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Prevalence of unsatisfactory dental restorations in posterior primary teeth and associated factors

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Abstract: The aim of this study was to investigate the prevalence of unsatisfactory dental restorations on posterior primary teeth and associated factors in school children aged six to ten years. A cross-sectional study was conducted with children randomly selected from public schools in a small Brazilian town. Questionnaires were sent to the guardians addressing socioeconomic and behavioral aspects of the child. Oral examinations were performed at the schools to determine the quality of dental restorations, visible biofilm, and presence of moderate/extensive untreated caries (scores 3-6 ICDAS). This examination was performed by two previously trained and calibrated examiners. Associations were tested using multilevel logistic regression. Among the 400 children evaluated, 98 had restorations (217 teeth). The prevalence of unsatisfactory restorations was 34.6%. Restorations in amalgam were less likely to fail compared to those in glass ionomer cement (OR = 0.11; 95%CI: 0.02–0.49; p = 0.005). Children with moderate/extensive untreated caries were more likely to have unsatisfactory restorations (OR = 6.79; 95%CI: 2.20–20.93; p = 0.001). Children with a visible plaque index ≥ 20% were also more likely to have unsatisfactory restorations (OR = 2.28 95%CI: 1.05–4.92; p = 0.036). The prevalence of unsatisfactory restorations was high. The occurrence of this outcome was associated with restorative material, presence of caries, and visible plaque.

Keywords: Cross-Sectional Studies; Dental Restoration Failure; Longevity; Child.

Introduction

Direct dental restorations on primary teeth are common procedures[1,2] that aim to restore the shape and function of the tooth,[3,4] prevent the progression of caries, and maintain the tooth in the arch until its natural exfoliation.[5] However, restorations are subject to failure, leading to a cycle of reinterventions that weakens the dental structure and results in the need for increasingly complex procedures.[6] The most common reasons for failure of dental restorations are recurrent caries[7,8] and fracture of the tooth or restoration.[8] A retrospective study demonstrated a 37.7% failure rate among restorations on primary teeth.[9]

Restoration longevity depends on factors related to clinical aspects, dental material properties, dentist skills, and patient characteristics, such as age, socioeconomic status, risk of caries, caries activity/severity, and oral hygiene.[10,11] Some studies found that restoration failure on permanent teeth is associated with socioeconomic, individual, and behavioral factors.[11,12] However, few studies have investigated such associations among children in the primary dentition phase,[9,13] especially population-based studies. Identifying and minimizing factors that influence the quality of dental restorations is fundamental to enhancing restoration longevity. Moreover, monitoring dental restorations is important to detect failures and repairs them (when possible) rather than replacing the restoration.[6] Replacing a restoration not only weakens the structure of the tooth, but can also lead to the need for more complex dental procedures, generating higher costs and consuming oral health resources in the public sector.[6]

Therefore, the aim of the present study was to investigate the prevalence of unsatisfactory dental restorations on primary teeth and associated factors in schoolchildren aged six to ten years. The hypothesis is that the prevalence of unsatisfactory restorations is associated with the type of restorative material, the child's risk of caries, and poor oral hygiene.

Methodology

Ethical aspects

This study was developed following the "Strengthening the Reporting of Observational Studies in Epidemiology" guidelines (STROBE statement) and was approved by the Human Research Ethics Committee of the School of Dentistry under protocol numbers 11350919.4.0000.5108 and 3.366.387. The guardians of eligible participants received written information about the purpose of this study and informed consent was obtained from all mothers. Children who required dental treatment were referred to the pediatric clinic of the postgraduate program.

Study design and population

A cross-sectional study was conducted between August 2019 and March 2020 in Diamantina, a city located in southeastern Brazil. The city had an estimated population of 47,825 residents in 2020, with 6206 children enrolled in primary school in 2018. The proportion of individuals aged six to 14 years attending school was 97.8% in 2010.[14]

The inclusion criteria were enrolment in public schools in the city, six to ten years of age, with at least one deciduous posterior teeth, and authorization from a legal guardian to participate in the study. Children who declined participation and those with neuropsychomotor disabilities were excluded.

The sample size was calculated considering a 95% confidence level, 80% test power, and frequencies of unsatisfactory restorations determined in the pilot study (39.21% among non-exposed individuals [teeth restored with glass ionomer cement] and 60% among exposed individuals [teeth restored with other material]). A minimum sample of 198 restorations was required, to which 40 (20%) were added to compensate for possible dropouts, leading to a sample of 238 restorations.

