Virtual Reality for Supporting Depression and Anxiety: A Scoping Review

Nilufar Baghaei, Vibhav Chitale, Andrej Hlasnik, Lehan Stemmet, Hai-Ning Liang, Richard Porter

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Abstract

Background: Mental health conditions pose a major challenge to healthcare providers and society at large. The World Health Organization (WHO) predicts that by 2030, mental health conditions will be the leading disease burden globally. The current need for mental health care is overwhelming. In New Zealand, one in six adults have been diagnosed with common mental disorders such as depression, and anxiety disorders according to a national survey. Cognitive behavioral therapy (CBT) has been shown to effectively help patients overcome a wide variety of mental health conditions. Virtual Reality Exposure Therapy (VRET) might be one of the most exciting technology that is emerging in the clinical setting for the treatment of anxiety and depression.

Objective: This study aimed to investigate what VR technologies are currently being used to help suppress depression and anxiety. Primarily we identified whether the CBT was included as part of the virtual reality exposure therapy treatment (VRET), and if so, how? Equally important, the focus was set not only on VR hardware and used software tools but also on what the participants did in the virtual environment and how the virtual environment looked like

Methods: We performed a scoping review. To identify significant studies, we decided to use already aggregated sources in Google Scholar Database. Overall, the goal of our search strategy was to limit the number of initial results related to virtual reality in mental health to only a relevant minimum.

Results: Using our defined key words, Google Scholar identified more than 17300 articles. After applying all inclusion and exclusion criteria, we identified a total of 369 articles for further processing. After manual evaluation, 34 articles were shortlisted, of which 9 reported the usage of CBT with VR. All these articles were published between 2017 and 2021.

Conclusions: Majority of the studies demonstrated the use of VR to be effective for suppressing anxiety or depression in a range of settings and recommended its potential as tool for usage in a clinical environment. As standalone headsets are much easier to work with and more suitable for home usage, the shift from tethered VR headsets to standalone headsets in the mental health environment was not observed. A total of 9 studies explicitly mentioned the usage of CBT. Out of these, CBT was conducted within a virtual reality environment in 5 studies while in the remaining 4 studies CBT was used as an addition to VRET. All 9 studies reported the use of CBT either in vivo or inside a virtual environment to be effective in suppressing anxiety or depression.

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Review

Virtual Reality for Supporting Depression and Anxiety: A Scoping Review

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Abstract

Background: Mental health conditions pose a major challenge to healthcare providers and society at large. The World Health Organization (WHO) predicts that by 2030, mental health conditions will be the leading disease burden globally. The current need for mental health care is overwhelming. In New Zealand, one in six adults have been diagnosed with common mental disorders such as depression, and anxiety disorders according to a national survey. Cognitive behavioral therapy (CBT) has been shown to effectively help patients overcome a wide variety of mental health conditions. Virtual Reality Exposure Therapy (VRET) might be one of the most exciting technologies that is emerging in the clinical setting for the treatment of anxiety and depression.

Objective: This study aimed to investigate what VR technologies are currently being used to help support depression and anxiety. We investigated whether CBT was included as part of the virtual reality exposure therapy treatment (VRET), and if so, how? We also looked at what VR technologies and interventions have been used in recent studies on depression and anxiety.

Methods: We performed a scoping review. To identify significant studies, we decided to use already aggregated sources in Google Scholar Database. Overall, the goal of our search strategy was to limit the number of initial results related to virtual reality in mental health to only a relevant minimum.

Results: Using our defined key words, Google Scholar identified more than 17300 articles. After applying all inclusion and exclusion criteria, we identified a total of 369 articles for further processing. After manual evaluation, 34 articles were shortlisted, of which 9 reported the usage of CBT with VR. All these articles were published between 2017 and 2021.

Conclusions: Majority of the studies demonstrated the use of VR to be effective for supporting anxiety or depression in a range of settings and recommended its potential as tool for usage in a clinical environment. As standalone headsets are much easier to work with and more suitable for home usage, the shift from tethered VR headsets to standalone headsets in the mental health environment was not observed. A total of 9

studies explicitly mentioned the usage of CBT. Out of these, CBT was conducted within a virtual reality environment in 5 studies while in the remaining 4 studies CBT was used as an addition to VRET. All 9 studies reported the use of CBT either in vivo or inside a virtual environment to be effective in supporting anxiety or depression.

KEYWORDS

virtual reality; mental health; depression; anxiety; CBT

Introduction

Background

Mental health conditions are a major challenge for the society, healthcare providers, and health systems with the recent COVID-19 pandemic only worsening these pre-existing conditions [1]. Mental health services are struggling to meet the needs of users and fail to reach large proportions of those in need of care. The World Health Organization (WHO) predicts that by 2030, mental disorders will be the leading disease burden globally [2]. WHO has also estimated that anxiety disorders have cost the global economy approximately $1 trillion per year in lost productivity costs [3]. Between 75% and 85% of people with mental disorders remain untreated in developing countries with almost 1 million people taking their lives each year. In addition, according to the WHO, 1 in 13 globally suffers from anxiety with specific phobia, major depressive disorder and social phobia being the most common. Barriers to effective care include a lack of resources, lack of trained health-care providers and social stigma associated with mental disorders [2].
According to a recent NZ Health Survey, one in six New Zealand adults have been diagnosed with common mental disorders such as depression, and anxiety disorders. Māori and Pacific adults (indigenous population) have higher rates of being diagnosed with depression and anxiety than the rest of the population. There is also a certain level of societal stigma attached to mental health problems, preventing some people to access the available resources [4].

Mood disorders and anxiety disorders are closely linked and individuals who develop depression have often experienced an anxiety disorder earlier in life. Indeed, individuals with depression often experience symptomology similar to that characteristic of anxiety disorders, including nervousness, irritability, disturbed sleep or appetite, and poor concentration, among other symptoms [5].

Cognitive Behavioural Therapy

Cognitive behavioural therapy (CBT) is among the therapies commonly available for treating anxiety and depression. It is supported by many guidelines as a first line treatment for mood and anxiety disorders [55, 56]. CBT is a type of psychotherapeutic treatment that helps people learn how to identify and change destructive or disturbing thought patterns that have a negative influence on behaviour and emotions [6]. It is the most empirically supported therapy and has been shown to effectively help patients overcome a wide variety of mental health conditions including anxiety and depression [6].

Exposure Therapy

Exposure therapy, a form of behavioural therapy has become increasingly popular in recent years with both mental health consumers and treatment professionals as being the one of the most effective treatments for phobic anxiety disorders. The exposure therapies are usually conducted through in vivo exposure (IVE) or imaginal exposure (IE). In IVE therapy, the patient is deliberately exposed to the feared object or situation in real world. It is often used in the treatment of phobias or anxieties [7,

8]. Despite being an effective treatment, some IVE therapies may require to be conducted in public thereby risking patient confidentiality; or are too expensive or face difficulty in replicating the feared scenarios (e.g., fear of flying). To help with these IVE limitations, imaginal exposure (IE) therapy can be an alternative approach to trigger the feared situations through imagination. However, for IE therapy to be effective, the patient must be ready and willing to spend time and effort analysing their thoughts and feelings.

Virtual Reality and Virtual Exposure Therapy

The use of Virtual Reality (VR) in health care was pioneered by Hoffman et al, in the early 2000s, with a VR gaming system called SnowWorld, that was able to reduce pain perception during burn wound care in both adolescent [9] and adult patients [10]. Virtual reality (VR) is the use of computer modelling and simulation that enables a person to interact with an artificial three-dimensional (3-D) visual or other sensory environment. VR systems typically consist, of the following components:

- Graphics rendering units: The computer hardware to compute the virtual scene and render it to a frame buffer, ready to be sent to a display device. This is typically a high-end graphics computer.
- 3D stereo display units: It operates as the interface from the computer to the user. Visual information is often presented via large projection-based displays, or head-mounted-displays (HMD).
- Tracking system: Serves as the interface from the user to the computer. Modern HMDs include integrated head tracking, thereby allowing the user to move their head and have their visual perspective change in the virtual environment accordingly.
- Other interfaces include joysticks or sensory gloves which provide tactile feedback.
- Examples of recent popular VR devices Oculus Quest 2, HTC Vive, Sony PlayStation VR, etc.

Virtual Reality (VR) might be one of the most exciting emerging technologies that is rapidly gaining traction in the treatment of anxiety and depression [11–13]. Virtual Reality Exposure Therapy (VRET) is a modern type of exposure therapy that follows the same procedures as a traditional exposure therapy with the only difference being that the feared objects or situations are rendered within a virtual environment. A virtual environment provides greater degree of control for the therapists to customize, reproduce and tweak several treatment parameters according to the patient's needs. Such level of customization cannot be achieved in a traditional exposure therapy. Risk of privacy intrusion is reduced as everything is confined to a virtual environment. Furthermore, VRET is considered less frightening than in vivo exposure therapy according to the patients [14].
VR applications and VR exposure therapies (VRET) have also been shown to be effective in the treatment of a variety of other mental health conditions for instance specific phobias (acrophobia, arachnophobia) or social anxiety disorder (SAD), autism, panic disorder, posttraumatic stress disorder (PTSD), substance abuse or addiction disorders (alcohol, gambling) [7, 8, 15–21]. Thus, this study presents findings from a scoping review on the state-of-the-art VR therapies for supporting anxiety and depression.

