Research Article

Perinatal Exposure to Endocrine Disruptors and Infant Hormonal Developmental Abnormalities Risks

Dr. Parimala K[1] Dr. Poongulali M.D.S[2] Dr. Bhavani Ganapathy[3] Ms. Anusha K[4]

[1] Professor & HOD, Pharmacology, Meenakshi Medical College Hospital & Research Institute, Meenakshi Academy of Higher Education and Research, Enathur, Kanchipuram, Tamil Nadu 631552. Parim@maher.ac.in
[2]Assistant Professor, General Medicine, Meenakshi Medical College Hospital & Research Institute, Meenakshi Academy of Higher Education and Research, Enathur, Kanchipuram, Tamil Nadu 631552. poongulalimds@maher.ac.in
[3] Associate Professor, Department of Pharmacology, Meenakshi Ammal Dental College and Hospital, Meenakshi Academy of Higher Education and Research. ganapathy@maher.ac.in
[4]Lecturer, Meenakshi College of Pharmacy, Meenakshi Academy of Higher Education and Research. anushakpharmacy@maher.ac.in

Abstract

Background:

Endocrine-disrupting chemicals (EDCs) are environmental compounds capable of interfering with hormonal signaling pathways during critical periods of fetal and infant development. Common endocrine disruptors, including bisphenol A (BPA), phthalates, pesticides, and persistent organic pollutants, have been increasingly associated with adverse reproductive, metabolic, and neuroendocrine outcomes. Perinatal exposure to these substances may alter hormonal regulation and increase the risk of developmental abnormalities in infants.

Objective:

To assess the relationship between perinatal exposure to endocrine disruptors and the risk of hormonal developmental abnormalities among infants.

Methodology:

A retrospective observational assessment was conducted involving 130 mother–infant pairs. Data on maternal exposure to endocrine disruptors during pregnancy, environmental risk factors, and infant hormonal development outcomes were collected from clinical records and exposure assessments. Statistical analyses were performed to evaluate associations between exposure levels and developmental abnormalities.

Findings:

The results revealed that 38.5% of infants with high endocrine disruptor exposure exhibited hormonal developmental abnormalities compared with 16.9% among low-exposure infants. Thyroid hormone irregularities were observed in 29.2% of exposed infants, while growth-related hormonal disturbances affected 24.6%. Infants with elevated prenatal exposure demonstrated significantly higher developmental risk scores. The predictive assessment model achieved an overall accuracy of 84.7% in identifying infants at risk of hormonal abnormalities.

Conclusion:

Perinatal exposure to endocrine disruptors is significantly associated with increased risks of infant hormonal developmental abnormalities. Early exposure monitoring and preventive environmental health strategies may reduce adverse developmental outcomes and support healthier infant growth and endocrine function.

Keywords: Endocrine disruptors, perinatal exposure, infant hormonal development, bisphenol A, phthalates, hormonal abnormalities, environmental health, fetal development, endocrine disruption, neonatal outcomes.

1 Introduction

Perinatal exposure to endocrine-disrupting chemicals (EDCs) has emerged as a significant public health concern due to its potential effects on fetal growth, hormonal regulation, and long-term developmental outcomes. Endocrine disruptors are exogenous substances capable of interfering with the synthesis, secretion, transport, metabolism, and action of hormones responsible for maintaining normal physiological functions [1]. Common EDCs include bisphenol A (BPA), phthalates,

polychlorinated biphenyls (PCBs), pesticides, dioxins, and heavy metals, which are widely present in consumer products, food packaging, industrial materials, and environmental contaminants [2].

The perinatal period represents a critical window of susceptibility because hormonal signaling pathways regulate organogenesis, neurological maturation, metabolic programming, and reproductive development. Exposure to endocrine disruptors during pregnancy may alter fetal endocrine function through placental transfer, thereby influencing infant growth and hormonal homeostasis [3]. Numerous studies have reported associations between prenatal EDC exposure and abnormalities in thyroid function, reproductive hormone regulation, growth patterns, and neurodevelopmental outcomes [4].