Randomization

Participant selection was performed in two stages. In the first stage, the schools in the city were selected using a random number method. Three schools were randomly selected from a total of twelve public schools that met the age group of interest and that accepted to participate in the research. In the second stage, children who met the eligibility criteria were randomly selected from each school. If the guardians of a selected child did not authorize the child's participation, another drawing was performed for the replacement of the child.

Training and calibration

Training (theory and practice) was conducted with two researchers and calibration was performed for the criteria used to determine the clinical diagnosis of the following variables: restoration quality[15] (inter-examiner Kappa: 0.78; intra-examiner Kappa: 0.81 and 0.83) and dental caries[16] [inter-examiner Kappa: 0.79; intra-examiner Kappa: 0.78 and 0.80)]. The calibration involved the clinical examination of 30 children on two occasions with a one-week interval between evaluations. Training

and calibration involved the two researchers who were to perform the data collection and were conducted by an experienced researcher who served as the "gold standard".

Data collection

The guardians of the selected children were invited to participate in the study and answered a questionnaire sent home addressing socioeconomic and behavioral characteristics of the children. The dental examinations of the children were performed in the schools under natural light after tooth brushing. Unsatisfactory restoration was the main outcome and the independent variables were organized at two levels: tooth (1) and individual (2).

Dependent variable: quality of dental restorations

Dental restorations were assessed with regard to each clinical characteristic: marginal adaptation, surface defects, presence of recurring caries, marginal staining, and anatomic shape, following the modified criteria of the United States Public Health Service (USPHS).[15] Restorations categorized as *Alpha* (no defect) and those categorized as *Bravo* (localized defect that could be repaired) were considered satisfactory, whereas those categorized as *Charlie* (clinically unacceptable defect requiring replacement of restoration) were considered unsatisfactory.

Variables at tooth level (Level 1)

At tooth level (1), unsatisfactory dental restorations on posterior primary teeth were assessed according to (1) dental arch (maxillary or mandibular), (2) restoration class (Class I or II), and (3) type of restorative material (glass ionomer cement [conventional/resin modified], amalgam, composite resin, or zinc oxide with eugenol).

Variables at individual level (Level 2)

At individual level (2), unsatisfactory dental restorations on posterior primary teeth were assessed according to (1) sex (female or male) (2) age, (3) family income (using the monthly minimum wage (MMW) as reference [≥ two times MMW or < two times MMW), (4) mother's schooling (≥ 12 or < 12 years of study), (5) consumption of sweetened foods or beverages between meals (< twice or ≥ twice per day), (6) last dental appointment (< one year or > one year earlier), (7) tooth brushing frequency (≥ twice or < twice per day), (8) use of dental floss (yes or no), (9) sleep bruxism according to parental report (absent or present), (10) risk of dental caries according to the American Dental Association criteria[17] for children older than six years (low or moderate/high risk), (11) moderate/extensive untreated caries according to the International Caries Detection and Assessment System (scores 3-6 ICDAS)[16] (absent or present), visible plaque, and gingival bleeding index (< 20% or ≥ 20%).[18,19]

Data analysis

Descriptive statistics were performed to determine the distribution of the variables and respective frequencies at tooth (1) and individual (2) levels. A multilevel regression model was employed for the analysis of factors related to failed restorations on posterior teeth. The data were organized at (1) tooth level (teeth) and (2) individual level (children). Estimates considered the restricted maximum likelihood method and the predictive quasi-likelihood estimation. A null model was first run to evaluate the partition of the variability in the data between levels. Next, the characteristics were considered at both levels. The variance partition coefficient (VPC) was calculated to quantify the extent to which the variance in the response variable was the result of differences between groups or intra-group differences.

Variables at tooth level (1) were incorporated into the model individually before being tested together. Next, variables at individual level (2) were incorporated one by one based on the results of the Student's t-test and considering a p-value < 0.05. The multilevel model was constructed with variables that achieved a p-value < 0.25. Odds ratios (OR) and respective 95% confidence intervals (CI) were estimated for each analysis. The reliability estimate, which comprised only variables with a p-value < 0.05, was used to determine the fit of the final model. The Hierarchical Linear and Nonlinear

Modeling Software (HLM 6.08 statistical package) was used for the multilevel analysis.

Results

Among the 400 children examined, 98 had restored teeth and 217 restorations were analyzed. The response rate was 91.18%. Losses (8.82%) were due to incomplete questionnaires. The description of the sample and frequencies of the variables were organized on two levels: tooth (Table 1) and individual (Table 2). The prevalence of unsatisfactory dental restorations on primary teeth was 34.6%. The power of the sample for the main independent variable (type of restorative material) was 83%.