Objective

A scoping review methodology specified by Arksey and O'Malley [22] was followed in this study. This scoping review aimed to investigate two questions: (1) What VR technologies and interventions have recently been studied in depression and anxiety disorders (2) Whether cognitive behavioural therapy (CBT) was included as part of the virtual reality exposure therapy (VRET) and if so, how was CBT utilised (within VR environment or in addition to VR intervention)?
Since technology advances rapidly, it is critical to understand the current state-of-the-art technologies

being used especially in an interdisciplinary field such as virtual reality in mental health. Thus, to answer the first question, we studies the VR technology, types of interventions, participants' interaction during the intervention and how the virtual environments were created.
It is known that CBT is an effective tool used for the treatment of several mental health problems [6]. Common VR interventions such as virtual reality exposure therapy or VRET maybe sufficient to treat anxiety or depression however, combination of these interventions with CBT has been an understudied area. There is currently much less literature that specifically explores the effectiveness of CBT used in combination with common VR interventions. Thus, the second question systematically explores the usage of CBT along with VRET and provides a detailed review of how CBT was employed; whether it was used inside a virtual environment or additionally to VRET, and the effectiveness of this type of methodology in the treatment of anxiety or depression.

Methods

Search Strategy and Eligibility Criteria

We defined the search strategy specifically suited to find the most relevant papers that used virtual reality on supporting and enhancing the outcome for mental health issues particularly focusing on anxiety and depression.

Databases Searched

We used Google Scholar (https://scholar.google.com) as the primary source of materials included in this research. Google Scholar provides a simple and quick way to search across a variety of disciplines, databases, and journals. To limit the number of studies relevant to our research questions (RQs), we defined specific eligibility criteria and search terms. The goal of our search strategy was to limit the number of results related to our RQs to only a relevant minimum.

Search Terms

The search terms were discussed amongst the research team and were defined as "Anxiety", "Depression" and "Virtual Reality". Sometimes, virtual reality can also be acronymised as VR however, the full term was exclusively used during the search to avoid any potential conflicts with other terms that may use the VR acronym (e.g., Voice Recognition). These defined search terms also reflect the most used keywords of the studies relevant to our RQs.

Eligibility Criteria

Because information technology is evolving rapidly in terms of hardware and software related to virtual reality, we decided to limit the year of publication to 2017 in order to identify the state-of-the-art technologies. Therefore, the main article dates were set from 2017 to 2021. Google Scholar advance search allows selecting articles using only a limited set of criteria. When we used the search filter criteria "anywhere in the article" with the defined search terms "Virtual reality" "Depression", "Anxiety", the Google Scholar search yielded 17300 results. Based on our search strategy goal, we decided to use a combination of three search requests, that were compliant with the following rules:

- All the search terms must be present in the article.
- All the search terms must be present in the title of the article (not only in the article body).
- The article publication year must be within a specific range from 2017 - 2021.

With these rules in place, we were able to execute three separate search requests using the following combination of the search terms:

- "Virtual reality AND anxiety"

- “Virtual reality AND depression”
- “Virtual reality AND depression AND anxiety”

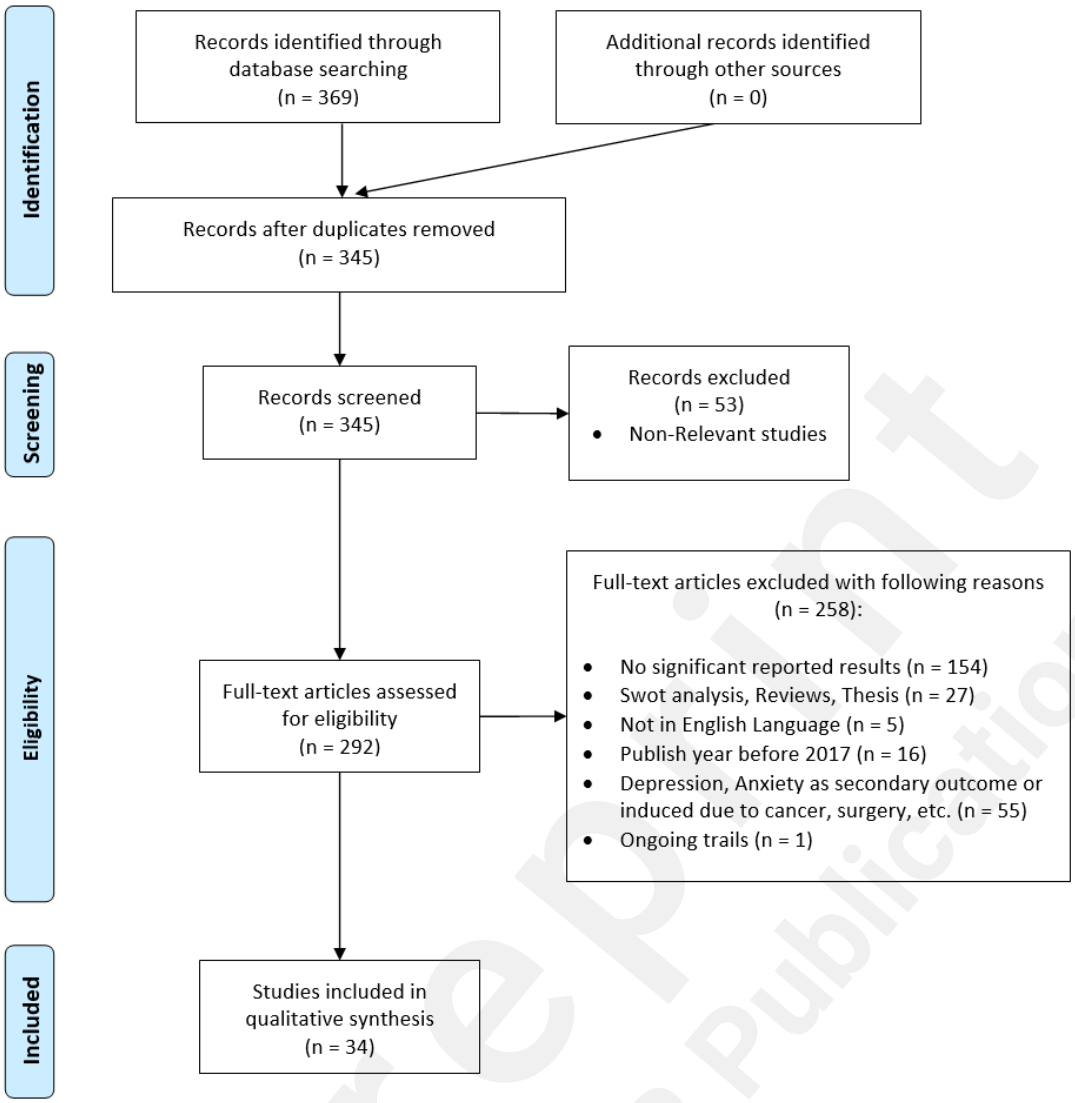
Some of the additional exclusion criteria were defined as follows:

- Duplicates, version updates or written in language other than English
- Swot analysis, thesis and citations, systematic reviews, or no significant reported results
- Anxiety or depression as a secondary aspect or induced due to an illness

A detailed explanation of the search strategy is provided in Appendix 1.

Study Selection

The search strategy yielded overall 369 articles. The first step included the removal of duplicates which was found to be 24 articles, thus reducing the number of articles to 345. Four authors screened the titles of these 345 articles for relevance. If a decision could not be made regarding the relevance of an article, then the abstract was taken into consideration. If the authors still lacked certainty, then the full text of the article was reviewed to reach the final decision.
In total, 53 articles were excluded due to the non-relevancy as determined by authors upon screening making the number of eligible articles as 292. The non-relevant articles included out of context studies such as those not targeting anxiety or depression. Few non-relevant articles targeted anxiety or depression but relied on technologies other than VR. The last screening step required articles to meet the defined eligibility criteria, which was assessed upon the full text review. A total of 34 articles were confirmed for the scoping review that met the eligibility criteria.
This study selection process is depicted in Figure 1.
Figure 1. Literature screening and selection flowchart following PRISMA guidelines



An in-depth breakdown of the study selection process is explained in below Table 1.

Table 1. The reasons for exclusions, the number of studies excluded and selected for final review

Search ID	Search terms	Results
1	Virtual reality AND anxiety	298
2	Virtual reality AND depression	62
3	Virtual reality AND depression AND anxiety	9
Total Collected		369
Exclusion ID		
1	excluding non-relevant studies	53
2	excluding duplicities and version updates	24
3	excluding documents with no significant reported results	154
4	excluding swot analysis, thesis and citations, system reviews	27
5	excluding documents not in the English language	5
6	excluding documents published before 2017	16
7	excluding documents with anxiety or depression as a secondary aspect or anxiety / depression induced due to cancer, surgery, etc.	55
8	excluding documents with ongoing trials	1
Total Excluded		335
Selected		**34**

Data Extraction

One of the authors performed the data extraction process while the data validity and accuracy were checked by the remaining authors. All the articles were downloaded as full text and maintained in a database shared amongst all authors. The following data was extracted:

1. Publication year and authors
2. Demographics such as sample size, age distribution, gender ratio
3. Methodology (e.g., study design, was CBT included, duration of study, number of sessions)
4. VR hardware and software details such as type of headset, toolkit used, what was the VR scenario and how was the VR environment designed
5. Key findings concerning the effectiveness of VR in supporting depression and anxiety, the role and significance of CBT if used.

