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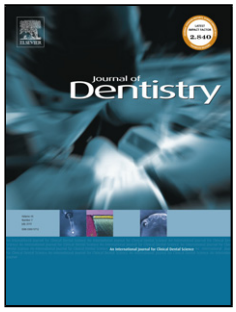

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Reasons for direct restoration failure from childhood to adolescence: a birth cohort study

Short title: Reasons for direct restoration failure in a birth cohort

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Abstract

Objectives: The aim of this study was to assess the prevalence of direct restorations in posterior teeth in children aged 12, from a birth cohort, and to test the association between the quality of the restorations and individual variables experienced in the life cycle. Methods: All live-born children in Pelotas, in 2004, were prospectively

investigated and a representative sample was assessed for oral conditions at ages 5 and 12. The outcome was the quality of the restoration (satisfactory/unsatisfactory). Independent variables included socioeconomic, behavioral and oral health characteristics at the individual level and the size of cavity and material at the tooth level. Associations were tested using multilevel logistic regression models. Results: A total of 1,000 participants and 249 restorations in the permanent dentition were examined. Most of the restorations were composites (73.5%), while only 6.8% were amalgam. After adjusted analyses, children whose parents received information on how to prevent their child from developing caries before reaching 5 years of age had 91.0% less chance of having an unsatisfactory restoration compared to children whose parents never received information (OR=0.09; 95% CI 0.01-0.59). Also, the chances of presenting unsatisfactory restorations were 5.3 higher in children at high-risk for untreated dental caries in the permanent dentition, in comparison with children at low risk (OR=5.32; 95% CI 1.07-26.6). Conclusions: Low-risk for untreated dental caries and having received information on preventing dental caries, reduced the chance of presenting failed restorations, showing that factors related to individuals play an important role in the quality of restorations.

Clinical significance

Our findings highlight the role that individual-related factors play in restoration longevity in children, reinforcing the need for a patient-centered approach in restorative dentistry.

Keywords: Dental Restorations; Dental Restoration Failure; Cohort Studies; Child; Posterior Teeth; Longevity.

Introduction

Dental caries affects individuals worldwide and although a reduction in its prevalence has been observed in some countries, it continues to be considered a public health problem on a global scale [1]. Therefore, there still exists a high demand for dental restorative treatments, especially for posterior teeth [2]. For these cases, direct restorations are the first choice of restorative treatment by dentists [3]. In the past, amalgam was the most commonly used restorative material for posterior restorations

[4], however, in recent decades, composite resin has become an alternative for restoring posterior teeth, overtaking amalgam as the material of choice [5]. Environmental contamination by the mercury present in amalgam restorations and its possible effect on the population's health are some of the main reasons for the reduced use of amalgam [6].

However, despite the restrictions related to the use of amalgam, either composite or amalgam are the materials currently used for direct restorations, presenting similar annual failure rates [7]. Recurrent caries and tooth or restoration fractures are the restoration failures most reported in the available literature [8, 9, 10]. In addition, current literature argues that these individual-related variables, such as socioeconomic status [11] and risk of caries, can play an important role in the longevity of restorations [12].

As yet, there have been no population-based longitudinal studies that have investigated the association between an individual's characteristics experienced during life (socioeconomic, behavioral and oral health characteristics) and failure of restorations in posterior teeth in childhood. In this age group, there is not only the challenge of the technical difficulty related to the child's behavior [13], which may be associated with the occurrence of failures in subsequent restorations, but there is also the challenge of maintaining oral health care, providing an environment for progression of caries adjacent to the restoration.

This study aimed to assess the type of material and the quality of the direct restorations in posterior teeth in a birth cohort study. The role of factors experienced in the life cycle on the occurrence of unsatisfactory restorations was investigated.

Materials and methods

This study is reported in accordance with the STROBE statements guidelines.

Study design

This was a longitudinal prospective study produced from data collected in a population-based birth cohort started in 2004, in the city of Pelotas, in Southern Brazil.

Pelotas cohort study 2004

The 2004 birth cohort aimed to investigate the impact of early life exposures on health outcomes throughout the life cycle. The mothers of children born in 2004 in the five maternity hospitals in the city, were invited to participate in the study. A total of 4,231 mothers were interviewed in the perinatal period, and information was collected concerning demographic and socioeconomic characteristics of the mother, lifestyle, use of health services, mother's mental health, growth and child development, morbidities, among other conditions.

