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# Virtual Reality Applications for Children and Adolescents in Mental Health: A Scoping Review of Assessment and Intervention in Clinical Practice

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## ABSTRACT

**Background:** The purpose of this scoping review was to synthesize literature on virtual reality (VR) applications used in assessment and treatment in youth mental health care. We studied the validity of assessment tools, the effectiveness of (preventive) interventions and their feasibility.

**Method:** The search was conducted in PubMed, Web of Science, Embase and PsycInfo. Studies were included if VR was used in a population of minors to assess prevent or treat mental health–related symptoms in clinical populations or at-risk groups.

**Results:** A total of 43 studies were included. Thirteen studies investigated the validity of VR assessment tools whereby the majority focused on the assessment of attention-deficit hyperactivity disorder symptoms. These studies found that VR shows a performance advantage over traditional assessment tools by increasing sensitivity and specificity. Effectiveness was studied in 30 studies including youth with autism spectrum disorder, anxiety, attention difficulty and behaviour problems. The working mechanisms of these VR interventions encompassed skills practice, exposure and relaxation. VR interventions show promising results for all working mechanisms, with most evidence for social skills and communication training for children with autism spectrum disorder. Importantly, none of these applications have been tested more than once. Nearly half of all included studies lacked feasibility measures, while the rest showed inconsistencies in their feasibility assessment.

**Conclusions:** VR applications for youth in mental health show promise. More standardized testing and replication studies with transparent VR feasibility assessments are needed to determine their effectiveness and utility in clinical practice.

**Trial Registration:** The protocol was preregistered at OSF (https://doi.org/10.17605/OSF.IO/YZV37)

## 1 | Introduction

Mental health services for children and adolescents keep evolving to improve their adequacy and effectiveness. Adaptations involving immersive Virtual Reality (VR) and VR headsets have recently become more popular as the costs for hardware and development have decreased. In the past decades, numerous new diagnostic VR tools and VR interventions have been developed for child and adolescent mental health (Blanco et al. 2024). The question arises whether and to what extent these applications improve mental health services. Therefore, this review aims to synthesize literature on immersive VR applications for youth, including assessment tools, preventive and goal-directed interventions and their validity, effectiveness and feasibility.

When youth face severe challenges associated with mental health, the first step is often to undergo clinical assessment for a better understanding of the symptomatology. It is important that clinical assessment is reliable, valid and standardized (Kline 2015), as its outcomes are directional for deciding on

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**Summary**

What Is Known?

- Numerous VR applications have been developed for youth in the past years, but their effectiveness and utility in clinical practice are unknown.
- Feasibility of VR applications is a requirement for implementation in clinical practice.

What Is New?

- More than 40 studies have assessed the validity or effectiveness of VR applications in mental health for youth.
- Variations of the virtual classroom paradigm can improve ADHD assessment.
- None of the VR applications have been tested more than once. Although some other applications could be considered conceptual replications, similarities have not yet been systematically demonstrated.
- The feasibility assessment of VR applications is either lacking or only sparsely described

What Is Relevant?

- There is an urgent need for more (replication) studies including transparent feasibility assessments. This will lead to more evidence-based VR applications, which in turn will increase the likelihood of their integration in clinical practice

treatment strategies. Assessments traditionally consist of pen-and-paper tasks, (multi)informant and self-report and (cognitive) tasks administered in laboratory settings. These types of assessments can lead to inaccurate conclusions due to a variety of reasons. For example, some traditional diagnostic tools have low ecological validity (Schmuckler 2001) or rely on subjective (self-)reports (De Los Reyes et al. 2011). Undiagnosed, misdiagnosed and overdiagnosed youth do not receive appropriate treatment (Aggarwal and Angus 2015; Merten et al. 2017; Sheldrick et al. 2011), which can have negative consequences, such as deterioration of symptoms and unnecessarily long treatments (Webster et al. 2016). To quantify behaviour and symptoms in a way that is ecologically valid, individuals should be assessed in specific and realistic situations. Technological innovations may offer a solution to this need.

In VR, it is possible to create environments that resemble real-life situations and to measure behaviour without biased (self-)reports. VR allows for complete control over visual and acoustic stimuli presented to a user, which makes environments highly adaptable to different age groups and varying needs, such as for example different levels of complexity. Additionally, it can combine recordings of behaviour such as movement, reaction time and eye-tracking, making for a more complete picture of behaviour. Such multimodal assessments are promising for capturing heterogeneous symptom presentations (Wiebe et al. 2023). VR assessment does not only effectively measure executive functioning (EF) but additionally reflects EF in everyday life more realistically than traditional tests and is therefore more ecologically valid (Lalonde et al. 2013). In the context of psychology, the term 'ecological validity' describes the degree to which observations in controlled situations can be generalized to real-life contexts (Kihlstrom 2021). VR technology has the potential to increase ecological validity by incorporating relevant real-life stimuli. For example, a specific VR tool, the virtual classroom, has been designed to assess cognitive functions associated with attention-deficit/hyperactivity disorder (ADHD) in a realistic and relatable environment. It has been found to discriminate reliably between a clinical and nonclinical population, and to additionally counter the underestimation of distractibility of traditional cognitive performance tests by using authentic distraction stimuli such as a classroom noise or activity occurring outside of the window (Parsons et al. 2019; Rizzo et al. 2006). VR assessment may thereby have a higher specificity and sensitivity than traditional assessments of ADHD-related symptoms. It is crucial to evaluate how VR assessments compare to validated traditional tests to conclude on their potential to improve clinical assessment (Bauer et al. 2012).

VR is not only a promising technology for clinical assessment but also poses a potential solution to overcome challenges for psychological interventions for youth. The effectiveness of psychotherapies for anxiety, depression, ADHD and conduct problems in youth has generally stagnated or even decreased over the course of the past 50 years. Possible explanations refer to rigid treatment structure, changing means of communication and the rate at which the nature of youth dysfunction is shifting, which might be faster than treatments are evolving (Weisz et al. 2019). For example, interventions often involve in vivo exposure and skills practice, which can be difficult to implement due to reasons such as time constraints and practical limitations in real-life settings.

VR technology is highly adaptable in relatively little time, which makes it possible to flexibly tailor treatments to specific needs. VR interventions include both preventive applications (aimed to reduce the risk of developing severe mental health issues) and curative interventions for clinical populations. Besides the potential for increasing ecological validity, VR technology can increase accessibility of intervention situations. For example, social communication skills can be practiced in different social situations with different conversation partners without having to leave the therapist's office. Another advantage is the highly immersive nature of VR: It can be challenging to stay engaged with relaxation exercises or psychoeducation due to external stimuli, which can be minimized by practicing relaxation or giving psychoeducation in immersive VR environments. Immersion can also lead to more authentic emotional engagement than roleplay when practicing skills. For example, not all children with high reactive aggression will be triggered sufficiently in traditional forms of psychotherapy. Evoking moderate levels of aggression in treatment is useful as children can then practice newly learned emotion regulation skills in a safe environment. With VR, the therapist can evoke these emotions by tailoring the behaviour of virtual characters in ways that are triggering reactive aggression in their clients (Alsem et al. 2021). Similarly, social skills for adolescents with autism spectrum disorder (ASD) can be trained



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in safe and realistic environments, meaning that those skills can be practiced in an ecologically valid way without having to be exposed to stress-inducing real-life social environments (Chen et al. 2024). However, even though VR applications such as these show promising results, it is still unclear how they compare to traditional interventions.

To evaluate the utility of a VR tool in clinical practice, the VR-specific feasibility of the application should be assessed. Feasibility is a broad concept that, in the context of VR mental health applications, generally refers to whether the applications can be used as intended in clinical practice. Although general feasibility and VR-specific feasibility share common aspects, they are conceptually distinct because immersive VR introduces characteristics that are absent from conventional technologies. Beyond being usable and acceptable, VR applications should elicit the psychological experience necessary for the application to be delivered as designed. Accordingly, it has been argued that VR mental health applications should be tolerable, usable, create a high sense of presence and perceived realism and be satisfactory for the user—in order to live up to their promise and be feasible for use in clinical practice (Krupljanin et al. 2025; Mummah et al. 2016; Vasser and Aru 2020). For example, clients will not engage with applications that are intolerable thus prompting negative physical symptoms. This will lead to dropouts and refusal to use the application again. Applications with a high sense of presence, describing feeling present in the virtual environment, are associated with higher engagement and the intensity of induced emotions, which is desirable in exposure therapy for instance (Brade et al. 2017; Jicol et al. 2021). VR exposure applications with a low sense of presence can evoke less intense emotions and lower engagement than expected. As for perceived realism, it is important that the users perceive the virtual environment is coherent and believable rather than as realistic as possible. Humanoid avatars for example can even decrease the sense of presence if they are too realistic (Vinayagamoorthy et al. 2004). Lastly, given that VR systems were initially not built for children, VR headset suppliers issued safety warnings about improper fitting of the headset potentially leading to adverse effects, strongly advising adult supervision and avoiding prolonged exposure. A recent review investigated risks of VR use among children and adolescents and found that health concerns mainly emerge in relation to unsupervised and extensive use of VR, such as VR games, but not in relation to therapeutic applications (Kaimara et al. 2022). VR-specific feasibility assessments are therefore necessary to monitor potential adverse effects and, given that practical constraints can strongly affect clinical utility, to inform implementation in clinical practice.

This review provides an overview of youth VR mental health applications across prevention, assessment and intervention. It examines the target groups these applications were developed for, their intended goals, and their reported effectiveness or, in the case of assessment applications, their validity and reliability. In addition, it explores how VR feasibility was assessed across these applications and what these evaluations revealed. The goal is to draw a conclusion on the state of the art and contribute to a better understanding of the applicability and utility of VR technology in mental health for different child and adolescent target groups.

## 2 | Method

This systematic review follows the guidelines of PRISMA-ScR (Tricco et al. 2018) and the protocol was preregistered at OSF (https://doi.org/10.17605/OSF.IO/YZV37).