The extracted data allowed us to generate information related to our RQs especially on determining the experimental setup and significance of CBT. Moreover, the data provided useful insights on developing the statistics of the articles used in the review.

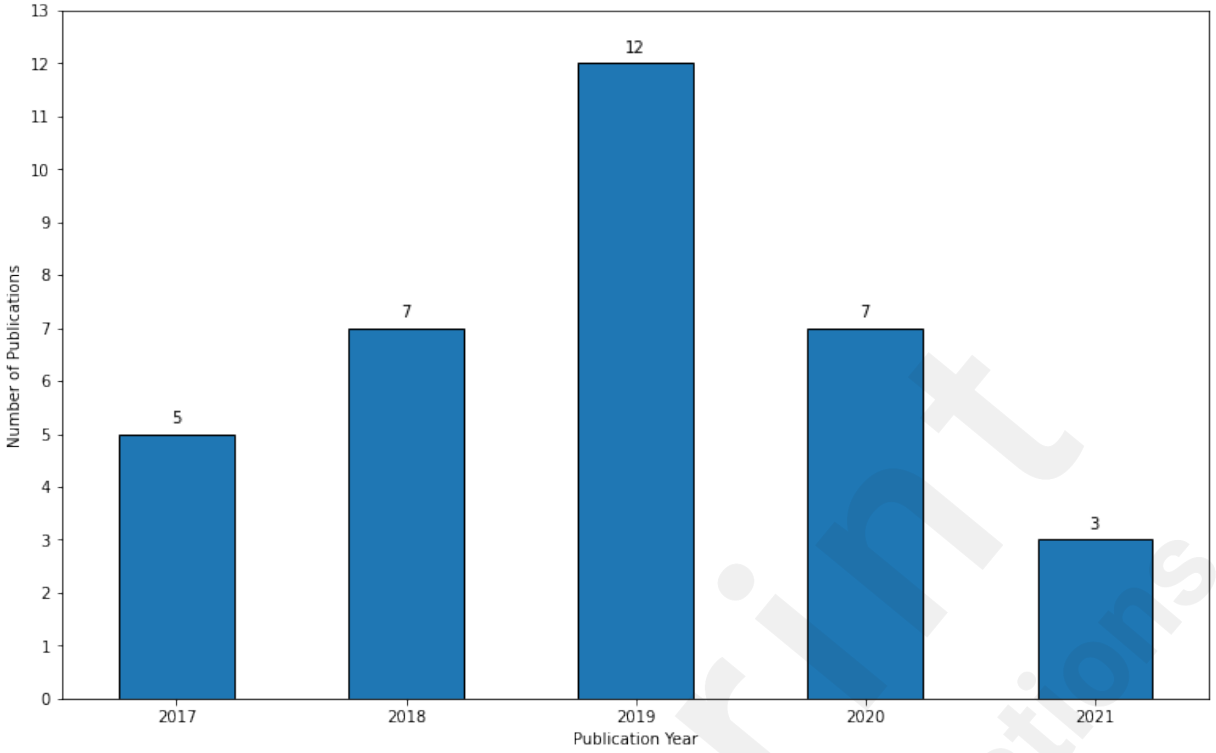
Results

Publications Statistics

A total of 34 articles were selected for this scoping review (Appendix 2). Articles with no information available were discarded during plotting.

Figure 2 shows the majority of the articles being published in the year 2019 [23–34], comprising 35.29% (n = 12) of total articles. Articles published in 2018 [35–41] and 2020 [13, 42–47] were of equal proportions 20.59% (n = 7) while those published in 2017 [12, 48–51] were the third highest 14.7% (n = 5). Recent publications from early 2021 [52–54] were also selected (n = 3).

Figure 2. Number of publications per year



Demographics

Figure 3 shows the participant's average age distribution. The age distribution is particularly dominated by the two age groups of 21 to 30 years and 31 to 40 years comprising of 67 % of total articles. The lowest average age group was 0 to 10 years whereas the highest average age group was 71 to 80 years indicating that the participants across all age groups were recruited for VR support in tackling depression or anxiety.

Figure 3. Average age group distribution

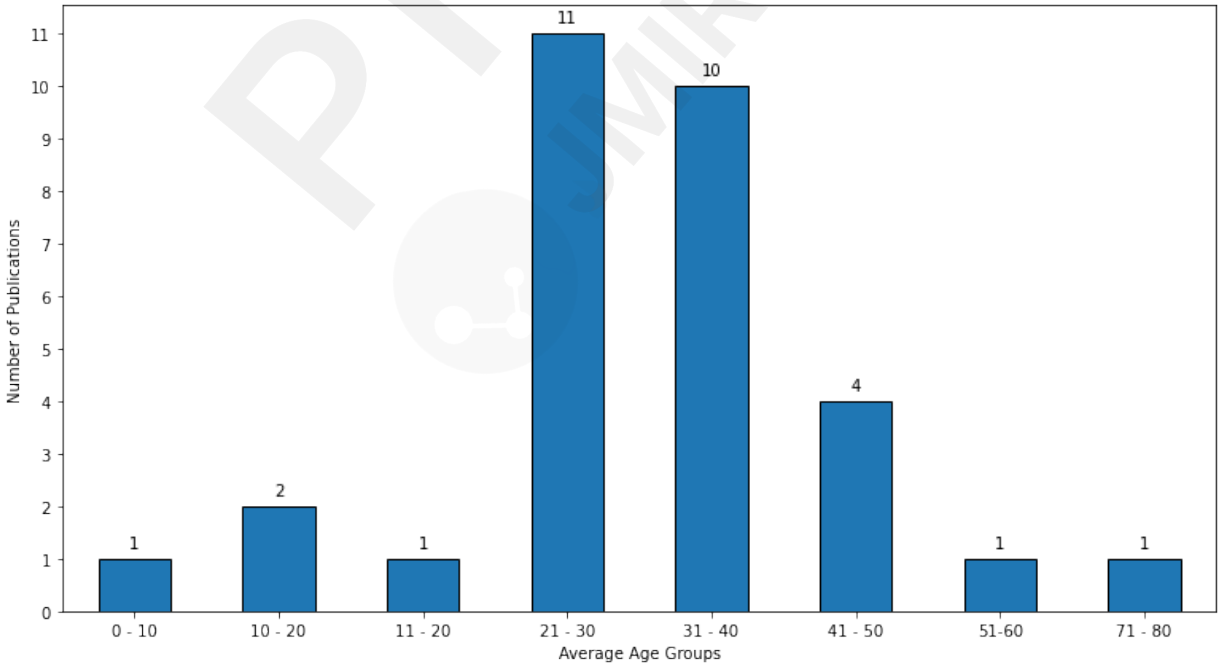
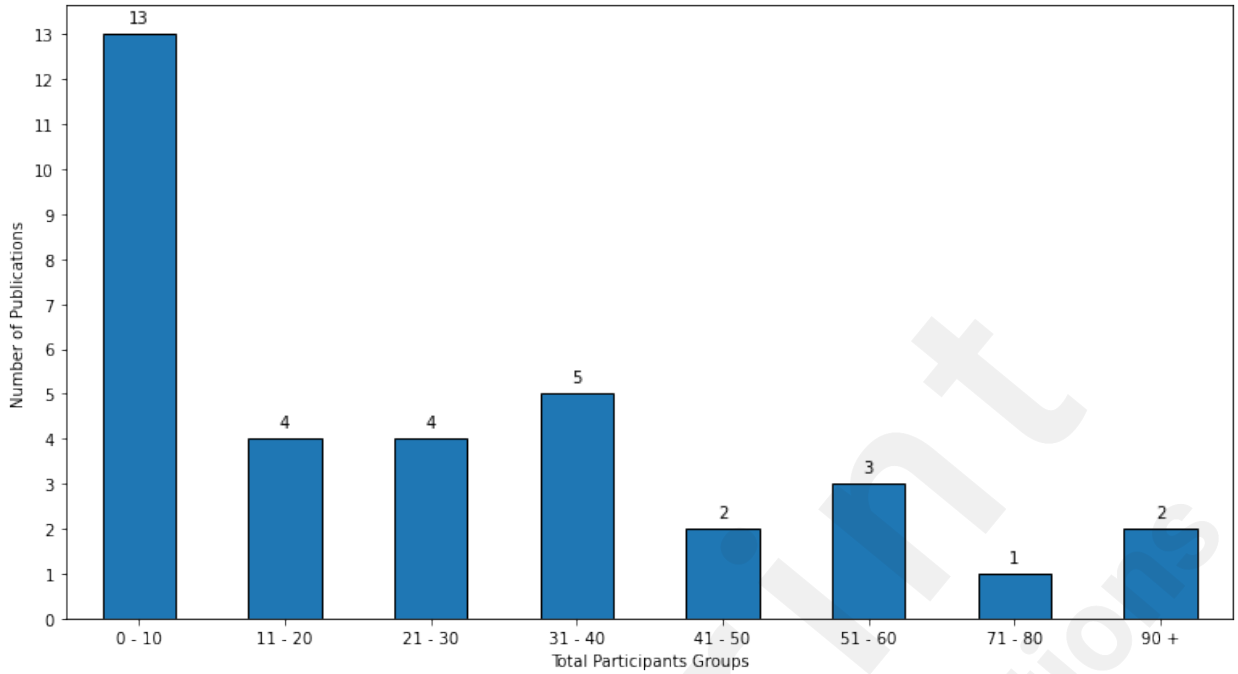