In 2009, the first oral health sub-study was carried out with a representative subsample of the 2004 birth cohort (1,303 children aged 5).All children selected in the sample were invited, by telephone, to participate in the study (n = 1,303) and of these, 1,129 were dentally examined (response rate of 86.6%) and the mothers were interviewed. In 2017, the second oral health follow-up was carried out when the adolescents were 12 year-old, and the same sample of children selected in 2009 was invited to participate in this assessment.

In the second follow-up, data were collected by nine dentists and seven interviewers (previously trained and calibrated), through an interview with the participants and their caregivers. The interview consisted of a questionnaire comprising questions related to the use of dental services by the adolescent, bruxism, hygiene and use of dental services by the adolescent's mother, family functionality, parental stress, educational style, sense of coherence, oral hygiene habits and use of dental fluoride. In addition, a clinical examination was conducted by the dentist to investigate posterior restorations, dental caries and other clinical conditions. The inter-examiner agreement obtained through the Kappa coefficient ranged from 0.83 to 0.95 for dental caries and between 0.66 and 0.84 for quality of restoration.

Tooth-level variables

Presence of restoration was assessed at 12 years using the DMFS index (decayed, missed and filled surfaces for permanent teeth), according to the criteria suggested by the World Health Organization [14]. When a filled surface was present, the restoration was assessed according to the material used, quality and number of surfaces involved. Material was categorized as (0) composite, (1) amalgam or (2) other (glass ionomer cement). The criteria proposed by Hickel [15], adapted for epidemiological studies, was used to evaluate the quality of restoration. According to the criteria, restorations were classified as (0) satisfactory or (1) unsatisfactory

(outcome). In the event of an unsatisfactory restoration, the reason for the failure was recorded as (0) secondary caries, (1) total or partial fracture, (2) severe wear (exposing dentin), (3) moderate or severe pain, and (4) other (large proximal excess, exacerbated roughness, lack of proximal contact).

The number of surfaces involved in the restoration was also collected and categorized as (0) one, (1) two or (2) three or more surfaces.

Individual-level variables

Individual variables were collected from the different waves in this cohort. Family income at birth was collected in a continuous way in Brazilian real (BRL) and categorized into quintiles. Mothers were asked (when children were 5 and 12 years old) about orientations, by way of the following question: "Have you ever received guidance on how to prevent your kid from developing decay?", with yes/no response options. Based on these two variables, a new variable was created to represent if mothers have received information on how to prevent their child from developing caries, with the follow categories: never; yes, after 5 years old; yes, before 5 years old.

In relation to the child's intake of sweet foods, information was collected at 5 years (reported by mothers) and at 12 years of age (self-reported). The question was "How many times a day does the child eat sweet foods between meals", with the response options (0) never, (1) more than once a day, (2) once a day, (3) twice a day, and (4) three times or more a day. Both variables were dichotomized into (0) less than twice a day and (1) twice or more a day. Based on these two variables, a new variable was created to represent if children have been exposed to a high consumption of sweet foods between meals during childhood, with the following categories: never exposed; exposed to high sugar intake at 12 years old; exposed to high sugar intake starting from 5 years old.

Information was collected on the use of dental services at age 12, where the mother responded if the child had visited the dentist and the type of service used (public service or private). Untreated dental caries (DS or dS from DMF-S and dmf-S) was continuously collected at ages 5 and 12, and was then divided into tertiles. The highest tertile was considered as having high risk and the first and second tertiles were considered as carrying a lower risk. The variables were then combined into a risk variable, resulting in four different untreated dental caries risk groups from 5 to 12 years of age: (1) those who were always at low risk; (2) those who were at high risk only with

deciduous teeth; (3) those who were high risk only with permanent teeth; and (4) those who were always at high risk.

Data analysis

Statistical analysis was conducted with STATA/SE 12.0 (Stata Corp, College Station, TX, USA). Descriptive analysis was performed, presenting the relative and absolute frequencies, means and standard deviations of the variables of interest. Associations between variables were tested using the chi-squared test and chi-squared test for linear trends. Multilevel logistic regression models were used to analyze the factors associated with the quality of restorations, considering random effects and two levels of data organization: tooth-level (level 1) and individual-level (level 2).