### 2.1 | Eligibility Criteria

The initial eligibility criteria were adapted throughout the screening process. Records were included if they were published in peer-reviewed journals available in English, reported novel findings (i.e., no reviews, meta-analyses, clinical guidelines or commentaries), if the average age of the target population was 18 years or younger, if immersive 3D VR technology was used (i.e., head mounted displays, Google cardboard boxes, CAVE system, 360° videos) and if VR was used to contribute to assess, prevent or treat mental health-related symptoms in clinical populations or at-risk groups. We also included studies with typically developing populations if the aim was to assess mental health–related symptoms. Studies were only included if they had a controlled experimental design. If VR applications were aimed at prevention, the records were only included if the aim was to directly prevent severe mental health–related symptoms or to foster buffering skills such as emotion regulation or relaxation. Goal-directed VR applications were also included if they aimed to train other skills if those skills were deficient because of mental health–related reasons. We excluded studies assessing VR applications in hospital settings, because these were mainly focused on state anxiety for medical procedure and not on general mental health.

### 2.2 | Search Strategy

The search was conducted in four databases, PubMed, Web of Science, PsycInfo and Embase. All records up until the 29th of July 2024 (updated on 17th of February 2026) were included. The keyword terms were discussed with the research team and refined after screening the first 100 records of the initial search on PubMed. The keyword searches consisted of three groups of keywords, one for VR, one with population terms and one with purpose terms (e.g., assessment, prevention or intervention). See the Figure 1 for an overview of the search terms. For more detailed information regarding the search queries used for each database, please contact the first author. The search results were uploaded to Rayyan (Ouzzani et al. 2016), where potential duplicates were automatically detected and manually removed by the first screener.

### 2.3 | Study Selection and Data Extraction

The first 50 articles were screened by two independent researchers (the first and last author), whereby 98% interrater agreement on inclusion decisions was achieved. The remaining articles were screened by the first author. The screening resulted in 238 records for full-text screening. Again, 10% of the records were screened by two independent screeners. The interrater agreement was 100%. The final selection consisted of 13 assessment and 30 intervention studies. All but one included intervention



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studies assessed the effectiveness of curative rather than preventive interventions. During two screening phases, numerous preventive intervention studies were excluded because the target group was not an at-risk group. See Figure 2 for the details of the study selection process. Two papers have been published on one intervention study, whereby each paper focused on different

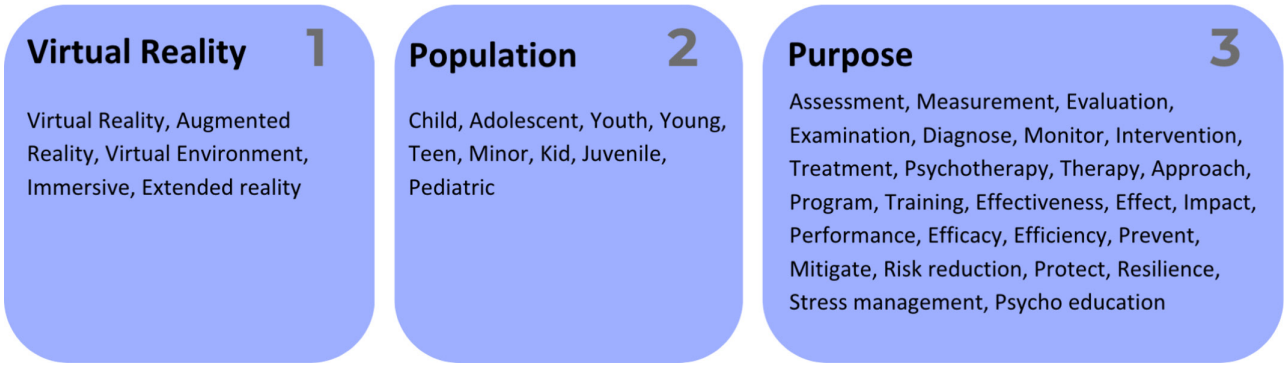


**FIGURE 1** | Overview search terms.

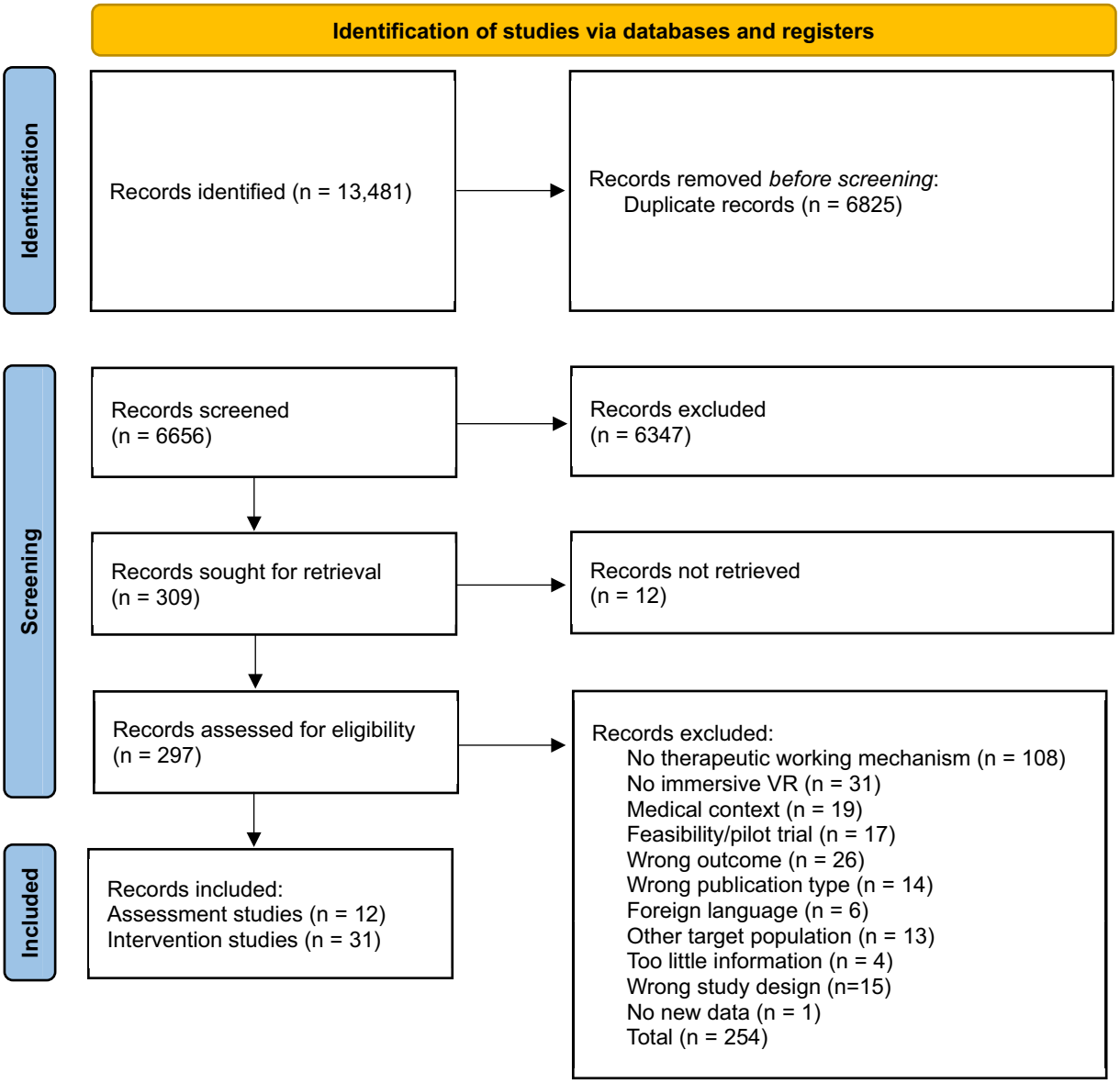


**FIGURE 2** | PRISMA flow diagram.



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outcomes of the same sample. We counted these as two separate papers in the study selection but not as separate research projects. For completeness, we included all 43 papers in Table 1 but only considered 42 studies for the description of the study characteristics below, avoiding double data use.

An estimation of the informative value of the study results was made by categorizing the study designs. Out of these 42 reports, 19 are randomized controlled trials (RCTs) and 14 reports used a within-subject design. Single-case experimental design (SCED) was applied in six studies, and two studies were non-RCTs. One validation study applied a cross-sectional design as they matched data assessed in VR with parent reports.

Data extraction consisted of study characteristics, effectiveness and VR feasibility. If studies did not explicitly refer to variables as VR feasibility measures, but if they assessed aspects such as tolerability, usability, presence, realism or satisfaction rated by the user, they were classified as VR feasibility measures. Outcome variables such as effectiveness or treatment completion were not considered VR feasibility assessments. VR feasibility outcomes were only included if their assessment was described in the methods. The results of the data extraction are summarized in the narrative synthesis and Tables 1–3.

## 3 | Results

### 3.1 | Study Characteristics

In total, 43 studies were included. Most studies (79%) were published between 2018 and 2026, with 12 studies published in 2025 (28%). Thirteen studies investigated the validity of VR assessment tools, 28 studies assessed the effectiveness of VR interventions and one application was aimed at prevention. The studies were carried out in North America, Asia, Europe and Australia, whereby almost half of the studies were conducted in Asia (43%). The participants' age ranged from 3 to 17 years old and on average participants consisted of 35% girls, 65% boys and 0.02% transgender youth. Thirty-one studies targeted clinical populations such as youth with ADHD, ASD, anorexia nervosa and anxiety/phobias whereas seven studies described target groups with problem behaviour but did not assess whether clinical cutoffs were met. These target populations were therefore considered subclinical. Four studies included typically developing children or youth: Three studies validated assessment applications, and one evaluated the effects of an application promoting resilience in migrant adolescents. An overview of the characteristics and demographics of all studies is provided in Table 1.