Figure 4 depicts the distribution of total participants. Most of the articles (38.24%) included fewer than 10 participants [24, 29–32, 34–36, 38–40, 43, 53] while 2 studies had more than 90 participants

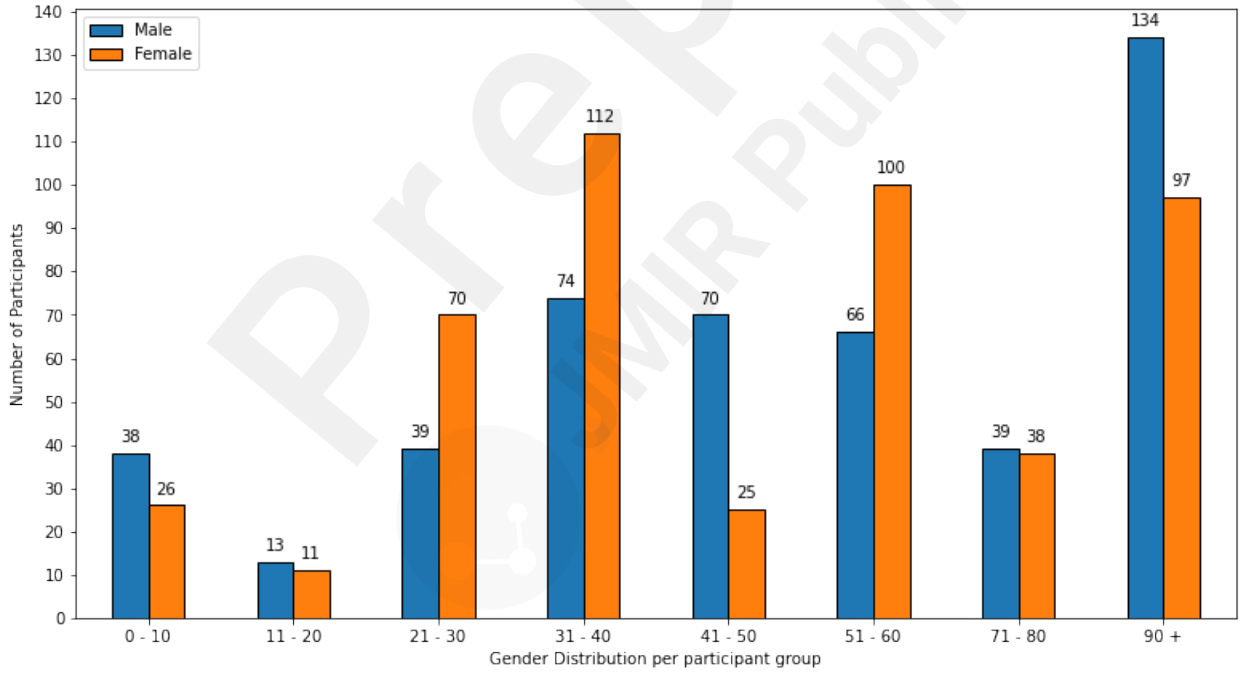
[33, 52].

Figure 4. Distribution of total participants across studies



Similarly, the gender distribution of participants is shown in Figure 5. The total number of female and male participants were 479 and 473, respectively, indicating an equal gender ratio among participants.

Figure 5. Gender distribution of participants



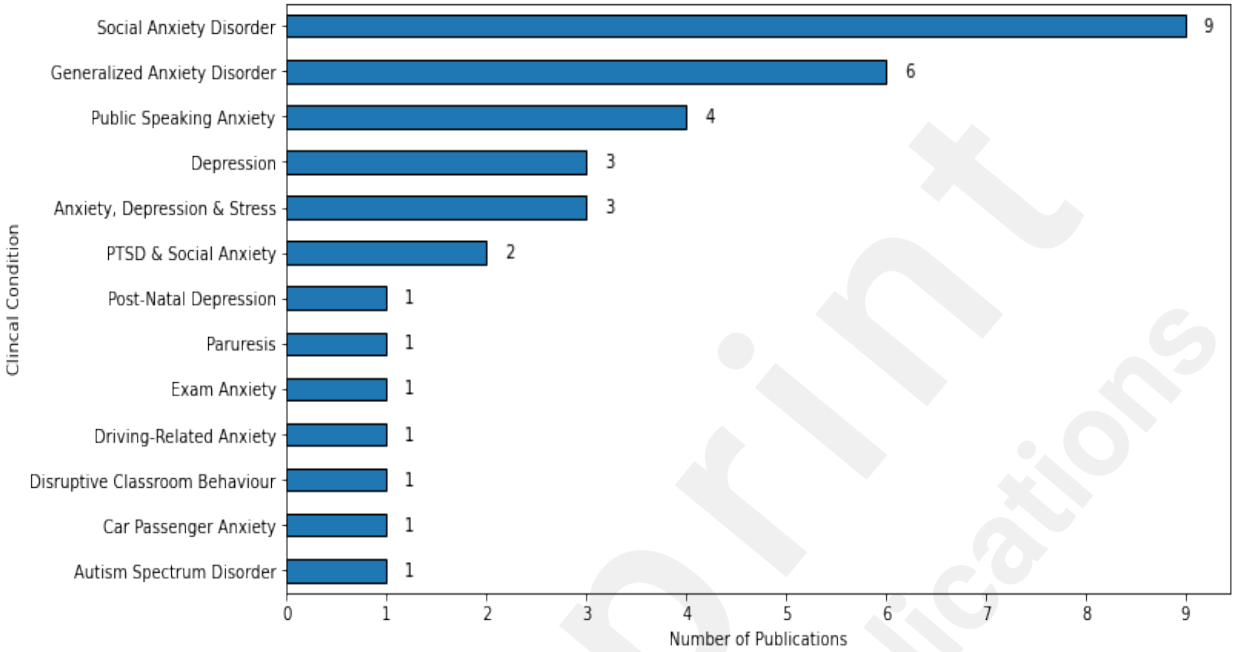
Clinical Conditions

Figure 6 illustrates the count of clinical conditions per publication. Overall, most studies centred around one or the other type of anxiety condition (n = 25) compared with depression (n = 4). Social anxiety disorder (SAD) was most studied with 9 studies focusing on using VR therapy solely for SAD patients [27, 32, 35, 39, 45, 48, 50–52]. Generalised anxiety disorder [25, 26, 37, 40, 44, 47] was next (n = 6) followed by public speaking anxiety [12, 29, 49, 54] (n = 4). The rest of the studies aimed at specific clinical conditions such as paruresis [38], exam anxiety [46], driving-related

anxiety [36] or car passenger anxiety [28], disruptive behaviour in classroom [43], or social anxiety in children with autism spectrum disorder [31].

Fewer studies (n = 4) focused on using VR therapy exclusively for the treatment of individuals with depression [13, 24, 34, 41] whereas 5 studies were found that targeted multiple conditions such as stress [23, 33] or post-traumatic stress disorder [42, 53] or panic disorder [30] in addition to anxiety and depression.

Figure 6. Number of publications per clinical conditions



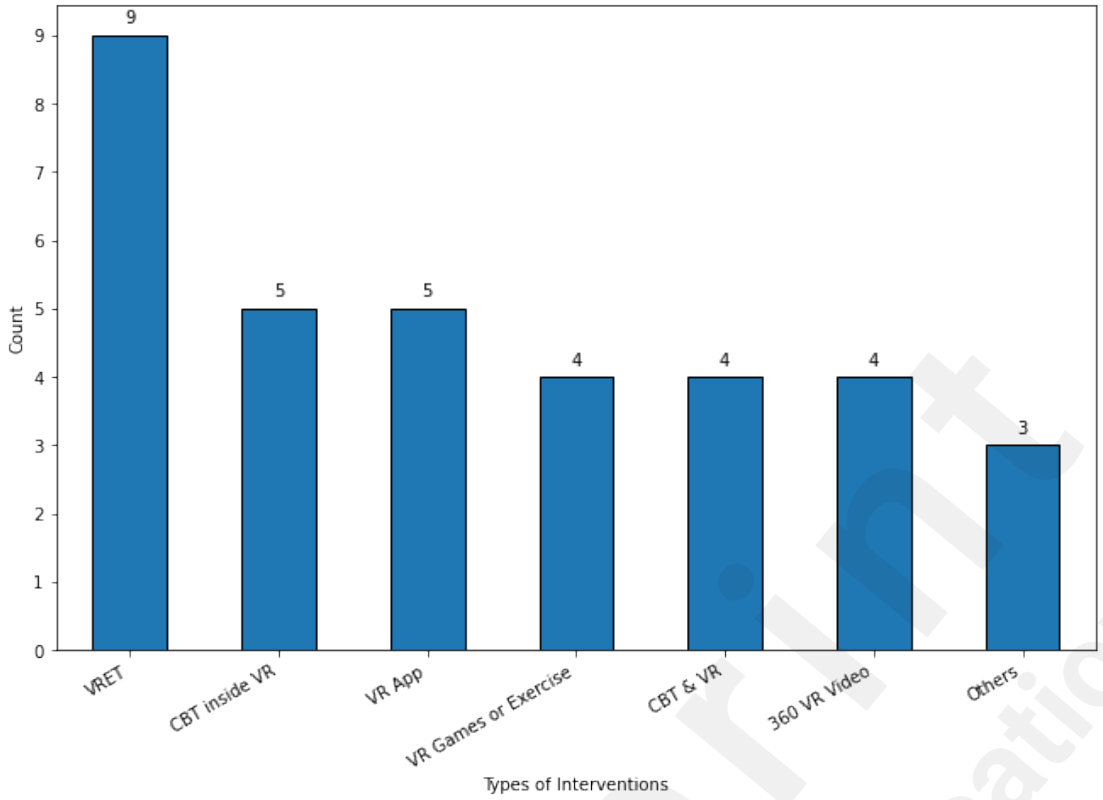
Investigating the Research Questions

RQ1: What VR technologies and interventions are currently being utilised in studies in depression and anxiety?

