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Effects of XR Technologies Interventions on Body Functions, Activities and/or Participation of Children and Adolescents with Neurological Disorders: : A Systematic Review Protocol

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ADMINISTRATIVE INFORMATION

Support - No support.

Review Stage at time of this submission - Completed but not published.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 21 October 2026 and was last updated on 21 October 2026.

INTRODUCTION

Review question / Objective To evaluate the effects of extended reality (XR) technology-based therapeutic interventions on Body Functions and Activities and Participation in children and adolescents with neurological and neurodevelopmental disorders, using the International Classification of Functioning, Disability and Health (ICF) as the reference framework.

Review questions

(1) What types of XR technologies and therapeutic interventions have demonstrated effects on Body Functions and/or Activities and Participation in children and adolescents with neurological disorders? (2) In which neurological and neurodevelopmental disorders have XR-based therapeutic interventions demonstrated effects on Body Functions and/or Activities and Participation? (3) Which specific Body Functions and Activities and Participation domains, as classified by the ICF, have shown statistically significant improvements following XR-based therapeutic interventions?

Condition being studied Neurological or neurodevelopmental disorders in children and adolescents encompass a heterogeneous group of conditions affecting the development and functioning of the central and/or peripheral nervous system. These conditions may result in motor, sensory, cognitive, behavioral, communicative, and social impairments, leading to limitations in daily activities and restrictions in participation across educational, recreational, family, and community environments.

This systematic review focuses on pediatric neurological and neurodevelopmental conditions, including Cerebral Palsy, Autism Spectrum Disorder, Developmental Coordination Disorder, acquired brain injury, and other conditions associated with impairments in functioning. Although these disorders differ in their etiology, clinical manifestations, and functional severity, they

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frequently require individualized rehabilitation interventions aimed at improving functional abilities, independence, and participation.

Extended reality (XR) technologies, including non-immersive virtual reality, immersive virtual reality, augmented reality, and mixed reality, have emerged as therapeutic tools in pediatric neurorehabilitation. These technologies provide interactive environments that can support repetitive, task-oriented practice, multisensory feedback, motivation, and active engagement in rehabilitation activities.

The International Classification of Functioning, Disability and Health (ICF) provides the conceptual framework for examining the effects of XR interventions across two principal components: Body Functions and Activities and Participation. This approach enables the evaluation of therapeutic outcomes beyond isolated impairments, considering their potential relevance to functional performance and everyday life.

Accordingly, this review examines the reported therapeutic effects of XR interventions across different pediatric neurological and neurodevelopmental conditions, with particular emphasis on identifying the ICF domains in which statistically significant improvements have been observed.

METHODS

Participant or population The population of interest comprises children and adolescents (0–18 years) with neurological or neurodevelopmental disorders who participated in studies evaluating extended reality (XR) technologies as therapeutic interventions.
Eligible participants include children and adolescents with Cerebral Palsy, Autism Spectrum Disorder, Developmental Coordination Disorder, acquired brain injury, and other neurological or neurodevelopmental conditions associated with impairments in Body Functions, limitations in Activities, and/or restrictions in Participation, as defined by the International Classification of Functioning, Disability and Health (ICF).
The review encompasses pediatric populations with different clinical presentations and levels of functional impairment, including motor, sensory, cognitive, behavioral, communicative, and social difficulties.

Studies involving these populations were eligible when XR-based interventions were used for therapeutic or rehabilitation purposes and reported at least one outcome related to ICF Body Functions and/or Activities and Participation.

The review was not restricted to a specific neurological diagnosis, XR technology, or rehabilitation setting, allowing the examination of therapeutic outcomes across heterogeneous pediatric neurological and neurodevelopmental populations.

Intervention The interventions of interest comprise therapeutic approaches using extended reality (XR) technologies in children and adolescents with neurological or neurodevelopmental disorders. XR encompasses non-immersive virtual reality (VR), immersive virtual reality (VR), augmented reality (AR), and mixed reality (MR).

Eligible interventions include interactive, screen-based virtual environments; immersive virtual environments delivered through head-mounted displays; augmented reality applications integrating digital elements into the physical environment; and mixed reality systems combining physical and virtual environments.