The results of the multilevel logistic regression analysis are displayed in Table 3, with odds ratios (ORs) presented separately for each level. This cross-sectional study found that 98 children had dental restorations in posterior primary teeth. After the adjustments on the tooth level (1), restorations in amalgam were less likely to fail compared to those in glass ionomer cement (OR = 0.11; 95%CI: 0.02–0.49; p = 0.005). After adjustments on the individual level (2), children with moderate/extensive untreated caries (OR = 6.79; 95%CI: 2.20–20.93; p = 0.001) and those with a visible plaque index ≥ 20% (OR = 2.28; 95%CI: 1.05–4.92; p = 0.036) were more likely to have unsatisfactory restorations. A total of 29.3% of the variance in unsatisfactory restorations could be attributed to variables at the individual level (2).

Discussion

The present cross-sectional study evaluated the effect of clinical and individual variables on the quality of restorations on posterior primary teeth. The results demonstrated that restorative material, presence of moderate/extensive untreated caries, and a high visible plaque index were associated with failed restorations on posterior primary teeth. Therefore, the tested hypothesis was partially accepted.

The prevalence of unsatisfactory dental restorations was relatively high in this study (34.6%). This result is compatible with findings described in a retrospective study addressing defective restorations and factors associated with dental reinterventions, in which the prevalence of defects in restorations on primary teeth was 37.7%.[9]

At tooth level, amalgam was the restorative material with the lowest likelihood of failure compared to glass ionomer cement in both the unadjusted and adjusted models. This may be attributed to the good mechanical properties of amalgam.[20] Currently, however, this material is often not inadvisable due to the toxicity of mercury to human health and the

Table 1. Descriptive analysis of the sample according to variables at tooth level (1) (total number of restorations evaluated: 217).

Variables	Satisfactory restorations	Unsatisfactory restorations	Total of restorations
	n (%)	n (%)	n (%)
Tooth level (1)			
Type of tooth			
Maxillary molar	54 (67.5)	26 (32.5)	80 (36.9)
Mandibular molar	88 (64.2)	49 (35.8)	137 (63.1)
Type of restoration			
Class I	110 (67.1)	54 (32.9)	164 (75.6)
Class II	32 (60.4)	21 (39.6)	53 (24.4)
Restorative material			
Glass ionomer cement	75 (61)	48 (39)	123 (56.7)
Amalgam	18 (94.7)	1 (5.3)	19 (8.8)
Composite resin	46 (66.7)	23 (33.3)	69 (31.8)
Zinc oxide cement/eugenol	3 (50)	3 (50)	6 (2.8)

Table 2. Descriptive analysis of the sample according to variables at individual level (2) (number of patients evaluated: 98).

Variables	Satisfactory restorations	Unsatisfactory restorations	Total of restorations
	n (%)	n (%)	n (%)
Individual level (2)			
Age (years)			
6–8	28 (41.2)	40 (58.8)	68 (69.4)
9–10	21 (70.0)	9 (30.0)	30 (30.6)
Sex			
Female	26 (54.2)	22 (45.8)	48 (49.0)
Male	23 (46.0)	27 (54.0)	50 (51.0)
Family income*			
≥ 2 monthly min. wages	1 (20.0)	4 (80.0)	5 (5.1)
< 2 monthly min. wages	48 (51.6)	45 (48.4)	93 (94.9)
Mother's schooling (years of study)			
12 or more	7 (53.8)	6 (46.2)	13 (13.3)
Up to 11	42 (49.4)	43 (50.6)	85 (86.7)
Consumption of sweetened foods or beverages between meals			
Less than twice per day	32 (55.2)	26 (44.8)	58 (59.2)
More than twice per day	17 (42.5)	23 (57.5)	40 (40.8)
Child's last dental appointment			
Less than one year earlier	37 (58.7)	26 (41.3)	63 (64.3)
More than one year earlier	12 (34.3)	23 (65.7)	35 (35.7)
Child's tooth brushing frequency			
Two or more times per day	38 (50.0)	38 (50.0)	76 (77.6)
Less than twice per day	11 (50.0)	11 (50.0)	22 (22.4)
Use of dental floss			
Yes	8 (50.0)	8 (50.0)	16 (16.3)
No	41 (50.0)	41 (50.0)	82 (83.7)
Possible sleep bruxism (parental report)			
No	36 (49.3)	37 (50.7)	73 (74.5)
Yes	13 (52.0)	12 (48.0)	25 (25.5)
Risk of caries			
Low	2 (50.0)	2 (50.0)	4 (4.1)
Moderate/High	47 (50.0)	47 (50.0)	94 (95.9)
Moderate/extensive untreated caries (3-6 ICDAS II)			
No	8 (80.0)	2 (20.0)	10 (10.2)
Yes	41 (46.6)	47 (53.4)	88 (89.8)
Visible plaque			
< 20%	29 (63.0)	17 (37.0)	46 (46.9)
> 20%	20 (38.5)	32 (61.5)	52 (53.1)
Gingival bleeding			
< 20%	44 (51.2)	42 (48.8)	86 (87.8)
> 20%	5 (41.7)	7 (58.3)	12 (12.2)