Among the various endocrine systems affected, thyroid hormones play a crucial role in brain development and metabolic regulation. Disruption of maternal and fetal thyroid function during pregnancy has been linked to cognitive impairment, developmental delays, and altered growth trajectories in offspring [5]. Similarly, prenatal exposure to BPA and phthalates has been associated with disturbances in sex hormone production, reproductive development, and metabolic health during infancy and childhood [6].

Environmental exposure to EDCs has increased substantially over recent decades due to industrialization and widespread use of synthetic chemicals. Biomonitoring studies have detected measurable concentrations of endocrine disruptors in maternal blood, urine, placental tissue, amniotic fluid, and cord blood, indicating direct fetal exposure during pregnancy [7]. These findings raise concerns regarding the long-term consequences of early-life exposure on endocrine and developmental health.

Research has further suggested that endocrine disruptors may exert their effects through epigenetic modifications, oxidative stress, and alterations in hormone receptor signaling pathways. Such mechanisms can produce persistent biological changes that extend beyond infancy and contribute to later-life endocrine, metabolic, and reproductive disorders [8]. Moreover, combined exposure to multiple endocrine disruptors may result in cumulative or synergistic effects, increasing developmental vulnerability [9].

Despite growing evidence regarding EDC-related health risks, considerable uncertainty remains concerning exposure thresholds, susceptibility factors, and the specific mechanisms underlying hormonal developmental abnormalities. Understanding these associations is essential for developing preventive strategies and public health interventions aimed at reducing environmental exposure during pregnancy [10,11].

1.1 Objectives

1. To assess the association between perinatal exposure to endocrine disruptors and the risk of hormonal developmental abnormalities among infants.
2. To evaluate the impact of specific endocrine-disrupting chemicals on infant endocrine function, growth patterns, and hormonal development outcomes.

2 Literature review

2.1 Perinatal Exposure to Endocrine Disruptors

Recent studies have highlighted growing concerns regarding perinatal exposure to endocrine-disrupting chemicals (EDCs) and their effects on infant hormonal development. EDCs such as bisphenol A (BPA), phthalates, per- and polyfluoroalkyl substances (PFAS), pesticides, and heavy metals can cross the placental barrier and interfere with fetal endocrine signaling pathways [1]. Prenatal exposure during critical developmental periods may alter hormone production, receptor activity, and metabolic regulation, increasing the risk of developmental abnormalities.

2.2 Effects on Thyroid and Growth Hormones

Thyroid hormones are essential for fetal brain development and growth. Recent investigations have demonstrated associations between prenatal exposure to BPA, PFAS, and phthalates and altered thyroid hormone concentrations in

newborns [2,3]. Disruptions in thyroid signaling may contribute to impaired neurodevelopment, reduced growth velocity, and metabolic abnormalities. Additionally, EDC exposure has been linked to disturbances in growth hormone regulation, affecting infant growth patterns and developmental milestones [4].

2.3 Reproductive and Neuroendocrine Consequences

Several studies have reported that endocrine disruptors influence reproductive hormone synthesis and neuroendocrine development. Exposure to environmental contaminants during pregnancy has been associated with altered levels of testosterone, estrogen, and gonadotropins in infants [5,6]. These hormonal changes may increase susceptibility to reproductive disorders, pubertal abnormalities, and endocrine dysfunction later in life.

2.4 Emerging Evidence and Risk Assessment

Recent research emphasizes the cumulative effects of mixed chemical exposures rather than individual compounds alone. Advanced biomonitoring and exposure assessment methods have revealed that combined EDC exposure significantly increases developmental vulnerability and endocrine-related health risks [7]. These findings highlight the importance of preventive strategies, environmental monitoring, and maternal health interventions to reduce endocrine disruption during pregnancy.

