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Research Paper

Virtual Reality-Assisted Applied Behavior Analysis in Autism Spectrum Disorder: Opportunities, Challenges, and Future Directions for Emotion Regulation and Caregiver Training

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ABSTRACT

Autism Spectrum Disorder (ASD) is a prevalent neurodevelopmental condition characterized by challenges in social communication and restrictive behaviors. Among its core difficulties, emotion regulation (ER) remains a critical but under-addressed domain, closely linked to behavioral dysregulation, social withdrawal, and reduced adaptive functioning. Applied Behavior Analysis (ABA) is widely recognized as an evidence-based intervention for ASD and has shown utility in targeting ER through reinforcement-based learning. However, ABA's implementation is often limited by high cost, caregiver fidelity issues, and limited contextual generalization—particularly in low- and middle-income countries (LMICs). Virtual Reality (VR) technologies offer immersive, interactive, and controlled environments that can complement ABA strategies, particularly for ER training. Emerging studies suggest VR may enhance engagement, enable safe emotional rehearsal, and support skill generalization in children with ASD. Additionally, caregiver-mediated VR models hold promise in increasing training scalability and contextual relevance. Yet, most existing evidence comes from pilot studies conducted in high-income countries, with limited exploration of caregiver roles, cultural adaptability, or long-term sustainability. This narrative review critically synthesizes literature on VR-assisted ABA interventions for ER in children with ASD, with a special focus on caregiver-mediated models and LMIC applicability. It outlines key trends, highlights feasibility findings, and identifies major research gaps—particularly the need for culturally tailored, longitudinal, and caregiver-integrated approaches. The review argues that while VR can bridge existing gaps in ASD behavioral care, its widespread adoption requires rigorous validation, ethical safeguards, and contextual sensitivity.

Keywords: *Virtual Reality-Assisted Applied Behavior Analysis, Autism Spectrum Disorder, Opportunities, Emotion Regulation, Caregiver Training*

Autism Spectrum Disorder (ASD) affects approximately 1 in 31 children aged 8 years in the United States, underscoring its growing global significance as a neurodevelopmental condition (Maenner et al., 2023). In India, prevalence estimates indicate approximately 1.12 per 100 children aged 2–9 years, although under-diagnosis, limited specialist services, and rural–urban disparities likely underestimate the true burden

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(Thomas et al., 2023; Divan et al., 2015). Together, these findings position ASD as a major public health, clinical, and educational concern across both high-income and low- and middle-income country (LMIC) settings (Maenner et al., 2023; Thomas et al., 2023; Divan et al., 2015).

ASD is characterized by persistent challenges in social communication and restricted, repetitive behaviors (American Psychiatric Association [APA], 2020). Increasing evidence identifies difficulties in emotion regulation (ER)—the ability to monitor, evaluate, and modulate emotional responses—as central to ASD and closely associated with behavioral challenges and psychiatric comorbidities (Mazefsky & White, 2014; Mazefsky et al., 2013). Children with ASD frequently demonstrate heightened emotional reactivity, limited coping strategies, and reduced frustration tolerance, restricting participation in educational and community settings while increasing caregiver burden (Mazefsky et al., 2013; Greaves et al., 2025; Restoy et al., 2024).

Applied Behavior Analysis (ABA) remains a gold-standard intervention for improving social, communication, and behavioral outcomes in ASD through reinforcement-based strategies grounded in operant conditioning (Baer et al., 1968; Rodgers et al., 2020). However, implementation challenges remain substantial, particularly in LMICs such as India, where shortages of trained professionals, high financial costs, intensive therapy requirements, and caregiver fidelity concerns limit accessibility and long-term delivery (Divan et al., 2015; Divan et al., 2021). These barriers are compounded by urban concentration of services, limited insurance coverage, and considerable out-of-pocket expenditure for families (Divan et al., 2015; Divan et al., 2021).

Digital health innovations, particularly Virtual Reality (VR), are increasingly being explored to augment behavioral interventions in ASD. VR provides immersive environments that enable children to rehearse emotional and social skills, receive immediate feedback, and practice learned behaviors in simulated real-world settings (Parsons & Cobb, 2011; Riva et al., 2016). Emerging evidence suggests VR-assisted approaches may improve emotion regulation, anxiety management, and executive functioning, with randomized and quasi-experimental studies reporting improvements in ER-related outcomes following structured VR training (Failla, 2024; Yeh & Meng, 2025).