*Monthly minimum wage in 2019: R$ 954.

Table 3. Null model (random effect) and multilevel models (unadjusted and adjusted) for variables at tooth level (n = 217) and individual level (n = 98) associated with unsatisfactory dental restorations in children aged six to ten years.

Random effect	Standard deviation	Variance component	df	chi-square	p-value
Intercept, U0	116.857	136.556	97	15.264.846	< 0.001
Variable	Unsatisfactory restoration (%)	Unadjusted OR 95%CI	p-value	Adjusted OR 95%CI	p-value
Tooth level (1)					
Type of tooth					
Maxillary molar	26 (32.5)	1			
Mandibular molar	49 (35.8)	1.59 (0.65-3.86)	0.304		
Type of restoration					0.286
Class I	54 (32.9)	1	0.625		0.61
Class II	21 (39.6)	0.70 (0.17-2.93)			
Material					
Glass ionomer cement	48 (39.0)	1		1	
Amalgam	1 (5.3)	0.09 (0.01-0.79)	0.030	0.11 (0.02-0.49)	
Composite resin	23 (33.3)	0.35 (0.07-1.85)	0.216	0.37 (0.06-2.31)	
Zinc oxide/Eugenol	3 (50.0)	1.84 (0.10-32.85)	0.675	1.84 (0.17-20.10)	
Individual level (2)					
Sex					
Female	32 (33.3)	1			
Male	43 (35.5)	1.03 (0.47-2.30)	0.933		
Age (each year)		0.72 (0.51-1.03)	0.072		
Family income*					
≥ 2 monthly min. wages	2 (22.2)	1			
< 2 monthly min. wages	73 (35.1)	0.57 (0.13-2.51)	0.453		
Mother's schooling					
12 or more years of study	12 (44.4)	1			
Up to 11 years of study	63 (33.2)	1.34 (0.41-4.36)	0.617		
Consumption of sweetened foods or beverages between meals					
Less than twice per day	27 (29.7)	1			
More than twice per day	48 (38.1)	1.41 (0.63-3.14)	0.399		
Child's last dental appointment					
Less than one year earlier	43 (29.9)	1			
More than one year earlier	32 (43.8)	2.16 (0.94-4.96)	0.069		
Child's tooth brushing frequency					
Two or more times per day	57 (33.7)	1			
Less than twice per day	18 (37.5)	1.31 (0.51-3.37)	0.603		
Use of dental floss					
Yes	10 (31.3)	1			
No	65 (35.1)	1.04 (0.35-3.11)	0.936		

Continue

Continuation

Possible sleep bruxism (parental report)					
No	61 (36.1)	1			
Yes	14 (29.2)	0.76 (0.30-1.95)	0.572		
Risk of caries					
Low	5 (62.5)	1			
Moderate/High	70 (33.5)	0.34 (0.04-2.58)	0.292		
Moderate/extensive untreated caries (3-6 ICDAS)					
No	2 (7.4)	1		1	
Yes	73 (38.4)	7.30 (1.33-39.87)	0.022	6.79 (2.20-20.93)	0.001
Visible plaque index					
< 20%	29 (27.1)	1		1	
> 20%	46 (41.8)	2.47 (1.09-5.60)	0.030	2.28 (1.05-4.92)	0.036
Gingival bleeding index					
< 20%	62 (34.4)	1			
> 20%	13 (35.1)	1.00 (0.32-3;09)	0.998		

*Monthly minimum wage in 2019: R$ 954.

environment,[20,21] which has led to a reduction in the use of amalgam.[22] Moreover, tooth preparation for restorations with this material is less conservative, which goes against current recommendations for minimal interventions. Thus, adhesive materials, such as glass ionomer cement and composite resins, are widely employed due to the less invasive cavity preparation, which is restricted to the removal of the carious tissue.[23,24,25] Considering these results, more frequent monitoring of restorations performed with glass ionomer cement is warranted.

