

# Incidence of dental caries in primary dentition and risk factors: a longitudinal study

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**Abstract:** The objectives of this prospective, longitudinal, population-based study were to estimate the incidence of dental caries in the primary dentition, identify risk factors and determine the proportion of children receiving dental treatment, through a two-year follow up. The first dental exam was conducted with 381 children aged one to five years, at health centers during immunization campaigns; 184 of them had dental caries and 197 had no caries experience. The second exam was carried out two years later at a nursery or at home with the same individuals who participated in the first exam. The diagnosis of dental caries was performed using the dmft criteria. Parents were interviewed regarding socioeconomic indicators. Descriptive, bivariate and adjusted Poisson regression analyses were performed. Among the 381 children, 234 were reexamined after two years (non-exposed: 139; exposed: 95). The overall incidence of dental caries was 46.6%. The greatest incidence of dental caries was found in the group of children with previous caries experience (61.1%). Among the children without dental caries in the first exam, 36.7% exhibited caries in the second exam. The majority of children (72.6%) received no treatment for carious lesions in the two-year interval between examinations. Children with previous dental caries (RR: 1.52, 95%CI: 1.12–2.05) had a greater risk of developing new lesions, compared with the children without previous dental caries. The incidence of dental caries was high and most of children's caries were untreated. Previous caries experience is a risk factor for developing new carious lesions in children.

**Keywords:** Dental Caries; Tooth, Deciduous; Oral Hygiene; Incidence.

## Introduction

Dental caries is one of the most frequent chronic conditions in childhood. Approximately 50% of preschool children in different countries have caries experience.<sup>1</sup> This estimate is confirmed in studies conducted in Brazil, where prevalence rates range from 20.3%<sup>2</sup> to 53.6%.<sup>3</sup> Dental caries exerts a negative impact on the quality of life of both the child and the family,<sup>2</sup> and is considered a public health problem.

The etiology of dental caries in childhood is associated with eating habits,<sup>4,5</sup> irregular tooth brushing<sup>6,7</sup> and socioeconomic indicators.<sup>8</sup> Children from economically vulnerable families have a higher



prevalence rate of dental caries.<sup>9,10</sup> The same is true for children whose mothers have a low level of education.<sup>11</sup> The socioeconomic status of the family can influence parents'/caregivers' perceptions regarding the oral health of their children. Parents with a disadvantaged socioeconomic status may have less knowledge regarding the factors associated with caries and dental care needs, as well as less access to healthcare services.<sup>5,12,13</sup>

Approximately 48% of Brazilian children aged five years have untreated dental caries,<sup>13</sup> which can cause pain and affect both their nutritional status and physical development.<sup>14</sup> Untreated dental caries is also the most common reason for hospital admissions.<sup>15</sup> Considering the significant proportion of untreated caries and its impact on quality of life, it is important to identify children with dental caries and determine the risk factors of this adverse oral health condition. The assessment of caries-related risk factors is useful to the planning of public health policies based on scientific evidence, and is crucial to identifying the early stages of the disease in children who are susceptible to aggravation of tooth decay.<sup>16</sup>

The determination of factors that may favor the occurrence of dental caries is accomplished primarily through cross-sectional studies. However, the cross-sectional design does not allow the determination of causality among variables, and provides weaker evidence of associations. Thus, longitudinal studies are needed, because they allow cause-and-effect relationships to be determined, and risk factors to be confirmed.<sup>17</sup> Longitudinal studies also provide data on the incidence of adverse health conditions. However, information on the incidence of caries in the primary dentition remains scant.<sup>18,19</sup> Incidence data are important to assessing the magnitude of the health problem and the effectiveness of preventive measures, as well as to enabling access to health services.

The aim of the present study was to assess the oral health status of Brazilian children in a two-year period, and to identify the incidence of carious lesions, risk factors and the frequency of deciduous teeth that remain untreated.