Despite this promise, evidence remains limited by small pilot studies, short follow-up periods, heterogeneous outcome measures, and limited cultural adaptation for LMIC settings (Carnett et al., 2022; Yang & Wang, 2025; Failla, 2024).

Although child-focused VR interventions continue to expand, caregiver-mediated VR–ABA models remain underdeveloped despite caregivers being central to skill generalization beyond clinical settings (Divan et al., 2021; Pacione, 2022). Scalable digital approaches, including VR-supported caregiver training, may improve treatment fidelity, sustainability, and accessibility—particularly in settings such as India where specialist resources remain limited (Divan et al., 2015; Soccini et al., 2025).

However, evidence examining caregiver-integrated VR approaches remains scarce, with important unanswered questions surrounding usability, digital literacy, cultural adaptation, and integration within existing health and educational systems (Carnett et al., 2022; Shen et al., 2025; Soccini et al., 2025).

Research question and objectives

What is the current state of evidence on virtual reality–assisted ABA interventions for emotion regulation in children with ASD, and how can caregiver-mediated models be optimized for culturally diverse and resource-constrained settings such as India?

The objectives are to:

1. Synthesize recent empirical evidence (2017–2025) on VR-integrated ABA and related behavioral interventions targeting emotion regulation in children with ASD (Carnett et al., 2022; Failla, 2024; Yang & Wang, 2025).
2. Evaluate the role, feasibility, and acceptability of caregiver-mediated VR–ABA and VR-supported caregiver training approaches in ASD (Pacione, 2022; Soccini et al., 2025).
3. Identify key knowledge and implementation gaps and propose future research and policy directions relevant to LMIC and Indian settings (Divan et al., 2015; Shen et al., 2025).

METHODOLOGY

This narrative review synthesizes and critically evaluates literature on Virtual Reality (VR)–assisted Applied Behavior Analysis (ABA) interventions targeting emotion regulation in children with Autism Spectrum Disorder (ASD). A structured literature search was conducted across **PubMed, Scopus, and Google Scholar**.

Search terms included combinations of **"Autism Spectrum Disorder," "Virtual Reality," "Applied Behavior Analysis," "emotion regulation," "caregiver training,"** and **"digital interventions."**

Studies published between **2015 and 2025** were prioritized to ensure contemporary relevance. Inclusion criteria comprised peer-reviewed studies examining VR, ABA, or integrated VR–ABA interventions in ASD, with emphasis on emotional, behavioral, or caregiver-mediated outcomes.

Given the emerging and interdisciplinary nature of VR-assisted behavioral interventions, a narrative review approach was adopted to synthesize diverse study designs, conceptual frameworks, and contextual considerations, particularly relevant to low- and middle-income settings.

From Known to Unknown: Identifying the Gap

Although ABA demonstrates established clinical efficacy in ASD, implementation in LMIC settings such as India remains constrained by workforce shortages, financial burden, and challenges maintaining intervention fidelity across home and school environments (Divan et al., 2015; Divan et al., 2021). Simultaneously, VR-based interventions show potential for improving emotion regulation and engagement, but evidence remains dominated by small, short-term studies conducted primarily in high-income countries, with limited focus on caregiver-mediated delivery, low-cost technologies, and culturally adaptive approaches (Carnett et al., 2022; Failla, 2024; Yang & Wang, 2025).

Research integrating ABA principles and VR within caregiver-led emotion regulation models tailored to Indian family structures, digital realities, and implementation contexts remains limited, despite growing interest in technology-enabled autism services in LMIC

settings (Divan et al., 2015; Shen et al., 2025). This review addresses this gap by integrating behavioral theory, emerging VR technologies, and LMIC-specific contextual considerations to inform future intervention development and evaluation.

