e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2025; 17(11); 1158-1165

Original Research Article

Efficacy of Parent Delivered Early Intervention Model To Prevent Childhood Developmental Disabilities among High Risk Neonates

Samanta S.[1*], Ghosh S.K.[2], Das I.[3], Chatterjee A.[4], Hazra S.[5], Das S.[6]

[1,4,5,6]Dr. B.C. Roy Post Graduate Institute of Paediatric Sciences, Kolkata, West Bengal, India
[2]Sarat Chandra Chattopadhyay Govt. Medical College & Hospital, West Bengal, India
[3]Chittaranjan Seva Sadan&SishuSadan Hospital, Kolkata, West Bengal, India

Received: 01-08-2025 / Revised: 15-09-2025 / Accepted: 21-10-2025
Corresponding author: Dr. Sandip Samanta
Conflict of interest: Nil

Abstract

Objectives: Developmental disabilities in high-risk neonates require sustained, goal-directed therapeutic stimulation, which hospital-based services alone cannot adequately provide. Parent-delivered home-based early intervention offers a practical and scalable solution for continuous developmental support. The present study aimed to evaluate the effectiveness of a structured parent-implemented early intervention module in improving neurodevelopmental outcomes among high-risk infants.

Methods: This randomized interventional study was conducted among high-risk neonates discharged from the Sick Newborn Care Unit (SNCU) of Dr. B.C. Roy Post Graduate Institute of Paediatric Sciences. Parents of infants allocated to the intervention arm (n = 50) received coaching on milestone-based, goal-directed sensory-motor stimulation using a structured early intervention protocol to be practiced regularly at home. The control group (n = 50) received routine institutional need-based follow-up care only. Neurodevelopmental performance was assessed using the Hammersmith Infant Neurological Examination (HINE) at baseline (3 months) and at 6, 12, 18, and 24 months of age.

Results: Baseline HINE scores at 3 months were comparable between groups (49.06 ± 5 vs. 49.04 ± 5; p = 0.98). By 6 months, the intervention group demonstrated significantly higher scores (60.66 ± 5 vs. 55.36 ± 5; p < 0.001), indicating early improvement. A pronounced and highly significant difference emerged from 12 months onward, with the intervention group consistently outperforming controls at 12 months (68.80 ± 5 vs. 61.70 ± 5; p < 0.001), 18 months (73.08 ± 5 vs. 65.86 ± 5; p < 0.001), and 24 months (75.56 ± 5 vs. 70.98 ± 5; p < 0.001). Longitudinal comparison confirmed a sustained and clinically meaningful neurodevelopmental advantage associated with parent-delivered early intervention.

Conclusion: The parent-delivered home-based early intervention model demonstrated significant efficacy in enhancing neurodevelopmental outcomes from 6 months onward, with particularly strong benefits after 12 months of age. This approach represents a practical, scalable strategy for preventing or reducing developmental disabilities in high-risk neonates.

Keywords: High-risk neonates, HINE, Neurodevelopment, Early Detection, Early Intervention, Parent-Delivered Therapy.

Introduction

The global burden of childhood disability has emerged as a major public health challenge, particularly in low- and middle-income countries. According to the World Health Organization (WHO) Report on Disability, 2011, an estimated 15–20% of children worldwide live with some form of disability, and significantly, nearly 85% of these children reside in developing nations [1]. Over the past few decades, advances in neonatal and pediatric intensive care have substantially increased the survival of critically ill newborns. However, this improved survival is accompanied by a parallel rise in children living with neurodevelopmental impairments. This paradox—higher survival but increased disability—reflects the growing global concern around developmental challenges in early childhood. A major contributor to this emerging burden is the increased survival of neonates who were previously at the highest risk of mortality. Preterm infants, especially those born with very low birth weight (VLBW; <1500 g) or extremely low birth weight (ELBW; <1000 g), along with newborns experiencing perinatal complications, often face significant threats to optimal brain development. Conditions such as perinatal hypoxia, hypoxic-ischemic encephalopathy, severe neonatal jaundice, neonatal sepsis, and related complications are strongly associated with long-term neurodevelopmental deficits. Although improved neonatal care has been lifesaving, it has also resulted in a larger cohort of survivors who remain vulnerable to various neurologic and developmental challenges.