### 3.2 | Synthesis of Results

#### 3.2.1 | Assessment Studies

The assessment studies are shortly described in Table 2. Nine out of the 13 assessment studies used VR applications for assessing ADHD-symptoms. Eight of these VR applications consisted of some sort of immersive virtual classroom with an integrated variation of golden standard *Conners' Continuous Performance Test* (CPT) (Conners 2000). This laptop-based paradigm is used to assess attention-related problems under varying controlled conditions. The hypothesized added value of an immersive version thereof lies in the higher ecological validity: the distractors and cues in a Virtual Classroom paradigm resemble real-life situations, implying that the performance of such an assessment paints a more accurate picture of the child's behaviour. Six of these eight studies compared a standard attention assessment such as a CPT to CPT in a virtual classroom, aiming to evaluate differences in diagnostic validity. These studies showed that the VR-CPT was found to increase specificity and sensitivity compared to the non-VR assessment, as it was found to discriminate slightly better between children with ADHD and controls (Adams et al. 2009; Negut et al. 2017; Pollak et al. 2009; Rodríguez et al. 2018), and to discriminate better between medicated and unmedicated children with ADHD compared to non-VR assessment (Díaz-Orueta et al. 2014; Pollak et al. 2010). The last study assessing attention-related problems in a virtual classroom aimed to assess the improvement after a cognitive training in VR environment as compared to traditional assessment. A within-subject design yielded comparable results between the two assessments. Given that the VR assessment is more ecologically valid, it may provide more incremental information about how these effects transfer to real-life functioning than the traditional test (Coleman et al. 2019). One of the two remaining virtual classroom studies applied a cross-sectional design to determine the convergent validity of the VR assessment against validated parent-reported ADHD assessment tools. The modest correlations found suggest that this objective assessment may be used additionally to subjective reports (Bai et al. 2025). The last virtual classroom study used this set up in combination with the Stroop paradigm (Stroop 1935) to assess EF: After finding high correlations between the VR-Stroop and the standardized Delis–Kaplan Executive Function System, this study examined how the results of both assessments related to behavioural EF. The VR-Stroop was found to reflect everyday behavioural EF more accurately than the traditional assessment, implying higher ecological validity than a traditional form of assessment (Lalonde et al. 2013).

The remaining four studies had various aims and target groups. Two studies focused on assessing aggression, one more generally and one directed at siblings. While the study focusing on general aggression found only little convergence between the VR assessment and self-report questionnaires (Westerveld et al. 2025), the study on sibling aggression found small to moderate associations for some types aggression and self-reports of aggression towards the sibling. These associations did not emerge in relation to parent- and sibling-reported aggression, suggesting that VR assessment may complement self-report methods (Van Berkel et al. 2025).

One study used interactive VR vignettes to measure social information processing and aggression in children with disruptive behaviour problems and thereby confirmed the added value of a virtual environment approximating reality: The responses to the interactive VR vignettes were found to explain aggressive behaviour observed by teachers more accurately than the responses to traditional audio-vignettes, suggesting a higher ecological validity. Given that the children reported VR to be more engaging, VR vignettes could have led to more authentic social information processing and aggressive responses than regular audio-vignettes (Verhoef et al. 2022). Another study compared a VR assessment of body image



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**TABLE 1** | Study characteristics and demographics grouped by the category of application and ranked alphabetically.

| Study | Country | Study design | VR device | VR application | Target population | Age range | Sample size | Gender |
|---|---|---|---|---|---|---|---|---|
| *Assessment applications* | | | | | | | | |
| Adams et al. (2009) | USA | Within-subject | 3D virtual reality dome by Elumens | VR classroom paradigm with CPT (Rizzo et al. 2006) | ADHD | 8–14 | 35 | 35 m |
| Bai et al. (2025) | China | Cross-sectional | HMD nonspecified | VR classroom paradigm with CPT variation (VRAT; no reference provided) | Typically developing children | 6–8 | 425 | 236 m/189 f |
| Coleman et al. (2019) | USA | Within-subject | HMD nonspecified | VR classroom paradigm with CPT | Attention problems | 6–13 | 15 | 12 m/3 f |
| Díaz-Orueta et al. (2014) | Spain | Within-subject | HMD nonspecified | VR classroom paradigm with CPT variation (AULA; Climent and Bantarla 2010) | ADHD | 6–16 | 57 | 42 m/15 f |
| Fisher et al. (2020) | France | Within-subject | Oculus Rift HMD | Rating 3D standardized female avatars | Anorexia nervosa | 11–18 | 31 | 31 m |
| Lalonde et al. (2013) | Canada | Within-subject | Visor HMD | VR classroom paradigm with Stroop (ClinicaVR: Classroom-Stroop; Henry et al. 2012) | Typically developing adolescents | 13–17 | 38 | 18 m/20 f |
| Negut et al. (2017) | Romania | Within-subject | eMagin Z800 3D Visor HMD | VR classroom paradigm with CPT (ClinicaVR: Classroom-CPT Version v2.0.3; Rizzo et al. 2006) | ADHD | 7–13 | 75 | 45 m/30 f |
| Pollak et al. (2009) | Israel | Within-subject | HMD nonspecified | VR classroom paradigm with CPT (Adaptation of Rizzo et al. 2006) | ADHD | 9–17 | 37 | 37 m |
| Pollak et al. (2010) | Israel | Within-subject | eMagin Z800 3DVisor HMD | VR classroom paradigm with CPT (Adaptation of Rizzo et al. 2006) | ADHD | 11–17 | 27 | 16 m/11 f |
| Rodríguez et al. (2018) | Spain | Within-subject | HMD nonspecified | VR classroom paradigm with CPT variation (AULA; Climent et al. 2011) | ADHD | 6–16 | 338 | 241 m/97 f |
| Van Berkel et al. (2025) | Netherlands | Within-subject | HMD nonspecified | Aggression provoking VR scenarios (adapted from Alsem et al. 2023) | Typically developing children | 8–15 | 52 | 26 m/26 f |

(Continues)



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**TABLE 1** | (Continued)

| Study | Country | Study design | VR device | VR application | Target population | Age range | Sample size | Gender |
|---|---|---|---|---|---|---|---|---|
| Verhoef et al. (2022) | Netherlands | Within-subject | HTC Vive VR HMD | 6 aggression provoking VR scenarios | Aggressive behaviour | 7–13 | 184 | 184 m |
| Westerveld et al. (2025) | Netherlands | Within-subject | Oculus Rift HMD | 5 VR scenarios (based on Verhoef et al. 2021) | Incarcerated adolescents | 15–23 | 84 | 84 m |
| *Intervention applications* | | | | | | | | |
| Alsem et al. (2023) | Netherlands | RCT | Oculus Rift S HMD | Anger provoking VR scenarios (YourSkills VR; Alsem et al. 2021) | ADHD | 8–13 | 115 | 115 m |
| Azimisefat et al. (2022) | Iran | RCT | Oculus Rift Dk2 HMD | 4 different VR scenarios of acrophobic scenarios | Specific phobia | 16–18 | 45 | 45 f |
| Biggs et al. (2025) | Canada | Within-subject | Pico Goblin HMD | Anxiety inducing 360° videos | Anxiety disorders | 7–17 | 45 | 7 m/37 f/1 t |
| Bioulac et al. (2020) | France | RCT | HMD nonspecified | Attention training in VR classroom paradigm | ADHD | 7–11 | 51 | 41 m/10 f |
| Bossenbroek et al. (2020) | Netherlands | SCED | HTC Vive VR HMD | VR biofeedback game using breathing (DEEP, Van Rooij et al. 2016) | Anxiety and disruptive behaviours | 12–17 | 8 | 7 m/1 f |
| Cheng et al. (2015) | Taiwan | SCED | I-Glasses PC 3D Pro | VR social scenarios | ASD | 10–13 | 3 | 3 m |
| Cho et al. (2002) | South Korea | RCT | HMD Daeyang ERC, Seoul, Korea and InterTrax II head tracker | Attention training in basic VR classroom | Attention and behavioural problems | 12–16 | 27 | NA |
| Farrell et al. (2021) | Australia | SCED | Oculus Rift HMD | 360° videos of dogs | Specific dog phobia | 8–12 | 8 | 4 m/4 f |
| Felnhofer et al. (2025) | Austria | RCT | HTC Vive VR HMD | VR biofeedback game 'Conquer Catharsis' (Lenz et al. 2020) | Depression and/or anxiety | 9–18 | 39 | 7 m/32 f |
| Hu et al. (2024) | China | SCED | CAVE system | AR emotion recognition program for teaching emotion recognition skills (ARERP) | ASD | 4–6 | 4 | 3 m/1 f |
| Ip et al. (2018) | Hong Kong | RCT* | Our-side CAVE VR system (a.k.a., half-CAVE) | Six VR learning scenarios for emotional and social adaptation skills | ASD | 7–11 | 72 | 64 m/8 f |