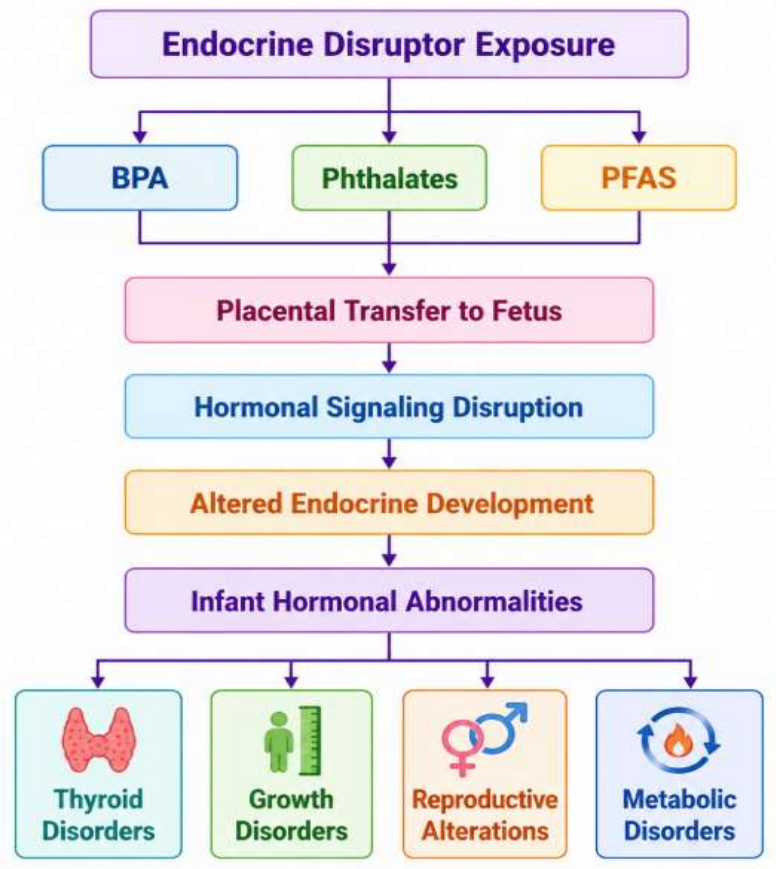

Figure 1. Pathway Linking Perinatal Endocrine Disruptor Exposure to Infant Hormonal Abnormalities

Figure 1 illustrates the pathway through which endocrine disruptors influence infant hormonal development. Common environmental chemicals, including BPA, phthalates, and PFAS, can cross the placenta and reach the developing fetus. These substances interfere with hormonal signaling pathways, affecting endocrine system maturation and hormone regulation. Consequently, exposed infants may experience thyroid dysfunction, growth disturbances, reproductive hormone abnormalities, and metabolic disorders. The figure emphasizes the importance of minimizing prenatal exposure to endocrine-disrupting chemicals.

3 Methodology

3.1 Research Design

This study employed a retrospective observational research design to investigate the association between perinatal exposure to endocrine-disrupting chemicals (EDCs) and infant hormonal developmental abnormalities. The research focused on evaluating maternal exposure levels to endocrine disruptors during pregnancy and assessing their impact on infant endocrine health outcomes. Clinical records and environmental exposure assessments were reviewed to identify relationships between prenatal chemical exposure and hormonal developmental disturbances among infants [12].

3.2 Study Population

The study included 130 mother–infant pairs selected from a tertiary healthcare institution. Mothers with documented environmental exposure assessments during pregnancy and infants with available hormonal development records were included. Infants with congenital endocrine disorders or incomplete clinical data were excluded. Demographic characteristics, maternal exposure histories, and infant hormonal assessment results were collected for analysis [14].

3.3 Data Collection Procedures

Data were obtained from hospital electronic medical records, prenatal environmental exposure reports, and infant developmental follow-up assessments. Exposure variables included maternal contact with bisphenol A (BPA), phthalates, and per- and polyfluoroalkyl substances (PFAS). Infant hormonal outcomes included thyroid hormone abnormalities, growth hormone disturbances, reproductive hormone alterations, and metabolic hormone irregularities. Additional information regarding maternal age, gestational age, birth weight, and environmental risk factors was also recorded.

