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ORIGINAL ARTICLE

Risk Factors for the Incidence of Dental Caries in Low, Very Low, and Extremely Low Birth Weight Children: A Cohort Study

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ABSTRACT

Objective: To assess the incidence of caries in a two-year period among low birth weight (LBW), very low birth weight (VLBW), and extremely low birth weight (ELBW) children considering socioeconomic indicators, dietary factors and oral hygiene. **Material and Methods:** A convenience sample was formed of 42 low birth weight children aged two to five years at baseline. Two examiners diagnosed caries using the World Health Organization criteria. Birth weight, socioeconomic indicators and diet were collected from medical records and questionnaires. Binomial models were used to estimate unadjusted and adjusted rate ratios (RR) and respective 95% confidence intervals for the factors evaluated. **Results:** Thirty-six children were re-examined after two years. The incidence of dental caries was 36.7%. The dmft index was 0.44 (±1.25) at baseline and increased to 1.36 (±3.85) at follow-up. VLBW children (1,000 to 1,500 g) (RR=0.23; 95%CI: 0.08-0.72) and LBW children (1,500 to 2,500 g) (RR=0.06; 0.01-0.55) had fewer carious lesions compared to ELBW children (<1,000 g). Carious lesions were more frequent among children with a lower income (RR=6.05; 1.05-34.84) and less frequent among those who did not consume sweetened juice, tea or yogurt (RR: 0.21; 0.07-0.62). **Conclusion:** An inverse dose-response relation was found between birth weight and the incidence of caries. A lower income and the consumption of sweetened beverages were risk factors for the development of caries.

Keywords: Infant, Premature; Dental Caries; Pediatric Dentistry; Oral Health.

Introduction

The World Health Organization (WHO) defines newborns with low birth weight (LBW) as those born weighing < 2,500 grams (g). Children born weighing <1,500 grams (g) are defined as very low birth weight (VLBW) infants and more severe cases (<1,000 grams (g) at birth) constitute extremely low birth weight (ELBW) [1]. Preterm birth is defined as childbirth occurring before 37 complete weeks of gestational age [2].

Prematurity and LBW are the leading cause of death among children under five years of age [2] and can have immediate and long-term impacts on general and oral health [3]. Indeed, the entire organism can be affected, especially neurocognitive development and growth [4]. Thus, birth conditions can also affect the structure of the teeth and may increase the susceptibility to dental caries [5]. The literature reports that LBW children are more vulnerable to enamel hypomineralization and hypoplasia [6,7] due to *in utero* undernutrition, which can impair tooth development [8]. The last trimester of pregnancy is critical to the optimal incorporation of minerals into the enamel matrix. Thus, as preterm children have less time for the incorporation of these minerals, tooth enamel in this population is more porous and has more structural defects that can facilitate the colonization of dental plaque compared to full-term children [6,7]. Moreover, VLBW children received more sweetened drinks during the day and at night and may be breastfed less at night compared to normal birth weight (NBW) children. The explanation for this is that VLBW children may be hospitalized, spend more time in intensive care and have less contact with the mother for breastfeeding practices, receiving more parenteral nourishment and antibiotic therapy [9]. However, studies report conflicting data regarding differences in oral hygiene frequency between VLBW and NBW children [9,10]. Smoking on the part of the mother may also be associated with increased caries in this group of children, although several confounders, such as socioeconomic status, should be considered when interpreting this association. In addition, mothers who engage in risk behaviors may be less likely to take good care of their children's oral health and may therefore be more careless about their child's tooth brushing practices [10]. Lastly, there is evidence that LBW children develop dental caries in a shorter time than NBW children [11].

The interest in the association between birth weight and dental caries has increased in the last 20 years. The first systematic review on this issue was published in 2001 and included four observational studies [12]. The second was published 20 years later and included 59 studies [13]. Both systematic reviews reported cross-sectional or prevalence data and found no association between birth weight and dental caries [12,13]. Although the second systematic review included cohort studies, the incidence of caries related to birth weight was not analyzed [13].