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**TABLE 1** | (Continued)

| Study | Country | Study design | VR device | VR application | Target population | Age range | Sample size | Gender |
|---|---|---|---|---|---|---|---|---|
| Ip et al. (2024) | Hong Kong | RCT* | Oculus Rift HMD | 8 VR scenarios simulating typical school environment | ASD | 6–12 | 107 | 88 m/19 f |
| Julrode et al. (2025) | Thailand | RCT* | Meta Quest 2 | 4 VR modules focused on development of social reciprocity, affective expression, emotion recognition and daily living skills | ASD | 6–12 | 33 | NA |
| Kahlon et al. (2023) | Norway | RCT | Oculus Quest 1 HMD | Speech exercises in front of VR audience | Public speaking anxiety | 13–16 | 100 | 16 m/84 f |
| Klein Schaarsberg et al. (2025) | Netherlands | SCED | HMD nonspecified | 7 VR sessions focused on taking different perspectives in street fights | Disruptive behaviour | 16–17 | 3 | 3 m |
| Kouhbanani et al. (2021) | Iran | RCT | VR glasses nonspecified | VR intervention on behavioural difficulties and social skills (VR TEACCH) | ASD | 6–12 | 45 | 33 m/12 f (estimated) |
| Li et al. (2025) | China | NRCT | HMD nonspecified | Partially individualized VR training modules to target specific developmental goals | ASD | 5–9 | 124 | 75 m/49 f |
| Lu et al. (2025) | China | RCT | PICO Neo3 HMD | VR-based serious game 'The Transfer Student' (no reference) | Migrant adolescents | 12–17 | 39 | 28 m/11 f |
| Lyu et al. (2024) | China | RCT* | Volfoni Edge1.2 active 3D LCD shutter glasses HMD | Adaptive VR cognitive training | Depression | 12–17 | 73 | 24 m/49 f |
| Martin-Moratinos et al. (2025) | Spain | RCT* | Playstation 4 VR HMD | Serious VR game focused on cognitive training (The Secret Trail of Moon: MOON) | ADHD | 7–18 | 76 | 61 m/15 f |
| Maskey et al. (2019) | England | RCT* | CAVE system (Blue room VRE) | 360° videos specific to each child | ASD with specific phobia/fear | 7–15 | 32 | 25 m/7 f |
| Oh et al. (2022) | South Korea | NRCT* | Samsung Odyssey HMD | VR serious game based on ATA and Stroop test | ADHD | 8–13 | 16 | 10 m/6 f |

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**TABLE 1** | (Continued)

| Study | Country | Study design | VR device | VR application | Target population | Age range | Sample size | Gender |
|---|---|---|---|---|---|---|---|---|
| Thomson, Perera, et al. (2025) | USA | RCT | Meta Quest 2 | 4 consecutive modules focused on improving socioemotional functioning among youth with CD (ImpactVR, ArcheXR, 2024) | CD | 10–17 | 110 | 64 m/46 f |
| Thomson et al. (2026)[a] | USA | RCT | Meta Quest 2 | 4 consecutive modules focused on improving socioemotional functioning among youth with CD (ImpactVR, ArcheXR, 2024) | CD | 10–17 | 110 | 64 m/46 f |
| St-Jacques et al. (2010) | Canada | RCT | nVisor SX HMD | Different VR scenarios with spiders | Arachnophobia | 8–15 | 31 | 5 m/26 f |
| Vahabzadeh et al. (2018) | USA | SCED | BrainPowerSystem smart glasses | Smartglasses with pro-social cues and guidance for social communication (Empowered Brain, Face2Face module; Liu et al. 2017) | ASD | 6–9 | 4 | 4 m |
| Wei et al. (2026) | China | RCT | Pico 4 Enterprise HMD | Serious VR game focused on physical challenge, emotional activation and controlled social exposure (VR Cliff Descent module and VR Highline Challenge module) | Social anxiety disorder | 13–17 | 130 | 130 f |
| Whiteside et al. (2020) | USA | Within-subject | Smartphone and Daydream Viewer strap-on HMD | VR exposure to academic failure | Academic performance worries | 8–18 | 20 | 6 m/14 f |
| Wong et al. (2024) | Hong Kong | RCT | HMD nonspecified | 3 VR scenarios to practice social skills | ADHD | 6–12 | 90 | 73 m/17 f |
| Zhao et al. (2022) | China | RCT | HMD nonspecified | 6 training scenarios for cognitive, social, imitation, gross motor, emotional expression and language understanding | ASD | 3–5 | 44 | 35 m/9 f |

Abbreviations: (N)RCT = (non)randomized controlled trial, ADHD = attention-deficit/hyperactivity disorder, ASD = autism spectrum disorder, ATA = advanced test of attention, CD = conduct disorder, CPT = continuous performance task, f = female, HMD = head-mounted display, m = male, t = transgender youth, VR = virtual reality.

[a]This paper reports on the same intervention study and participant sample as Thomson, Perera, et al. (2025), but examines different treatment outcomes. Study characteristics are listed for completeness.

*Only a passive control group.



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**TABLE 2** | Overview of assessment study results ranked alphabetically.

| Study | Aims | Procedure | Primary outcome variable | Key findings | VR feasibility measure | VR feasibility findings* |
|---|---|---|---|---|---|---|
| Adams et al. (2009) | Investigate the ability of the VR-CPT in distinguishing between ADHD and healthy children as compared to a standard CPT. | All participants did a VR-CPT, followed by a regular CPT. | VR-CPT and regular CPT scores | VR-CPT resulted in improved specificity compared CPT without distractions (87.5% vs. 68.8%); sensitivity in identifying children with ADHD was relatively poor in both conditions (50%). | SSQ | Majority experienced no or minimal discomfort. |
| Bai et al. (2025) | Determine the convergent validity of the VRAT against established ADHD assessment tools (SNAP-IV and CPRS-48) in school-aged children. | Participants underwent the VRAT (13 min) and parents completed the SNAP-IV (Chinese version) and CPRS-48 questionnaires. | Swanson Nolan and Pelham, Version IV Scale-Parent Scales (SNAP-IV), Chinese version of the Conners' Parent Rating Scale–Revised (CPRS-48), VRAT scores | Moderate negative correlations between VRAT performance metrics and parent ratings of inattention and hyperactivity-impulsivity and satisfactory discriminant validity (at-risk vs. healthy) were found. | Not mentioned | |
| Coleman et al. (2019) | Demonstrate that changes in performance in VR-CPT after training can provide generalizable information about posttraining functional improvements. | Preintervention neuropsychological evaluation (incl. VR-CPT) followed by 5 weeks of computerized training sessions (25×). Second evaluation was administered after an average of 9.2 months. | VR-CPT scores, working memory subtests (Wechsler Intelligence Scale for Children, Fourth Edition), Cogmed Index Improvement | Moderate near-transfer effects of the cognitive training as measured by both the VR assessment and a standardized test battery. | Not mentioned | |
| Díaz-Orueta et al. (2014) | Analyse the convergent validity between a VR-CPT (AULA) and a CPT, assess whether differences between those children with ADHD who are under ongoing medical treatment and those who have not started it yet can be detected. | Half of the participants were administered first AULA and then Connors' CPT, and the other half the other way around. | Convergent validity | Bivariate correlations conducted among measures of AULA and CPT all statistically significant ($p < 0.01$) indicating convergent validity. AULA allows better differentiation between ADHD children under medical treatment and those who are not compared to CPT. | Not mentioned | |

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**TABLE 2** | (Continued)

| Study | Aims | Procedure | Primary outcome variable | Key findings | VR feasibility measure | VR feasibility findings* |
|---|---|---|---|---|---|---|
| Fisher et al. (2020) | Examine whether VR can improve body image perception and body image evaluation by adolescents with AN compared to a paper-based evaluation. | Evaluate body figures using paper-based Figure-Rating Scale, followed by a VR-based avatar rating scale (15 min). | Paper-based Figure-Rating Scale, VR-based avatar Rating Scale | Comparing the two evaluation methods, no statistically significant difference was found between average scores of BPI, body dissatisfaction, BMI of perceived and desired figures. | Not mentioned | |
| Lalonde et al. (2013) | Establish which traditional paper–pencil EF tests from the Delis–Kaplan Executive Function System (D-KEFS) are associated with performance on a VR-Stroop task and (2) compare D-KEFS tests and the VR-Stroop task in their ability to predict everyday EF and behaviour | Administration of paper-pencil EF tests and VR-Stroop task. | Behaviour Rating Inventory of Executive Function (BRIEF), Delis–Kaplan Executive Function System (D-KEFS), ClinicaVR: Classroom-Stroop | VR-Stroop task correlates with both traditional forms of EF assessment (D-KEFS, BRIEF). The performance on the VR-Stroop task was closely associated with performance on a paper–pencil inhibition task. The VR-Stroop performance more accurately reflected everyday behavioural EF than paper–pencil tasks. | SSQ (current study), SSQ and Realism subscale of Presence Questionnaire (validation study Henry et al. 2012) | No significant simulator sickness (current study), very few simulator sickness symptoms and good sense of presence (Henry et al. 2012). |
| Negut et al. (2017) | Evaluate the diagnostic validity of a VR-CPT in comparison to a traditional CPT. | After paper-and-pencil neuropsychological tests, participants completed either VR-CPT or traditional CPT. Testing session lasted 2 h. | WISC-IV subtests *digit span* and *letter numbering sequencing* (working memory), and subtests *coding and symbol search* (processing speed), d2 test of attention | The VR-CPT discriminates between children with ADHD and typically developing children similarly to a traditional CPT. CPT could not discriminate between these two groups when comparing reaction time to targets, whereas VR-CPT could. | SSQ | Majority experienced no or minimal discomfort (1.4% reported at least one severe symptom). |

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**TABLE 2** | (Continued)

| Study | Aims | Procedure | Primary outcome variable | Key findings | VR feasibility measure | VR feasibility findings* |
|---|---|---|---|---|---|---|
| Pollak et al. (2009) | Compare the performance of children with ADHD on a CPT embedded within a VR-CPT to no VR-CPT and the currently used Test of Variables of Attention (TOVA), and (2) assess how the VR environment is experienced. | All participants underwent 3 CPT's: VR-CPT, the same CPT without VR (no VR-CPT) and the TOVA. | VR- and CPT scores, TOVA scores | The results of the VR-CPT were similar to those obtained when the same children underwent a no VR-CPT and the TOVA. For ADHD, the VR-CPT was more sensitive than the TOVA on reaction time and rate of omission errors. | Subjective feedback questionnaire (enjoyment, feeling of success, discomfort and perceived difficulty; 1 item each) | VR was rated as more enjoyable but had similar levels of challenge, success and discomfort compared to TOVA. |
| Pollak et al. (2010) | Assess the ability of a VR-CPT to quantify the effect of pharmacological treatment (MPH) in ADHD. | All participants underwent 3 CPT's: VR-CPT, the same CPT without VR (no VR-CPT) and the TOVA. | VR- and CPT scores, TOVA scores | The VR-CPT was more sensitive than the TOVA and the no VR-CPT to the effect of MPH on rate of omission errors. The effect of MPH on other CPT parameters was comparable on the three types of CPT. | Subjective feedback questionnaire (enjoyment, feeling of success, discomfort and perceived difficulty; 1 item each) | VR-CPT was rated the most enjoyable and VR-CPT and TOVA were rated more comfortable than the no VR-CPT. |
| Rodríguez et al. (2018) | Compare the discriminant value of attentional variables produced by a VR-CPT (AULA) with that of variables from a traditional CPT (TOVA) for identifying ADHD. | VR: AULA; control: TOVA. | AULA scores, TOVA scores | AULA showed better sensitivity and specificity than TOVA. | Not mentioned | |