Glass ionomer cement is the most indicated material for dental restorations in pediatric dentistry[2,26] due to the release of fluoride, adhesivity to the tooth, and biocompatibility.[25] Moreover, the restorative technique involves fewer steps compared to composite resin, which reduces the patient's chair time.[2] Therefore, this material was used as a reference for the comparison of other restorative materials in the present study. Indeed, glass ionomer cement was the most frequently used material on the evaluated teeth, accounting for 56.7% of the restorations.

No significant difference was found in restoration failures performed with glass ionomer cement (conventional and resin-modified) and those performed with composite resin. Similar results were reported in a recent systematic review that compared the clinical performance of these materials in restorations on primary molars.[23] These findings suggest relative freedom in the choice of these restorative materials and dentists should consider other aspects such as the operational technique, the child's behavior, the individual caries risk, and access when performing restorations in children.[10,23]

In the present study, 29.3% of the variance in unsatisfactory restorations was related to individual level variables. In the final model, moderate/extensive untreated caries and visible dental plaque (> 20%) remained associated with unsatisfactory dental restorations. These results are compatible with the findings of previous studies, which suggest that dental caries is an important factor that affects the longevity of restorations.[8,22] Moreover, restoration survival is longer in patients who perform better routine biofilm control,[8,19,27] as stagnant biofilm on the tooth surface leads to the development of caries[28] and restoration failure can occur at the tooth-restoration interface. A wide confidence interval was observed for the presence of moderate/extensive untreated caries in the present study (Table 3). It is suggested that this may be related to the small number of children who did not have moderate/

extensive untreated caries (10%). In other words, there was sample homogeneity, in this sense, it is recommended that in future studies this variable be considered as exposure. In the present study, sample calculation considered presence or absence of glass ionomer cement dental restorations as an exposure factor, while the presence of moderate/extensive untreated caries was not considered as an exposure factor.

Studies evaluating the quality of restorations have found a greater occurrence of failure and a reduction in the longevity of Class II restorations compared to Class I restorations.[19,23] However, no significant association was found between the type of restoration (Class I or II) and unsatisfactory restoration in the present investigation. This may have occurred because the restorations had not been in the oral cavity long enough to demonstrate such an association. As the present study had a cross-sectional design, the restorations were not monitored over time.

Although socioeconomic variables influence health-related issues,[29,30] no associations were found between unsatisfactory restorations and family income or mother's schooling. The lack of statistically significant associations in this respect may have been due to the homogeneity of the sample, which was composed of public school students mainly from low-income families and little schooling.

This study has the limitations inherent to the cross-sectional design, as the restorations were not followed up from the beginning, the initial quality of all restorations was assumed to be the same,[12] and the technique employed was not known. Therefore, these variables were not controlled. Despite the high prevalence of unsatisfactory dental restorations, this number may have been underestimated, as the dental examination was not conducted under ideal conditions in terms of lighting, prophylaxis, and drying of the teeth. Thus, longitudinal studies should be conducted in which dental restorations are monitored long-term from the onset so that these variables can be controlled. Another limitation of the study was that only students from public schools were included. Future studies with representative samples of the general population are recommended.

This study has strong points that should be highlighted. Multilevel statistical analysis is the most recommended for situations in which the variables interact with the outcome on different levels, as occurred in the present study.[12] Moreover, the population-based design enables the determination of the prevalence of a health condition and associated factors in the population studied. Another relevant point of this study is its originality. Previous studies addressing the quality of dental restorations using the modified USPHS criteria on the population level are scarce.

Based on the findings of the present study, amalgam restorations are less likely to fail than glass ionomer cement restorations. Moreover, patients with moderate/extensive untreated caries and a dental plaque index higher than 20% were more likely to have unsatisfactory restorations. These results underscore the importance of monitoring dental restorations and employing an integral preventive approach for the control of etiological factors of caries. In addition, this cross-sectional study helps to identify the factors associated with failure of dental restorations, so that they can be worked on, aiming to increase the longevity of restorations and reduce the spending of public resources on oral health in the country.[12]

Conclusions

Restoration failure was associated with the restorative material, presence of moderate/extensive untreated caries, and visible plaque. Dentists should be aware not only of factors related to the restored tooth, but also those related to the patient, which are important aspects in the failure of dental restorations.

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