The cohort study design enables the determination of the incidence of health outcomes and has shown that LBW newborns are at increased risk for the development of carious lesions compared to normal birth weight (NBW) newborns [11,14-16]. Among preterm newborns, there seems to be a correlation between lower birth weight (LBW, VLBW and ELBW categories) and a lower number of sound primary teeth [16]. However, no correlation was found between birth weight categories and the development of dental caries, possibly because the authors considered "sound teeth" as the absence of "dental caries" and "developmental enamel defects" (DED) [16]. In contrast, another study reported that a higher birth weight was weakly associated with a slightly increased risk of caries (adjusted OR per 100-g increase: 1.05; 95%CI: 1.01-10.8). The authors stated that the relationship between increased birth weight and an increased risk of caries remains unclear [17].

As the increased risk of caries among LBW children compared to NBW children is established [11,14-16], there is a need to investigate whether a correlation exists between dental caries and low birth weight categories. Moreover, only two cohort studies have conducted repeated dental examinations to determine the incidence of dental caries [11,15]. Therefore, the present study aimed to investigate the incidence of caries in a two-year period among LBW, VLBW and ELBW children aged two to five years, considering risk factors such as socioeconomic characteristics, dietary aspects and oral hygiene. The following were the two hypotheses tested: 1) the incidence of caries among birth weight categories is increased after two years; 2) Dietary habits and income exert an influence on the occurrence of caries.

Material and Methods

Study Design and Participants

This study was reported following the recommendations of the STROBE statement for cohort studies [18]. A prospective cohort study was conducted with LBW children recruited from the hospital affiliated with the Federal University of Minas Gerais, Belo Horizonte, Brazil. This hospital is a reference center for LBW children. Data collection was performed between June 2017 and December 2019. In June 2017, we invited a convenience sample of 42 children aged two to five years to participate in the study (25 girls and 17 boys; mean age: 3.0 years ± 1.08). The power of the sample was calculated considering a type I error of 0.05. All children lived in the city of Belo Horizonte or the metropolitan region and had access to optimally fluoridated drinking water (0.7 ppm F). The children were examined at two-time points: 2017 (baseline) and 2019 (follow-up).

The inclusion criteria were children with primary teeth between two and five years of age born with < 2,500 g and referred for clinical care at the university hospital. The exclusion criteria were children out of the age range and those born with more than 2,500 g.

Data Sources/Measurements

The diagnosis of dental caries was performed using the decayed, missing and filled teeth (dmft) index recommended by the World Health Organization [13]. Two examiners underwent training and calibration exercises for the clinical examination. The calibration process was performed in three stages. The examiners 1) studied the dmft criteria, 2) analyzed photographs of carious lesions for preliminary training and 3) clinically examined 16 children two to five years of age recruited from the university dental clinic on two occasions with a one-week interval between evaluations. The calibration was supervised by an experienced pediatric dentist who served as the "gold standard". The children who participated in the calibration process were not included in the main study. Cohen's Kappa coefficients for intra-examiner (K = 0.88 for both examiners) and inter-examiner (K = 0.85 and 0.89 for the two examiners) agreement were excellent and the examiners were considered able to conduct the study [19]. During the clinical examination, the child remained in a chair facing the examiner, who used an artificial head lamp, disposable mouth mirror and gauze to clean and dry the teeth. After two years, the entire calibration process was repeated prior to the follow-up examinations.

Variables

The dental examination was first performed in the maxillary arch, followed by the mandibular arch. Then, the quadrants of both arches were evaluated in the following sequence: from distal to mesial teeth on the right side, followed by distal to the mesial teeth on the left side. All children only had primary teeth baseline. At follow-up, some children had also permanent incisors and first molars, which were also considered for the incidence of caries. Children with treatment needs were referred to the dental school of the university.

