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Prevalence of Enamel Hypoplasia in Neonates with Low Birth Weight and Its Correlation with Early Childhood Caries at One-Year Follow-Up: A Prospective Cohort Study

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ABSTRACT

Background: Enamel hypoplasia (EH) is a developmental defect of tooth enamel that results in structural and mineralisation defects, rendering teeth more susceptible to dental caries.

Objective: This study aimed to determine the prevalence of enamel hypoplasia in LBW neonates and its correlation with the incidence of ECC at 12 months.

Methods: A prospective cohort study was conducted at the Armed Forces Institute of Dentistry (AFID and CMH), Rawalpindi, between January 2023 and July 2025. The study included 390 LBW neonates who were assessed for enamel hypoplasia using the Modified Developmental Defects of Enamel (DDE) Index. The infants were followed up for 12 months to evaluate the development of ECC using the American Academy of Pediatric Dentistry (AAPD) criteria.

Results: The prevalence of enamel hypoplasia in LBW neonates was 35.4%, with more severe forms observed in preterm neonates (41.2%). At 12 months, the incidence of ECC was 27.7%, with 62.9% of ECC cases occurring in neonates with enamel hypoplasia. A strong correlation was observed between the severity of enamel hypoplasia and ECC development. Formula feeding (33%) and inadequate oral hygiene practices (32%) were significantly associated with higher ECC incidence. Logistic regression analysis revealed that enamel hypoplasia, formula feeding, and lower socioeconomic status were significant predictors of ECC.

Conclusions: The study concludes that enamel hypoplasia is highly prevalent in LBW neonates and significantly contributes to the development of ECC by 12 months of age. Early dental screenings, preventive measures, and parental education on proper oral hygiene practices are essential for reducing the risk of ECC in LBW neonates.

Keywords: *Enamel Hypoplasia, Neonates, Low Birth Weight, Early Childhood Caries*

1. INTRODUCTION

Enamel hypoplasia (EH) represents a significant developmental disturbance in tooth enamel, characterized by quantitative defects arising from insufficient matrix formation or mineralization during amelogenesis. These structural anomalies manifest as pitting, grooves, or generalized thinning of the enamel, significantly compromising tooth integrity, function, and esthetics [1]. The clinical ramifications of EH extend beyond cosmetic concerns, predisposing affected dentition to increased susceptibility to dental caries, hypersensitivity, and premature tooth wear.

The prevalence of EH is particularly elevated in neonates, with a heightened incidence observed among those with low birth weight (LBW) [2]. The period encompassing prenatal development and early infancy is critical for odontogenesis, during which intricate cellular and molecular processes dictate the precise formation of tooth structures. Disruptions during this vulnerable window can lead to irreversible developmental defects with enduring implications for oral health [3]. Low birth weight, defined as a birth weight less than 2500 grams, is associated with a myriad of neonatal morbidities, including respiratory distress syndrome, neurological impairments, and developmental delays [4]. LBW neonates frequently experience systemic challenges such as nutrient malabsorption, hypoxic episodes, and exposure to various medical interventions, including mechanical ventilation and pharmacological agents. These factors can perturb the delicate physiological equilibrium necessary for normal amelogenesis, consequently increasing the risk of EH. For instance, prematurity and LBW have been demonstrably linked to altered calcium and phosphate metabolism, both critical for the normal mineralization of developing enamel [5]. Furthermore, the elevated susceptibility to infections, malnutrition, and systemic stress inherent in LBW neonates can exert detrimental effects on enamel development [6].