## Methodology

A longitudinal study was conducted in the city of Diamantina, located in the northern portion of the state of Minas Gerais, in southeastern Brazil. The Human Development Index for the city is 0.716.<sup>20</sup> According to the last census of the *Instituto Brasileiro de Geografia e Estatística* – IBGE,<sup>21</sup> Diamantina has a population of 45,880 inhabitants, 2992 of whom are children aged two to six years. The study population included children from four to seven years of age.

### Study design

This study was conducted at two moments: baseline (T0) and follow-up (T1). In 2010 and 2011 (T0), 381 children aged one to five years were examined to determine prevalence of dental caries and identify associated factors, and their parents were interviewed regarding socioeconomic indicators. At a second moment (2012 and 2013) (T1) the children were reexamined to verify dental caries incidence and identify risk factors; in addition, it was ascertained whether the children diagnosed with caries in the first exam received dental treatment.

### T0 – baseline

In the first phase, the study population included children from one to five years of age, who had been treated at the basic healthcare units (n = 10) of the city during immunization campaigns held in 2010 and 2011. In these immunization campaigns, vaccination coverage was higher than 90%. In 2010, 3713 children were immunized (coverage: 97.28%), whereas in 2011, 3107 (coverage: 99.29%) children were treated during immunization campaigns. The sample size for T0 was calculated considering a 44.8% prevalence rate for caries in the deciduous dentition,<sup>22</sup> a 95% confidence interval and a 5% standard error, which established a minimum sample of 380 children. Systematic sampling was adopted for the purpose of randomization, using the following procedure: the children were arranged in a line; the first child was examined, the second was not, the third was examined, and so on.

Prior to the fieldwork, ten examiners underwent a training and calibration exercise for the diagnosis of dental caries. Calibration was performed using

images of different clinical situations on two separate occasions, with a one-week interval between sessions. The minimum kappa intraexaminer agreement was 0.81, and the maximum was 0.90. The minimum kappa interexaminer agreement was 0.80, and the maximum was 1.

During the exam, the child remained seated in front of the examiner and facing a window to make utmost use of natural light. Dental caries was diagnosed using the criteria of the World Health Organization.<sup>23</sup> Dental caries was dichotomized as absent or present. Oral hygiene quality was evaluated based on the presence of biofilm. Tooth surfaces were scraped with a clinical probe, and the presence of biofilm indicated unsatisfactory oral hygiene.

The parents/caregivers were interviewed to determine socioeconomic indicators (mother's schooling, monthly household income and place of residence) and child's age and sex. After the diagnosis of dental caries, all parents/caregivers and children received instructions regarding oral hygiene and diet. Parents/caregivers of children who had carious lesions were informed of the need for treatment, and were instructed to seek dental services at the university clinic or family health units of the Brazilian public healthcare system.

## T1 – follow-up

This second phase was conducted by two researchers, who contacted the parents/caregivers and children to invite them to participate in the reevaluation of oral conditions. A clinical examination was carried out at the place where the child spent most of the time: nursery school or home. In the event that the child and parents/caregivers were not found during telephone contact or upon the first visit, three attempts were made before considering the data as lost.

The children were divided in two groups based on the presence of dental caries in first exam. The exposed group was composed of children with previous dental caries experience ( $n = 184$ ), and the non-exposed group ( $n = 197$ ), of children who had no previous dental caries experience. The diagnosis of new cases of dental caries and oral hygiene was performed using the same criteria employed during

the first exam. The incidence of dental caries was determined by comparing the two oral examinations. During the second exam, the researchers were blinded to each of the groups. During the second interview, parents/caregivers confirmed the information on socioeconomic indicators.

The treatment of carious lesions during the two-year interval was determined by comparing the two exams. Each carious tooth observed during the first examination, either remained with caries or had received some form of treatment (restoration or extraction). For cases in which a tooth was missing, the parents/caregivers were asked to explain why it was missing, and there was also the possibility of exfoliation, considering the child's age and the presence/absence of the contralateral tooth.

## Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS for Windows version 20.0, SPSS Inc., Chicago, USA). Associations were tested using bivariate analysis (chi-squared test and McNemar's test) between the outcome variable (new dental caries) and the independent variables (socio-demographic and clinical characteristics). Poisson regression with robust variance was used to determine interactions among the variables. The magnitude of the association of each factor with further episodes of dental caries was assessed using non-adjusted and adjusted relative risk (RR), respective 95% confidence intervals (CI) and p-values (Wald test). Explanatory variables with a p-value of  $\leq 0.25$  in the bivariate analysis were incorporated into the multivariate model.

This study received the approval of the Human Research Ethics Committee of the *Universidade Federal de Minas Gerais* – UFMG (Brazil) (protocol: 181/2010). The participants' rights were protected and parents/caregivers read and signed a statement of informed consent prior the participation of their children.

## Results

### T0 – baseline

Table 1 shows the characteristics of participants. The prevalence of dental caries was 48.3%. The

statistical analysis (chi-squared test and Poisson regression with robust variance) revealed that dental caries was significantly associated with inadequate oral hygiene ( $p < 0.001$ ), low income ( $p < 0.001$ ) and lower level of mother's schooling ( $p = 0.001$ ). In the adjusted multivariate regression model, inadequate oral hygiene (PR: 3.14; 95%CI: 1.13–2.15) and low income (PR: 1.56; 95%CI: 2.33–4.24) remained associated with a greater prevalence rate of dental caries, independently of

the other variables (place of residence, mother's schooling, child's age and sex).

### T1 – follow-up

Among the 381 children, 234 were reexamined after two years, corresponding to a 61.4% response rate (exposed group: 51.63%; non-exposed group: 70.55%). The main reasons for the losses were moving to another city or address and absence from daycare or from place of residence after three attempts to visit.

Among the children examined, 55.1% were male and the mean age was 5.33 ( $\pm 1.08$ ) years. Most mothers had schooling  $\leq$  eight years (52.6%), and 84.2% of the families had a household income  $\leq$  twice that of the Brazilian monthly minimum wage.

Among the 139 children who had no dental caries experience at baseline, 51 (36.7%) developed carious lesions during the two-year follow up. Among the 95 children with dental caries experience at the first exam, 58 (61.1%) developed new carious lesions during the follow-up. Thus, a total of 109 (51 + 58) (46.6%) children had carious lesions in the follow-up time. Most caries remained untreated at the end of the follow-up period (Tables 2 and 3). Comparing the two dental examinations, a high percentage of children (72.6%) diagnosed with carious lesions at the first exam remained without treatment at the second exam. The remaining children had been submitted to restoration or extraction of at least one decayed tooth.

In the bivariate analysis, new caries lesions were significantly associated with inadequate oral hygiene ( $p = 0.009$ ) (Table 4). The risk factors of these new

**Table 1.** Characteristics of participants at baseline (n = 381).

Characteristics	n (%)
Sex	
Male	188 (49.3)
Female	193 (50.7)
Dental caries	
No	197 (51.7)
Yes	184 (48.3)
Place of residence	
Urban area	276 (72.4)
Rural area	105 (27.6)
Mother's schooling	
> 8 years	146 (39.5)
$\leq$ 8 years	224 (60.5)
Household income	
> 2 times monthly min wage	87 (22.9)
$\leq$ 2 times monthly min wage	293 (77.1)
Age	
Minimum: 1 year	-
Maximum: 5 years	-
Median: 3 years	-

**Table 2.** Characteristics of carious lesions after two years (upper teeth).

Dental caries (Second exam)	Caries diagnosed at first examination									
	Tooth 55	Tooth 54	Tooth 53	Tooth 52	Tooth 51	Tooth 61	Tooth 62	Tooth 63	Tooth 64	Tooth 65
Decayed (%)	22 (88.0)	22 (91.6)	3 (50.0)	26 (81.2)	22 (50.0)	20 (45.4)	16 (59.2)	4 (66.6)	23 (71.9)	11 (57.9)
Restored without caries (%)	3 (12.0)	1 (4.2)	3 (50.0)	6 (18.8)	8 (18.1)	8 (18.2)	9 (33.3)	2 (33.4)	5 (15.7)	7 (36.9)
Restored with decay (%)	0 (0.0)	1 (4.2)	0 (0.0)	0 (0.0)	2 (4.5)	1 (2.3)	0 (0.0)	0 (0.0)	2 (6.2)	1 (5.2)
Missing due to caries (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (11.4)	5 (11.3)	2 (7.5)	0 (0.0)	2 (6.2)	0 (0.0)
Exfoliated (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	7 (16.0)	10 (22.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total (%)	25 (100)	24 (100)	6 (100)	32 (100)	44 (100)	44 (100)	27 (100)	6 (100)	32 (100)	19 (100)