XR interventions may be delivered as stand-alone therapeutic approaches or combined with conventional rehabilitation, including physical therapy, occupational therapy, or other therapeutic interventions. Both individual and group-based interventions, as well as supervised or independently performed activities, are considered where reported.

Interventions may target motor, sensory, cognitive, communicative, behavioral, and social functions, as well as functional activities and participation. Therapeutic activities may involve task-oriented practice, repetitive movements, interactive exercises, virtual simulations, and game-based rehabilitation activities.

No restrictions were established regarding the specific XR device or software, intervention frequency, session duration, total treatment duration, or intervention intensity. These characteristics were extracted and descriptively analyzed when reported in the included studies.

Only interventions using XR for therapeutic or rehabilitation purposes were eligible. Applications used exclusively for assessment, diagnosis, or educational purposes without a therapeutic component were outside the scope of the review.

Comparator This systematic review include both comparative and non-comparative intervention

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studies. Comparative studies may evaluate extended reality (XR) interventions against conventional rehabilitation, usual care, alternative therapeuticinterventions, or control conditions. Non-comparative studies, including single-group pre-post intervention designs, also was eligible. The presence of a control or comparison group was not a mandatory inclusion criterion.

Study designs to be included This systematic review included experimental and quasi-experimental studies evaluating the effects of extended reality (XR)-based therapeutic interventions in children and adolescents with neurological or neurodevelopmental disorders.Eligible study designs comprised randomized controlled trials (RCTs), non-randomized controlled intervention studies, and quasi-experimental studies, including single-group pretest–posttest designs.Both controlled and uncontrolled intervention studies were eligible, provided that they reported quantitative outcomes related to Body Functions and/or Activities a.

Eligibility criteria Studies were eligible for inclusion according to the PICOS framework (Population, Intervention, Comparator, Outcomes, and Study Design).
Inclusion criteria
Population: Children and adolescents with neurological or neurodevelopmental conditions.
Intervention: Therapeutic interventions using extended reality (XR) technologies, including non-immersive virtual reality, immersive virtual reality, augmented reality, and mixed reality, delivered either as stand-alone interventions or in combination with other rehabilitation approaches.
Comparator: Studies with or without a control group were eligible. Comparative studies could evaluate XR interventions against conventional rehabilitation or other comparison conditions, while uncontrolled studies could assess changes following the intervention.
Outcomes: Studies reporting changes in at least one outcome related to Body Functions and/or Activities and Participation, classifiable according to the International Classification of Functioning, Disability and Health (ICF).
Study design: Randomized controlled trials and non-randomized experimental intervention studies, including quasi-experimental and pretest–posttest designs.
Publication period and language: Studies published in English between January 2011 and October 2025.

Exclusion criteria

Studies were excluded when they did not meet the specified population, intervention, outcome, study design, publication period, or language criteria. Studies without an XR-based therapeutic intervention or without outcomes relevant to the ICF components of interest were not eligible.

Information sources PubMed, and Web of Science.

Main outcome(s) The main outcomes were the effects of extended reality (XR)-based therapeutic interventions on Body Functions and Activities and Participation in children and adolescents with neurological or neurodevelopmental disorders, classified according to the International Classification of Functioning, Disability and Health (ICF).

Outcomes were organized into two main ICF components:

Body Functions (b1–b8): Mental Functions; Sensory Functions and Pain; Voice and Speech Functions; Functions of the Cardiovascular, Haematological, Immunological and Respiratory Systems; Functions of the Digestive, Metabolic and Endocrine Systems; Genitourinary and Reproductive Functions; Neuromusculoskeletal and Movement-Related Functions; and Functions of the Skin and Related Structures.

Activities and Participation (d1–d9): Learning and Applying Knowledge; General Tasks and Demands; Communication; Mobility; Self-Care; Domestic Life; Interpersonal Interactions and Relationships; Major Life Areas; and Community, Social and Civic Life.

Treatment outcomes were extracted from the assessment instruments and statistical analyses reported in the included studies. Statistically significant effects ($p < 0.05$) and non-significant findings were identified and descriptively synthesized according to ICF domain, XR modality, and neurological or neurodevelopmental condition.