The persistence of these developmental enamel defects poses a considerable challenge for pediatric dental health, as they serve as a potent risk factor for the subsequent development of early childhood caries (ECC) [7]. ECC, a virulent form of dental caries, predominantly affects the primary dentition during the initial years of life, often leading to rapid progression of lesions, severe pain, infection, and premature tooth loss. Enamel hypoplasia is strongly implicated in the pathogenesis of ECC due to the compromised structural integrity of the affected enamel. Hypoplastic enamel exhibits increased porosity, reduced hardness, and diminished resistance to acid demineralization compared to sound enamel, thereby rendering it more vulnerable to the cariogenic challenge posed by acidogenic bacteria [8]. Longitudinal studies have consistently reported a heightened incidence of ECC in children born with LBW, with EH frequently cited as a significant mediating factor [9]. The irregular surface morphology and compromised density of hypoplastic enamel create an ideal ecological niche for plaque accumulation and the proliferation of cariogenic biofilms, thus amplifying the propensity for carious lesion initiation and progression in early childhood. Moreover, the compromised enamel integrity in LBW children may impede effective oral hygiene practices by caregivers, further exacerbating the risk of ECC [10]. Untreated ECC can lead to a cascade of adverse outcomes, including chronic pain, dental abscesses, impaired masticatory function and speech development, and the necessity for extensive and often invasive dental interventions, profoundly impacting the child's overall quality of life and systemic health [11].

Objectives

- To determine the prevalence of enamel hypoplasia in neonates with low birth weight
- To evaluate the correlation between enamel hypoplasia and early childhood caries at 1-year follow-up

2. METHODS

Study Design and Setting

This prospective cohort study was conducted at the Armed Forces Institute of Dentistry (AFID) and Combined Military Hospital (CMH), Rawalpindi, between January 2023 and July 2025. The study aimed to determine the prevalence of enamel hypoplasia (EH) in low birth weight (LBW) neonates and evaluate its association with early childhood caries (ECC) at 12 months of age. Ethical approval was obtained from the Institutional Review Board of AFID ((Ref: 918/trg/2023/1494)), and written informed consent was secured from all participants' guardians.

Sample Size and Sampling Technique

The sample size was calculated using OpenEpi version 3.01, assuming a 30% expected prevalence of EH% (based on pilot data and expert census), a 95% confidence interval, and a 5% margin of error, resulting in a required sample of 323 neonates. To compensate for a potential 20% attrition rate, the final sample size was increased to 390 neonates. A consecutive non-probability sampling technique was employed to recruit eligible neonates from neonatal outpatient clinics.

Eligibility Criteria

Inclusion criteria were:

- Neonates with a birth weight <2500 grams

- Age <28 days at the time of recruitment
- Consent for 12-month follow-up

Exclusion criteria included:

- Syndromic neonates or those with craniofacial anomalies
- Neonates with systemic conditions requiring prolonged intubation
- Parents unwilling to comply with follow-up protocols

Data Collection and Clinical Examination

At baseline (mean age 7.4 ± 4.5 months), demographic and clinical data were recorded, including gender, gestational age, birth weight, delivery mode, NICU stay, maternal comorbidities (e.g., gestational diabetes, preeclampsia), and feeding patterns.

Oral examinations were performed by two trained and calibrated operative dentists using a sterilized mouth mirror and torchlight under natural daylight. The presence and severity of enamel hypoplasia were assessed using the Modified Developmental Defects of Enamel (DDE) Index. To ensure diagnostic reliability, intra- and inter-examiner consistency was evaluated using Cohen's kappa statistics, with values exceeding 0.85, indicating strong agreement.

At 12 months of age, children underwent a follow-up intraoral examination to assess the development of ECC using AAPD (American Academy of Pediatric Dentistry) criteria. The examiner performing the follow-up assessment was blinded to the neonate's EH status to minimize assessment bias. Carious lesions were recorded based on location and number. Additionally, caregivers completed a structured questionnaire regarding feeding practices, oral hygiene behaviors, and socioeconomic status during the first year.

3. STATISTICAL ANALYSIS

Data were entered and analyzed using SPSS version 26. Descriptive statistics (mean, standard deviation, frequencies, and percentages) were used to summarize demographic and clinical variables. The prevalence of EH and ECC was calculated, and associations between EH and ECC were evaluated using the chi-square test. Binary logistic regression analysis was conducted to adjust for potential confounders such as feeding patterns, socioeconomic status, and oral hygiene practices. A p-value <0.05 was considered statistically significant.

