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A scoping review of play and exploratory behaviours in preterm infants and their impact on developmental outcomes

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Abstract
Play and exploratory behaviour are essential for early learning, cognitive growth, and sensorimotor development. Preterm infants, born before 37 weeks of gestation, are at higher risk for delayed or altered development due to neurophysiological immaturity and limited early experiences. Despite its importance, there remains limited synthesized evidence on the types, patterns, and developmental aspects of play behaviour in preterm infants.
Objective: To map existing evidence on the nature, development, assessment, and outcomes of play and exploratory behaviours in preterm infants during the first year of life, including potential interventions aimed at enhancing such behaviours.
Methods: Articles were searched on PUBMED, Google Scholar, Research Gate, CINAHL using the following search terms Play, preterm, NICU, play behaviour, sensorimotor, play exploration. The inclusion criteria were: a) Full-text articles are included b) Articles published in English c) Preterm infants less than or equal to 37 weeks gestational age in NICU settings d) Focused on play, exploration, or related behaviours. The following articles were excluded: a) Systematic reviews, b) Case reports, and c) Medical intervention d) Studies involving full term infant.
Results: Out of 140 articles reviewed seven met the inclusion criteria which investigates play, exploratory behaviour, or related developmental constructs in preterm infants. Research highlights that play plays a crucial role in normalizing the NICU experience strengthening parent-infant bonding, and supporting emotional, social, and cognitive development. Purposeful sensory stimulation such as tactile, auditory, and visual input further contributes to improved physical growth, enhanced motor skills, and emotional well-being in neonates. It also helps reduce stress and fosters secure attachment.
Conclusion: This scoping review provides a foundational understanding of the current landscape of research on play and exploratory behaviour in preterm infants in the NICU. More detail extensive research is required for understanding further advantages in starting play intervention in NICU.

Keywords: Play, preterm, NICU, play behaviour, sensorimotor, play exploration

Introduction
Preterm infants admitted to Neonatal Intensive Care Units (NICUs) experience an environment that is markedly different from the womb. They are exposed to painful medical procedures, bright lights, unpredictable sounds, and long periods of separation from parents, all of which can affect their neurodevelopment, stress regulation, and bonding. Preterm infants, especially those born before 37 weeks of gestation, are at increased risk for delayed or altered development of these behaviours due to neurophysiological immaturity and limited early sensorimotor experiences [1].
Increasingly, researchers and clinicians have emphasized the role of play and play-related interventions as potential mediators of developmental outcomes in the NICU. Play and exploratory behaviour are foundational for early learning, cognitive development, and sensorimotor integration in infancy. Play is conceptualized not merely as recreation but as a developmentally essential form of interaction and stimulation. In neonatology, play encompasses sensorimotor, auditory, visual, tactile, kinesthetic, and relational activities that can be safely adapted for medically fragile infants. Play is increasingly recognized as a therapeutic tool that fosters neuroplasticity, stress regulation, parent-infant bonding, and acquisition of early functional skills [1].

Despite growing recognition of the importance of early play, there is a lack of synthesized evidence mapping the types, patterns, and developmental correlates of play behaviours in preterm infants.

Methodology

This is a scoping review, carried out in a tertiary care hospital provide a foundational understanding of the current landscape of research on play and exploratory behaviour in preterm infants in the NICU. The inclusion criteria include full-text articles published in English within the last 15 years that focus on preterm infants (≤37 weeks gestational age) admitted to NICU settings and explore aspects related to play, exploration, or similar behaviours. The exclusion criteria include case reports, dissertations, and conference abstracts and studies that focus exclusively on full-term infants or are systematic reviews.

The search strategy involves systematically identifying and retrieving relevant articles from multiple databases, including PubMed, Google Scholar, ResearchGate, and CINAHL. The following key terms were used to search the articles: play, preterm, NICU, play behaviour, sensorimotor, play exploration. Articles containing these words anywhere in the article were reviewed. A search filter was applied to include only studies published within the last 15 years. Since the review aimed to explore the role of play and play-related interventions in the NICU, only articles that examined play, sensory stimulation, or developmental care as interventions and reported infant developmental, sensory, or neurobehavioral outcomes were included. The selection of studies was carried out in two phases. First, titles and abstracts were screened for relevance. Next, the full text of potentially eligible articles was reviewed based on the inclusion criteria.