**Table 3.** Characteristics of carious lesions after two years (lower teeth).

Dental caries (Second exam)	Caries diagnosed at first examination									
	Tooth 75	Tooth 74	Tooth 73	Tooth 72	Tooth 71	Tooth 81	Tooth 82	Tooth 83	Tooth 84	Tooth 85
Decayed (%)	19 (47.5)	28 (65.1)	4 (100)	4 (100)	4 (50.0)	5 (55.5)	6 (85.7)	6 (85.7)	31 (72.1)	21 (47.8)
Restored without caries (%)	15 (37.5)	14 (32.5)	0 (0.0)	0 (0.0)	1 (12.5)	1 (11.1)	0 (0.0)	1 (14.3)	9 (20.9)	19 (43.2)
Restored with decay (%)	5 (12.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (4.5)
Missing due to caries (%)	1 (2.5)	1 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (7.0)	2 (4.5)
Exfoliated (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (37.5)	3 (33.4)	1 (14.3)	0 (0.0)	0 (0.0)	0 (0.0)
Total (%)	40 (100)	43 (100)	4 (100)	4 (100)	8 (100)	9 (100)	7 (100)	7 (100)	43 (100)	44 (100)

**Table 4.** Distribution of dental caries (second exam) according to presence of dental caries at first examination, characteristics of child and socioeconomic indicators.

Variable	New carious lesions		p-value
	Absent n (%)	Present n (%)	
Dental caries (first exam)			
No	88 (63.3)	51 (36.7)	-
Yes	37 (38.9)	58 (61.1)	0.169*
Sex			
Male	55 (52.4)	50 (47.6)	-
Female	40 (38.1)	50 (47.6)	0.438**
Age (years)			
3	2 (66.7)	1 (33.3)	-
4	40 (65.6)	21 (34.4)	-
5	26 (40.6)	38 (59.4)	0.847***
6	34 (51.5)	32 (48.5)	-
7	23 (57.5)	17 (42.5)	-
Oral hygiene			
Satisfactory	74 (62.2)	45 (37.8)	-
Unsatisfactory	51 (44.3)	64 (55.7)	0.009**
Place of residence			
Urban area	119 (54.1)	101 (45.9)	-
Rural area	6 (42.9)	8 (57.1)	0.582**
Mother's schooling			
> 8 years	70 (56.9)	53 (43.1)	-
≤ 8 years	53 (49.1)	55 (50.9)	0.238**
Household income <sup>c</sup>			
> 2 times monthly min wage	103 (52.3)	94 (47.7)	-
≤ 2 times monthly min wage	21 (58.3)	15 (41.7)	0.587**

\*McNemar Test; \*\*Chi-square test; \*\*\*Chi-square test for linear trend ( $p < 0.05$ ).

lesions were identified by incorporating the variables with a  $p$ -value  $\leq 0.20$  in the bivariate analysis (caries at first exam and inadequate oral hygiene) into the Poisson regression model with robust variance.

In the adjusted multivariate regression model, only the dental caries at the first examination remained associated with new carious lesions (RR: 1.52; 95%CI: 1.269–2.182;  $p = 0.006$ ) (Table 5).

**Table 5.** Relative risk and confidence intervals for associations among caries at first examination, oral hygiene and new carious lesions.