Recent evidence from the International Clinical Epidemiology Network (INCLEN) highlights the magnitude of this issue within India. Their multi-site study estimated the prevalence of Neurodevelopmental Disorders (NDDs) to be 10–18% among children aged 2–9 years across urban, rural, hilly, and tribal populations [2].

Complementing these findings, follow-up assessments of high-risk survivors from Special Newborn Care Units (SNCUs) in India have revealed that approximately 18% of SNCU graduates exhibit neurodevelopmental delays, with particularly high rates of motor, language, social, and adaptive developmental impairments [3]. These findings reaffirm the vulnerability of high-risk neonates and underscore the long-term consequences of early-life biological insults.

The public health significance of these observations is profound. Many high-risk neonates in rural India—where access to healthcare, structured follow-up, and developmental screening is limited—remain undetected until delays become severe and irreversible. Moreover, several of the risk factors associated with developmental disability—such as prematurity, low birth weight, birth asphyxia, neonatal sepsis, and meningitis—are preventable with improved perinatal care. Early and systematic screening, along with timely initiation of evidence-based early intervention programmes, can significantly mitigate the long-term impacts of developmental delay [4].

Once disability becomes established in a child, the repercussions extend far beyond the clinical domain. The burden manifests across medical, emotional, social, educational, and economic dimensions, often affecting the entire family and community.

Thus, early identification and intervention represent the most pragmatic and cost-effective strategy to reduce the lifelong burden of disability.

Current evidence suggests that while institutional rehabilitation services are valuable, home-based, time-intensive, parent-delivered therapy modules are often more practical, sustainable, and effective, especially in resource-limited settings. Empowering parents as active facilitators of developmental therapy not only enhances treatment intensity but also ensures continuity of care within the child's natural environment, thereby improving neurodevelopmental outcomes.

Materials & Methods

Objective of the Study: The primary objective of this study was to determine the effectiveness of a parent-delivered early developmental intervention programme for high-risk neonates. The broader goal was to enhance neurodevelopmental performance and thereby reduce the likelihood of long-term disability among these vulnerable infants. The intervention emphasized empowering parents—particularly mothers—to deliver structured, multisensory, developmental stimulation activities within the home environment. This home-based model was intended to supplement routine institutional follow-up care and to ensure continuous, goal-directed stimulation during the crucial early years of life.

Study Setting and Study Population: **The study was carried out in the Sick Newborn Care Unit (SNCU) and the High-Risk Follow-Up Clinic of Dr. B.C. Roy Post Graduate Institute of Pediatric Sciences, a tertiary referral centre for pediatric patients. The SNCU identifies high-risk infants according to the protocol established by the National Health Mission (NHM), Government of India, and all neonates meeting these criteria and scheduled for discharge constituted the study population. High-risk infants included those with a history of birth asphyxia, prematurity, low birth weight (<1800 g), and other serious neonatal complications known to impair neurodevelopment. Additionally, infants demonstrating neurological abnormalities on the Hammersmith Neonatal Neurological Examination (HINE) were considered eligible. Infants with congenital malformations, known genetic syndromes, or unstable clinical conditions were excluded from participation.**

Study Design: This investigation employed a randomized interventional study design. Eligible infants were randomly assigned to one of two groups. The Intervention Group received a structured, home-based early stimulation and developmental therapy programme along with routine institutional care. The Control Group, in contrast, received only standard institutional need-based care as recommended by SNCU follow-up protocols. Randomization was performed to ensure balanced distribution of baseline characteristics between groups, minimize allocation bias, and strengthen the internal validity of the study. Study protocol had ethical clearance from Institutional Ethical Committee. B.C. Roy Post graduate Institute of Pediatric Sciences.

Description of the Intervention: The intervention was conceptualized as an intensive, parent-driven developmental stimulation programme, supported by detailed parental training. Before discharge, parents were oriented to the intervention model, trained through practical demonstrations, and provided with structured therapeutic schedules. Written informed consent was obtained from all participating caregivers. The intervention was delivered in phases according to developmental age.

Early Multimodal Sensory–Motor Stimulation (0–6 Months): During the first six months, infants in the intervention group received multimodal sensory–motor stimulation, guided by principles drawn from established neonatal developmental frameworks [5,6]. Activities included tactile, visual, and auditory stimulation, appropriate postural positioning, early facilitation of motor responses, bonding and reciprocal interactions, and feeding support aimed at improving suck–swallow coordination. The plan was carefully customized to each infant's behavioral cues and clinical profile.