Conceptual framework: VR–ABA–caregiver model for ER in LMICs

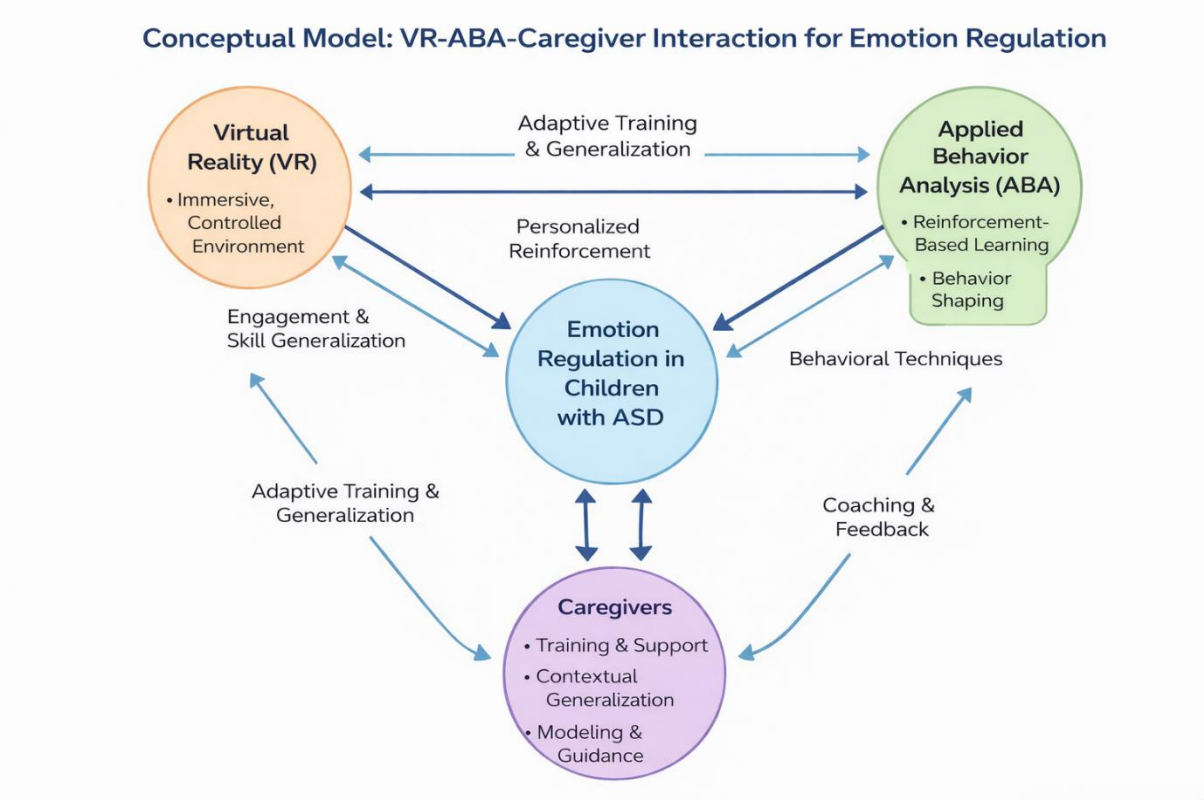

Figure 1. Conceptual model of VR-assisted ABA for emotion regulation.

The framework illustrates interactions among **(1) Child emotion regulation (ER) skills** (emotional reactivity, coping, frustration tolerance), **(2) Caregiver ABA fidelity** (reinforcement delivery, generalization support), **(3) VR technological affordances** (immersive rehearsal, real-time feedback, adaptive difficulty), and **(4) LMIC contextual moderators** (digital infrastructure, cultural norms, policy systems, family structures). Dashed pathways indicate hypothesized moderation effects.

This review adopts an integrative framework combining Applied Behavior Analysis (ABA), Virtual Reality (VR), caregiver mediation, and low- and middle-income country (LMIC) contextual factors to understand emotion regulation interventions in Autism Spectrum Disorder (ASD), particularly within India.

The framework includes four components:

1. **Child ER domain:** Targets emotional reactivity, coping strategies, and frustration tolerance using ABA-consistent VR scenarios structured around antecedent–behavior–consequence principles (Mazefsky & White, 2014; Baer et al., 1968).
2. **Caregiver mediation:** Focuses on caregiver-delivered reinforcement, communication support, and skill generalization across settings to address fidelity challenges common in LMIC contexts (Divan et al., 2021).

3. **VR platform:** Utilizes immersive rehearsal, adaptive learning, and real-time feedback to support behavioral training, with potential scalability through low-cost digital systems suitable for Indian settings (Carnett et al., 2022; Shen et al., 2025).
4. **LMIC contextual moderators:** Incorporates structural, cultural, and policy influences—including access barriers, stigma, caregiving patterns, and disability frameworks—that shape intervention feasibility (Divan et al., 2015; Thomas et al., 2023).

The framework is informed by operant conditioning (Baer et al., 1968), social learning principles, self-regulation frameworks (Mazefsky et al., 2013), and implementation science approaches relevant to resource-constrained environments (Pacione, 2022). Together, these components provide a basis for understanding how VR-assisted ABA may strengthen emotion regulation and caregiver-supported intervention delivery in ASD.