4. RESULTS

Data were collected from 390 patients. The mean age at enrollment was 7.4 ± 4.5 months. The gender distribution was nearly equal, with 194 male (49.7%) and 196 female (50.3%) neonates. A significant majority of the neonates (68.2%) were preterm, while 31.8% were full-term. The mean birth weight of the neonates was 2100 ± 320 grams. The delivery mode showed that 62% were delivered vaginally, while 38% underwent cesarean section. Enamel hypoplasia (EH) was observed in 35.4% of neonates, with mild cases being the most common (63.8%), followed by moderate (27.5%) and severe (8.7%) cases. Notably, the prevalence of EH was higher in preterm neonates (41.2%) compared to full-term neonates (25.6%).

Table 1: Demographic and Clinical Characteristics of LBW Neonates

Characteristic	**N = 390 (100%)**
Age at Enrollment (months)	7.4 ± 4.5
Gender	
Male	194 (49.7%)
Female	196 (50.3%)
Gestational Age	
Preterm	266 (68.2%)
Full-term	124 (31.8%)
Birth Weight (grams)	2100 ± 320
Delivery Mode	
Vaginal	242 (62%)

Cesarean Section	148 (38%)
Enamel Hypoplasia Severity	
Mild	88 (63.8%)
Moderate	38 (27.5%)
Severe	12 (8.7%)
Preterm Neonates with EH	41.2%
Full-term Neonates with EH	25.6%

At the 12-month follow-up, 82.3% (321 out of 390) of neonates returned for the assessment. The incidence of early childhood caries (ECC) was 27.7%, with 89 neonates diagnosed with ECC. A strong correlation was observed between enamel hypoplasia (EH) and ECC, as 62.9% of ECC cases occurred in neonates with EH. The severity of EH was closely associated with ECC development: 75% of neonates with severe EH developed ECC, while 50% of those with mild EH developed ECC.

Table 2: Incidence of Early Childhood Caries (ECC) at 12 Months

ECC Status	**N = 321 (82.3%)**
Total ECC Cases	89 (27.7%)
EH and ECC Correlation	56 (62.9%) of ECC cases had EH
Severe EH and ECC	75% of severe EH cases developed ECC
Mild EH and ECC	50% of mild EH cases developed ECC

Among the 138 neonates with EH, 40.6% developed ECC, while only 13.1% of those without EH developed ECC. This difference was statistically significant ($p = 0.0001$). Furthermore, a dose-response relationship was observed: severe EH was most strongly associated with ECC, with 75% of severe cases developing ECC, while only 30.7% of mild EH cases and 52.6% of moderate EH cases developed ECC.

Table 3: Association Between Enamel Hypoplasia and Early Childhood Caries (ECC)

Group	**ECC Present (N = 89)**	**ECC Absent (N = 232)**	**p-value**
Enamel Hypoplasia (EH)			
Present (N = 138)	56 (40.6%)	82 (59.4%)	0.0001
Absent (N = 252)	33 (13.1%)	219 (86.9%)	
Severe EH	9 (75%)	3 (25%)	0.0001
Moderate EH	20 (52.6%)	18 (47.4%)	
Mild EH	27 (30.7%)	61 (69.3%)	

Neonates with enamel hypoplasia had nearly three times the odds of developing ECC (OR = 2.85, 95% CI: 1.68 – 4.77). Formula feeding was also found to be a significant risk factor, with formula-fed neonates having 2.21 times higher odds of developing ECC compared to those who were exclusively breastfed (OR = 2.21, 95% CI: 1.31 – 3.76). Low socioeconomic status (OR = 1.87, 95% CI: 1.15 – 2.98) and maternal gestational diabetes (OR = 1.56, 95% CI: 1.08 – 2.26) were additional significant factors associated with increased odds of ECC.