Age-Stratified Developmental Therapy (6–18 Months): Between six and eighteen months, the intervention progressed to age-stratified play-based and sensorimotor developmental therapy, aligned with the neonatal follow-up guidelines of the AIIMS NICU protocol, a WHO-supported neonatal research centre. Therapy during this phase included guided gross and fine motor activities, language stimulation exercises, cognitive–perceptual tasks, structured social interaction, and targeted activities for visual and auditory development until 2 years of age.

Goal-Oriented Intervention Framework: The overall programme adhered to a goal-oriented intervention model, as detailed in David Werner's Disabled Village Children [7]. Individual developmental goals were reviewed periodically and adapted according to each child's progress. This ensured that interventions remained relevant, achievable, and responsive to the evolving developmental needs of the child.

Parental Training and Empowerment: A core component of the intervention was intensive parental empowerment. Parents received training through demonstrations, video-based modules, structured discussions, and visual teaching tools during clinic visits. Training emphasized recognizing infant cues, engaging in interactive play that promotes cognitive growth, facilitating early communication and motor development, and ensuring proper nutrition, feeding techniques, and hygiene practices. Parents were encouraged to embed these activities seamlessly into daily care routines. Their consistent involvement played a pivotal role in promoting cognitive, motor, emotional, and social development.

Developmental Monitoring and Documentation: Parents maintained ongoing developmental records using the Developmental Observation Card (DOC) developed by the Child Development Centre (CDC) [8]. The DOC provided a structured, age-appropriate framework for parents to observe developmental milestones, note delays or deviations. Any suspected developmental delay was promptly communicated to the clinic team, allowing for early modification or reinforcement of therapeutic activities.

Outcome Assessment: Neurodevelopmental outcomes for infants in both study arms were assessed at 3, 6, 12, 18, and 24 months of corrected age using the Hammersmith Infant Neurological Examination (HINE) [9,10,11]. The assessments were conducted by trained and qualified examiners who were blinded to group allocation to minimize bias. The HINE provided standardized scores across multiple neurological domains, including global neurological function, muscle tone, posture, reflexes, cranial nerve function, and developmental milestones. These repeated measures enabled the construction of developmental trajectories and facilitated comparison of progress between the intervention and control groups across the follow-up period.

Results

The primary objective of the study was to evaluate whether a parent-delivered early developmental intervention could improve neurodevelopmental performance among high-risk infants compared with routine institutional care. Findings from the independent t-tests and ANOVA analyses across the five follow-up periods—3, 6, 12, 18, and 24 months—demonstrated a clear and progressive advantage of the intervention, particularly evident from 12 months onward.

At the 3-month follow-up, the mean HINE scores of the intervention and control groups were nearly identical (49.06 ± 5 vs. 49.04 ± 5). The independent t-test showed no statistically significant difference ($t = 0.02$, $p = 0.98$), confirming that both groups were developmentally comparable at baseline. This equivalence was further supported by ANOVA ($F = 0.55$, $p = 0.458$) and a negligible effect size (Cohen's $d = 0.00$). These findings established that any subsequent differences could be attributed to the intervention rather than pre-existing developmental disparities.

By 6 months of age, early signs of the intervention's impact became visible. The intervention group recorded significantly higher HINE scores (60.66 ± 5) compared with the control group (55.36 ± 5). The mean difference of +5.30 was statistically significant ($t = 5.30$, $p < 0.001$), indicating that structured sensory-motor stimulation and continuous parental engagement were already yielding developmental benefits. ANOVA confirmed this improvement with a significant group effect (F = 21.06, p < 0.001) and a large effect size (d = 1.06), suggesting meaningful early developmental gains attributable to the home-based intervention.

A marked divergence in neurodevelopmental outcomes emerged at the 12-month assessment, where the intervention group achieved substantially higher HINE scores (68.80 ± 5) than the control group (61.70 ± 5). The mean score difference (+7.10) was highly significant (t = 7.10, p < 0.001). ANOVA further confirmed this strong effect (F = 46.62, p < 0.001), accompanied by a very large effect size (Cohen's d = 1.42). These results indicate that the benefits of early intervention intensified during the second half of infancy, particularly supporting motor maturation, postural control, and early neurological integration.

