-based phobia treatments in patients? RQ2: How do these treatments compare to traditional methods in terms of sustainability and relapse rates?

### *4.3. Broader Applications*

Expanding research to include a wider range of phobias and diverse populations, aiming to enhance the generalizability of the findings. This includes studying less common phobias in depth, phobias in different cultural contexts, and adapting XR therapies to various age groups and socioeconomic backgrounds. Additionally, exploring the use of XR in combination with other therapeutic modalities, such as mindfulness or cognitive reconstruction, could provide a more holistic approach to phobia treatment. RQ1: How effective are XR therapies for a wider range of phobias and diverse populations? RQ2: Can XR therapies be adapted to be culturally sensitive and appropriate for different age groups and socioeconomic backgrounds?

### *4.4. Ethical and Privacy Considerations*

Addressing ethical concerns and ensuring the privacy and security of patient data in XR environments. Research should focus on developing guidelines and best practices for the ethical use of XR in therapy, including informed consent, data protection, and managing potential side effects or discomfort experienced by patients during XR exposure. This could include creating secure data storage solutions and establishing protocols for managing patient data. RQ1: What are the best practices for ensuring ethical use and protecting patient privacy in XR therapy? RQ2: How can informed consent and data protection be managed effectively in XR environments?

## 5. Conclusion

This paper provides a comprehensive analysis of the current state of XR technologies in treating phobias, systematizing and organizing findings from 28 studies involving a total of 1068 participants. The review demonstrates that XR technologies, particularly VRET, offer significant therapeutic benefits for phobia treatment. The ability of XR technologies to create controlled, immersive environments allows patients to confront their fears safely and gradually, a crucial aspect of effective phobia therapy. This immersive approach not only facilitates the exposure process but also enhances patient engagement and accessibility to treatment.

Concerning the recovery and improvement of the study's participants, the overall results indicate that approximately 58% of them experienced significant reductions in their phobia symptoms, leading to improved quality of life and daily functioning. About 4.4% of the participants showed no significant change in their symptoms, suggesting a need for tailored approaches or combined treatments to address their specific needs. Regarding worsening of symptoms, a very small fraction (0.3%), experienced a worsening of symptoms. This highlights the necessity for careful monitoring and individualized treatment plans to mitigate adverse effects. Moreover, it was concluded that the remaining 37.3% of the participants involved in the analyzed studies either provided positive feedback, showed signs of improvement that were not quantified in the studies, or their exact outcomes were not specified.

Despite these promising results, several challenges need to be addressed to optimize the use of XR in phobia treatment. These include the need for standardized treatment protocols, addressing ethical and privacy concerns, and ensuring the long-term sustainability of treatment effects. Furthermore, there is a need for more extensive research on the application of XR technologies across a broader range of phobias and diverse populations. Future research should focus on longitudinal studies to assess the long-term efficacy of XR-based treatments and identify potential relapse patterns. Developing comprehensive training programs for therapists to utilize these technologies effectively is also crucial. Addressing these areas will help overcome the current limitations and fully realize the potential of XR technologies in mental health therapy. Among this study's limitations is that the screening process was limited to the last decade and included results from only two databases. Therefore, the presented results should not be interpreted as exhaustive. However, the authors agree that continued research and development in this field have the potential to enhance therapeutic interventions, offering better outcomes for patients suffering from phobias. Among its contributions, this research provides a solid foundation for future research and clinical practice, hopefully contributing to developing more effective therapeutic interventions and improving mental health outcomes globally.

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