Results

Out of 140 articles, 7 articles that met the inclusion criteria were added to the scoping review. Fig 1: Flowchart of the articles reviewed for the study

The flowchart depicts the systematic search and screening of articles across various databases using predefined keywords. Studies published in the last 15 years were reviewed, and after applying inclusion and exclusion criteria, seven articles were finalized for the review.

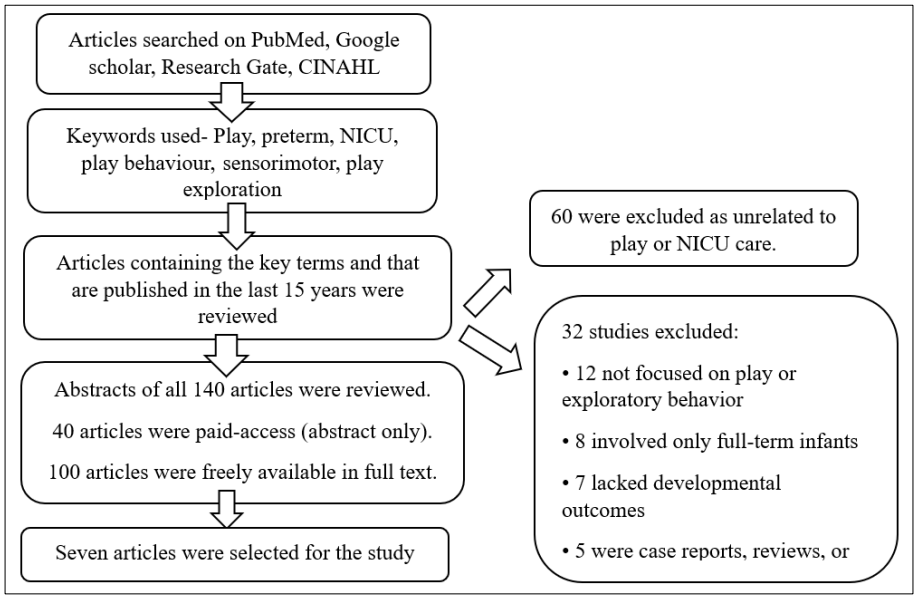

Fig 1: Represents the summary of all the articles included in the review.

Table 1: Summary table of the reviewed research articles.

Sr. No.	Title	Author/Year	Intervention	Type of Play/Stimulus	Population	Outcomes	Key Findings
1	Hugsy: A Comforting Solution for Preterm Neonates Designed to Enhance Parent-Child	Claes *et al*. (2017) [2]	Hugsy device	Multisensory (heartbeat, smell, touch)	Preterm infants in NICU	Stress, bonding, comfort	Improved comfort, simulated kangaroo care, enhanced parent-infant bonding
2	Effect of Crochet Octopus on Physiological Parameters and Comfort Level among Preterm Infants	El-Farrash *et al*. (2023) [3]	Crochet Octopus	Tactile/comfort device (tentacles mimic umbilical cord)	Preterm infants in NICU	Respiratory rate, heart rate, comfort scale	Improved physiological stability and comfort; no major effect on SpO_2 or temperature
3	Heartbeat Nest: A Sensory Device to Support Preterm Infants in the NICU	EL-Ghany *et al*. (2023) [4]	Heartbeat nest	Use of a soft "nest" embedding a recorded maternal heartbeat and gentle vibrations, placed around the infant during rest periods	6 preterm infants (32-34 weeks GA)	Improved Self-regulation and physiological stability	Enhanced physiological stability (heart rate, respiratory rate), longer calm-alert states, and reduced behavioral signs of stress
4	Music therapy enhances preterm infant's signs	Palazzi *et al*. (2021) [5]	MUSIP (music therapy)	Maternal singing, vocal play	30 mother-infant dyads	Engagement (eye opening,	Music therapy increased infant alertness and

