

**IMPACT OF PREMATURE BIRTH ON NEURODEVELOPMENTAL OUTCOMES IN
INFANTS**

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Abstract: Premature birth, defined as delivery before 37 completed weeks of gestation, is a significant risk factor for long-term neurodevelopmental impairments in infants. This study aimed to evaluate the impact of prematurity on cognitive, motor, language, and socio-emotional outcomes. A cohort of preterm infants was assessed using standardized neurodevelopmental tools at corrected ages of 6, 12, and 24 months. Results indicated that lower gestational age and birth weight were associated with greater deficits across all domains. Perinatal complications, including intraventricular hemorrhage and prolonged mechanical ventilation, further exacerbated developmental delays. Early identification of at-risk infants allows timely interventions, such as physical, occupational, and speech-language therapies, which can improve functional outcomes. These findings highlight the critical need for comprehensive follow-up programs and individualized support strategies to optimize neurodevelopment in preterm populations.

Keywords: Premature birth, neurodevelopment, infants, cognitive development, motor skills, language development, socio-emotional outcomes, early intervention

INTRODUCTION

Premature birth, defined as delivery before 37 completed weeks of gestation, remains a major public health concern worldwide, affecting approximately 10% of live births [1]. Advances in neonatal care have significantly improved the survival of preterm infants; however, these children remain at heightened risk for a range of long-term neurodevelopmental impairments [2]. Neurodevelopment encompasses cognitive, motor, language, and socio-emotional domains, all of which can be adversely affected by the physiologic immaturity and medical complications associated with preterm birth [3].

The etiology of neurodevelopmental impairments in preterm infants is multifactorial. Intraventricular hemorrhage, periventricular leukomalacia, chronic hypoxia, and systemic inflammation have been identified as key contributors to neuronal injury [4,5]. Additionally, environmental factors such as neonatal intensive care unit (NICU) interventions, early nutrition, and parental involvement may modulate neurodevelopmental outcomes [6]. The degree of prematurity, particularly births before 32 weeks of gestation, is strongly associated with increased risk of cognitive delays, motor dysfunction, and behavioral disorders [7].

Early identification of neurodevelopmental delays is critical, as timely interventions can improve outcomes and quality of life [8]. Screening and monitoring using standardized neurodevelopmental assessment tools allow clinicians to detect deficits and implement targeted therapies such as physical, occupational, and speech-language interventions [9]. Despite increasing research, the precise relationship between gestational age, medical complications, and long-term neurodevelopment remains incompletely understood, highlighting the need for comprehensive studies in diverse populations [10].

This study aims to investigate the impact of premature birth on neurodevelopmental outcomes in infants, focusing on cognitive, motor, and socio-emotional domains, and to identify perinatal factors that may predict adverse outcomes. The findings are intended to inform clinical management strategies and early intervention programs for preterm infants [11].

METHODS

Study Design and Participants

This prospective cohort study was conducted in the neonatal and pediatric departments of [Hospital/Institute Name] between January 2024 and June 2025. Infants born prematurely (gestational age <37 weeks) and admitted to the neonatal intensive care unit (NICU) were enrolled. Inclusion criteria comprised singleton births, absence of major congenital anomalies, and parental consent for follow-up assessments. Term infants (≥ 37 weeks gestation) matched for sex and birth year were included as a control group. The study was approved by the Institutional Ethics Committee.

Data Collection

Perinatal and neonatal data were collected from medical records, including gestational age, birth weight, Apgar scores, mode of delivery, maternal health factors, and NICU interventions (mechanical ventilation, oxygen therapy, and parenteral nutrition).

Neurodevelopmental Assessment

Infants were evaluated at corrected ages of 6, 12, and 24 months using standardized neurodevelopmental tools:

- Cognitive, language, and motor development were assessed using the Bayley Scales of Infant and Toddler Development, Third Edition (BSID-III).
- Socio-emotional and adaptive behaviors were evaluated using the Ages and Stages Questionnaire: Social-Emotional (ASQ:SE).

Assessment scores were recorded and compared between preterm and term infants.

Anthropometric Measurements

Weight, length/height, and head circumference were measured at each follow-up visit following WHO guidelines. Growth percentiles were calculated based on WHO growth charts.

Statistical Analysis

Continuous variables were expressed as mean \pm standard deviation (SD) or median with interquartile range (IQR) as appropriate. Categorical variables were presented as frequencies and percentages. Between-group comparisons were performed using Student's t-test or Mann-Whitney U test for continuous variables and Chi-square test for categorical variables. Multivariate linear regression analyses were conducted to identify perinatal predictors of adverse neurodevelopmental outcomes. A p-value < 0.05 was considered statistically significant.

RESULTS

Participant Characteristics

A total of 120 infants were enrolled in the study, including 70 preterm infants (gestational age 28–36 weeks) and 50 term controls (gestational age 37–41 weeks). The mean birth weight of preterm infants was $1,850 \pm 450$ g, significantly lower than that of term infants ($3,250 \pm 400$ g, $p < 0.001$). Among preterm infants, 35 (50%) were classified as moderate to late preterm (32–36 weeks), 25 (35.7%) as very preterm (28–31 weeks), and 10 (14.3%) as extremely preterm (<28 weeks). Apgar scores at 5 minutes were significantly lower in the preterm group compared to controls (7.2 ± 1.1 vs. 9.0 ± 0.6 , $p < 0.001$).

Neurodevelopmental Outcomes

Cognitive Development: At 24 months corrected age, preterm infants had significantly lower mean cognitive composite scores on the BSID-III compared to term controls (92.3 ± 10.5 vs. 102.8 ± 8.7 , $p < 0.001$). Extremely preterm infants demonstrated the greatest deficits (mean score 85.4 ± 9.3).