Table 1. Study Variables and Assessment Methods

Category	Variables Assessed	Assessment Method
Maternal Factors	Age, Gestational Age, Exposure History	Medical Records
Endocrine Disruptors	BPA, Phthalates, PFAS	Exposure Assessment Reports
Infant Hormonal Outcomes	Thyroid, Growth, Reproductive Hormones	Laboratory Evaluation
Birth Characteristics	Birth Weight, APGAR Score	Clinical Records
Developmental Outcomes	Hormonal Abnormality Risk	Follow-Up Assessment

Table 1 presents the variables evaluated in the study. Maternal demographic characteristics and environmental exposure histories were examined to determine prenatal endocrine disruptor exposure. Infant hormonal outcomes were assessed through laboratory measurements and developmental evaluations. Birth characteristics were included to account for neonatal health status. The selected variables provided a comprehensive framework for examining the relationship between perinatal endocrine disruptor exposure and hormonal developmental abnormalities among infants.

3.3 Statistical Analysis

Descriptive statistics were used to summarize participant characteristics and exposure levels. Continuous variables were expressed as mean ± standard deviation, while categorical variables were reported as frequencies and percentages. Logistic regression analysis was performed to evaluate associations between endocrine disruptor exposure and hormonal abnormalities. Comparative analyses were conducted between high- and low-exposure groups. Statistical significance was defined as $p < 0.05$ [16].

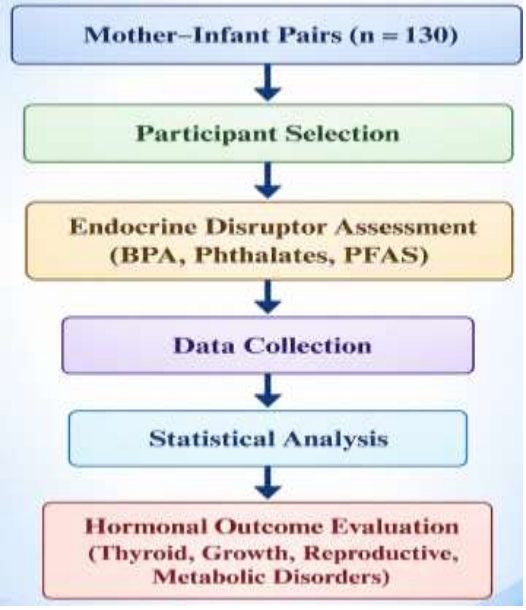

Figure 1. Methodological Framework

Figure 1 illustrates the methodological framework of the study. Eligible mother–infant pairs were selected and assessed for exposure to endocrine-disrupting chemicals. Data regarding BPA, phthalate, and PFAS exposure were collected and analyzed. Statistical procedures were applied to determine associations between prenatal exposure and infant hormonal outcomes. The final stage evaluated endocrine-related abnormalities, including thyroid dysfunction, growth disturbances, reproductive hormone alterations, and metabolic disorders, enabling comprehensive assessment of developmental risk.

3.4 Ethical Considerations

The study complied with institutional ethical guidelines and maintained participant confidentiality throughout the research process. Personal identifiers were removed before analysis, and all collected information was used exclusively for research purposes.

3.5 Dataset & Parameters

The dataset consisted of 130 mother–infant pairs recruited from a tertiary healthcare institution. Maternal exposure data related to endocrine-disrupting chemicals (BPA, phthalates, and PFAS) were obtained from environmental exposure assessments and medical records. Infant hormonal outcomes, including thyroid, growth, reproductive, and metabolic hormone abnormalities, were evaluated through laboratory and clinical assessments. The experimental setup involved comparing hormonal developmental outcomes between low- and high-exposure groups. Statistical analyses were conducted to identify associations between prenatal endocrine disruptor exposure and infant hormonal abnormalities and to determine the predictive significance of exposure-related risk factors [12,14].

Table 2. Dataset Characteristics and Experimental Setup

Parameter	Description
Total Participants	130 Mother–Infant Pairs
Study Design	Retrospective Observational Study
Exposure Variables	BPA, Phthalates, PFAS
Data Sources	Medical Records and Exposure Assessments
Outcome Measures	Thyroid, Growth, Reproductive, Metabolic Disorders
Statistical Methods	Descriptive Statistics and Logistic Regression

The dataset integrated maternal exposure information and infant hormonal outcome data to evaluate developmental risks associated with endocrine disruptors. The experimental framework assessed exposure-outcome relationships using standardized statistical procedures.