	of engagement and sustains maternal singing in the NICU					smiling), maternal singing	sustained maternal singing
5	A Pacifier-Activated Music Player With Mother's Voice Improves Oral Feeding in Preterm Infants	Maitre *et al*. (2014) [6]	Pacifier-Activated Music Player (PAM)	Operant conditioning with maternal voice	94 preterm infants (34-35 weeks PMA)	Feeding skills, oral intake, time-to-full feeds	PAM group had faster feeding acquisition, higher intake, shorter tube feeding
6	Effects of Early Intervention on Visual Function in Preterm Infants: A Randomized Controlled Trial	Fontana *et al*. (2020) [7]	Multisensory stimulation	Multisensory (infant massage, visual interaction, parental training)	57 very preterm infants (25-29 weeks GA)	Visual maturation	EI group showed significantly better visual outcomes at term equivalent age
7	Visual stimulation in the neonatal and paediatric intensive care	Aguiar *et al*. (2023) [8]	Visual Stimulation Kit	High-contrast black-white patterns	Infants with prolonged NICU stays	Visual function, prevention of delayed visual maturation	Kit provided environmental enrichment, supporting visual development

Discussion

This scoping review aims to provide a foundational understanding of the current landscape of research on play and exploratory behaviour in preterm infants in the NICU.

In neonatology, play encompasses sensorimotor aspect the auditory, visual, tactile, kinesthetic, and relational activities that can be safely adapted for medically fragile infants.

Play is increasingly recognized as a therapeutic tool that fosters neuroplasticity, stress regulation, parent infant bonding, and acquisition of early functional skills [1].

Sensory Play Sensory-based interventions such as kangaroo care, infant massage, and tactile containment provide preterm infants with patterned, predictable input resembling intrauterine experiences.

Devices like Hugsy, Claes *et al*. (2017) replicate aspects of skin-to-skin care by embedding maternal smell, heartbeat, and warmth, thereby reducing infant stress and promoting bonding. It is a supportive tool that enhances Kangaroo Care and nurtures infant comfort inside the incubator. It combines a soft swaddling blanket, positioning pillows, and a heartbeat recording-and-playback module to recreate the reassuring sensations of a parent's embrace. During Kangaroo Care, the blanket keeps the baby warm during transfers, doubles as a wrap for skin-to-skin holding, and absorbs the parent's scent. A pulse sensor records the parent's heartbeat, which can later be gently played back through a small vibrating speaker placed beneath the baby. When the infant is returned to the incubator, the scented blanket and positioning pillows help maintain a womb-like posture, while the rhythmic heartbeat playback provides soothing sound and vibration. By integrating several non-pharmacological strategies such as skin-to-skin contact, swaddling, facilitated tucking, heartbeat sound and vibration, and aromatherapy Hugsy offers a comforting environment that promotes emotional and physiological well-being [2].

The crochet octopus is a soft, hand-made toy introduced into NICU care to provide comfort to preterm infants. Its tentacles resemble the umbilical cord, offering a familiar and secure tactile experience that mimics the intrauterine environment. In the study by El-Farrash *et al*. (2023), preterm infants given a crochet octopus showed significant improvements in physiological stability, including lower respiratory and heart rates. Comfort levels are also improved, with infants demonstrating calmer states and reduced signs of distress. However, no significant changes were observed in oxygen saturation or body temperature. The findings suggest that the crochet octopus serves as a simple, low-cost, and non-pharmacological developmental care tool that enhances comfort and stability, complementing other sensory and play-based 9interventions used in the NICU [3].

Similarly in a study by Abd ElGhany (2023) Findings revealed significant improvements in the study group's physiological stability, with lower heart and respiratory rates and higher oxygen saturation. Infants also showed higher comfort levels and reduced pain scores post-intervention (p<0.001). The heartbeat nest effectively mimicked the intrauterine environment, promoting relaxation, comfort, and physiological regulation. The researchers concluded that integrating such non-pharmacological, developmental care interventions in NICUs can enhance preterm infants' comfort and reduce distress [4].

Auditory and Vocal Play the auditory domain has been extensively studied, as preterm infants are responsive to parental voice and rhythm. The MUSIP study, Palazzi *et al*. (2023) explored the effects of maternal singing to preterm infants in the NICU. Mothers were encouraged to sing lullabies or soft, rhythmic melodies during caregiving. This intervention promoted positive infant behaviors such as eye opening, smiling, and calm alert states-and supported maternal well-being, helping reduce anxiety and enhance emotional connection with their babies. The study emphasized the therapeutic value of music as a simple, non-invasive strategy to encourage bonding and regulate infant behaviour in the NICU environment [5].