To answer this question, we developed a robust data extraction process which was explained in the earlier section. We reviewed the articles and extracted details such as types of VR interventions plotted in Figure 7, types of VR headsets shown in Figure 8, additional monitoring software and hardware, details about what the participants did during the intervention, number of sessions depicted in Figure 9, and how long the interventions lasted.

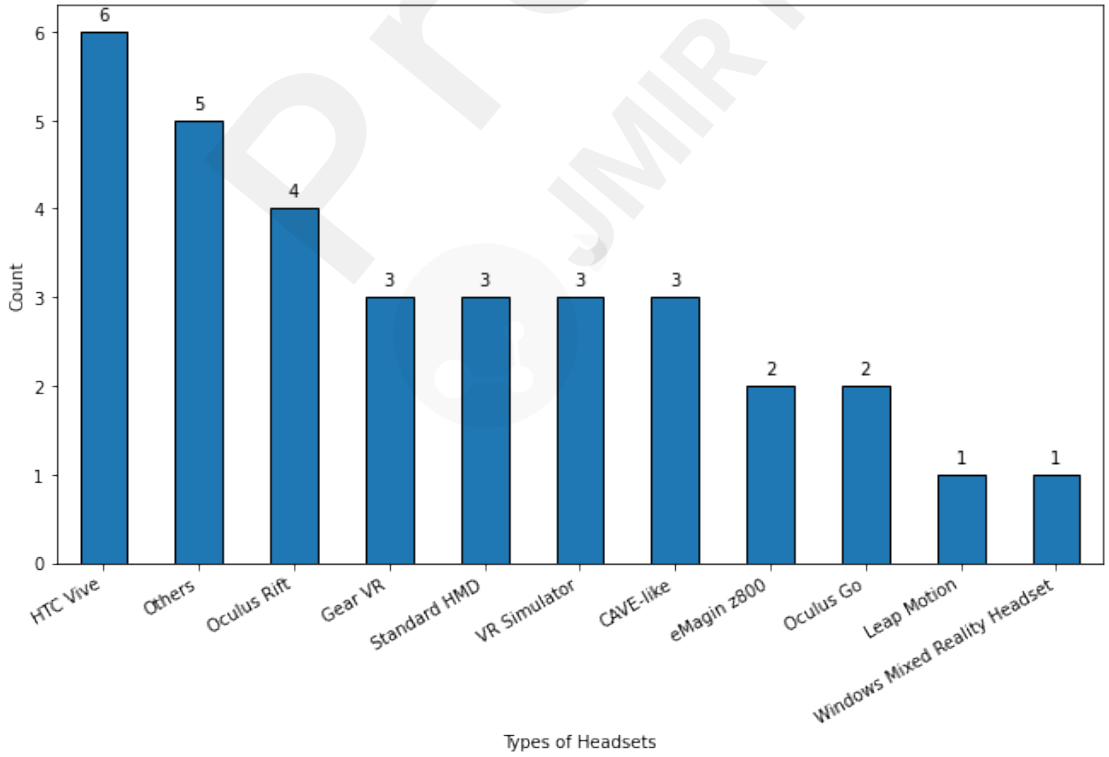
The most frequent type of VR intervention was VRET(standard VR scene), used in total 9 studies [23, 29, 32, 38, 39, 45, 51, 53, 54]. Interestingly, two studies employed behaviour therapy in addition to VRET using commercial simulator software in the treatment of social anxiety disorder [39] and public speaking anxiety [29]. It was followed by CBT inside VR [24, 26, 35, 48, 52] and VR application [28, 31, 33, 41, 50] interventions used in 5 studies each. Two studies used a unique use of VR applications using music therapy [31] (where participants had to sing a song in virtual hall) and art therapy [33] (where in participants performed activities using a tilt brush VR application). The VR music therapy was used in the treatment of social anxiety of adolescents with autism spectrum disorder. Other interventions applied were VR games or exercises [13, 43, 44, 47], CBT in addition to VR [12, 25, 36, 37], and 360-degree VR video [34, 42, 46, 49]. Three studies used different types of VR interventions such as visuo-haptic-based multimodal feedback VR system [30], VR-based neurofeedback therapy [40]and a VR task tracking avoidance behaviour [27].

Figure 7. Types of VR interventions



The most popular VR headset among the articles was HTC Vive (n = 6) while Oculus Rift was the next frequently used VR headset (n = 4). Three studies utilised Gear VR, different types of VR simulators and CAVE-like systems, one used Leap Motion *[30]* and one used Windows Mixed Reality Headsets *[34]*. A regular feature among most studies was the external monitoring of additional data such as heart rate, eye movement or EEG readings during the intervention or pre and post intervention.

Figure 8. Types of VR Headsets



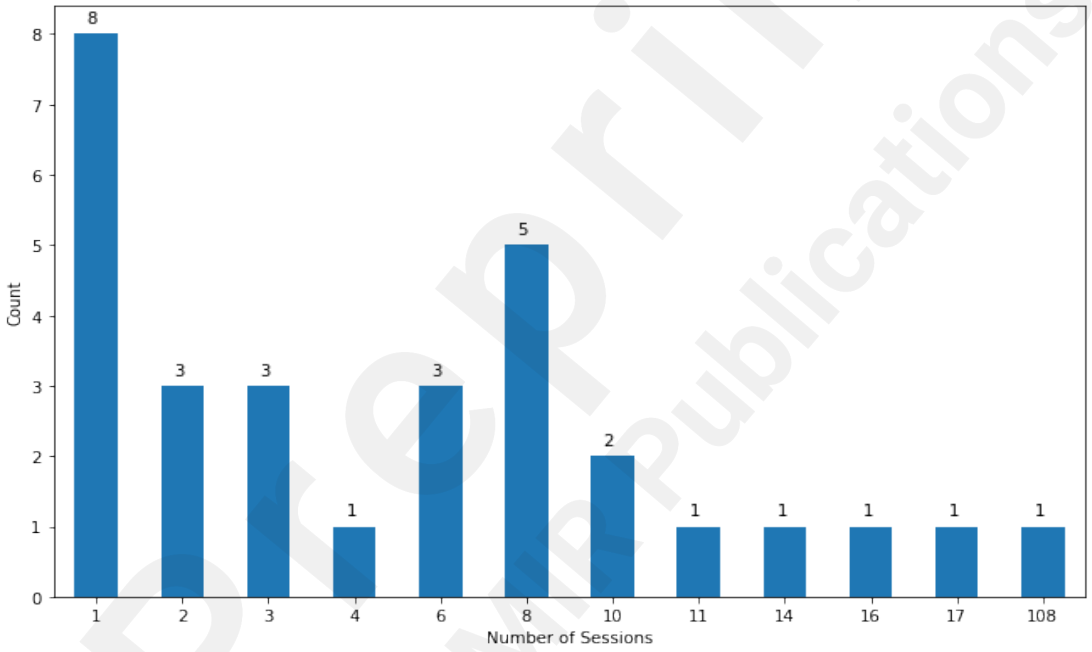
A wide range of VR environment or scenarios were observed. A workplace environment or a job

interview was the most common virtual environment for participants with SAD. A conference room or classroom was usually used for public speaking anxiety whereas virtual nature exposure was a common scenario seen in studies focusing on both anxiety and depression. An interesting virtual environment of underwater world exploration was used in the treatment of state anxiety and disruptive classroom behaviour, wherein the movement was controlled through participants breathing using a VR biofeedback game intervention [43].

Figure 9 shows a wide variability in the number of sessions that the participants underwent for the VR therapy. A single session was used in most studies (n = 8) while the average number of sessions seen was 8. Notably one of the studies had a total of 108 trial sessions which was an outlier as the range of sessions was observed from 1 to maximum 17. The session time ranged from 2 to 90 minutes depending upon the type of VR intervention.

A recent study by Jeong et al. [52] aimed to identify the number of sessions that were sufficient for a successful VR intervention in treatment of SAD, concluding 9 to 10 sessions or possibly fewer sessions (5 to 6) of VR-based CBT can be effective in the treatment of social anxiety disorder. Increasing the number of sessions above this provided minimal additional benefits.

Figure 9. Number of VR Sessions



RQ2: Whether cognitive behavioural therapy (CBT) was included as part of the virtual reality exposure therapy (VRET) and if so, how was CBT used (within VR environment or in addition to VR intervention)?

To answer the second question, we systematically reviewed the articles and extracted relevant data that explored the usage of CBT along with other VR interventions. We then formulated a review table, (Table 2) that described the CBT methodology in terms of how CBT was employed, what was the VR experiment and the key findings.