Child's sex and birth weight were collected from medical records. The mothers answered a questionnaire addressing the child's age, mother's age, parent's schooling level, monthly family income, dietary habits and oral hygiene habits. Birth weight was categorized as extremely low birth weight (ELBW: <1,000 g), very low birth weight (VLBW: more than 1,000 to 1,500 g) or low birth weight (LBW: more than 1,500 to 2,500 g) [1]. Parental schooling was categorized by the median of the sample: ≤ eight or > eight years of study. Family income was defined using the monthly minimum wage as the unit of analysis, which corresponded to nearly US$ 250 at the time of data collection. This variable was dichotomized based on the median as ≤ two or > two times the monthly minimum wage. The questionnaires also addressed bottle feeding habits (yes/no), the consumption of milk with sugar using a glass/cup (yes/no), the consumption of juice, tea, or yogurt sweetened by parents or caregivers (yes/no), infant formulas (yes/no), chips/snack foods (yes/no) and sweets (yes/no), use of toothpaste during tooth brushing (yes/no), frequency of tooth brushing, who tooth brushed the child's teeth (parent/child) and the use of a fluoride toothpaste (yes/no).

Statistical Analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS, Version 26.0IBM Corp., Armonk, N.Y, USA). The dependent variable was the incidence of dental caries in two years (from baseline to follow-up). The frequency of carious lesions per tooth (number of decayed, missing and filled primary teeth) at baseline and follow-up was analyzed descriptively.

Mean and median values were calculated for the incidence of caries, number of decayed, missing and filled teeth and continuous variables. The independent covariates collected at baseline were child's sex, birth weight and age, mother's and father's schooling level, monthly family income, number of children with bottle feeding habits, consumption of milk with sugar using a glass/cup, consumption of sweetened juice, tea, or yogurt, infant formulas, chips/snack foods, sweets and tooth brushing habits (use of toothpaste during tooth brushing, frequency of tooth brushing, who tooth brushed the child's teeth and the use of fluoride toothpaste).

Negative binomial regression models were used to estimate unadjusted and adjusted rate ratios (RR) and respective 95% confidence intervals (CI) for each covariate. Unadjusted negative binomial regression models were conducted to estimate the unadjusted RR (95% CI) and p-value for each covariate separately. Covariates with a p-value < 0.25 were incorporated into the adjusted negative binomial regression model and only those with a p-value < 0.05 were maintained in the final model. The inclusion of variables with a traditional level (0.05) into the model may fail to identify important variables, whereas including variables with higher p-values has the disadvantage of questionable importance. Thus, we followed the recommendation proposed by Hosmer and Lemeshow to include variables with a p-value < 0.25 into the model [20]. The chi-squared test of the residual deviance of the result and the ratio between residual deviance and the degree of freedom were used for the evaluation of the goodness of fit of the final model [21,22]. Collinearity of the variables was tested using the variance inflation factor.

Ethical Clearance

This study received approval from the institutional review board of the Federal University of Minas Gerais (Certificate No: 66632817.7.0000.5149) and was conducted following the ethical principles stipulated in the Declaration of Helsinki. Parents who agreed to their child's participation signed a statement of informed consent.

Results

In June 2017, we invited a convenience sample of 42 children aged two to five years to participate in the study (25 girls and 17 boys; mean age: 3.0 years ± 1.08). Two years later, thirty-six children (86%) from the baseline sample participated in the follow-up evaluation. Six children (14%) (four girls and two boys; mean age: 3.0 ± 0.89) were lost to follow-up due to loss of contact (n = 4) and parents who declined to participate (n = 2). No differences were found between the children included and those lost to follow-ups regarding sex (p = 0.534), age (p = 369) or dental caries (p = 0.371) at baseline. The follow-up sample consisted of 21 girls and 15 boys four to seven years of age (mean: 5.6 ± 1.12 years). According to the birth weight categorization, 12 children in the sample had ELWB, 14 had VLWB and 10 had LBW.

The incidence of dental caries in two years was 36.7% (48 teeth affected by new carious lesions). The mean number of new carious lesions per child in two years was 0.97 (± 3.14). The data on dental caries experience are shown in Table 1. The dmft index was 0.44 (± 1.25) at baseline and increased to 1.36 (± 3.85) at follow-up. Moreover, all components of dfmt index increased in two years.

Table 1. Caries experience at baseline and follow-up among 36 children.