ABA and Emotion Regulation in ASD

Historical Overview of Applied Behavior Analysis

Applied Behavior Analysis (ABA) emerged from mid-20th century behavioral science grounded in operant conditioning and antecedent–behavior–consequence principles, with Baer et al. (1968) establishing foundational dimensions of ABA as a scientific discipline (Baer et al., 1968). In ASD intervention, ABA expanded following early autism intervention work and now encompasses approaches including discrete trial training, naturalistic developmental behavioral interventions, and functional assessment targeting socially meaningful behaviors across settings (Baer et al., 1968; Rodgers et al., 2020). However, in India and other low- and middle-income countries (LMICs), limited specialist training and inconsistent implementation remain barriers to standardized ABA delivery, particularly for emotion regulation–focused interventions (Divan et al., 2015; Divan et al., 2021).

Core Challenges in Emotion Regulation in ASD

Children with ASD commonly experience difficulties in emotion regulation (ER), including heightened emotional reactivity, impaired coping strategies, and reduced recovery from distress (Mazefsky & White, 2014). Longitudinal evidence indicates that emotion dysregulation contributes to challenging behavior, reduced learning opportunities, and increased risk for anxiety and mood disorders (Greaves et al., 2025; Restoy et al., 2024). Neurodevelopmental characteristics—including atypical arousal regulation, executive functioning differences, and reduced social-emotional awareness—further contribute to persistent ER difficulties (Mazefsky et al., 2013; Nuske et al., 2023). These challenges may be amplified in LMIC settings where specialist supports and emotion-focused interventions remain limited (Divan et al., 2015; McConkey, 2022).

How ABA Addresses Emotion Regulation

Although initially developed to target observable behaviors, ABA principles increasingly extend to emotion regulation–related domains in ASD. Behavior analytic approaches conceptualize emotional responses as modifiable through environmental structuring, reinforcement, and adaptive behavior shaping (Baer et al., 1968; Rodgers et al., 2020). Evidence supports ABA-based approaches for improving emotional and social functioning; for example, Du et al. (2024) reported improvements in social communication and emotional development following ABA training in children with ASD. Systematic reviews further suggest that interventions incorporating visual supports, functional communication training,

reinforcement strategies, and structured coping instruction can reduce dysregulation and associated behavioral challenges (Nuske et al., 2023; Jasni et al., 2025). In LMIC contexts, these findings emphasize the value of caregiver-mediated adaptations that improve feasibility across home and school environments (Divan et al., 2015; Divan et al., 2021).

Limitations: Fidelity, Cost, and Generalization

Despite strong empirical support, ABA implementation faces challenges related to fidelity, accessibility, and generalization. Maintaining intervention fidelity outside specialist settings can be difficult, with caregiver-mediated models often demonstrating reduced effectiveness when training and supervision are limited (Divan et al., 2021; Pacione, 2022). Traditional ABA also remains resource intensive, commonly requiring 25–40 hours of weekly intervention and specialist delivery, limiting accessibility in LMIC settings where services remain scarce and financially burdensome (Divan et al., 2015; McConkey, 2022). Additionally, gains in emotion regulation may not consistently generalize across home, school, and community settings without structured planning and reinforcement (Baer et al., 1968; Nuske et al., 2023). Long-term evidence examining emotion regulation outcomes, caregiver well-being, and functional adaptation also remains limited, particularly within LMIC populations (Nuske et al., 2023; Greaves et al., 2025). These limitations highlight the need for scalable approaches, including caregiver-mediated and technology-supported models such as virtual reality.

Virtual Reality in Autism Interventions

Overview of VR Technologies in Healthcare and Education

Virtual Reality (VR) comprises computer-generated immersive environments that simulate real-world experiences through visual, auditory, and, in some systems, haptic feedback (Parsons & Cobb, 2011). Across healthcare and education, VR has been applied in rehabilitation, pain management, surgical simulation, and skills training by enabling controlled, repeatable practice with real-time feedback (Riva et al., 2016). Use of VR in neurodevelopmental conditions, including ASD, has expanded substantially, with over 60 studies published between 1998 and 2024; however, most evidence originates from high-income settings and relies on comparatively expensive hardware systems (Parsons & Cobb, 2011; Riva et al., 2016; Carnett et al., 2022). For LMIC settings such as India, VR presents opportunities for scalable digital interventions but also challenges related to affordability, infrastructure, and cultural adaptation.