A total of 9 studies mentioned the use of CBT with other interventions. Only those studies that explicitly mentioned CBT were selected. Of these, 3 studies focused on treatment of social anxiety disorder and two generalised anxiety disorder. One study targeted both social anxiety and generalised anxiety disorder. One study mentioned the use of CBT for depression. CBT inside a virtual reality environment was the most used (n = 5) while 4 studies used CBT in addition to VRET. Three studies made use of commercial software for exposing participants in the virtual environment [36, 37, 48]. Notably there was no common hardware or software across all studies except the use of a head mounted display. Total participants varied from 2 to 115.

All studies reported that the use of CBT was associated with a reduction of symptoms of anxiety or depression with one study even reporting that conducting CBT inside a virtual environment was more effective than CBT with in vivo exposure on the primary outcome measure of anxiety symptoms in a randomised controlled trial (RCT). It was also found to be more practical by therapists rather than conducting CBT with in vivo exposure [48].

Table 2. Review of CBT studies

ID	Condition	CBT Type	VR Toolkit	VR Scenario & Total Participants (n)	Summary of Findings
Anderson et al., (2017) [12]	Public speaking anxiety	CBT & VR	NA[a]	Participants gave a speech in front of the increasing number group in a virtual conference room, classroom, auditorium (n = 28)	Participants showed statistically significant improvement on all self-report measures from pre-treatment to follow-up
Stamou et al., (2019) [24]	Post-Natal Depression	CBT inside VR	NA	The participants were exposed to a series of virtual stressors, while at the same time, they were asked to tidy up the virtual house (n = 6)	All participants reported feeling better, more relaxed and with improved mood, better self-esteem, and improved sleep and appetite
Guitard et al., (2019) [25]	Generalised Anxiety Disorder	CBT & VR	A 6-side CAVE[b]-Like system and wireless motion tracking	The three standardised VE of an emergency room (n = 11), an apartment (n = 15), a student room (n = 2)	The standardised VE induced significant anxiety. No difference was found between standardised VE and imagined scenario
Geraets et al., (2019) [26]	Generalised & Social Anxiety Disorder	CBT inside VR	Head-mounted display (Sony HMZ-T1), joystick.	A virtual street, bus, cafe and supermarket environments were available. Patients tested their beliefs and feedback was given on cognitions and behaviour (n =	Two patients dropped out of treatment. Social anxiety and quality of life improved at post-treatment. At follow-up, depressive symptoms decreased,

				15)	social anxiety was maintained
Kovar I, (2018) [35]	Social Anxiety Disorder	CBT inside VR	HTC Vive + controllers	Public speaking, a telephone call from a random institution, criticism of their appearance, a job interview or refusal (n = 10)	Most significant improvement in the length of fluent speech. VRET[c] improved reaction speed by 204.8 seconds. No effect in job interview VE
Zinzow et al., (2018) [36]	Driving-Related Anxiety	CBT & VR	Drive Safety CDS-250 driving simulator. Three 19-inch LCD screen displays.	Lane Keeping Straight / Changing / Mirrors, Speed Control Straight, Pedals and Stopping, Functional Object Detection–Basic, Turning Left / Right (n = 8)	Hyperarousal in driving situations declined by 69%, aggressive driving declined by 29%, and risky driving declined by 21%
Tarrant et al., (2018) [37]	Generalised Anxiety Disorder	CBT inside VR	SPSS software, Gear VR 19-channel EEG[d], Brain Master[e]	A mindfulness meditation by Story Up VR[f] (n = 12)	The VR meditation significantly reduced subjectively reported anxiety.
Bouchard et al., (2017) [48]	Social Anxiety Disorder	CBT[g] inside VR[h] (RCT[k])	Virtually Better[i], eMagin z800 head-mounted display, InterSense Inertia Cube motion Tracker	Eight VE[j] such as a meeting room, job interview, introducing oneself and facing criticism situations (n = 59)	Conducting CBT with in-virtuo exposure was effective and more practical for therapists than CBT with in vivo exposure
Jeong et al., (2021) [52]	Social Anxiety	CBT inside VR	Desktop / mobile version with monitor of eye movement, speaking	Some VEs were classroom, auditorium, job interview, train, cafe (n = 115)	Short-term VR-based individual CBT of 9-10 sessions may be effective. Minimal benefit if extended

	time, heart rate	

Limitations

The following limitations should be considered when interpreting the results of this review. The developed search strategy was limited to using Google Scholar for efficient and accurate search results. This may have excluded qualified articles from additional databases. In searching for studies, the terms "anxiety" and "depression" exclude studies using terms such as major depressive disorder (MDD) or phobia. Moreover, due to the large number of articles reviewed, there is a possibility of overlooking valid publications that might have met the inclusion criteria. Non-English articles were not included in this review either.

Conclusions & Future Work

Majority of the studies we reviewed demonstrated the use of VR to be effective for supporting anxiety or depression in a range of settings and recommended its potential as tool for usage in a clinical environment. As standalone headsets are much easier to work with and more suitable for home usage, the shift from tethered VR headsets to standalone headsets in the mental health environment was not observed. A total of 9 studies explicitly mentioned the usage of CBT. Out of these, CBT was conducted within a virtual reality environment in 5 studies while in the remaining 4 studies CBT was used as an addition to VRET. All 9 studies reported the use of CBT either in vivo or inside a virtual environment to be effective in supporting anxiety or depression.

Although a considerable number of studies (n = 34) were included in this review, some areas are still under research thereby lowering the percentage of such studies to be included. Specifically, we found a lot of studies dedicated to one or the other form of anxiety, whereas a limited number of studies were found concentrating on depression (n = 4). Supporting people with depression in VR settings could be an interesting area to explore for health and technology researchers in future.

Few studies conducted a randomised controlled trial, as shown in Appendix 2. Future research could use the VR scenarios and technologies outlined in this review to conduct RCTs to test the effectiveness and cost/benefits of using VR in the treatment of depression and anxiety.

Out of the total 34 reviewed articles, only 9 studies explicitly mentioned the use of CBT in combination or additionally to VRET. All the 9 studies reported improvement in participants' anxiety or depressive symptoms via CBT in addition to VRET or CBT within a virtual environment. Since there is little literature on the combination of CBT and VRET, the comprehensive review produced by this study is effective in offering new insights and allow for further research in the use of CBT and VRET for variety of mental health conditions in future.

Acknowledgements

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Search strategies

Multimedia Appendix 2

A summary of reviewed articles

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Abbreviations

3-D: Three dimensional

BD: Beck depression inventory

BFNE: Brief fear of negative evaluation scale

CAVE: Cave automatic virtual environment

CBT: Cognitive behavioral therapy

EDA: Exploratory data analysis

EEG: Electroencephalogram

HMD: Head-mounted display

IE: Imaginal exposure

IVE: In-vivo exposure

LSAS: Liebowitz social anxiety scale

NA: Not available

NZ: New Zealand

PTSD: Post-traumatic stress disorder
PRISMA: Preferred reporting items for systematic reviews and meta-analyses
RCT: Randomised controlled trial
RQ: Research question
SAD: Social anxiety disorder
SADS: Social avoidance and distress scale
STAI: State-trait anxiety inventory
SUDS: Subjective units of distress scale
VE: Virtual environment

VR: Virtual reality
VRET: Virtual reality exposure therapy
WHO: World health organization

[a] NA: Not Available
[b] CAVE: Cave Automatic Virtual Environment
[c] VRET: Virtual Reality Exposure Therapy
[d] EEG: Electroencephalogram
[e] BrainMaster Technologies, Inc., United States
[f] Story Up VR, Columbia, MO, United States
[gg] CBT: Cognitive Behaviour Therapy
[hh] VR: Virtual Reality
[i] http://www.virtuallybetter.com/
[j] VE: Virtual Environment
[k] RCT: Randomised Controlled Trial

Discussion

Virtual reality therapy has been used widely for treating variety of mental health conditions. This scoping review covered 34 articles which used VR for treatment of various syndromes of anxiety and depression. It was observed that, majority of the studies demonstrated a reduction in symptoms of anxiety or depression with the use of VR. Furthermore, most of the studies had a follow up session post intervention to record the effects of the therapy on whether the anxiety or depression improvements were still maintained in the participants. Most suggest effectiveness and acceptability in a range of clinical settings.