Caries Experience	Baseline Mean (SD)	Follow-up Mean (SD)
dmft	0.44 (1.25)	1.36 (3.85)
Number of cavitated teeth	0.39 (1.23)	1.08 (3.18)
Number of missing teeth*	0 (0.0)	0.03 (0.17)
Number of filled teeth	0.08 (0.37)	0.25 (0.87)

*Only missing teeth due to dental caries considered. SD: standard deviation.

Figures 1 and 2 describe the frequency of dental caries at baseline and after two years. More primary teeth had carious lesions at follow-up compared to baseline. For maxillary teeth, the central incisors were the most affected at baseline (n = 3) and the second molars were the most affected after two years (n = 9). For mandibular teeth, the first molars were the most affected both at baseline (n = 7) and at follow-up (n = 9).

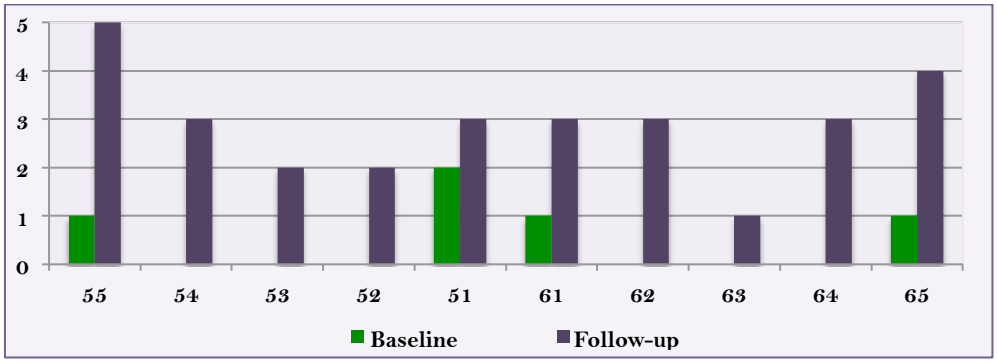

Figure 1. Number of maxillary teeth affected by dental caries at baseline and follow-up.

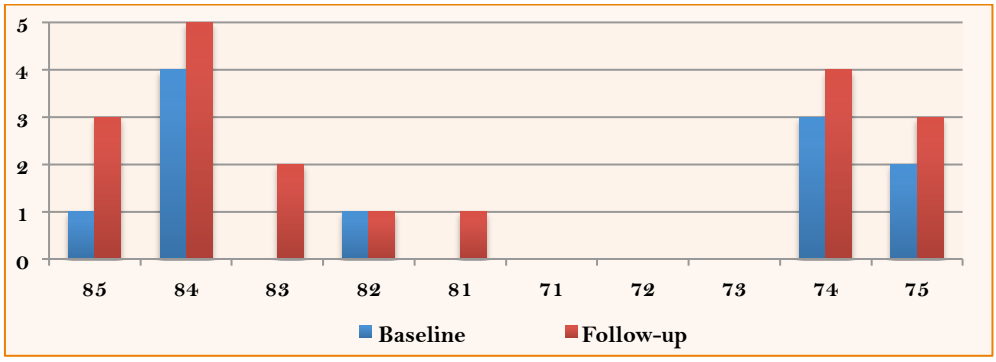

Figure 2. Number of mandibular teeth affected by dental caries at baseline and follow-up.

As a high percentage of mothers reported good tooth brushing habits (97.2% of children used toothpaste when brushing and 92% of mothers reported a brushing frequency of twice per day), it was not possible to incorporate these variables into the binomial regression model. Table 2 displays the binomial regression models for the incidence of dental caries and covariates. The following covariates had a p-value < 0.25 in the unadjusted model and were therefore incorporated into the adjusted model: age at baseline, birth weight, monthly family income, consumption of sweetened juice, tea or yogurt, consumption of sweets and the use of fluoride toothpaste. Birth weight, monthly family income and the consumption of sweetened juice, tea or yogurt achieved a p-value < 0.05 after the adjustments and were therefore maintained in the final model as significant risk factors for dental caries. A dose-response relation was found between birth weight and the incidence of dental caries. Children born with VLBW (RR = 0.23; 95% CI: 0.08-0.72) and LBW had a lower incidence of caries (RR = 0.06; 95% CI: 0.01-0.55) compared to ELBW children. Children from families with an income ≤ two times the monthly minimum wage had a higher incidence of dental caries (RR = 6.05; 95% CI: 1.05-34.84) compared to those from families with an income > two times the monthly minimum wage. Children who did not consume sweetened juice, tea or yogurt had a lower incidence of dental caries (RR = 0.21; 95%CI: 0.07-0.62) compared to those who consumed these items (Table 2). The adjusted model showed a good fit to the data (ratio between residual deviance and degree of freedom = 1.074). The variance inflation factor was below 10 for all variables and demonstrated no collinearity.