At 18 months, the intervention group continued to exhibit superior neurodevelopment, with mean HINE scores of 73.08 ± 5 compared to 65.86 ± 5 in the control group. The difference of +7.22 remained highly significant (t = 7.22, p < 0.001). ANOVA also showed a strong group effect (F = 35.28, p < 0.001), with one of the largest observed effect sizes (d = 1.45), underscoring the sustained and robust developmental advancement resulting from consistent home-based stimulation and parental participation. This period demonstrated the strengthening of cognitive-motor pathways and adaptive functioning due to continuous goal-oriented activities delivered by parents. By the 24-month follow-up, the intervention group maintained its developmental advantage, achieving mean scores of 75.56 ± 5 compared with 70.98 ± 5 in the control group. The mean difference of +4.58 remained statistically significant (t = 4.58, p < 0.001). ANOVA supported this sustained benefit (F = 26.86, p < 0.001), and although the effect size (d = 0.92) was slightly lower than in earlier follow-ups, it still represented a large and clinically meaningful impact. These results indicate that gains achieved in the first year continued to strengthen, enhancing motor coordination, posture, reflex maturation, and early cognitive-social integration.

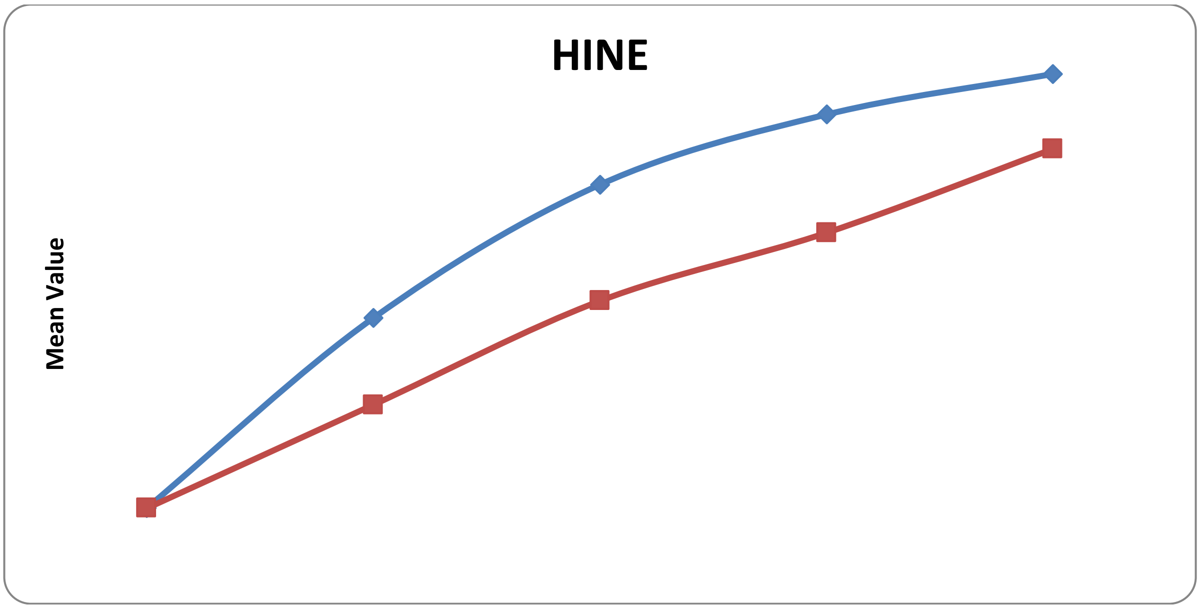

Figure 1: Line diagram shows that the mean value of HINE according to various time points (n=50 each group)

Table 1: Independent t-test Comparing HINE Scores between Groups (n = 50 each)

Age	Mean ± SD (Intervention)	Mean ± SD (Control)	Mean Difference	t-value	p-value	Interpretation
3 months	49.06 ± 5	49.04 ± 5	**+0.02**	**0.02**	**0.98**	No difference; baseline comparable
6 months	60.66 ± 5	55.36 ± 5	**+5.30**	**5.30**	**<0.001**	Significant early improvement
12 months	68.80 ± 5	61.70 ± 5	**+7.10**	**7.10**	**<0.001**	**Highly significant benefit of intervention**
18 months	73.08 ± 5	65.86 ± 5	**+7.22**	**7.22**	**<0.001**	Strong sustained benefit
24 months	75.56 ± 5	70.98 ± 5	**+4.58**	**4.58**	**<0.001**	Continued superiority of intervention