Studies also highlight the importance of olfactory stimulation, as exposure to maternal scent has been linked with improved physiologic regulation and early feeding behaviours [5].

Similarly, the Pacifier-Activated Music Player (PAM) that delivers the mother's voice as positive reinforcement has demonstrated efficacy in accelerating oral feeding skills and reducing dependence on tube feeding. This operant conditioning approach reinforces oral-motor skills and motivates infants to coordinate sucking, swallowing, and breathing. In Maitre *et al*.'s (2014**)** trial, preterm infants exposed to the PAM showed faster acquisition of oral feeding, earlier transition from tube to independent feeding, and shorter hospital stays. The study highlighted that early exposure to the maternal voice via the PAM not only improved feeding competence but also strengthened the infant-mother bond. By using voice into a structured, emotionally meaningful activity, the auditory stimulation operates as an interactive form of play, fostering bonding, sensory regulation, and early social engagement [6].

Visual Play and Environmental Enrichment Visual development in preterm infants is often compromised due to delayed maturation and sensory deprivation in NICUs. Studies demonstrate that targeted visual stimulation, including high-contrast black-and-white patterns and structured parent-infant visual interaction, enhances cortical visual responses.

Fontana *et al*. (2020) evaluated an early intervention program for very preterm infants, delivered from soon after birth until term-equivalent age. The program combined infant massage, guided visual engagement, and structured parental training aimed at enhancing sensory and relational input. Infants who received the intervention showed significantly better visual function at term-equivalent age compared with controls. The authors highlighted that gentle visual tracking exercises and parent-infant interaction created opportunities for visual play, supporting maturation of ocular motor and attentional systems during a critical developmental window [7].

Aguiar *et al*. (2023) designed visual stimulation kits including high-contrast patterns, light-reflective materials, and simple tracking tools for use in NICU and PICU settings. Their study demonstrated that these kits were feasible, safe, and effective in stimulating infants with prolonged hospital stays, helping to prevent or mitigate delayed visual maturation (DVM). The intervention encouraged caregivers to introduce visual play sessions adapted to each infant's tolerance, promoting early engagement with the visual environment while respecting medical fragility. This approach recognized that even fragile infants benefit from structured visual play, encouraging them to experiment with focus, tracking also nurturing visual curiosity, attention, and early social connection [8].

In conclusion, these findings establish play as a multidimensional construct in NICU care, encompassing sensory, auditory, visual, technological, and specialist-facilitated domains. The evidence highlights that play plays a crucial role in normalizing the NICU experience, strengthening parent-infant bonding, and supporting emotional, social, and cognitive development. Purposeful sensory stimulation, including tactile, auditory, and visual input, contributes to improved physical growth, enhanced motor skills, and emotional well-being in neonates, while also reducing stress and fostering secure attachment. Visual stimulation nurtures infants' awareness of their surroundings, supports focus and tracking, and strengthens early bonds with caregivers, as opportunities to observe faces, explore shapes, and follow movement foster curiosity and lay the groundwork for visual attention and perception. Olfactory stimulation builds familiarity and security by helping infants recognize comforting scents, particularly of the mother, forming early associations that support memory and emotional stability. Auditory stimulation shapes early communication pathways, encouraging calmness, attentiveness, and social connection while supporting the rhythmic patterns needed for later language skills. Tactile stimulation refines body awareness and sensory integration, fostering comfort, self-regulation, and the foundations of coordinated movement. Vestibular and kinesthetic stimulation cultivates balance, spatial orientation, and postural control, preparing infants for smooth motor coordination and active engagement with their environment.

This scoping review provides a foundational understanding of the current landscape of research on play and exploratory behaviour in preterm infants in the NICU. However, the study has certain limitations, including the exclusion of paid-access articles, the absence of a meta-analysis, and the limited availability of relevant research sources, which may have restricted the comprehensiveness of the findings. Therefore, more detailed and extensive research is required to further understand the potential advantages of initiating play interventions in the NICU, with future studies recommended to include paid articles and consider the socioeconomic factors of the population.

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