VR in Child-Focused ASD Interventions

1. Social Cognition

Children with ASD frequently experience difficulties recognizing emotions, interpreting social cues, and responding appropriately in social situations (Mazefsky & White, 2014). VR allows repeated rehearsal of social interactions within controlled environments such as classrooms or playgrounds while minimizing real-world social demands (Parsons & Cobb, 2011; Riva et al., 2016). A systematic review reported positive effects of VR interventions on social skills, particularly among children with stronger cognitive and language abilities using immersive systems (Carnett et al., 2022). Additional evidence suggests VR may improve engagement and provide safe opportunities for practice, although generalization to everyday settings remains challenging (Carnett et al., 2022; Failla, 2024).

2. Sensory Desensitization

Sensory over- or under-responsivity frequently interferes with learning, participation, and emotion regulation in ASD (Mazefsky et al., 2013). VR enables graded exposure to sensory stimuli such as noise, visual complexity, or environmental unpredictability, supporting desensitization and adaptive coping practice under controlled conditions (Riva et al., 2016; Carnett et al., 2022). Although sensory outcomes remain less frequently studied, VR's capacity to manipulate environmental demands offers potential advantages when integrated with behavioral reinforcement and caregiver support (Carnett et al., 2022; Failla, 2024).

3. Adaptive Behavior

Adaptive behaviors—including daily living skills, community participation, and vocational readiness—remain critical long-term outcomes in ASD (Greaves et al., 2025). VR training has been used to teach practical skills such as road safety, transportation use, and vocational preparation within safe and repeatable settings (Parsons & Cobb, 2011; Carnett et al., 2022). Evidence suggests VR may support adaptive functioning, particularly when combined with behavioral reinforcement approaches, and may strengthen rather than replace existing interventions (Carnett et al., 2022; Failla, 2024). However, application within LMIC contexts remains limited, emphasizing the need for culturally adapted VR environments.

Key Global Studies and Emerging Trends

Several trends characterize current VR-ASD research. First, there has been increasing adoption of immersive systems, although accessibility remains limited in LMIC settings (Carnett et al., 2022; Failla, 2024). Second, recent studies increasingly evaluate usability, acceptability, and engagement, with evidence suggesting generally positive user experiences among children with ASD (Failla, 2024). Third, emotion regulation has emerged as a growing intervention target, with early studies reporting improvements in anxiety management, stress coping, and behavioral regulation, though evidence remains dominated by small samples and short follow-up periods (Failla, 2024; Yang & Wang, 2025).

Attention has also shifted toward potential risks, including cybersickness, sensory overload, dizziness, and eye strain, emphasizing the need for monitoring and ethical safeguards (Kourtesis et al., 2024; Failla, 2024). Importantly, substantial gaps remain in LMIC-focused research, with limited evidence examining caregiver-mediated VR, low-cost delivery systems, or culturally adapted interventions relevant to contexts such as India (Carnett et al., 2022; McConkey, 2022; Shen et al., 2025).

Overall, VR interventions in ASD demonstrate considerable promise but remain dominated by early-phase studies conducted in high-income countries, with limited longitudinal evidence and minimal evaluation of caregiver-mediated or culturally adapted approaches.

Study	Country	Sample	Focus	Outcome	Limitation
Yang & Wang (2025)	Global (Review)	20+ studies	VR for social skills	Improved social interaction	Heterogeneous methods
Yeh & Meng (2025)	Taiwan	n ≈ 30	VR social training	Improved behavior& brain activity	Small sample
Carnett et al. (2022)	USA	Review	VR behavioral interventions	Effective for adaptive skills	Limited RCTs
Du et al.	China	n ≈ 60	ABA program	Improved	Institutional

Study	Country	Sample	Focus	Outcome	Limitation
(2024)				emotional & social skills	setting bias
Nuske et al. (2023)	Global	Review	Emotion regulation interventions	Moderate improvements in ER	Lack of VR integration
Lovell & Wetherell (2024)	UK	n = 18 caregivers	VR stress reduction	Reduced caregiver stress	Not ABA-focused
Moraes et al. (2022)	Brazil	n ≈ 40	VR + motor training	Improved engagement	Not ER-focused
Julrode et al. (2025)	Thailand	n ≈ 25	Gamified VR	Improved social reciprocity	Short-term outcomes

VR for Caregiver-Mediated Training

Caregiver Fidelity as a Bottleneck in ABA

Caregiver-mediated implementation is critical for sustaining Applied Behavior Analysis (ABA) outcomes and generalizing emotion regulation gains beyond clinical settings (Divan et al., 2021; Pacione, 2022). However, caregiver fidelity—the accurate and consistent implementation of behavioral strategies—remains a major challenge, particularly when training is brief, poorly supervised, or lacks feedback mechanisms (Divan et al., 2015; Pacione, 2022). Limited training opportunities, caregiver burden, competing responsibilities, and inconsistent adherence reduce intervention scalability and effectiveness (Divan et al., 2015; Divan et al., 2021).