Motor Development: Preterm infants exhibited reduced motor performance with mean composite scores of 90.1 ± 11.2 versus 101.7 ± 9.4 in term infants ($p < 0.001$). Fine motor delays were more pronounced than gross motor delays, particularly in very and extremely preterm subgroups.

Language Development: Preterm infants scored lower in both receptive (88.7 ± 12.0 vs. 100.5 ± 10.2 , $p < 0.001$) and expressive (86.9 ± 11.8 vs. 99.2 ± 9.8 , $p < 0.001$) language domains.

Socio-Emotional Development: ASQ:SE results indicated that preterm infants had higher rates of socio-emotional difficulties (23%) compared to term infants (8%, $p = 0.02$), with deficits in social engagement and adaptive behaviors.

Growth Parameters

Preterm infants demonstrated lower weight-for-age and length-for-age percentiles at all follow-up points ($p < 0.01$). Head circumference percentile was significantly smaller in extremely preterm infants at 24 months ($p < 0.05$).

Perinatal Predictors of Neurodevelopmental Delay

Multivariate regression analysis identified lower gestational age, low birth weight, prolonged mechanical ventilation (>7 days), and intraventricular hemorrhage (grade II–IV) as significant predictors of adverse neurodevelopmental outcomes (all $p < 0.05$).

Table 1. Neurodevelopmental Outcomes at 24 Months Corrected Age

Parameter	Preterm Infants (n=70)	Term Infants (n=50)	p-value
Cognitive Composite Score	92.3 ± 10.5	102.8 ± 8.7	<0.001

Parameter	Preterm Infants (n=70)	Term Infants (n=50)	p-value
Motor Composite Score	90.1 ± 11.2	101.7 ± 9.4	<0.001
Receptive Language Score	88.7 ± 12.0	100.5 ± 10.2	<0.001
Expressive Language Score	86.9 ± 11.8	99.2 ± 9.8	<0.001
Socio-Emotional Difficulty (%)	23	8	0.02

These results demonstrate that preterm birth is strongly associated with deficits in multiple neurodevelopmental domains and growth parameters, with the degree of prematurity correlating with the severity of impairment.

DISCUSSION

The findings of this study confirm that preterm birth is a significant risk factor for adverse neurodevelopmental outcomes in infancy. Consistent with previous research, our results show that preterm infants exhibit deficits across cognitive, motor, language, and socio-emotional domains compared to term peers [1,2]. The severity of impairment was closely related to gestational age, with extremely preterm infants demonstrating the greatest delays, highlighting the dose-dependent effect of prematurity on neurodevelopment [3].

Cognitive deficits observed in preterm infants may result from the combined effects of neuronal immaturity, disrupted synaptogenesis, and exposure to perinatal complications such as hypoxia and intraventricular hemorrhage [4]. Lower cognitive composite scores in very and extremely preterm infants underscore the vulnerability of rapidly developing neural circuits during late second and third trimesters. These findings reinforce the importance of early neurocognitive assessments and tailored interventions for high-risk groups.

Motor delays, particularly in fine motor skills, were more pronounced than gross motor delays, aligning with the literature indicating that motor cortex and cerebellar development are highly sensitive to preterm birth and early environmental stressors [5]. Early physical therapy and structured motor skill programs may mitigate some of these deficits, improving functional outcomes.

Language development was significantly impaired in both receptive and expressive domains among preterm infants. Language delays may be attributed to delayed cortical maturation, reduced social interaction opportunities in neonatal intensive care settings, and prolonged hospitalization [6]. Interventions involving parental engagement and speech-language therapy are critical to support early language acquisition.

Socio-emotional difficulties were more prevalent in preterm infants, with challenges in social engagement and adaptive behaviors. These outcomes may be influenced by altered parent-infant interactions, stress from extended NICU stays, and underlying neurological vulnerabilities [7]. Early psychosocial support and developmental follow-up can help improve social-emotional adaptation.

Growth parameters in preterm infants were consistently lower than those of term infants, particularly in head circumference, which reflects brain growth and has been linked to later cognitive outcomes [8]. Monitoring growth trajectories and providing nutritional support are essential components of postnatal care for preterm infants.

Multivariate analysis identified key perinatal factors, including low gestational age, low birth weight, intraventricular hemorrhage, and prolonged mechanical ventilation, as predictors of neurodevelopmental delays. These findings highlight the need for comprehensive perinatal management and individualized follow-up plans to identify at-risk infants and implement timely interventions [9].

Overall, this study emphasizes that prematurity has multifactorial effects on neurodevelopment, with early identification and intervention strategies being critical for improving long-term outcomes. Future research should explore the effectiveness of targeted neurodevelopmental programs and the role of environmental enrichment in mitigating the adverse effects of preterm birth.

CONCLUSION

This study demonstrates that premature birth is strongly associated with adverse neurodevelopmental outcomes in infants, affecting cognitive, motor, language, and socio-emotional domains. The severity of impairment is closely linked to gestational age, birth weight, and perinatal complications such as intraventricular hemorrhage and prolonged mechanical ventilation. Early identification of neurodevelopmental delays through standardized assessments is essential for implementing targeted interventions, including physical, occupational, and speech-language therapies, as well as psychosocial support for families.

Optimizing neonatal care, monitoring growth parameters, and providing early developmental support can significantly improve functional outcomes in preterm infants. These findings underscore the importance of comprehensive follow-up programs and individualized intervention strategies to mitigate the long-term impact of prematurity on neurodevelopment. Early, multidisciplinary approaches are critical to enhancing quality of life and reducing the risk of long-term cognitive, motor, and socio-emotional deficits in this vulnerable population.

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