The variables in the model were selected according to a hierarchical model proposed by Correa et al., [11], where independent variables were ordered by their levels into four blocks to determine their entry into the multivariable model. The socioeconomic variable was placed in the most distal position in relation to the outcome, followed by behavioral variables, at risk for untreated dental caries, and tooth-level variables. Variables were adjusted by co-variables in the same and in the more distal blocks of the model. A stepwise backward selection was used to select variables in each block. For retention in the final model, variables had to present a p-value $\leq$ 0.250. Odds Ratio (OR) and 95% Confidence interval were obtained. Goodness-of-fit of models was assessed using deviance (-2 log likelihood). For all analyses, a confidence level of 95% was considered.

Ethical issues

All stages of this survey were approved by the Ethics Committee of the Faculty of Medicine at the Federal University of Pelotas, no. 1.841.984. Written informed consent was obtained from all participants or from their parents or legal guardians.

Results

A total of 1,303 individuals were invited to participate in the study and, of these, 1,000 participants and 249 restorations were found (response rate of 76.7% vis-à-vis the original oral health sample) (Fig. 1). Table 1 shows the descriptive analysis of the sample according to the variables at the individual and tooth levels. In relation to the

restorations evaluated, nearly $^{3}/_{4}$ involved one surface of the tooth, and $^{3}/_{4}$ were made of composite resin, while only 17 restorations (6.8%) were of amalgam. Moreover, the prevalence of unsatisfactory restorations was 8.4%.

Table 2 presents the results of a bivariate analysis, comparing children with/without restorations according to the different variables. A total of 156 children had restorations. It was possible to observe that the sample of children presenting restorations was comparable to children without restorations, excepting with regard to the risk for untreated dental caries. Children at low risk for untreated dental caries presented a lower prevalence of restorations compared with children at high risk at least once during their childhood.

The results of crude and adjusted multilevel logistic regression models are presented in Table 3, specifying the blocks and levels used for this analysis. After adjustment, having received guidance for preventing caries and risk for untreated dental caries was associated with restoration quality. Children whose parents received information on how to prevent their child from developing caries before 5 years old, had 91.0% less chance of having an unsatisfactory restoration compared to children whose parents never received any information (OR= 0.09; 95% CI 0.01-0.59). In addition, the chances of presenting unsatisfactory restorations were more than five times higher in the group of children with a high risk of untreated dental caries in the permanent dentition, irrespective of risk in deciduous teeth, in comparison with children that were always at low risk for untreated dental caries (OR= 5.32; 95% CI 1.07-26.6). None of the tooth-level variables (material and number of surfaces) was associated with quality of restoration.

Discussion

To our knowledge, this is the first population-based study that assessed the effect of individuals' variables collected in the life cycle, on restoration quality in children. In this study, low risk for untreated dental caries and having received information on how to prevent dental caries, reduced the chance of restoration failure, thus reinforcing the importance of carrying out an integral, preventive approach in the control of caries and when performing restorative procedures. Moreover, we found a low prevalence of amalgam restorations in the studied population, demonstrating that the professionals have chosen to perform restorations with tooth-colored materials.

Due to the absence of clinical follow-up of the restorations in this study, we do not know the exact moment they were fitted, so it was not possible to perform a survival analysis of the restorations and to investigate their longevity, which is a limitation of our study. However, this study allows for a longitudinal investigation of the influence of many individuals' variables, collected during the life cycle, in a representative sample, which permits extrapolation of findings to the real population, which is difficult to perform in clinical studies. The collection of exposure variables at different moments of children's lives allowed us to investigate the effect that accumulation of risk over time can have on restoration outcomes.

Another potential limitation that should be discussed is related to the fact that some variables were self-reported by individuals or by their mothers, such as the questions regarding intake of sweet foods, which may lead to inaccuracy of data. Considering that respondents knew that the interview was related to dental issues, some participants could have reported a lower sugar consumption. In this way, the effect of sugar consumption could be underestimated.

Our findings demonstrate that dental caries plays a fundamental role in the quality of restorations. Children with a low risk for untreated dental caries and those whose parents have received guidance on how to prevent the disease, were less likely to suffer restoration failure. These findings reinforce the importance of treating caries through non-operatory and minimally invasive strategies, seeking to avoid purely operative approaches, not only to prevent and treat the disease but also to contribute to the restoration's longevity, avoiding individuals entering in the so-called drill-and-fill restorative death spiral. Results of several previous studies with different designs corroborate the notion that dental caries is one of the main risk factors for failure of restorations, negatively influencing their longevity [9, 12, 16, 17, 18].