These barriers are amplified in LMIC contexts such as India, where specialist availability remains limited and caregivers often rely on informal guidance rather than structured training programmes (Divan et al., 2015; McConkey, 2022). Telehealth-delivered caregiver training has shown promise but still requires sustained support and monitoring to maintain fidelity over time (Pacione, 2022; Shen et al., 2025).

VR may address these limitations by providing immersive rehearsal, behavioral modelling, and immediate feedback to strengthen caregiver-delivered ABA and emotion regulation strategies (Carnett et al., 2022; Soccini et al., 2025).

Feasibility Studies Using VR to Support Caregivers

Most VR research in ASD remains child-focused; however, emerging evidence suggests VR may also support caregivers. A pilot study involving 18 caregivers of children with ASD found that brief VR relaxation experiences reduced perceived stress at three- and seven-day follow-up, indicating VR feasibility and acceptability within caregiver populations (Lovell & Wetherell, 2024).

Additional work highlights the value of integrating caregivers as guides or co-users within VR environments to improve engagement and skill generalization (Soccini et al., 2025). However, empirical studies directly examining VR-mediated caregiver training for ABA or emotion regulation remain limited, with no published implementation studies identified within Indian autism services (Carnett et al., 2022; Shen et al., 2025).

Advantages: Scalability, Standardization, and Safe Rehearsal

VR offers several advantages for caregiver-mediated ABA and emotion regulation training. Standardized virtual modules can improve training consistency while reducing reliance on repeated in-person instruction (Carnett et al., 2022; Shen et al., 2025). VR environments can also model caregiver behaviors, reinforcement delivery, communication prompting, and coping strategies in controlled settings (Carnett et al., 2022; Soccini et al., 2025).

Importantly, caregivers can repeatedly practice challenging situations—including emotional dysregulation episodes or behavioral escalation—in safe environments where errors can be reviewed without affecting the child (Soccini et al., 2025; Failla, 2024). Combined with telehealth or brief clinician support, VR may improve accessibility in resource-constrained settings (Pacione, 2022; Shen et al., 2025).

Barriers: Usability, Cost, Technology Literacy, and Cultural Adaptation

Despite its potential, VR implementation faces usability, accessibility, and infrastructure challenges. Cybersickness, device discomfort, limited digital literacy, and home-space constraints may affect caregiver engagement (Kourtesis et al., 2024; Lovell & Wetherell, 2024). Financial barriers—including hardware, software, maintenance, and connectivity requirements—remain particularly relevant in LMIC settings (McConkey, 2022; Shen et al., 2025).

Cultural adaptation is equally critical. VR systems developed in high-income settings may not align with Indian caregiving structures, language diversity, or daily routines (Divan et al., 2015; McConkey, 2022). Furthermore, evidence remains limited regarding whether VR caregiver training improves real-world implementation, child emotion regulation outcomes, or sustainable service delivery (Carnett et al., 2022; Shen et al., 2025).

Although VR represents a promising adjunct for caregiver-mediated ABA and emotion regulation training, culturally grounded and implementation-focused research remains necessary before broader adoption in LMIC contexts such as India.

Ethical and Cultural Considerations

ABA, Compliance, and Autonomy Debates

Although Applied Behavior Analysis (ABA) remains an evidence-based intervention for ASD, ethical concerns persist regarding historical emphasis on compliance, normalization, and adult-directed behavior change (Baer et al., 1968; McConkey, 2022). Critics argue that some ABA practices may prioritize behavioral conformity over emotional wellbeing, autonomy, and authentic self-expression, potentially contributing to masking and psychological distress (McConkey, 2022). These concerns underscore the importance of prioritizing autonomy, beneficence, non-maleficence, and justice within caregiver-mediated and technology-assisted interventions, including VR-supported approaches (Peck et al., 2021; Kourtesis et al., 2024). Ethical implementation should also incorporate autistic perspectives wherever feasible.