Outcome assessment time points corresponded to those reported in the original studies, primarily pre-intervention and post-intervention assessments, with follow-up measurements considered when available.

Given the heterogeneity of study designs, interventions, assessment instruments, and reported effect measures, no meta-analysis or pooled effect estimates were performed.

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Quality assessment / Risk of bias analysis No formal methodological quality assessment or risk-of-bias evaluation was performed for the included studies. The review focused on the descriptive synthesis of reported therapeutic outcomes, classified according to the International Classification of Functioning, Disability and Health (ICF).

Study design characteristics, including randomized and non-randomized intervention designs, were considered when describing the available evidence. However, no standardized risk-of-bias assessment tool or formal grading of the certainty of evidence was applied.

Consequently, the findings were interpreted descriptively, acknowledging that differences in methodological quality and potential sources of bias across the included studies may influence the reliability of the reported intervention effects.

Strategy of data synthesis A descriptive and narrative synthesis of the included studies was conducted, following the International Classification of Functioning, Disability and Health (ICF) as the conceptual framework for organizing therapeutic outcomes.

Data were summarized according to study characteristics, participant characteristics, neurological or neurodevelopmental conditions, extended reality (XR) technology, intervention protocols, and reported therapeutic outcomes.

Intervention effects were classified into two main ICF components: Body Functions (b1–b8) and Activities and Participation (d1–d9). Outcomes were categorized according to the specific ICF domains assessed in each study.

Statistically significant ($p < 0.05$) and non-significant findings were identified based on the statistical results reported in the original studies. A descriptive cross-analysis was conducted to examine patterns of reported effects according to XR modality, neurological or neurodevelopmental condition, and ICF domain.

The synthesis focused on identifying the functional domains in which statistically significant improvements were reported and examining differences in the distribution of these findings across technologies and clinical populations.

Given the heterogeneity of study designs, participant characteristics, XR interventions, outcome measures, and assessment instruments, quantitative pooling was not considered appropriate. Therefore, no meta-analysis or pooled effect estimates were performed.

Findings were interpreted narratively, considering the variability of the available evidence and the limitations associated with comparing outcomes across heterogeneous studies.

Subgroup analysis Descriptive subgroup analyses were conducted to explore patterns of therapeutic outcomes across different extended reality (XR) technologies and neurological or neurodevelopmental conditions.

Studies were grouped according to XR modality, including non-immersive virtual reality, immersive virtual reality, augmented reality, and mixed reality, and according to the neurological or neurodevelopmental condition of the participants.

Within these subgroups, reported intervention outcomes were classified according to the International Classification of Functioning, Disability and Health (ICF), distinguishing between Body Functions (b1–b8) and Activities and Participation (d1–d9).

The analyses examined the distribution of statistically significant ($p < 0.05$) and non-significant findings across XR modalities, clinical conditions, and ICF domains, aiming to identify patterns and differences in the reported therapeutic outcomes.

Given the heterogeneity of the included studies and the absence of a meta-analysis, subgroup comparisons were descriptive and exploratory. No pooled subgroup effect estimates or formal statistical tests of differences between subgroups were performed.

Sensitivity analysis No formal sensitivity analyses were conducted in this systematic review. Given the heterogeneity of the included studies in terms of study design, participant characteristics, neurological or neurodevelopmental conditions, extended reality (XR) interventions, and outcome measures, a descriptive and narrative synthesis was performed without meta-analysis.

Consequently, no sensitivity analyses involving the exclusion of studies based on methodological quality, risk of bias, study design, or other methodological characteristics were undertaken.

The findings were interpreted considering the heterogeneity of the available evidence and the

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potential influence of methodological differences across studies on the reported therapeutic outcomes.

Country(ies) involved Chile. All authors involved in this systematic review are based in Chile and are affiliated with Chilean academic institutions.

Keywords Extended Reality; Virtual Reality; Augmented Reality; Mixed Reality; Pediatric Neurorehabilitation; Neurological and Neurodevelopmental Disorders; International Classification of Functioning, Disability and.

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