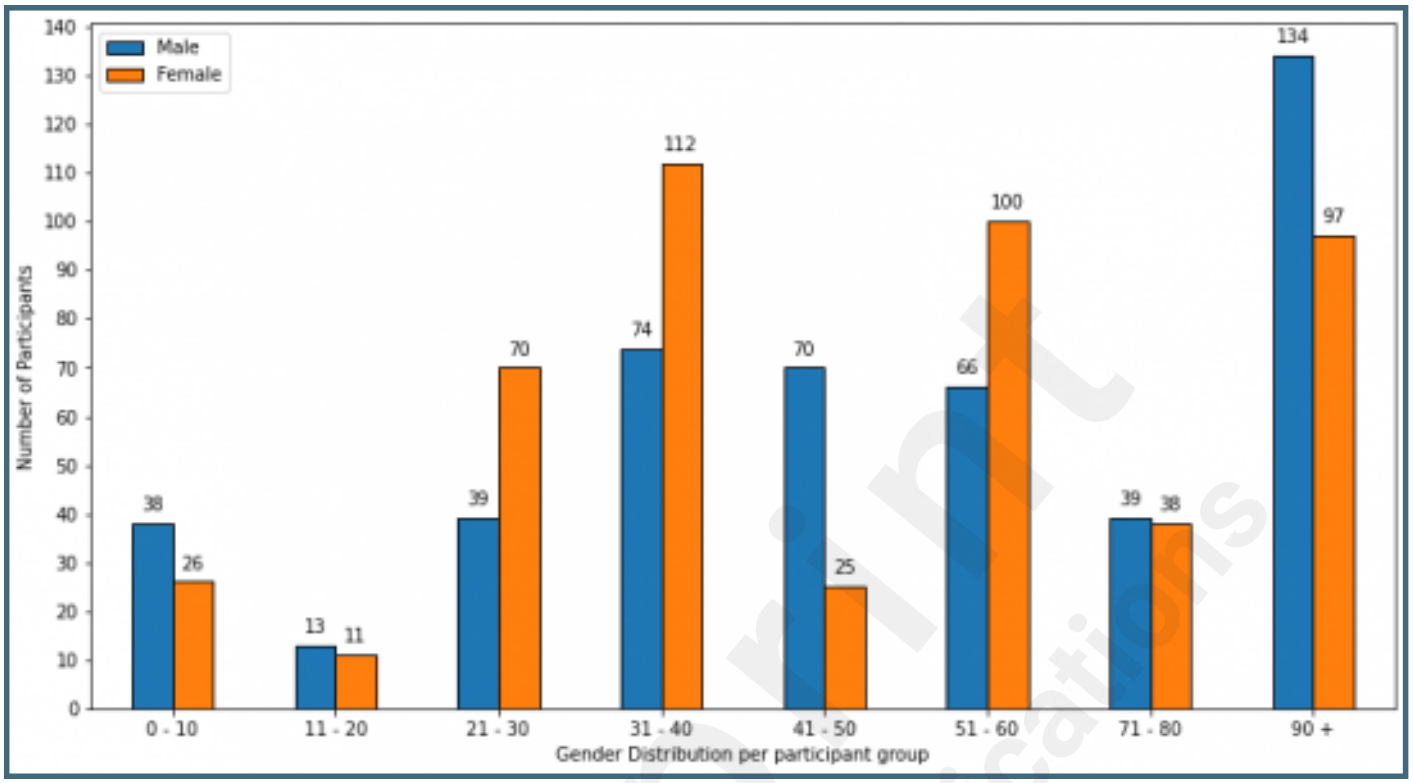
To gain a deeper understanding about the participants, we performed an exploratory data analysis (EDA) that visualised the participants' demographics such as their average age-groups (Figure 3), gender ratio (Figure 5) or the total number of participants (Figure 4) involved in the studies. The EDA revealed that the two most common average age group amongst participants were of the young to middle aged adults of 21-30 and 31-40 years. The data as depicted in Figure 4 shows that there is a lack of research on the older as well as the younger population with only a handful of studies covering these age groups. Moreover, visualising the gender distribution in Figure 5 showed that there was almost no gender bias present across the studies since the gender ratio of males (473) to females (479) was almost the same. Interestingly, Figure 4 shows that the most frequent sample size consisted of only 0-10 total participants suggesting that there is a need to cover a larger sample size for a conclusive proof of the presented results.

Although standalone VR headsets are becoming more affordable to obtain and easier to work with and more suitable for home usage, the shift from tethered VR headsets to standalone headsets in mental health studies has not been observed yet. Manufacturers such as Sony, Samsung, Google, HTC, Microsoft have heavily invested in their own VR products, but based on our study, HTC Vive and Oculus Rift were the most frequently used headsets. In terms of software assets, generally studies used Unity 3D, and none of the studies used its major rival Unreal Engine for developing the VR scenes. It was also interesting to see that more recent studies did not invest in creating their own virtual environment but instead used off-the-shelf products. For those who did develop their own VR environment, the 3ds Max studio was the primary modelling tool.

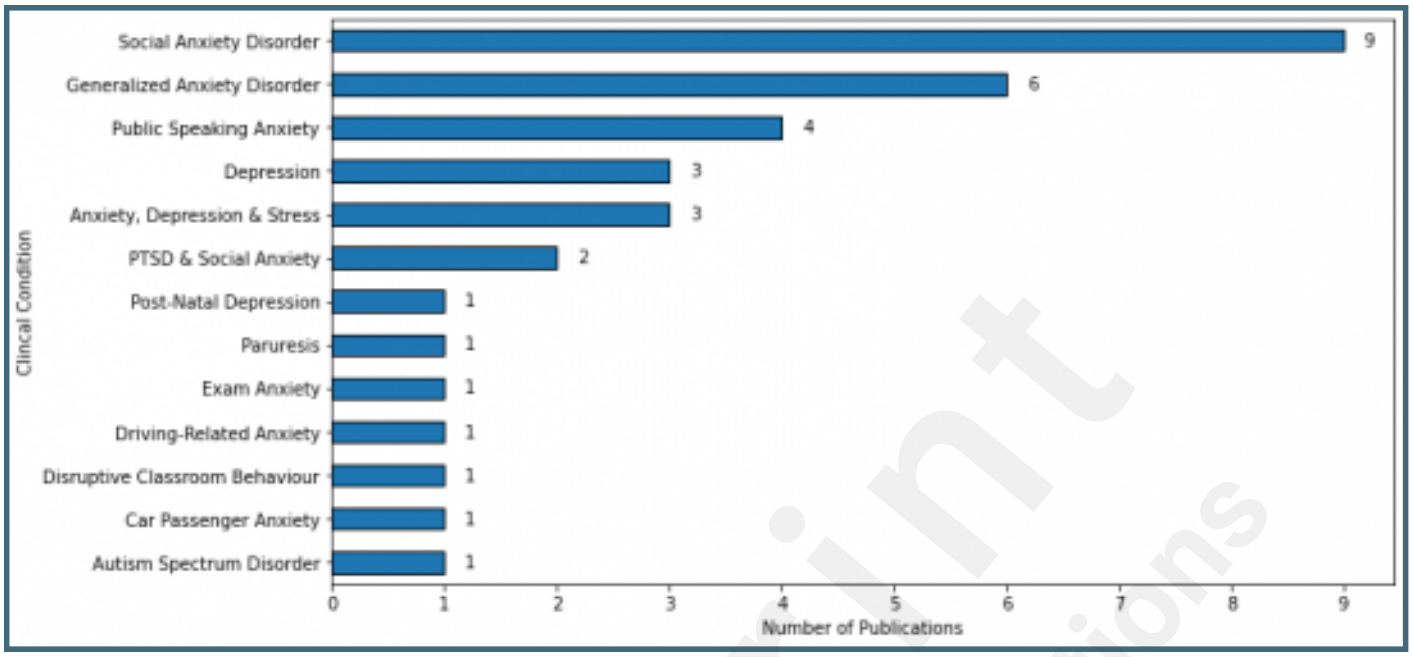
Supplementary Files

Figures

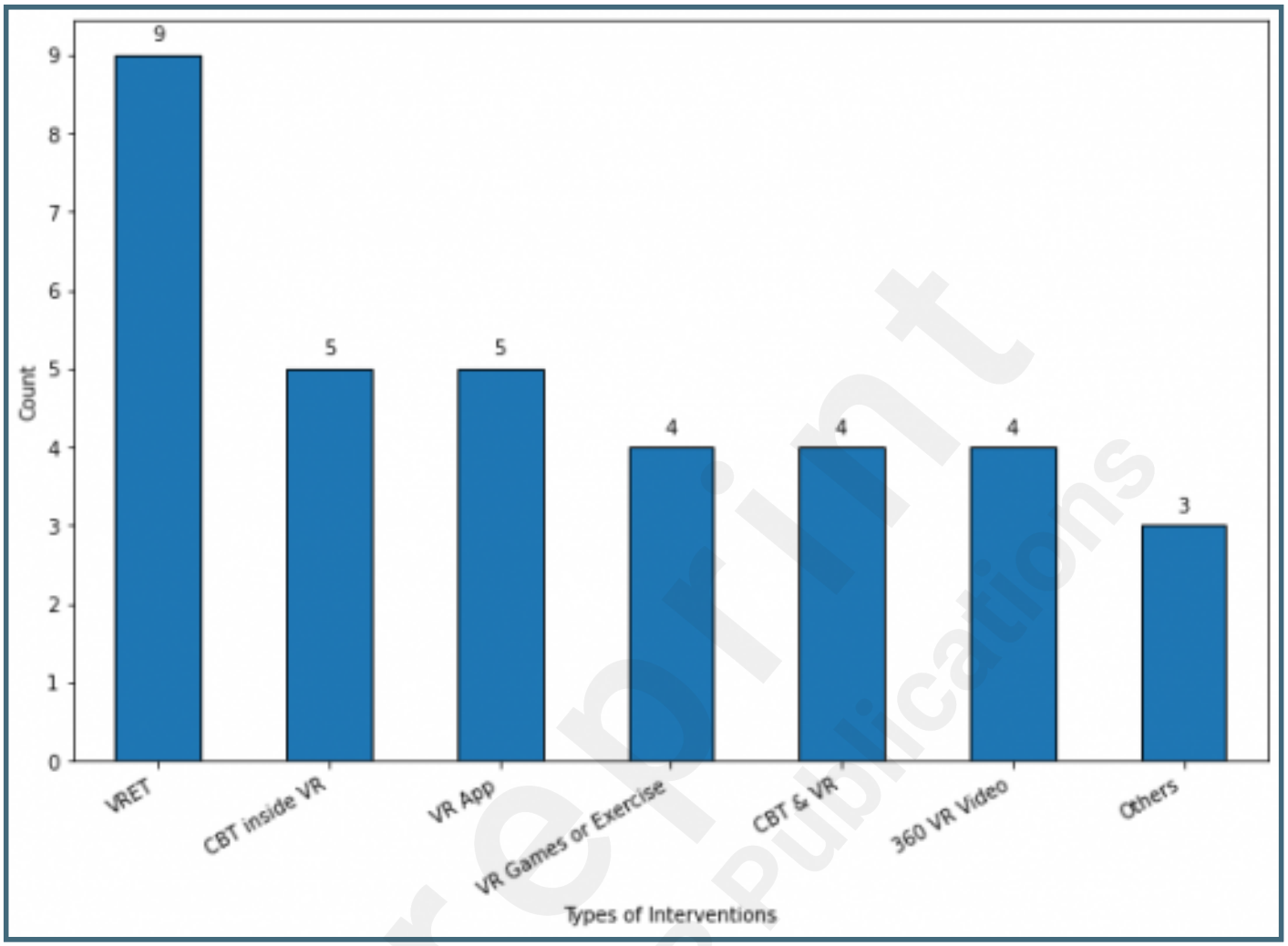
Gender distribution of participants.