Having received information on how to prevent caries has also demonstrated the protective effect on tooth loss and consequent need for dental prosthesis in another birth cohort [19], suggesting that preventive measures can have a long-term effect on oral health. It is important to highlight that our findings, together with the current knowledge about the role that individual variables exert on longevity of restorations, suggest that a patient-centered approach to individuals' health would also contribute to the success of dental treatment, i.e. healthy individuals lead to healthy restorations. In this way, a common risk factor approach [20] also integrating structural determinants of

oral health inequalities, seems to be a useful alternative for developing future strategies to promote better health conditions, mainly at the population level.

It is worth mentioning that none of the dental level variables investigated in this study was associated with quality of restoration. In contrast, the vast majority of the studies showed an association between size of cavity and longevity of restorations [8, 12, 21, 22, 23]. The absence of any association in our study can probably be explained by the age of the population, as three-quarters of restorations involved only one surface. Although the tendency for an increased chance of failure was observed, the statistical significance was not present due to the low power to demonstrate this association.

Another important finding was the low prevalence of dental amalgam restorations in our study population, showing that, nowadays, this material is barely used any longer, being used less than glass ionomer cement to perform dental restorations in children. The data found are representative, since the restorations evaluated have a maximum of 7 years of longevity, depicting the clinical reality of the city of Pelotas. Our findings reinforce the need for a broad discussion about the actual need for teaching and use of dental amalgam in dental schools.

Another factor that may affect the choice of restorative material is the age of the patient. In childhood, there is a greater technical challenge for dentists with regard to restoration, since care is often hampered by the child's behavior, therefore, in these cases it is important that dentists use the restorative material with which they are most familiar to avoid prolonging clinical time, thereby contributing to a successful treatment. Therefore, following the current trend of reducing the teaching and use of amalgam, the technical sensitivity of composite resin is probably lower, making it the restorative material of choice among professionals for use in pediatric dentistry. In addition, new, simpler and faster techniques have been used to perform posterior direct restorations, such as the use of bulk-fill composites [24].

Although this study shows some associations between individuals' variables collected in the life cycle and restoration quality in children, it is important that these individuals continue to be monitored in order to verify, in the long-term, if the situations experienced early on will continue to influence future restorative outcomes in adulthood.

Conclusions

Within the limits of this study, low risk for untreated dental caries and having received information to prevent dental caries, reduced the chance of presenting unsatisfactory restorations in children, showing that factors related to individuals play an important role on the quality of restorations. These findings highlight the need for a patient-centered approach in restorative dentistry.

Conflict of interest

The authors state that there are no potential conflicts of interest that could have inappropriately influenced their work.

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Fig. 1 – Flow Chart of participant's inclusion process.