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**TABLE 2** | (Continued)

| Study | Aims | Procedure | Primary outcome variable | Key findings | VR feasibility measure | VR feasibility findings* |
|---|---|---|---|---|---|---|
| Van Berkel et al. (2025) | Assess the convergent validity of VR-assessment measuring sibling aggression. | 3 VR scenarios (1 neutral, 2 aggression provoking; by VR company CleVR) | VR observed aggression, vignette-based aggression, self-reported and sibling-reported aggression, parent reported aggression. Differentiation of psychological and physical (and object-directed in VR) aggression across all measures. | Small to moderate associations between VR-observed physical aggression and self-reported physical and psychological aggression towards the sibling as well as observed task-directed aggression was positively related to self-reported psychological aggression towards the sibling. Parent- and sibling-reported aggression was not significantly related to observed aggression, neither was vignette-based aggression. | Not mentioned | |
| Verhoef et al. (2022) | Examine whether interactive VR provides a better assessment of children's aggressive social information processing and responding than a standard, vignette-based assessment. | Each assessment was 45 min, completed on two different days with approximately 1 week in between. Vignettes entailed the exact same content as VR but were audiotaped. | Aggressive SIP, real-life aggressive behaviour | VR predicted real-life aggressive behaviour and reactive and proactive motives for aggression better than vignette assessment. | Igroup Presence Questionnaire (current study), enthusiasm about VR (2 items, self-developed; pilot study) (Verhoef et al. 2021) | Children more immersed in VR than with vignettes (current study). They were more enthusiastic about VR than the vignettes (pilot study Verhoef et al. 2021). |
| Westerveld et al. (2025) | Assess the convergent validity of the VR-assessment measuring self-control and aggression. | 5 interactive VR scenarios, of which 4 contained social triggers that may elicit aggression. | Convergent validity (reactive aggression, hostile intent attribution and self-control) | Little convergence between VR and self-report questionnaires. | Not mentioned | |

Abbreviations: ADHD = attention-deficit/hyperactivity disorder, AN = anorexia nervosa, CPT = continuous performance task, D-KEFS = Delis–Kaplan Executive Function System, MPH = methylphenidate, SIP = social information processing, SSQ = Simulator Sickness Questionnaire, TOVA = Test of Variables of Attention, VR = virtual reality, WISC-IV = Wechsler Intelligence Scale for Children–Fourth Edition.
*VR feasibility findings as reported by the authors.



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**TABLE 3** | Overview of intervention study results grouped by working mechanism and ranked alphabetically.

| Study | Aims | Procedure | Primary outcome variable | Key findings | Feasibility outcome variable | Feasibility findings* |
|---|---|---|---|---|---|---|
| *Exposure* | | | | | | |
| Azimisefat et al. (2022) | Investigate the efficacy of VRET and EMDR on symptoms of acrophobia and anxiety sensitivity. | 6 × 60-min VRET (first session psychoeducation without VR); 6 × 60-min EMDR (first session no EMDR); waitlist had 6-week reassessment. | Severity measure for acrophobia (SMA), anxiety sensitivity index (ASI-R) | Both VRET and EMDR reduced acrophobia and anxiety sensitivity vs. waitlist control; no difference between them. | Not mentioned | |
| Biggs et al. (2025) | Compare VRE to imaginative exposure (IE) on anxiety elicited, homework completion and preparation for subsequent exposures. | 2 × 60-min sessions with both VR and IE (randomized order); practice with one of the two between sessions. | Spence Children's Anxiety ScaleChild and Parent Versions (SCAS-C/P), subjective units of distress (SUDS) | Both VRE and IE caused moderate anxiety that reduced with exposure and led to lower anxiety in later sessions. | SSQ, user experience interview | VRE associated with more physical symptoms compared to IE, unlikely clinical significance. VRE was rated more realistic than IE. |
| Farrell et al. (2021) | Examine efficacy of VR one-session treatment for specific phobias. | 3-h VR exposure per OST principles (Ollendick et al. 2009; Öst 1997). | Clinician Severity Rating (CSR), parent-rated target symptoms, behavioural approach task (BAT), self-report scales (Spence Children's Anxiety Scale Child and Parent Versions SCAS-P/SCAS-C); Fear Survey Schedule for Children–Revised Child Version (FSSC-R-C) | CSR and parent-rated target symptoms improved from pre- to post- and follow-up (88% showed improvement at follow-up and 75% recovered). Other measures unchanged. | Perceived realism (1 item, sd) | Level of reality of the VR was rated 'a little bit like real life.' |

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**TABLE 3** | (Continued)

| Study | Aims | Procedure | Primary outcome variable | Key findings | Feasibility outcome variable | Feasibility findings* |
|---|---|---|---|---|---|---|
| Kahlon et al. (2023) | Evaluate whether VRET is more efficacious than online PE or waitlist, and whether VRET followed by online exposure therapy is more efficacious than VRET alone or online PE followed by online exposure therapy. | VR: 3-week self-guided speech training (30–60 min/week); online PE: 3 online modules about PSA (30–60 min); waitlist later received PE. | Public Speaking Anxiety Scale (PSAS) | VRET and online psychoeducation both reduced PSA vs. waitlist; VRET had a larger effect. No group differences were found combining the interventions. | Not mentioned | |
| Maskey et al. (2019) | Compare VRE for specific phobia with usual care. | 1 CBT session + 4 × 20-min VRE; control: no treatment until 6-month follow-up. | Target behaviour rating, Spence Children's Anxiety Scale-parent and child version (SCAS--P/C), fear survey schedule for children–revised (FSSC-R) | 1/3 of treated children showed real-life phobia improvements 2 weeks and 6 months after treatment. | Not mentioned | |
| St-Jacques et al. (2010) | Assess if a combined treatment with mostly VR–based exposure increases phobic children's motivation towards therapy compared to children who only receive in vivo exposure and to assess the effectivity of VRE. | 4× VRE + 1× in vivo exposure; control: 5× in vivo. All sessions 60 min. | 'Why Are You in Therapy?' Questionnaire, Treatment-Related Discomfort Questionnaire, Shortened version of the Spider Phobia Beliefs Questionnaire, Spider Phobia Questionnaire for Children, Behavioural Approach Test (BAT) | VR reduced fear more than in vivo, but motivation was similar. | Child Presence Questionnaire, Cybersickness Questionnaire | Feeling of presence was adequate, little cybersickness. |

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**TABLE 3** | (Continued)

| Study | Aims | Procedure | Primary outcome variable | Key findings | Feasibility outcome variable | Feasibility findings* |
|---|---|---|---|---|---|---|
| Wei et al. (2026) | Evaluate the efficacy of immersive virtual reality (VR) extreme sports games as a therapeutic modality for adolescent girls with social anxiety disorder. | 12 VR sessions for 60 min (3×/week); control received 12 sessions for 60 min (3×/week) of conventional individual physical exercises. | Social Phobia and Anxiety Inventory for Children (SPAI-C), Perceived Stress Scale (PSS-10), Children's Depression Inventory–Second Edition (CDI-2) | VR group showed significant improvements for anxiety, depression and perceived stress symptoms compared to the control group. | Not mentioned | |
| Whiteside et al. (2020) | Test whether two forms of exposure to worries (verbal IE and VR exposure therapy, VRET) would be effective and acceptable forms of exposure with youth. | 20 × 60-min therapist-guided exposures (VR and verbal; order randomized). | Anxiety ratings: Subjective Units of Distress (SUDS) | Both were effective but VRET was not superior to verbal exposure. | SSQ-modified, semistructured qualitative interview (usability, preference, realism) | Low average score of physical symptoms, physical symptoms did not vary across exposure types. Verbal exposure was rated more realistic than VRET, but participants strongly preferred using VRET over verbal exposure. |
| *Relaxation* | | | | | | |
| Felnhofer et al. (2025) | Compare a VR-biofeedback (BF) training to standard 2D-BF training to investigate treatment modality superiority. | 10 × 50–60-min therapist-guided trainings (VR-BF and 2D-BF). | Chronic stress (Perceived Stress Scale) | Both treatment groups showed stable improvements over time for chronic stress. VR-BF was not superior to 2D-BF. | Recording of side effects like nausea (current study), Igroup Presence Questionnaire (feasibility study Lenz et al. 2020) | No side effects recorded (current study). High sense of being spatially present and high experienced realism (Lenz et al. 2020) |
| *Skills practice* | | | | | | |