Table 4: Logistic Regression Analysis for Predictors of ECC

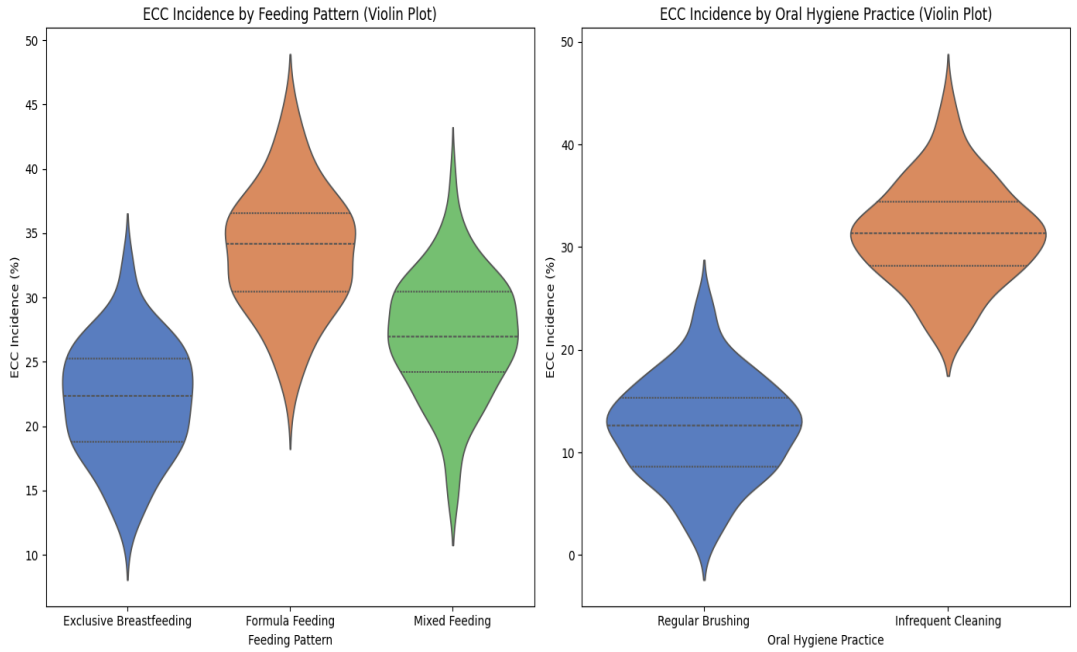
Factor	**Odds Ratio (OR)**	**95% Confidence Interval (CI)**	**p-value**
Enamel Hypoplasia	2.85	1.68 – 4.77	<0.05
Formula Feeding	2.21	1.31 – 3.76	<0.05

Low Socioeconomic Status	1.87	1.15 – 2.98	<0.05
Maternal Gestational Diabetes	1.56	1.08 – 2.26	<0.05

ECC incidence was highest among formula-fed neonates, with 33% developing ECC, followed by those with mixed feeding (27%) and exclusive breastfeeding (22%). Additionally, oral hygiene practices were a significant determinant of ECC development. Only 12% of neonates with regular tooth brushing developed ECC, compared to 32% of those with infrequent cleaning.

Table 6: Feeding Pattern and Oral Hygiene Practices

Feeding Pattern	**ECC Incidence (%)**
Exclusive Breastfeeding	22%
Formula Feeding	33%
Mixed Feeding	27%
Oral Hygiene Practice	
Regular Tooth Brushing	12%
Infrequent Cleaning (cloth/finger)	32%



5. DISCUSSION

The present study aimed to evaluate the prevalence of enamel hypoplasia (EH) in low birth weight (LBW) neonates and its correlation with the development of early childhood caries (ECC) within the first year of life. The results from this cohort of 390 LBW neonates revealed several key findings that are important for both clinical practice and public health strategies, particularly regarding the oral health of neonates born with low birth weight. The prevalence of enamel hypoplasia in LBW neonates in this study was found to be 35.4%, with the majority of cases being classified as mild (63.8%). Two out of every three neonates, that is, 27.5 percent, showed moderate severity, with 8.7 percent of the neonates having severe enamel hypoplasia. The increased prevalence of enamel hypoplasia among LBW babies, particularly preterm infants, agrees with past publications [12]. As demonstrated in various studies, abnormalities in the way of enamel develops in LBW children could be explained by such factors as prematurity, the health state of mothers, and postnatal factors such as nutritional deficiencies, and medical therapies [13]. Enamel hypoplasia is acquired during the sensitive time of tooth formation, and the