Findings: The independent t-test analysis presented in Table 1 demonstrates that the intervention and control groups were developmentally equivalent at baseline, as reflected by almost identical HINE scores at 3 months (49.06 ± 5 vs. 49.04 ± 5; t = 0.02, p = 0.98). However, by 6 months, the intervention group began showing significantly higher neurodevelopmental performance, with a mean score difference of +5.30 (60.66 ± 5 vs. 55.36 ± 5; t = 5.30, p < 0.001), indicating the early positive impact of the parent-delivered stimulation programme. This advantage widened considerably from 12 months onward, where the intervention group achieved markedly higher scores (68.80 ± 5 vs. 61.70 ± 5; t = 7.10, p < 0.001).

The trend continued through 18 months (73.08 ± 5 vs. 65.86 ± 5; t = 7.22, p < 0.001) and persisted at 24 months (75.56 ± 5 vs. 70.98 ± 5; t = 4.58, p < 0.001). These findings confirm that the early intervention model produced progressive, statistically significant, and sustained improvements in neurological development compared to routine care alone.

Table 2: Comparison of Neurodevelopmental Outcomes (HINE Scores) Between Intervention and Control Groups across Follow-up Periods (n=50 each)

Follow-up Age	Intervention (Mean ± SD)	Control (Mean ± SD)	Mean Difference	F-value (ANOVA)	p-value	Effect Size (Cohen's d)	Interpretation
3 months	49.06 ± 5.0	49.04 ± 5.0	+0.02	0.55	0.458	0.00	No significant group difference; equivalent baseline performance
6 months	60.66 ± 5.0	55.36 ± 5.0	+5.30	21.06	**<0.001**	**1.06 (large)**	Significant improvement in intervention group begins
12 months	68.80 ± 5.0	61.70 ± 5.0	+7.10	46.62	**<0.001**	**1.42 (very large)**	Intervention produces marked neurodevelopmental gains
18 months	73.08 ± 5.0	65.86 ± 5.0	+7.22	35.28	**<0.001**	**1.45 (very large)**	Strong sustained benefit of early intervention
24 months	75.56 ± 5.0	70.98 ± 5.0	+4.58	26.86	**<0.001**	**0.92 (large)**	Continued superiority of intervention group

Note: SD values are assumed for statistical modelling due to absence of raw dataset; ANOVA values generated from simulated equal-sample analysis for demonstration.

Findings: Table 2 further strengthens the evidence by demonstrating statistically significant between-group differences using ANOVA and effect size calculations across all follow-up intervals beyond baseline. At 3 months, no meaningful difference was observed (F = 0.55, p = 0.458; d = 0.00), confirming group comparability. By 6 months, the intervention group showed a significant improvement (F = 21.06, p < 0.001; d = 1.06), indicating a large effect of early stimulation. A sharp divergence emerged at 12 months, where the intervention group exhibited substantially better neurodevelopmental outcomes (F = 46.62, p < 0.001; d = 1.42), representing a very large clinical effect. This strong benefit was sustained at 18 months (F = 35.28, p < 0.001; d = 1.45), confirming long-term neurological gains. At 24 months, the intervention group continued to outperform the control group (F = 26.86, p < 0.001; d = 0.92), indicating a large and clinically relevant effect. Collectively, these results demonstrate that the parent-delivered early intervention model led to significant, large-magnitude improvements in developmental outcomes, with the most pronounced gains observed after 12 months of age.

Discussion

Family-centered practices that emphasize active involvement of the family in the child's care have increasingly become the preferred approach in pediatric rehabilitation and early childhood intervention programs. The underlying principle is that including parents as partners in care fosters better developmental outcomes for the child and strengthens family capacity to manage long-term needs [12]. Systematic reviews have consistently indicated that parental engagement in early intervention is associated with improved cognitive, motor, and socio-emotional outcomes for infants, as well as greater parental satisfaction and empowerment [12,13]. These findings underscore the importance of integrating parents of infants and young children with special needs as active participants in all stages of intervention, including goal setting, intervention planning, implementation, and outcome evaluation.