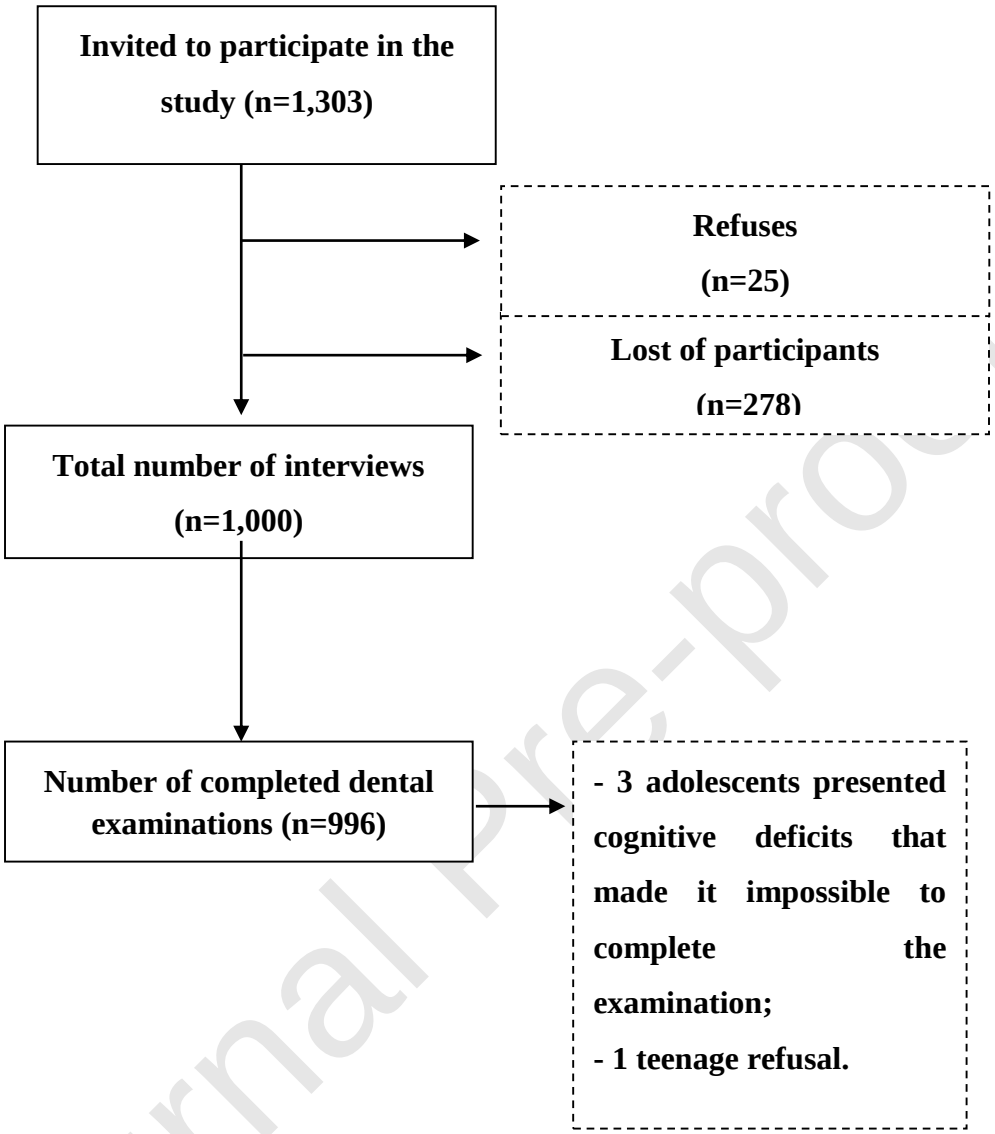

Table 1. Descriptive analysis of the sample according to the variables at individual and tooth level (1,000 children, 249 restorations).

Variable/Category (n)	N (%)	95% CI
Level 2 – Individual		
Familiar income at birth (quintiles) (1,000)		
1	168 (16.8)	14.5-19.3
2	210 (21.0)	18.5-23.7
3	183 (18.3)	15.9-20.8
4	223 (22.3)	19.8-25.0
5	216 (21.6)	19.1-24.3
Has the mother ever been received guidance to prevent child from caries? (942)		
Never	154 (16.3)	14.1-18.7
Yes, after 5 years old	356 (37.8)	34.8-40.9
Yes, before 5 years old	432 (45.9)	42.8-49.0
Intake of sweet foods – Twice or more between meals (940)		
Never exposed	326 (34.7)	31.7-37.7
Exposure only at 12 years old	234 (24.9)	22.2-27.7
Exposure starting from 5 years old	380 (40.4)	37.3-43.5
Use of dental service at age 12 (832)		
Public service	303 (36.4)	33.4-39.5
Private	529 (63.6)	60.5-66.6
Risk for untreated dental caries (1,000)		
Always low risk	553 (55.3)	52.2-58.4
High risk in deciduous	188 (18.8)	16.4-21.4
High risk in permanent	130 (13.0)	11.0-15.2
Always high risk	129 (12.9)	10.9-15.1
Level 1 - Tooth		
Number of surfaces involved (249)		
1	191 (76.7)	71.0-81.8
2	29 (11.7)	7.9-16.3
3 or more	29 (11.7)	7.9-16.3
Material (249)		
Composite	183 (73.5)	67.5-78.9
Amalgam	17 (6.8)	4.0-10.7
Other	49 (19.7)	14.9-25.2
Quality (249)		
Unsatisfactory	21 (8.4)	5.3-12.6
Satisfactory	228 (91.6)	87.4-94.7
Failure reason (18)		
Secondary caries	4 (22.2)	6.4-47.6
Partial or total fracture	9 (50.0)	26.0-73.9
Severe wear exposing dentin	4 (22.2)	6.4-47.6
Others	1 (5.6)	0.2-27.3

Table 2. Distribution of posterior restorations according to individual level variables (1,000 children, 249 restorations).