Table 2. Risk factors for incidence of dental carious lesions after two years among low birth weight children.

Variables	Incidence of Dental Caries Mean; Median	Unadjusted RR (95% CI)	p-value	Adjusted RR (95% CI)	p-value
Sex					
Male	0.60; 0	1			
Female	1.24; 0	1.28 (0.45-3.68)	0.642		
Age at Baseline		0.54 (0.27-1.11)	0.092		
Birth Weight					
ELBW	1.67; 0	1		1	
VLBW	1.08; 0	0.87 (0.36-2.11)	0.754	0.23 (0.08-0.72)	0.012
LBW	0.09; 0	0.17 (0.03-0.84)	0.042	0.06 (0.01-0.55)	0.012
Mother's Schooling					
> 8 years of study	0.76; 0	1			
≤ 8 years of study	1.86; 0	1.33 (0.55-3.24)	0.531		
Father's schooling					
> 8 years of study	1.00; 0	1	1.000		
≤ 8 years of study	0.93; 0	1.00 (0.37-2.70)			
Monthly Family Income					

> 2 times MMW*	0.08; 0	1	0.037	1	
≤ 2 times MMW*	1.42; 0	6.18 (1.12-34.16)		6.05(1.05-34.84)	0.044
Consumption of Milk with Sugar Using Glass					
Yes	1.17; 0	1	0.711		
No	0.78; 0	0.84 (0.30-2.26)			
Frequency of Milk Consumption with Added Sugar per Day**		1.03 (0.75-1.41)	0.876		
Consumption of sweetened juice, tea or yogurt					
Yes	3.25; 0	1	0.118	1	
No	0.69; 0	0.55 (0.26-1.16)		0.21 (0.07-0.62)	0.005
Infant Formulas					
Yes	0.73; 0	1	0.753		
No	1.08; 0	1.20 (0.39-3.64)			
Chips/Snack Foods					
Yes	2.17; 0	1	0.711		
No	0.85; 0	0.70 (0.30-1.64)			
Sweets					
Yes	2.63; 0	1	0.250		
No	0.58; 0	0.54 (0.19-1.55)			
Who Brushes Child's Teeth					
Parents	0.61; 0	1	0.476		
Child	1.62; 0	1.46 (0.52-4.08)			
Use of Fluoride Toothpaste					
Yes	0.52; 0	1	0.241		
No	2.86; 0	1.88 (0.66-5.37)			

*MMW = Monthly Minimum Wage; ELBW = Extremely Low Birth Weight (less than 1,000 g); VLBW = Very Low Birth Weight (more than 1,000 g to 1,500 g); NBW = Normal Birth Weight (more than 1,500 g to 2,500 g). **Using glass or cup.

Discussion

The present study confirmed the first hypothesis of an increase in dental caries with a decrease in birth weight among children. Some dietary habits and a lower socioeconomic status increased the risk of caries in these children after two years. However, other dietary variables were not associated with the increase in dental caries.

The occurrence of carious lesions increased in the two-year period analyzed. This result is expected, as five-year-old children are more likely to develop caries compared to younger children [23]. The increase in the risk of the development of dental caries with age is due to the prolonged exposure of primary teeth to the oral environment [23].