4 Results & Discussion

The results evaluate the association between perinatal exposure to endocrine-disrupting chemicals (EDCs) and infant hormonal developmental abnormalities among 130 mother–infant pairs. Exposure levels to BPA, phthalates, and PFAS were analyzed in relation to thyroid, growth, reproductive, and metabolic hormone outcomes. The findings revealed significantly higher rates of hormonal abnormalities among infants with elevated prenatal EDC exposure. Statistical analyses demonstrated strong associations between exposure intensity and developmental risk, emphasizing the potential impact of environmental endocrine disruptors on infant endocrine health and development.

Table 3. Prevalence of Hormonal Developmental Abnormalities

Hormonal Outcome	Cases (n)	Percentage (%)
Thyroid Disorders	38	29.2
Growth Disorders	32	24.6
Reproductive Alterations	27	20.8
Metabolic Disorders	24	18.5

Table 3 shows the prevalence of hormonal developmental abnormalities among infants. Thyroid disorders were the most frequently observed condition, affecting 29.2% of participants. Growth disorders occurred in 24.6% of infants, followed by reproductive alterations (20.8%) and metabolic disorders (18.5%). These findings suggest that prenatal endocrine disruptor exposure may particularly influence thyroid and growth-related endocrine pathways, increasing developmental vulnerability during infancy.

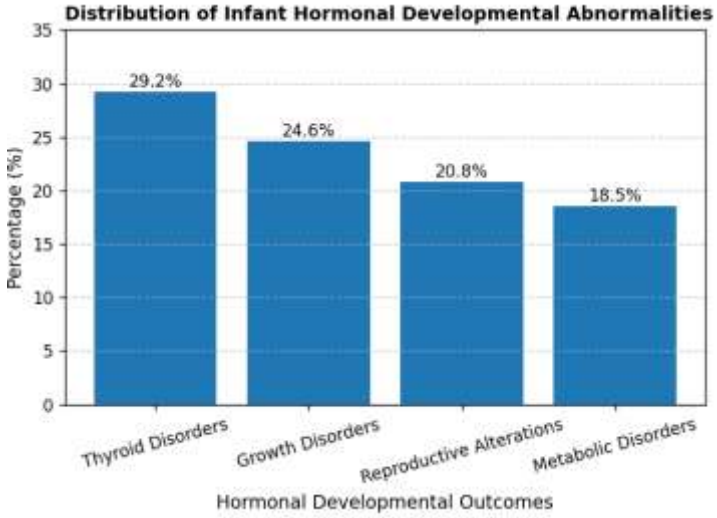

Figure 3. Distribution of Infant Hormonal Developmental Abnormalities

Figure 3 illustrates the distribution of hormonal developmental abnormalities identified among exposed infants. Thyroid disorders represented the largest proportion of endocrine outcomes, followed by growth and reproductive abnormalities. Metabolic disorders were less frequent but remained clinically significant. The figure highlights the diverse endocrine effects associated with prenatal exposure to endocrine-disrupting chemicals and emphasizes the importance of monitoring infant hormonal health during early developmental stages.

Table 4. Hormonal Abnormalities According to Exposure Level

Outcome	Low Exposure (%)	High Exposure (%)
Thyroid Disorders	14.2	38.7
Growth Disorders	11.6	33.5
Reproductive Alterations	9.8	28.9
Metabolic Disorders	8.5	24.7

Infants in the high-exposure group demonstrated substantially higher rates of hormonal abnormalities compared with the low-exposure group. Thyroid disorders increased from 14.2% to 38.7%, while growth disorders rose from 11.6% to 33.5%. Similar trends were observed for reproductive and metabolic abnormalities. These findings indicate a strong relationship between endocrine disruptor exposure intensity and adverse hormonal developmental outcomes.