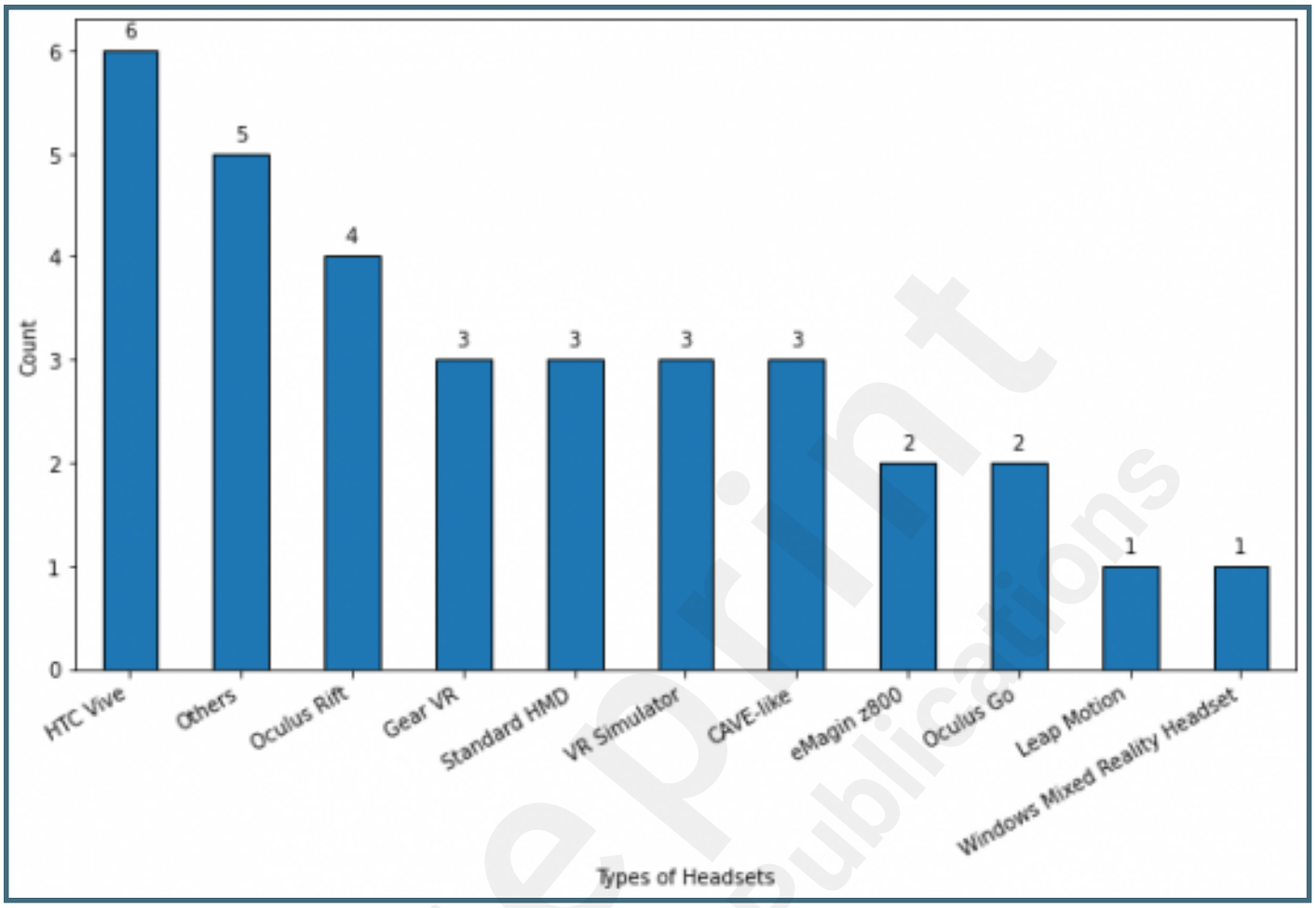
Number of publications per clinical conditions.



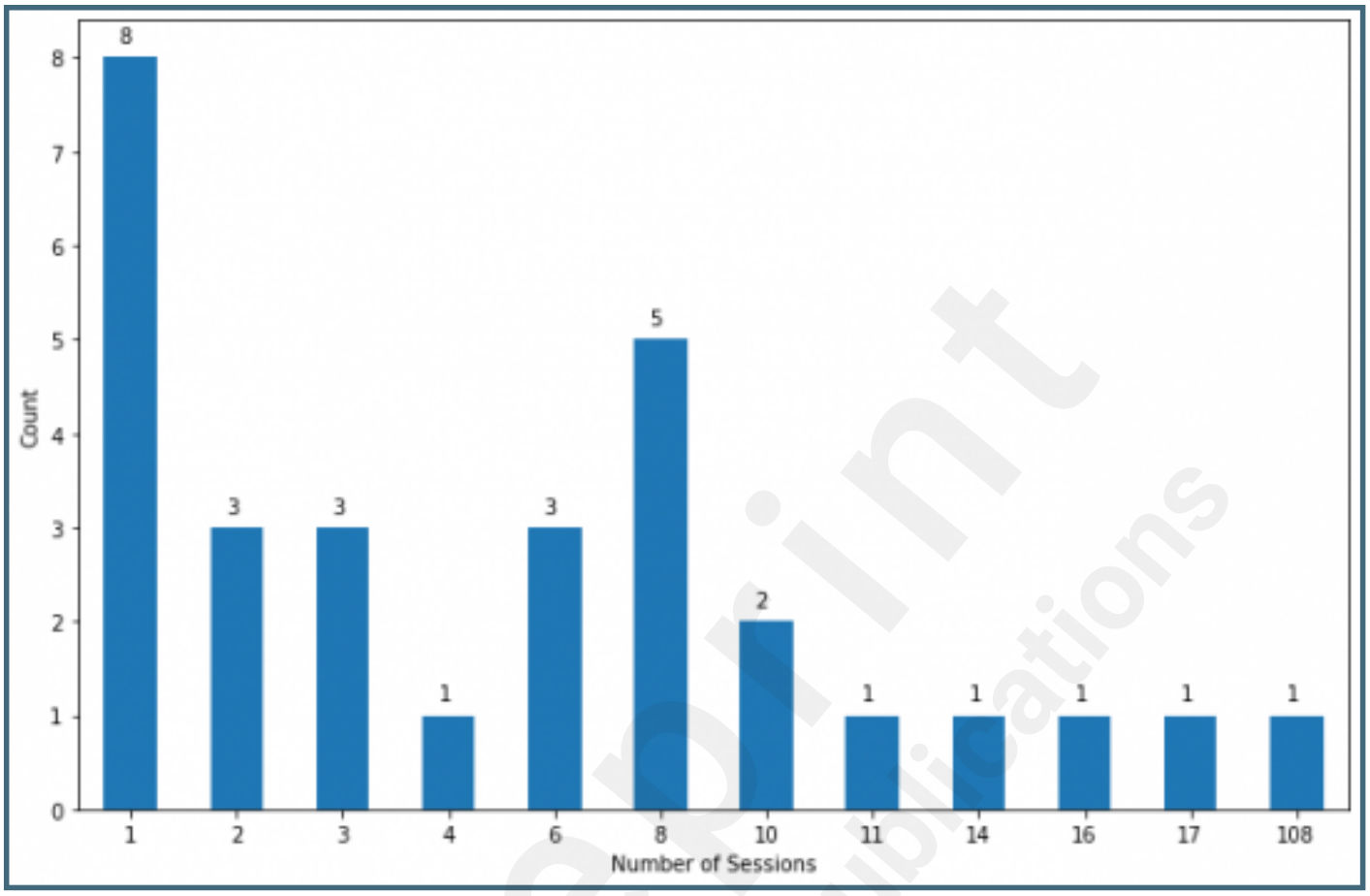
Types of VR interventions.



Types of VR Headsets.



Number of VR Sessions.



Multimedia Appendixes

Search strategy.
URL: http://asset.jmir.pub/assets/ce4482f793616d05a0b10499e205fdf0.docx

List of articles.
URL: http://asset.jmir.pub/assets/c32accbcb3b6e1cece25a2ec6101800b.docx