Few studies have evaluated the association between birth weight categories and dental caries. One study found that VLBW children were more likely to develop cavitated and non-cavitated caries (OR: 1.4; 2.9-67.4) compared to LBW children (OR: 5.63; 2.3-15.1). However, the authors did not find a dose-response relationship considering ELBW (OR: 8.4; 2.1-34.0) [16]. Another study reported contrary results, showing that a higher birth weight was weakly associated with a slight increase in carious lesions [17]. A possible explanation for the dose-response relationship between lower birth weight and a higher incidence of dental caries found by our team may be explained by the presence of hypomineralized teeth and eating habits [11,24].

Defects during the formation of tooth enamel during intrauterine life may favor the disruption of the enamel structure, predisposing teeth to the colonization of dental plaque [15]. Another study by our team evaluated the prevalence of DED in the same sample as that used in the present investigation [25] and the group of children born with < 2,500 g had a significantly higher mean DED in primary teeth (1.93 ± 3.8) compared to NBW children (0.38 ± 0.9) (p=0.007). It is likely that the vulnerability of the low birth weight group may have predisposed these children to dental caries. Newborns with a lower birth weight may have an increased likelihood to be bottle fed and are more vulnerable to early weaning. As the aim is to gain weight, the higher frequency of bottle feeding results in a higher risk of dental caries [16]. Malnutrition is another factor found in many children with low birth weight, which can reduce salivary flow and alter saliva's composition and buffering capacity, leading to increased susceptibility to carious lesions [11].

Dietary habits also play a significant role in the development of dental caries, as frequent exposure to sugar, snacks and sweetened beverages combined with poor oral hygiene facilitates the colonization of cariogenic bacteria and, consequently, favors the development of caries [26]. In the present study, the non-consumption of sweetened juice, tea and yogurt had a protective effect, minimizing the occurrence of caries. Indeed, many parents and caregivers have the habit of sweetening beverages for their children and offering sweetened yogurt.

The association between socioeconomic status and the occurrence of dental caries was confirmed in the present investigation. Previous studies have demonstrated that children from families with a low socioeconomic status are twice as likely to have dental caries than those in higher income strata [27]. LBW is also associated with a low socioeconomic status [12]. The association between poor oral health in children and a low socioeconomic status is related to the lower access to health services in this population [28].

This study has some limitations that should be considered. Recall bias and reporting bias may have occurred, as the mothers may not remember precise details regarding their children's diet, oral health and hygiene. Indeed, recall and reporting bias are major challenges in epidemiological research, as many studies involve the collection of data using questionnaires and interviews [29,30]. As a strong point, we retrieved 86% of the original sample. One may expect the loss of up to 20% of the sample in epidemiological studies [31]. Thus, the impact of such loss was minor. Despite the small sample size and selection of participants by convenience, the binomial regression analysis resulted in precise effect estimates with narrow 95%CIs, demonstrating the robustness of the statistical analysis. Moreover, we performed dental examinations at two time points, which enabled incidence analysis. The few previous studies that evaluated the association between LBW and the incidence of caries in children [11,15] did not consider the different birth weight categories. Despite the limitations presented here, we found that the VLBW and LBW children had a lower incidence of caries compared to ELBW children. Thus, this study is particularly important, as it offers a dose-response analysis of different cutoff points for birth weight and the incidence of dental caries.

The present findings highlight the importance of monitoring low-birth-weight children by a multidisciplinary team. Dentists should provide special health care for ELBW, VLBW and LBW children in the form of more frequent appointments to monitor their oral health. Further cohort studies with a longer follow-up period are needed to determine whether the incidence of dental caries in this group of children occurs during the mixed and permanent dentition phases.

Conclusion

The present study confirms the importance of investigating the association between the incidence of dental caries and different birth weight categories, as an inverse dose-response relation was found: very low birth weight and low birth weight children had a lower incidence of caries compared to extremely low birth weight children. A lower socioeconomic status and the consumption of sweetened juice, tea or yogurt were risk factors for dental caries.

Authors' Contributions

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FGC	https://orcid.org/0000-0003-2510-1329	Conceptualization, Methodology, Formal Analysis and Writing - Review and Editing.
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CCM	https://orcid.org/0000-0001-9072-3226	Conceptualization, Methodology, Formal Analysis, Writing - Review and Editing and Supervision.

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

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Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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