Variable/Category (n)	Dental restoration		
	Absence N(%)	**Presence N(%)**	**p-Value**
Level 2 – Individual			
Block 1			
Familiar income at birth (quintiles) (1,000)			0.120**
1	146 (86.9)	22 (13.1)	
2	181 (86.2)	29 (13.8)	
3	155 (84.7)	28 (15.3)	
4	184 (82.5)	39 (17.5)	
5	178 (82.4)	38 (17.6)	
Block 2			
Has the mother ever been received guidance to prevent child from caries?(942)			0.112*
Never	138 (89.6)	16 (10.4)	
Yes, after 5 years old	293 (82.3)	63 (17.7)	
Yes, before 5 years old	365 (84.5)	67 (15.5)	
Intake of sweet foods – Twice or more between meals (940)			0.072*
Never exposed	285 (87.4)	41 (12.6)	
Exposure at 12 years old	188 (80.3)	46 (19.7)	
Exposure starting from 5 years old	322 (84.7)	58 (15.3)	
Use of dental service at age 12 (832)			0.589*
Public service	244 (80.5)	59 (19.5)	
Private	434 (82.0)	95 (18.0)	
Block 3			
Risk for untreated dental caries (1,000)			**<0.001***
Always low risk	492 (89.0)	61 (11.0)	
High risk in deciduous	148 (78.7)	40 (21.3)	
High risk in permanent	99 (76.2)	31 (23.8)	
Always high risk	105 (81.4)	24 (18.6)	

* Chi-square test. **Linear trend test.

Table 3. Crude[c] and adjusted[a] odds ratios for independent variables from tooth and individual level and quality of restorations of a 12-year-old population. Pelotas, RS, Brazil. Multilevel analysis (n = 156 children; 249 restorations).

Variable/Category	Crude analysis OR[c] (95% CI)	Block 1 OR[a] (95% CI)	Block 1 + 2 OR[a] (95% CI)	Block 1 + 2 + 3 OR[a] (95% CI)
LEVEL 2 – INDIVIDUAL				
Block 1				
Familiar income in quintiles (ref = 1)				
2	0.52 (0.05-5.73)	0.58 (0.05-6.82)	0.65 (0.07-5.57)	0.54 (0.05-5.91)
3	0.25 (0.02-4.22)	0.23 (0.17-3.29)	0.34 (0.03-3.65)	0.55 (0.03-8.85)
4	1.90 (0.23-15.8)	1.70 (0.21-13.9)	2.05 (0.34-12.4)	1.87 (0.25-13.7)
5	0.08 (0.00-1.81)	0.10 (0.00-2.30)	0.16 (0.01-2.51)	0.33 (0.01-9.25)
Block 2				
Received guidance to prevent the child from having caries (ref = Never)				
Yes, after 5 years old	0.11 (0.02-0.62)		0.10 (0.02-0.52)	0.10 (0.02-0.52)
Yes, before 5 years old	0.08 (0.12-0.48)		0.09 (0.01-0.63)	0.09 (0.01-0.59)
Intake of sweet foods – Twice or more between meals (ref = Never exposed)				
Exposure at 12 years old	10.4 (0.50-22.1)		-	-
Exposure starting from 5 years old	17.4 (1.09-27.6)		-	-
Use of dental service at age 12 (ref = Public service)				
Private	0.80 (0.18-3.61)		-	-
Block 3				
Risk for untreated dental caries (ref = Always low risk)				
High risk in deciduous	0.33 (0.02-6.80)			0.38 (0.03-4.18)
High risk in permanent	6.80 (0.90-52.6)			5.32 (1.07-26.6)
Always high risk	13.9 (2.40-81.4)			5.15 (1.02-25.9)
LEVEL 1 – TOOTH				
Block 4				
Material (ref = Composite)				
Amalgam	2.79 (0.34-22.5)			-
Other	1.38 (0.26-7.33)			-
Number of surfaces involved (ref = 1)				
2	1.76 (0.23-13.5)			-
3 or more	4.96 (0.67-36.7)			-
Deviance (-2 log likelihood)	132.2 (Empty model)	119.8	113.6	105.0

Block 1: adjusted by socioeconomic variable (familiar income). Block 2: adjusted by block 1 + behavioral variables (guidance, intake of sweet foods and use of dental service). Block 3: adjusted by block 1 + 2 +risk for untreated dental caries variable.