Variable	Relative risk (unadjusted)	95%CI	p-value	Relative risk (adjusted)	95%CI	p-value
Dental caries (first exam)						
Absent	1.000	-	-	1.000	-	-
Present	1.664	1.26–2.18	< 0.001	1.525	1.12–2.05	0.006
Oral hygiene						
Satisfactory	1.000	-	-	1.000	-	-
Unsatisfactory	1.472	1.10–1.95	0.007	1.238	0.91–1.68	0.172

## Discussion

In the present study, approximately 46% of the children had new carious lesions over a period of two years. The incidence was even greater among children who had caries at the first examination (61.1%). The high incidence of dental caries in the primary dentition is in agreement with studies conducted on children in Thailand<sup>18</sup> and Sweden.<sup>19</sup>

Children with dental caries at the first examination were 1.52 times more likely to experience new dental caries over the two-year period. Thus, previous dental caries was a predictor for new dental caries. This finding lends support to the hypothesis that previous caries experience is indicative of the disease in the future,<sup>16,24,25,26</sup> especially in cases in which children are exposed to other risk factors for dental caries.

Inadequate oral hygiene (assessed in the present study by the presence of biofilm that adhered to the tooth surface) was associated with new carious lesions in the bivariate analysis. Biofilm is related to the presence of cariogenic bacteria and fermentable substances, which leads to demineralization and dental caries.<sup>6</sup> Brushing with fluoridated toothpaste is one of the measures for caries prevention.<sup>27</sup> However, this preventive measure may be inadequate in young children, due to their poor dexterity.<sup>28</sup> Thus, brushing should be practiced or supervised by parents/caregivers until the child is able to perform it alone.<sup>6</sup> Indeed, the association between dental caries and the recurrence of visible plaque may be related to a lack of oral hygiene monitoring by parents/caregivers. However, the multivariate model revealed that oral hygiene did not remain associated with new carious lesions. This finding may be explained by the collinearity between oral hygiene and caries at the first exam. Thus, although this variable did not remain

significant, it must be considered when investigating the risk of tooth decay.

Although the parents/caregivers were counseled regarding the importance of controlling factors associated with tooth decay, as well as the measures to be adopted for the prevention and control of the disease, the incidence of dental caries was high. This finding seems to be associated with the difficulty of understanding such measures on the part of parents/caregivers, or else the low priority given to oral health care.<sup>29</sup> In this respect, one must consider the influence of environmental and socioeconomic factors. While families may agree to follow the recommendations of dental professionals for the maintenance of their children's oral health, aspects such as level of comprehension and poor living conditions, as well as limited availability and access to health services may compromise the adoption and success of preventive measures. The present findings lend support to this hypothesis, insofar as new caries occurred more in children from families with a low socioeconomic status, although no statistically significant association was found between socioeconomic indicators and dental caries incidence. The absence of an association may be related to the fact that the sample is homogeneous with respect to socioeconomic indicators (place of residence, mother's schooling and household income). This makes it difficult to identify differences in the incidence of dental caries among children with higher or lower socioeconomic status.

Only 27.4% of children with dental caries diagnosed at the first examination had at least one treated tooth. The lack of treatment seems to reflect the lives of these children, and confirms that socioeconomic inequalities and limited access to health services exert an influence on the oral health of preschool children.<sup>12,13,28</sup>



This study has limitations due to the rate of sample loss caused by the high degree of mobility of the families. However, it also has strengths, such as the longitudinal design, which allowed the assessment of caries incidence and the establishment of a causal relationship among the variables. Moreover, this investigation provides greater evidence to complement earlier research, since the sample was taken from a population-based study.

The present findings demonstrate that dental caries still affects a large number of children and is a risk factor for developing further caries. Although this disease is a common occurrence in the primary dentition, its treatment is neglected; this can affect the quality of life of children and their families.<sup>30</sup> Thus, given the growing number of carious lesions in the primary dentition and the high proportion of children without dental treatment, this study underscores

the need to establish public policies and prevention programs aimed at reducing the incidence of dental caries and increasing access to oral health services.

## Conclusions

The incidence of caries in the primary dentition was high and the majority of children received no dental treatment. A previous caries experience in the primary dentition is a risk factor for developing new carious lesions in children.

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