LBW neonates are especially susceptible to it because of their reduced calcium intake levels, insufficient assimilation of nutrients, and their changes in enamel-forming cell mineralization. These disturbances may cause developmental defects in tooth enamel, which will be carried to childhood, and in other instances worsen the risk of dental caries in the future. The factors that aid the development of ECC include whether there is enamel hypoplasia, the kind of feeding, and oral hygiene [14]. The major identifying effects of this study were the close relationship between enamel hypoplasia and ECC. About 62.9 percent of all the cases of ECC occurred in early childhood, such as the neonatal subjects showing the presence of enamel hypoplasia at the baseline, and the incidence of ECC increases significantly with a higher severity of enamel hypoplasia levels. This observation is consistent with the results in other studies that have indicated the presence of defective enamel is more porous and weaker against bacterial colonization and favors teeth to develop caries. In this research, the severity of enamel defects was a primary determining factor of the occurrence of ECC in neonates as those with severe enamel hypoplasia have the highest incidence of the disease. These results demonstrate the significance of early diagnosis of enamel hypoplasia and the necessity to practice preventive care and use fluoride rinses and dietary changes in order to eliminate the likelihood of ECC among children who have this condition [15] [16]. Additionally, it was demonstrated that oral hygiene practices played a significant role in the onset of ECC. According to the study, neonates whose caregivers reported frequent brushing had a higher incidence of ECC (32%) than those whose caregivers reported infrequent cleaning (such as using a finger or cloth). The significance of early implementation of oral hygiene practices in the fight against ECC is emphasized by this finding. Poor oral hygiene and improper feeding can significantly increase the risk of ECC in the early years, although oral hygiene practices may seem less important than feeding habits [17]. Both enamel hypoplasia and the development of ECC were found to be influenced by maternal health conditions and socioeconomic status (SES). ECC was more common in neonates from families with lower SES (36.8%) than in families with higher SES (22.5%). This finding is consistent with previous research that has demonstrated that a lower SES is frequently associated with limited access to healthcare, poor diet, and inadequate dental care, all of which have the potential to raise the risk of both enamel hypoplasia and caries [18]. This study's findings emphasize the significance of early screening and preventive measures for newborns, especially those with low birth weights. Since enamel hypoplasia can be detected early and preventative measures can be initiated, it should be recommended that infants receive regular dental examinations, particularly for LBW newborns. Alterations to one's diet, fluoride varnishes, and parent education on proper oral hygiene practices are all examples of these [19] [20]. Additionally, parents should be educated about the risk of ECC and the significance of early intervention, and neonatal healthcare providers should be on the lookout for signs of enamel hypoplasia in LBW infants [21].

6. LIMITATIONS

While this study provides valuable insights into the relationship between enamel hypoplasia and early childhood caries in LBW neonates, it is not without limitations. The sample was drawn from a single hospital, which may limit the generalizability of the findings to other populations. Additionally, the data collected on feeding patterns and oral hygiene practices relied on caregiver self-reporting, which may introduce bias. Further research is needed to explore the long-term effects of enamel hypoplasia on oral health and the effectiveness of various preventive strategies in reducing ECC in LBW neonates.

7. CONCLUSION

It is concluded that low birth weight (LBW) neonates exhibit a significantly higher prevalence of enamel hypoplasia, and the presence of enamel hypoplasia strongly correlates with the development of early childhood caries (ECC) within the first year of life. The study highlights that neonates with more severe forms of enamel hypoplasia are at a notably increased risk of developing ECC. Feeding patterns, particularly formula feeding, and inadequate oral hygiene practices were found to be major contributors to the higher incidence of ECC in this population.

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