Informed Consent and VR Interventions

VR-based interventions introduce ethical considerations related to informed consent, safety, and data governance. Caregivers and children should be informed about potential risks including cybersickness, sensory overload, emotional distress, and immersive discomfort

(Kourtesis et al., 2024). Gradual exposure, monitoring, and developmentally appropriate consent and assent procedures are particularly important in ASD populations (Kourtesis et al., 2024; Failla, 2024).

VR systems may additionally collect sensitive behavioral information—including movement patterns, gaze behavior, voice recordings, and physiological signals—requiring clear policies regarding confidentiality, cybersecurity, and data access (Peck et al., 2021; Kourtesis et al., 2024). Equity of access also remains critical, as cost, language, and infrastructure limitations may disproportionately exclude families in resource-constrained settings (McConkey, 2022; Shen et al., 2025).

Cultural Barriers in India and LMIC Contexts

Cultural beliefs, stigma, caregiving norms, and health system limitations influence both the feasibility and ethical implementation of VR-assisted ABA in LMICs such as India (Divan et al., 2015; McConkey, 2022). Families may conceptualize emotional and behavioral difficulties differently, while hierarchical decision-making structures and stigma surrounding autism may influence help-seeking and engagement with technology (Divan et al., 2015; Thomas et al., 2023).

Interventions developed in high-income settings may also inadequately reflect local caregiving practices, language diversity, educational contexts, and resource constraints (McConkey, 2022). Context-sensitive implementation therefore requires caregiver involvement, cultural adaptation, and co-design approaches that align with local family structures and service realities (Divan et al., 2015; Soccini et al., 2025).

Need for Culturally Adapted VR Modules

VR interventions intended for India and other LMIC contexts must extend beyond language translation to incorporate culturally relevant settings, social norms, daily routines, and locally meaningful interaction patterns (McConkey, 2022; Shen et al., 2025). Modules should additionally account for infrastructure limitations, caregiver digital literacy, and safety safeguards including adjustable sensory intensity and caregiver oversight functions (Kourtesis et al., 2024; Peck et al., 2021).

Importantly, VR-assisted approaches should prioritize emotion regulation, adaptive functioning, and caregiver empowerment rather than behavioral conformity alone, aligning with neurodiversity-affirming perspectives (Peck et al., 2021; Failla, 2024). Without ethical and cultural adaptation, technology-based interventions risk reinforcing existing inequities rather than improving autism care access in LMIC settings (McConkey, 2022; Shen et al., 2025).

Emerging Trends and Future Directions

Gamification and Adaptive VR (AI-Based)

Recent advances in VR interventions for Autism Spectrum Disorder (ASD) increasingly incorporate gamification and artificial intelligence (AI)-driven adaptation. Adaptive VR systems can personalize learning based on performance, engagement, and sensory or cognitive profiles, aligning with behavioral principles of reinforcement and graduated task difficulty (Drigas & Sideraki, 2023; Julrode et al., 2025). For example, gamified VR environments simulating everyday contexts such as homes and classrooms have shown

potential for improving social reciprocity and emotion recognition in children with ASD (Julrode et al., 2025).

Systematic reviews suggest adaptive VR may strengthen engagement and learning transfer, although most evidence remains focused on social and academic outcomes rather than emotion regulation (Drigas & Sideraki, 2023; Failla, 2024). Long-term effectiveness, cost feasibility, and integration with behavioral frameworks remain underexplored, particularly in LMIC contexts (Shen et al., 2025).

Integration With Telehealth and Mobile Platforms

Integration of VR with telehealth and mobile technologies represents another emerging direction. Telehealth-delivered autism interventions have demonstrated feasibility in South Asia and other LMIC settings, highlighting potential to address workforce and geographic barriers (Divan et al., 2021; Pacione, 2022; Shen et al., 2025). Embedding VR modules within mobile systems alongside caregiver-mediated telehealth support could improve access to emotion regulation and ABA-consistent training while reducing travel and service burden for families (Divan et al., 2015; Shen et al., 2025).

Although early evidence suggests remotely delivered VR interventions may achieve outcomes comparable to in-person approaches, current studies remain limited and predominantly originate from high-income settings (Telehealth Blog, 2024; Failla, 2024).

Longitudinal Research Needs

Despite short-term improvements reported in social functioning and behavioral outcomes, long-term sustainability of VR intervention effects remains poorly understood. Existing evidence emphasizes the need for longitudinal research examining maintenance of gains, caregiver fidelity, generalization across settings, and long-term adaptive functioning (Moraes et al., 2022; Failla, 2024).