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**TABLE 3** | (Continued)

| Study | Aims | Procedure | Primary outcome variable | Key findings | Feasibility outcome variable | Feasibility findings* |
|---|---|---|---|---|---|---|
| Alsem et al. (2023) | Investigate whether VR enhances effectiveness compared to CBT without VR and care-as-usual. | 10 YourSkills VR or roleplay sessions teaching skills (control A); care-as-usual comparison (control B). | Aggression (Child Behaviour Checklist CBCL), Reactive and Proactive Aggression (IRPA), Teacher Report Form (TRF) | YourSkills VR reduced aggression more effectively than other conditions. | Immersion, emotional engagement, treatment appreciation (3, 4 and 3 sd items respectively; current study); treatment appreciation (2 sd items; Feasibility study Alsem et al. 2021) | Participants more immersed and emotionally engaged in YourSkills VR than in regular YourSkills, and appreciated it more than regular YourSkills (current study). Participants appreciated YourSkills VR highly (Alsem et al. 2021). |
| Bioulac et al. (2020) | Evaluate the efficacy of a cognitive remediation program in a VR classroom that aims to reduce cognitive distractibility in ADHD children. | VR group: 12 × 30-min cognitive remediation in VR; control A: methylphenidate (weekly check-ups); control B: Psychotherapy: 12 × 30 min. All interventions over 8 weeks. | VR-CPT scores, CPT scores, ADHD-Rating Scale | Attention training in VR reduced ADHD distractibility to a similar extent as pharmacological treatment measured with VR- and CPT, but not on a behavioural level. Both more effective than psychotherapy. | Not mentioned | |
| Bossenbroek et al. (2020) | Investigate the effect of DEEP on daily levels of state-anxiety and disruptive classroom behaviour in a clinical sample. | 6× up to 15-min game sessions over 4 weeks. | State-Trait Anxiety Inventory (STAI), disruptive classroom behaviour (based on teacher interviews) | DEEP reduced state-anxiety; mixed results on behaviour. | Not mentioned | |

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**TABLE 3** | (Continued)

| Study | Aims | Procedure | Primary outcome variable | Key findings | Feasibility outcome variable | Feasibility findings* |
|---|---|---|---|---|---|---|
| Cheng et al. (2015) | Evaluate the effectiveness of VR in enabling participants with ASDs to learn nonverbal communication, social initiations and social cognition. | 5 × 30–40-min sessions with VR social scenarios and questions. | Social Behaviour Scale (sd) | VR improved nonverbal communication and social cognition. | Not mentioned | |
| Cho et al. (2002) | Validate the use of VR in cognitive training for attention enhancement. | 8 × 20-min VR attention training (comparison and attention tasks) over 2 weeks; control: non-VR training. | CPT scores | Both training groups improved; VR group more improved (not significantly). | Not mentioned | |
| Hu et al. (2024) | Evaluate the effect of an AR emotion recognition program (ARERP) delivered in a group format on the emotion recognition of young autistic children. | 3 × 50-min group sessions/week over 2 months. | Emotion recognition in AR cartoons, still images and GIFs | Emotion recognition training had 100% success, retained 4–7 weeks. | Satisfaction (2 closed questions) | All children reported high satisfaction. |
| Ip et al. (2018) | Examine the efficacy of a VR-based training program on emotional and social adaptive skills for children with ASD. | 28 sessions over 14 weeks; 10-min VR exposure per session; waitlist control. | Psychoeducational Profile, Third Edition (PEP-3, Chinese version), subtests *affective expression* and *social reciprocity* | Significant improvements compared to waitlist control. | Not mentioned | |
| Ip et al. (2024) | Evaluate the effectiveness of a VR-enabled training program in enhancing affective expression and social reciprocity of children with ASD. | 15-week program, 2 sessions/week; 5 VR modules with 2–5 sessions each; exposure 7–8 min/session; waitlist control. | Psychoeducational Profile, Third Edition (PEP-3, Chinese version), subtests *affective expression* and *social reciprocity* | Significant improvements compared to waitlist control. | Physical symptoms (1 open question) | No physical symptoms beyond fatigue and eye strain. |

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**TABLE 3** | (Continued)

| Study | Aims | Procedure | Primary outcome variable | Key findings | Feasibility outcome variable | Feasibility findings* |
|---|---|---|---|---|---|---|
| Julrode et al. (2025) | Assess effectiveness of gamified VR training in enhancing social reciprocity, affective expression and daily living skills of children with ASD. | 16 × 30-min VR sessions in 8 weeks, control group continued with standard school activities. | Social responsiveness scale (SRS-2) | VR improved specific aspects of social functioning more than control, but not significantly (social communication and social motivation). | User interviews with caregivers and therapists | Children were more motivated and engaged compared to regular therapy. |
| Klein Schaarsberg et al. (2025) | Evaluate the added value of street temptations to address cognitive distortions and motivation for behaviour change in forensic youth care through mentalisation. | 7 VR sessions for 45–60 min. | Cognitive distortions, treatment motivation and emotion regulation (sd) | Indications for positive changes regarding cognitive distortions and emotion regulation. Perceived added value was reported during the interviews. | User interviews with adolescents and therapists | Technical issues, partly hindering execution as planned. |
| Kouhbanani et al. (2021) | Evaluate the effectiveness of a VR intervention based on the TEACCH method on social and behavioural problems of children with ASD. | 90 × 45-min daily sessions (7 days/week). | Children Autism Rating Scale II (CARS-II; behavioural symptom scores), Vineland Adaptive Behaviour Scale | VR + risperidone improved behaviour and social skills more durably than risperidone only. | Not mentioned | |

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**TABLE 3** | (Continued)

| Study | Aims | Procedure | Primary outcome variable | Key findings | Feasibility outcome variable | Feasibility findings* |
|---|---|---|---|---|---|---|
| Li et al. (2025) | Evaluate the effectiveness of fully immersive VR (FIVR) combined with psychological and behavioural interventions (PBI) for children with ASD. | 12-week program; PBI was conducted 6×/week, FIVR training was additionally delivered 3–5×/week. | Aberrant Behaviour Checklist (ABC), Children Autism Rating Scale, Neuropsychological functions, Psychoeducational Profile, Third Edition (PEP-3, Chinese version) | Both groups experienced an improvement after the 3-month intervention period. FIVR group demonstrated more pronounced improvements compared to the control group. | Satisfaction (Newcastle Satisfaction with Nursing Scales) | Satisfaction rate was higher among FIVR families. |
| Lu et al. (2025) | Assess the effectiveness of a VR serious game in improving migrant adolescents' psychological resilience. | VR: 35-min game; control: 35 min watching scenic VR-based relaxation video clips. | Psychological resilience (Connor–Davidson Resilience Scale-10, CD-RISC-10) | The VR intervention was more effective in improving migrant adolescents' psychological resilience. The control group's resilience remained unchanged. | Presence, usability | No scores provided, only in relation to effectiveness. |
| Lyu et al. (2024) | Investigate the effects of an attention and working memory cognitive training system based on VR in adolescents with mild to moderate depressive episodes. | 3 × 10-min VR tasks/session, 3 sessions/week, over 7 weeks; waitlist control. | Das-Naglieri Cognitive Assessment System (DN:CAS) | VR group improved on cognitive scales and depression compared to waitlist control. | Not mentioned | |

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**TABLE 3** | (Continued)

| Study | Aims | Procedure | Primary outcome variable | Key findings | Feasibility outcome variable | Feasibility findings* |
|---|---|---|---|---|---|---|
| Martin-Moratinos et al. (2025) | Evaluate the impact of a 20-session treatment of a VR serious game (MOON) on emotional regulation of children with ADHD. | VR: 12 face-to-face visits; control: 2 visits (pre-/postevaluation). | Strengths and Difficulties Questionnaire (SDQ) | MOON improved organisation, memory, inhibition, especially among more engaged patients. | Udvalg für Kliniske Undersogelser questionnaire | No mild, moderate or notable side effects were found. |
| Oh et al. (2022) | Assess the effectiveness of VR cognitive training for children with ADHD. | 8 VR training sessions. | Sense of Presence Scale, EEG | VR increased cognitive relief in ADHD group; EEG unchanged. | Not mentioned | |
| Thomson, Perera, et al. (2025) | Evaluate whether Impact VR led to reductions in CU traits, conduct problems (CPs) and both reactive and proactive aggression. | 4 VR sessions for 20–25 min; active control: one 25-min emotion recognition training session. | Callous-Unemotional Traits (ICU), Conduct Problems (BASC-3 Caregiver Rating Scales), Reactive–Proactive Aggression Questionnaire (RPQ) | Self-reported CU traits significantly decreased over time for the VR group, but not according to caregiver reports. No other clear changes over time or differences in change between groups. | Tolerability, Usability (feasibility study) Thomson, Kevorkian, et al. (2025) | No reports of negative symptoms, 90% of the clients experienced the modules as usable. |
| Thomson et al. (2026) | Testing the efficacy of impact VR in strengthening protective factors among adolescents with CD. | 4 VR sessions for 20–25 min; active control: one 25-min emotion recognition training session. | Penn Emotion Recognition Task (ER40), BASC-3 Youth Rating Scales (subscales *interpersonal (peer) relations, relations with parents* and *social stress*) | VR group showed less social stress than the active control group over time. No other significant improvements over time or differences in change between groups. | Tolerability, usability (feasibility study) Thomson, Kevorkian, et al. (2025) | No reports of negative symptoms, 90% of the clients experienced the modules as usable. |

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**TABLE 3** | (Continued)

| Study | Aims | Procedure | Primary outcome variable | Key findings | Feasibility outcome variable | Feasibility findings* |
|---|---|---|---|---|---|---|
| Vahabzadeh et al. (2018) | Explore the feasibility and efficacy of a computerized smart glasses intervention designed as a socio-emotional behavioural aid for students with ASD. | 2 × 10-min smart glasses with pro-social cues and guidance for social communication sessions; control: same without glasses. | Aberrant Behavioural Checklist (ABC), subtests *irritability, hyperactivity* and *social withdrawal* | VR improved autism symptoms: withdrawal, irritability, hyperactivity. | Physical symptoms, enjoyment (feasibility study Liu et al. 2017); physical symptoms (pilot study) (Keshav et al. 2017) | No physical symptoms, both participants found the system highly enjoyable (Liu et al. 2017); 19 out of 21 participants demonstrated high tolerability (Keshav et al. 2017) |
| Wong et al. (2024) | Use VR training to enhance social skills of children with ADHD. | 3-week, 12-session VR social skills; control: standard care and waitlist. | Social Skills Improvement System Rating Scale, Behaviour Rating Inventory of Executive Function | VR social skills training better than traditional and waitlist for ADHD. | SSQ, satisfaction (1 item, sd) | No one reported physical symptoms, all participants were satisfied with the VR training. |
| Zhao et al. (2022) | Explore the impact of VR to improve developmental behaviour areas of cognition, imitation and social interaction in children with ASD. | VR-based cognitive, imitation and social skills training (3×15 min/week) for 12 weeks alongside routine rehab; control: standard rehab. | Chinese version of Psychoeducational Profile, Third Edition (PEP-3), including *developmental and behavioural tests, child caregiver reports* and *composite scores* | VR group outperformed control in cognition and social skills. | Not mentioned | |

Abbreviations: ADHD = attention-deficit/hyperactivity disorder, ASD = autism spectrum disorder, CBT = cognitive behavioural therapy, EMDR = eye movement desensitisation and reprocessing, IE = imaginative exposure, PE = psycho education, SD = self-developed, VAS = visual analogue scale, VR = virtual reality, VRE = virtual reality exposure, VRET = virtual reality exposure therapy.
*Feasibility findings as reported by the authors.