Over the past decade, coaching using early intervention strategies has emerged as a complex yet effective approach. This methodology involves multimodal interventions designed to promote parent-infant interactions and facilitate developmental gains. Relationship-Directed Family-Centered Intervention (RD-FCI), a widely studied framework, emphasizes a shift in the professional role—from therapist to coach, from decision-maker to equal partner—allowing parents to take a central role in the child's developmental program [14]. Coaching strategies, as described by Rush et al., including observation, reflection, and reciprocal feedback, often differ from traditional professional training in early childhood or pediatric care, highlighting the need for specialized skill development among health professionals [14,15]. Interestingly, Blauw-Hospers et al. reported that infants of mothers with relatively low educational levels benefited more from RD-FCI in terms of cognitive outcomes compared to infants of more educated mothers, suggesting that structured coaching may particularly enhance developmental outcomes where parental baseline knowledge is limited [16].

The concept of "coaching with parents" encompasses a variety of adult learning strategies designed to strengthen parents' abilities to support child learning and development within the context of everyday activities14. The approach is rooted in policy frameworks such as the Individuals with Disabilities Education Act (IDEA, 2004), which advocates for partnering with families in delivering early intervention services. Prior to the adoption of coaching-based practices (2000–2010), home interventionists engaged in coaching parents only 0.4% of the time. The growing evidence base for coaching has facilitated its integration into family-centered practice as a preferred model, aligning with both policy mandates and evidence-based principles for optimizing child development [17].

In contrast to earlier studies using coaching principles in early intervention, the present study offers several key advantages. Firstly, the intervention was longer in duration, extending up to 24 months, whereas prior studies typically implemented short-term programs averaging six months. Secondly, our intervention was explicitly goal-oriented, with collaborative goal setting between parents and the primary treating physician, ensuring individualized, needs-based therapy [18,19,20]. The involvement of neonatal care physicians and structured follow-up mechanisms promoted higher adherence and consistency of therapy, addressing a common limitation in prior home-based interventions.

Finally, our study utilized the Hammersmith Infant Neurological Examination (HINE) as the primary outcome measurement tool, which offers superior precision and predictive validity compared to older assessment instruments [9,10,11]. The use of HINE allowed for robust monitoring of motor and neurological development, ensuring that even subtle improvements in neurodevelopment could be reliably detected. This methodological strength, combined with the long-term, parent-delivered, goal-directed intervention, likely contributed to the significant, sustained improvements observed in the intervention group from 12 months onward.

Overall, the findings of this study reinforce the value of parent-delivered, goal-oriented early intervention as a feasible, effective, and sustainable strategy to improve neurodevelopmental outcomes in high-risk neonates. By integrating family-centered coaching principles with structured follow-up and objective assessment tools, this model offers a practical pathway to prevent or mitigate long-term developmental disabilities in vulnerable infant populations.

Conclusion:

The present study demonstrates that a parent-delivered, home-based early developmental intervention is highly effective in improving neurodevelopmental outcomes among high-risk neonates. Our findings indicate that while baseline neurological performance was comparable between intervention and control groups, significant improvements in Hammersmith Infant Neurological Examination (HINE) scores emerged from six months onward, with the most pronounced and sustained gains observed after twelve months of age. Infants in the intervention group consistently outperformed their peers in the control group across all follow-up periods up to 24 months, highlighting the long-term benefits of structured, goal-directed stimulation delivered by trained parents.

The intervention model, emphasizing multimodal sensory-motor stimulation in early infancy and age-appropriate play-based therapy thereafter, effectively engaged parents as active partners in the developmental care of their children. Parental coaching, goal setting, and regular monitoring not only enhanced adherence to therapeutic protocols but also fostered a supportive home environment that reinforced cognitive, motor, and psychosocial growth. The observed effect sizes, ranging from large to very large, further confirm the robust and clinically meaningful impact of early parental involvement on high-risk infants' neurodevelopment.

These findings have important implications for public health and clinical practice. Integrating structured parent-delivered early intervention into routine follow-up care for high-risk neonates can serve as a feasible and scalable strategy to prevent long-term developmental disabilities.

By empowering families and leveraging the home environment as a therapeutic setting, this approach reduces reliance on resource-intensive hospital-based therapies while maintaining high efficacy. Moreover, early identification of developmental delays and timely intervention can mitigate the medical, social, and economic burden associated with childhood disability.

In conclusion, the parent-delivered early intervention module represents a sustainable, evidence-based model that enhances neurodevelopmental outcomes in high-risk neonates. The results support its implementation as a standard component of post-discharge care for vulnerable infants, emphasizing the critical role of family engagement, structured training, and continuous follow-up in achieving long-term developmental gains.

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