Critical questions remain regarding durability of emotion regulation gains, sustainability of caregiver-mediated implementation, and feasibility of long-term integration within resource-constrained systems such as India (Moraes et al., 2022; Shen et al., 2025). Addressing these gaps will require longitudinal and implementation-focused research designs.

Importance of LMIC-Focused Research and Policy Frameworks

Most VR and digital autism intervention research originates from high-income countries, limiting generalizability to LMIC settings (McConkey, 2022; Shen et al., 2025). Future efforts should prioritize culturally adapted interventions, accessible technologies, caregiver digital literacy support, and service models aligned with public health and education systems (McConkey, 2022; Failla, 2024; Shen et al., 2025).

For India and comparable settings, scalable solutions may include smartphone-based VR, low-bandwidth platforms, and community-integrated delivery models leveraging existing educational and healthcare networks (Divan et al., 2015; Shen et al., 2025). Policy frameworks addressing digital equity, accessibility, and disability inclusion will be essential to ensure technology-enabled autism care reduces—rather than reinforces—existing disparities (McConkey, 2022; Thomas et al., 2023).

Limitations and Critical Synthesis of Existing Evidence

Current evidence suggests that both Applied Behavior Analysis (ABA) and Virtual Reality (VR)-based interventions show promise in improving behavioral and emotional outcomes among children with Autism Spectrum Disorder (ASD). ABA consistently demonstrates effectiveness in strengthening adaptive behaviors through reinforcement-based mechanisms (Rodgers et al., 2020; Du et al., 2024), while VR interventions increasingly support social cognition, emotion recognition, and behavioral rehearsal within structured environments (Yang & Wang, 2025; Yeh & Meng, 2025). The ability of VR to simulate real-world scenarios aligns closely with ABA principles of reinforcement and repeated practice, highlighting potential synergy between behavioral science and immersive technology approaches.

However, current evidence remains fragmented and methodologically constrained. Findings regarding emotion regulation outcomes and generalization of VR-acquired skills remain inconsistent, partly due to variations in outcome measures, intervention designs, and VR technologies used across studies. Most VR-ASD research continues to rely on small samples, pilot designs, and short follow-up periods, limiting conclusions regarding long-term effectiveness. Evidence is also geographically concentrated within high-income countries, reducing applicability to low- and middle-income settings where caregiving structures, digital access, and service delivery models differ substantially. Furthermore, caregiver-mediated VR approaches remain underexplored despite caregiver involvement being critical for sustainability and ecological validity.

This review also has limitations characteristic of narrative syntheses. Relevant non-English studies, grey literature, or regional LMIC publications may not have been captured, and no formal quality appraisal or meta-analytic methods were employed. Limited Indian and South Asian VR-ASD evidence further necessitated conceptual extrapolation from high-income settings. Collectively, findings support the potential of VR-assisted ABA interventions while emphasizing the need for longitudinal, culturally adaptive, caregiver-integrated research supported by stronger implementation and LMIC-focused evidence frameworks.

CONCLUSION

Virtual Reality (VR)–assisted Applied Behavior Analysis (ABA) represents a promising emerging approach within autism intervention research, with potential to strengthen emotion regulation, increase engagement, and extend behavioral learning into ecologically relevant environments for children with Autism Spectrum Disorder (ASD) (Mazefsky & White, 2014; Failla, 2024). Existing evidence suggests that VR integrated with ABA-informed strategies may improve emotion regulation–related outcomes and strengthen caregiver-supported implementation when embedded within structured, behaviorally informed intervention models. However, current evidence remains limited by small samples, short-term follow-up, and a predominance of studies conducted in high-income settings, restricting conclusions regarding long-term effectiveness and broader applicability (Carnett et al., 2022; Failla, 2024; Shen et al., 2025).

For low- and middle-income settings such as India, caregiver-mediated and culturally responsive VR–ABA models may offer opportunities to address gaps in autism service delivery where specialist access remains limited (Divan et al., 2015; Divan et al., 2021). Realizing this potential will require longitudinal evaluation, culturally adaptive intervention design, integration with scalable digital health systems, and participatory approaches

involving caregivers, autistic individuals, clinicians, and policymakers (Pacione, 2022; Shen et al., 2025). Building an ethically grounded and contextually relevant evidence base will be essential to ensure VR-assisted ABA evolves from an emerging innovation into a feasible and equitable component of autism care across India and comparable LMIC settings (McConkey, 2022; Thomas et al., 2023).

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Conflict of Interest

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