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perception to paper-based version thereof in a sample of adolescents with anorexia nervosa, whereby it was expected that the adolescents would find three-dimensional bodies more realistic than two-dimensional bodies. The results imply that these two assessments are comparable in assessing body image perception and that VR was therefore not perceived as more realistic (Fisher et al. 2020).

In conclusion, most assessment research on ADHD-related problems has focused on the Virtual Classroom paradigm. These studies could be considered conceptual replications if the similarity of the applications were confirmed through systematic evaluation. The virtual classroom assessments show a performance advantage over traditional attention assessment tools in diagnostic validity. Additionally, they may add further value by predicting real-life behaviour more accurately than traditional assessments. To date, there is too little evidence to draw a conclusion on the added value of the other VR applications as compared to traditional tools.

### 3.2.2 | Intervention Studies

The intervention studies included 29 curative and one preventive application, which encompassed different three working mechanisms. Most applications were used for skills practice ($n = 21$), followed by exposure ($n = 8$). Lastly, one intervention used relaxation as working mechanism. The interventions are shortly described in Table 3, organized by working mechanism.

**3.2.2.1 | Skills Practice.** Nine studies used VR to train deficits in skills related to ASD (e.g., communication or emotion recognition), whereby the effectiveness was determined with either (N)RCT or SCED. They all used different simulated real-life training scenarios where participants could practice positive reinforcement. The training program length varied from 6 to 17 weeks, and all programs resulted in improved skills. Three RCTs found that the VR interventions were significantly better in training the ASD-related skills, both compared to waitlist control (Ip et al. 2024; Ip et al. 2018) as well as conventional therapy (Zhao et al. 2022). One non-RCT comparing a gamified VR training to standard school activities in enhancing ASD-related skills found that both groups improved on a comparable level (Julrode et al. 2025). One RCT compared VR training in addition to pharmacological treatment to only pharmacological treatment and found the VR group to be superior in improving behaviour and social skills at follow-up (Kouhbanani et al. 2021). Combining a regular behavioural intervention combined with VR training was also found to be superior to behavioural intervention only (Li et al. 2025). Three small-scale SCED studies found that the VR training was effective in improving social communication, social cognition and emotion recognition (Cheng et al. 2015; Hu et al. 2024; Vahabzadeh et al. 2018).

Five studies targeted children and adolescents with ADHD or attention difficulty and behaviour problems. Two RCTs compared applications aimed at improving social skills and emotion regulation in children with ADHD to a waitlist control group (Martin-Moratinos et al. 2025) or treatment as usual and waitlist control (Wong et al. 2024). Both VR trainings resulted in significantly larger improvements in the targeted behaviours as compared to the control groups. Three applications were aimed at cognitive training for youth with attention difficulty and behaviour problems (Bioulac et al. 2020; Cho et al. 2002; Oh et al. 2022). These trainings were based on skills measured in traditional ADHD assessments such as the CPT (Conners 2000) or the advanced test of attention (ATA, Fujioka et al. 2016). Two of them were RCTs with active and passive control groups, whereby active control groups entailed conventional training or pharmacological therapy. The RCT comparing VR training to a conventional cognitive training found that both interventions were effective compared to the passive control group, but that the VR group improved the most (Cho et al. 2002). The other RCT found that the VR cognitive training decreased distractibility to a similar extent as the pharmacological treatment when measured with VR- and CPT. This near-transfer effect of the VR training is plausible considering that the VR cognitive training is based on traditional ADHD assessments. However, the VR cognitive training was less effective in improving behavioural ADHD symptoms than the pharmacological treatment, implying that far-transfer of the VR training did not occur (Bioulac et al. 2020). The training effects of the third VR cognitive training were assessed in a non-RCT in both an ADHD group and a healthy control group (Oh et al. 2022). They found that the VR training increased the cognitive relief of ADHD-related symptoms for the ADHD group, but not for the healthy controls.

Seven more studies used VR for skills practice for other target groups, one of which was preventive in nature. Of the six curative studies, one RCT assessed the effectiveness of a VR training program aimed at reducing aggressive behaviour by comparing the VR training to the analogue variant of the same training and regular psychotherapy. The results highlight the overall superiority of VR training compared the analogue training and regular psychotherapy in reducing aggressive behaviour, whereby the superiority was stronger in comparison to regular psychotherapy (Alsem et al. 2023). An SCED study focused on evaluating a VR training aimed at improving mentalisation skills to address cognitive distortions and motivation for behaviour change in forensic youth. Indications for positive changes were found for cognitive distortions and emotion regulation, whereby the perceived added value was highlighted in user interviews (Klein Schaarsberg et al. 2025). Another SCED study combined VR with biofeedback including a breathing belt to practice regulating physiological symptoms of anxiety and disruptive classroom behaviour by playing a serious game using breathing techniques. A positive effect was found for state-level anxiety and a mixed effect for disruptive classroom behaviour implying the potential of this short intervention in classroom settings for anxiety (Bossenbroek et al. 2020). The fourth study targeted youth with mild to moderate depression and assessed the effectiveness of a cognitive training system based on virtual reality. This RCT compared the experimental group to waitlist control and found significantly enhanced cognitive abilities and a reduction in depressive symptoms favouring the VR condition (Lyu et al. 2024). Lastly, two articles reported on different outcomes of the same RCT comparing a VR training for emotion recognition aimed at youth with conduct disorder to an active control group receiving one evidence-based emotion recognition training session. One study found that self-reported callous-unemotional traits significantly decreased for the VR group but not according to



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caregiver reports (Thomson, Perera, et al. 2025), whereas the other reported on VR group showing less social stress over time compared to the control group (Thomson et al. 2026). Lastly, one RCT evaluated the effects of a preventive application aimed at strengthening resilience in Chinese migrant adolescents with a VR serious game compared to watching scenic VR clips and found that only the psychological resilience of the VR group improved (Lu et al. 2025).

Summarizing, especially intervention applications focusing on social and communication skills practice for youth with ASD hold promise considering that all studies found significant improvements across varying applications and ages. The other VR applications also show promise, but more research (especially replication studies) is needed to confirm their added value to existing interventions.

**3.2.2.2 | Exposure.** The eight VR applications using exposure as their working mechanism were all targeting anxiety-related symptoms varying in their degree of severity, ranging from less pervasive symptoms to anxiety disorders. One study tested the effectiveness of a VR application aimed at reducing performance anxiety with a within-subject design, instructing adolescents to engage with both virtual as well as verbal exposure. The VR application decreased worrying to a comparable degree as the verbal exposure did (Whiteside et al. 2020). Five studies used VR exposure to treat specific phobias such as acrophobia (Azimisefat et al. 2022), arachnophobia (St-Jacques et al. 2010), dog phobia (Farrell et al. 2021), social anxiety disorder (Wei et al. 2026) or specific phobias in combination with ASD (Maskey et al. 2019). Three of these were RCTs, two of which found that VR exposure has a similar effect to EMDR (Azimisefat et al. 2022), is superior to waitlist control (Azimisefat et al. 2022) and in vivo exposure (St-Jacques et al. 2010). The last RCT compared a VR serious game including physical challenges and social exposure to physical exercises only and found that the VR serious game was superior in reducing anxiety, depression and perceived stress symptoms (Wei et al. 2026). An SCED study showed that VR exposure can continue to have an effect over a longer period (Farrell et al. 2021). In addition, an RCT on VR exposure for children with both ASD and a specific phobia showed similar effectiveness results: The phobic behaviours could successfully be improved, and the effects were maintained over a longer period (Maskey et al. 2019).

One within-subject design study compared VR exposure to imaginative exposure in children with anxiety disorders, whereby both experimental groups received both forms of exposure in a randomized order. Afterwards, they were instructed to practice with either VR or imaginative exposure in between sessions. Both interventions led to reduced anxiety (Biggs et al. 2025). One application focused on reducing public speaking anxiety. A RCT design was used to compare VR exposure, online psychoeducation and a waitlist control group, whereby both experimental groups reduced anxiety levels compared to the waitlist group, with VR yielding a larger effect (Kahlon et al. 2023). Summarizing, these results indicate that VR exposure could be a viable alternative to traditional treatments such as in vivo exposure and EMDR, whereby more research (especially replication studies) is needed to confirm these findings.

**3.2.2.3 | Relaxation.** One RCT compared the effectiveness of VR biofeedback training to standard two-dimensional biofeedback training to practice relaxation. The results indicate that both treatment modalities were similarly efficacious in reducing chronic stress (Felnhofer et al. 2025).

### 3.2.3 | Feasibility

Table 2 (assessment studies) and Table 3 (intervention studies) provide an overview of whether VR-specific feasibility was assessed, which measures were included in the studies and what the findings were. Out of the 13 assessment studies, six studies (46%) reported VR-specific feasibility measures and two of these studies additionally referred to a preceding pilot study which included VR-specific feasibility measures (Lalonde et al. 2013; Verhoef et al. 2022). The type of measures as well as the methods of the assessment varied across these studies ranging from validated questionnaires to assess tolerability or presence to self-developed questions to assess presence and enjoyment. None of the studies explicitly reported that participants dropped out because of negative physical symptoms, which can be seen as an indirect measure of tolerability. For one study, two participants were excluded due to noncompliance with task directions (11%), although it is unclear whether this was related to the VR-specific feasibility (Coleman et al. 2019). The results of the tolerability assessments and the low drop-out rates suggest that the VR applications were tolerable. Studies assessing presence and enjoyment concluded that the participants felt present and that they enjoyed VR a lot.