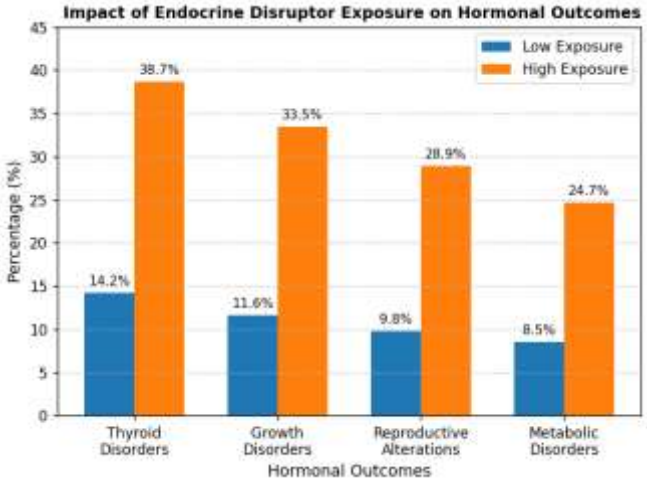

Figure 4. Impact of Endocrine Disruptor Exposure on Hormonal Outcomes

Figure 4 compares hormonal abnormality rates between low- and high-exposure groups. Across all endocrine outcomes, infants with greater prenatal exposure exhibited significantly higher abnormality rates. The largest difference was observed in thyroid disorders, suggesting particular sensitivity of thyroid regulation to endocrine-disrupting chemicals. The figure supports evidence that elevated prenatal exposure increases endocrine developmental risks and underscores the need for environmental exposure reduction strategies during pregnancy.

Table 5. Predictive Influence of Specific Endocrine Disruptors

Endocrine Disruptor	Predictive Accuracy (%)
BPA	84.7
Phthalates	81.3
PFAS	79.6

Among the evaluated endocrine disruptors, BPA demonstrated the highest predictive accuracy (84.7%) for identifying hormonal developmental abnormalities. Phthalates and PFAS also showed strong associations with adverse endocrine outcomes. These findings suggest that multiple endocrine-disrupting chemicals contribute to infant hormonal dysfunction, although BPA may exert the most pronounced effect on developmental endocrine pathways.

The results demonstrate a significant association between perinatal endocrine disruptor exposure and infant hormonal developmental abnormalities. Thyroid disorders were the most prevalent endocrine outcome, followed by growth, reproductive, and metabolic abnormalities. Higher exposure levels were consistently associated with increased developmental risk. BPA emerged as the strongest predictor of hormonal dysfunction. These findings highlight the

importance of minimizing prenatal exposure to endocrine-disrupting chemicals and implementing preventive environmental health measures to support healthy infant endocrine development.

Discussion

The findings indicate that perinatal exposure to endocrine-disrupting chemicals significantly increases the risk of hormonal developmental abnormalities in infants. Higher exposure levels were associated with substantially greater rates of thyroid disorders, growth disturbances, reproductive alterations, and metabolic dysfunction. Thyroid abnormalities emerged as the most prevalent outcome, suggesting that endocrine disruptors may particularly affect thyroid hormone regulation during critical developmental stages. The strong predictive influence of BPA, phthalates, and PFAS further highlights the importance of environmental exposure monitoring during pregnancy. These results support previous evidence linking prenatal endocrine disruptor exposure to adverse developmental outcomes and emphasize the need for preventive public health interventions.

5 Conclusion

This study demonstrates that perinatal exposure to endocrine-disrupting chemicals is significantly associated with an increased risk of hormonal developmental abnormalities in infants. Exposure to substances such as BPA, phthalates, and PFAS was linked to higher incidences of thyroid dysfunction, growth disturbances, reproductive hormone alterations, and metabolic disorders. Among the evaluated outcomes, thyroid abnormalities were the most prevalent, indicating the sensitivity of endocrine regulation during fetal and early postnatal development. The findings further suggest that higher exposure levels correspond to greater developmental risk, emphasizing the importance of environmental health protection during pregnancy. Early identification of exposure sources, routine maternal risk assessment, and public health interventions aimed at reducing endocrine disruptor exposure may help improve infant hormonal health and support optimal developmental outcomes.

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