Of the 29 intervention studies, 16 studies (55%) reported VR-specific feasibility measures and four of these additionally referred to a separate pilot trial including VR-specific feasibility outcomes (Alsem et al. 2023; Felnhofer et al. 2025; Thomson, Perera, et al. 2025; Vahabzadeh et al. 2018). Similarly to the assessment studies, VR-specific feasibility assessments and methods varied a lot. Tolerability was assessed the most frequently with either validated questionnaires or systematically asking participants how they felt. These studies reported that the majority of participants did not experience any or only minimal physical symptoms. Only a few studies found a small number of participants with mild adverse reactions to VR (Biggs et al. 2025; Ip et al. 2024; Keshav et al. 2017; St-Jacques et al. 2010; Whiteside et al. 2020). Other VR-specific feasibility measures included presence or immersion, enjoyment or satisfaction and perceived realism. However, these were operationalized heterogeneously across studies, most commonly using self-developed questionnaires or visual analogue scales or user interviews, limiting direct comparison between studies. The dropouts mentioned in the intervention studies were mainly due to personal reasons such as time constraints, illness and lost contact. None of the studies reported that participants dropped out because of negative physical symptoms. Therefore, it seems that the respective VR-specific feasibility requirements were met.

All of the studies describing some sort of VR feasibility assessment concluded explicitly that the application in question was feasible for further usage or implicitly by suggesting further usage of the application even if no VR feasibility measures were included. In conclusion, VR feasibility assessments ranged from



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absent to comprehensive, but the results were generally sparsely described.

## 4 | Discussion

This study aimed to shed more light on the current state of available VR applications used for mental health assessment and treatment in youth. Thereby, we focused on types of applications, target groups and intended goals, as well as the reported effectiveness, or in the case of assessment applications, their validity and reliability. This review also explored how VR-specific feasibility was evaluated across applications and what the results were. We included a total of 43 articles, consisting of 13 assessment studies and 29 intervention studies. Eighteen studies were conducted in Asia (43%), which might mirror the increasing investment in clinical research including cutting-edge technology in Asia (Grand View Research 2023). The evidence points to VR's potential to improve assessment and treatment of a variety of mental health problems in youth. Most VR assessment studies investigated the VR classroom paradigm, with compelling evidence showing a performance advantage over traditional assessment methods for assessing ADHD-related symptoms. Regarding VR intervention applications, VR applications focusing on social and communication skills practice for youth with ASD were supported by the most evidence; however, no strong conclusions can be drawn due to the applied study designs. There are a few studies indicating that VR interventions with different aims for other target groups have the potential to become be viable alternatives to regular treatments as they were comparable in effectiveness. Finally, VR-specific feasibility was tested inconsistently and with little transparency, and the effectiveness of most of the applications has not been replicated.

The main finding regarding VR assessment applications is that many variations of a promising paradigm, the virtual classroom for assessing ADHD-related symptoms, have been developed and tested based on the original application by Rizzo et al. (2006). This paradigm has demonstrated higher specificity and overall sensitivity compared to traditional laptop-based assessments and may help reduce misdiagnosis and underdiagnosis of ADHD. Its advantage lies in ecological validity: the virtual environment simulates real-life classroom distractions, making it more naturalistic and potentially more effective in capturing ADHD-related behaviours. Despite these promising results and over a decade of research since the first publication in 2009, it is unclear why the virtual classroom is not an established assessment tool in both research and clinical practice yet. One possible reason is that, although several studies use the same paradigm, they still involve different applications. This lack of uniformity likely contributes to the paradigm's limited recognition as an evidence-based tool. In conclusion, the virtual classroom paradigm holds clear potential for improving ADHD assessment, but its inconsistent implementation across studies remains a key barrier to clinical adoption.

One of our main findings regarding VR intervention applications is that VR intervention applications targeting social and communication skills for ASD led to significant improvements. However, since most of the evidence stems from small-scale SCED studies or RCTs with passive control groups, it is not possible to draw strong conclusions on VR social and communication skills practice's superiority compared to regular training. To conclude superiority, these effectiveness trials should also compare VR groups to active control groups. Ideally, the control condition would be an analogue version of the VR-training to isolate the added value of VR (Mohr et al. 2009). In conclusion, while early results are promising, stronger evidence from well-controlled trials is needed to determine whether VR offers clear advantages over conventional social skills training.

Secondly, we found that some VR applications are as effective as regular treatment in clinical populations, while showing advantages in terms of clinical utility. For example, VR exposure targeting anxiety-related symptoms performed similarly to evidence-based treatments such as imaginative or in vivo exposure, or EMDR. One advantage of VR exposure is that it does not depend on the participant's imaginative abilities or focus, nor on the availability of specific stimuli such as animals or other phobia-related triggers. As a result, VR exposure could have significant clinical implications in terms of accessibility and potentially cost-effectiveness, as it allows phobias to be targeted more directly. While more evidence is needed for VR exposure, the comparable effectiveness of this treatment modality to standard delivery suggests they may be superior options for addressing anxiety-related symptoms.

Importantly, out of the 29 studies assessing the effectiveness of VR interventions, none of the applications was tested more than once. One plausible explanation could be that funding agencies often prioritize novel ideas compared to reproducibility research. Another reason could be that some applications are considered similar enough to be comparable. This assumption has not been systematically evaluated yet. To avoid the continual development of new effective applications, more resources should be invested in multiple testing cycles of VR mental health applications and the systematic evaluation of similar applications. Practical implications and applicability should not be based on one-time studies to avoid overconfidence in results.

To better understand the applicability of VR in mental health, we investigated whether and how VR feasibility was evaluated across applications and what the outcomes were. The importance of assessing VR feasibility aspects such as tolerability, presence and perceived realism has become more evident in recent years (Birckhead et al. 2019; Krupljanin et al. 2025). Despite an increase in VR studies and the growing understanding of how VR feasibility aspects can influence clinical utility and therefore effectiveness outcomes, transparency in VR feasibility assessments is still lacking. Approximately half of the assessment and intervention studies did not report any VR feasibility measures. The inconsistency with which VR feasibility was assessed across all the included studies implies the underestimation of the importance of determining VR feasibility for the potential effectiveness of a VR application. Currently, there is no golden standard of VR feasibility assessment; however, several guidelines have been proposed (see, e.g., Mummah et al. 2016; Vasser and Aru 2020). Therefore, in studies on the validity and effectiveness of VR applications, it should be made clear which VR feasibility aspects are included and why. Effectiveness findings of new applications can and should only be interpreted in the context of VR-specific feasibility, allowing strengths and



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weaknesses of applications to be identified, areas for improvement to be highlighted, and ultimately, more clinically useful applications to be developed.

Several strengths and limitations of this scoping review should be acknowledged. First, to our knowledge, this is the first scoping review synthesizing information about VR mental health applications for children and adolescents across different target groups regarding the validity of assessment applications, the effectiveness of intervention applications and VR-specific feasibility. Categorizing the intervention applications by working mechanism rather than target group provides a better understanding of which therapeutic elements have been used for which aims in mental health applications for children and adolescents. On the other hand, no formal quality appraisal of the included studies was conducted, which limits the ability to draw firm conclusions about effectiveness and VR-specific feasibility. More broadly, as scoping reviews are primarily descriptive and exploratory, their findings offer limited grounds for causal or practice-oriented conclusions.

To conclude, there are indications that VR applications in both assessment and intervention have the potential to improve today's mental health services, especially in assessing ADHD symptoms. This review shows that most research on the other applications is still in an early development phase, with varying amounts of evidence per application, working mechanism and target group. Although some of the applications seem to be similar enough to be considered comparable, their comparability should be systematically evaluated before the effectiveness trials can be viewed as replications. VR-specific feasibility assessments were very heterogeneous ranging from absent to measuring several outcomes and were overall sparsely described. Future primary VR mental health research should focus on transparently reporting on VR-specific feasibility assessments and rigidly evaluating effectiveness. Evaluation of VR-specific feasibility and effectiveness should go beyond quantitative assessment as research shows that clinical utility can remain limited despite promising results (Kouijzer et al. 2023). While a qualitative approach can provide a more comprehensive picture of clinical utility, children's and adolescents' perspective on VR applications have rarely been investigated. Studies that did include their perspectives based their conclusions on surveys and/or a few open questions rather than in-depth interviews (see, e.g., Magar et al. 2025). We recommend further qualitative studies to provide a comprehensive picture on VR-specific feasibility and effectiveness. Primary studies should also examine age-related effects, as differences in age reflect substantial variation in developmental level. Future research should investigate more explicitly how both the potential benefits and the feasibility of VR may differ across age groups and across underlying mechanisms of change. VR research in the mental health field takes time because of developing and pilot testing applications whereas the technology itself is developing at a faster pace. Given the scarce resources and incentive structure in academia, fostering collaboration may improve the methodology and increase the number of replication studies. This, in turn, would lead to more systematically and thoroughly tested applications and increase the likelihood of their integration in clinical practice.

### Author Contributions

**Nina Krupljanin:** conceptualisation, literature search, analysis and synthesis, writing – original draft. **Lenneke R. A. Alink:** conceptualisation, writing – review and editing, supervision. **Anja van der Voort:** conceptualisation, writing – review and editing, supervision. **Catharina E. Bergwerff:** conceptualisation, literature search, writing – review and editing, supervision, funding acquisition.


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### Ethics Statement

A systematic review does not require ethical approval because it synthesizes existing publicly available data without involving new human participants or introducing additional ethical risks.

### Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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## Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** Supporting Information.



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