Original Research
Cariology

Prevalence and risk indicators for underlying dentin shadows among 12-year-old southern Brazilian schoolchildren

Patrícia Kolling MARQUEZAN[a]
Luana Severo ALVES[b]
Nailê DAMÉ-TEIXEIRA[c]
Marisa MALTZ[d]
Júlio Eduardo do Amaral ZENKNER[a]

[a]Universidade Federal de Santa Maria – UFSM, School of Dentistry, Department of Stomatology, Santa Maria, RS, Brazil

[b]Universidade Federal de Santa Maria – UFSM, School of Dentistry, Department of Restorative Dentistry, Santa Maria, RS, Brazil.

[c]Universidade de Brasília – UnB, Department of Dentistry, Brasilia, DF, Brazil.

[d]Universidade Federal do Rio Grande do Sul – UFRGS, Faculty of Odontology, Department of Social and Preventive Dentistry, Porto Alegre, RS, Brazil.

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Corresponding Author:
Júlio Eduardo do Amaral Zenkner
Email: jezenkner@gmail.com

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Abstract: This study aimed to assess the prevalence, extent, and associated factors of underlying dentin shadows (UDS) in the occlusal surfaces of permanent posterior teeth among 12-year-old schoolchildren from southern Brazil. A population-based cross-sectional study that included a representative sample of 1,528 schoolchildren was conducted in Porto Alegre, southern Brazil (participation rate: 83.2%). A questionnaire on sociodemographic characteristics, behavioral habits, and access to dental services was sent to parents/legal guardians of each student selected. Caries examination included the recording of non-cavitated and cavitated lesions, including the presence of UDS, as defined by the ICDAS Group (*i.e.*, a shadow of discolored dentin visible through an apparently intact enamel surface that may or may not show signs of localized breakdown – ICDAS Code 4). The association between predictor variables and UDS prevalence was assessed using survey Poisson regression models. The prevalence of UDS was 6.3% (95%CI = 1.2 –11.3). The mean number of affected teeth among the schoolchildren presenting UDS was 1.51 (95%CI = 1.40 –1.61), ranging from 1 to 6. Type of school (public, PR = 2.23, 95%CI = 1.22 –4.07) and caries experience (DMFT 1-2, PR = 2.41, 95%CI = 1.15 –5.04; DMFT ≥ 3, PR = 3.09, 95%CI = 1.52 –6.27) were significantly associated with UDS prevalence. In conclusion, this population-based cross-sectional study found a low prevalence of UDS in the occlusal surfaces of the permanent posterior teeth of 12-year-old southern Brazilian schoolchildren. Overall caries experience and type of school were associated with UDS in this population.

Keywords: Dental Caries; Cross-Sectional Studies; Epidemiology.

Introduction

Underlying dentin shadows (UDS) appear as a shadow of discolored dentin visible through an apparently intact enamel surface that may or may not show signs of localized breakdown.[1] According to the International Caries Detection and Assessment System (ICDAS), UDS are classified as Code 4.

Few studies have focused on investigating UDS, and most of those that have researched it were conducted using in vitro methodologies, and

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sought to evaluate the association between clinical and histological features.[2-5] According to these studies, UDS showed an important involvement of the dentin tissue, which affected the middle to the inner third of the dentin thickness.[2-5] However, these studies were performed with extracted teeth, and the Code 4 category comprised only a few teeth, ranging from 3 to 9 per study, totaling 25 teeth. More recently, two clinical studies by our research group investigated the radiographic pattern of ICDAS 4 lesions in permanent posterior teeth of adolescents and young adults.[6,7] After 95[6] and 142[7] UDS were assessed, most cases of clinically detectable UDS were found to have either no radiolucent image, or an image restricted to the enamel-dentin junction. Therefore, according to these findings, most cases of UDS would not require restorative treatment.

Although dentin tissue cannot be accessed to determine its clinical characteristics, and define its activity status, the UDS are classified as "probably active" lesions by the ICDAS Group.[8] Furthermore, the International Caries Classification and Management System (ICCMS™) classifies the UDS as "moderate stage of caries," and recommends operative care for active moderate lesions, a proposal that may lead dental professionals to consider the operative treatment as the first option for the management of UDS.[9] Considering this conflicting information, and the consequent high risk of overtreatment of these lesions, it would be useful to investigate the prevalence of UDS, as well as the factors associated with this specific type of caries lesion.

To the best of our knowledge, there is no epidemiological study that has specifically assessed the occurrence of UDS at the population level. Therefore, the aim of this population-based cross-sectional study was to assess the prevalence, extent, and associated factors of UDS in the occlusal surfaces of permanent posterior teeth of a representative sample of 12-year-old schoolchildren from southern Brazil.

Methodology

Study design and sample

A cross-sectional survey was conducted from September 2009 to December 2010 to assess the oral health status of 12-year-old schoolchildren attending public and private schools in Porto Alegre, southern Brazil.

The sample size was calculated to estimate the prevalence of dental caries in this population. A sample size of 1,331 was calculated as the number needed to estimate a prevalence of 60% with a precision level of 3% for a 95% confidence interval. A design effect of 30% and a non-response error of 40% were added to the sample size, and a final sample size of 1,837 was estimated. A multistage probability sampling strategy was used. The primary sampling unit consisted of five geographical areas organized according to the municipal water fluoridation system. The schools within each area were randomly selected proportional to the number of existing private and public schools. A total of 42 schools were included in the study (33 public and 9 private). Schoolchildren born in 1997 or 1998 were randomly selected proportionally to school size.

Data collection

A questionnaire on sociodemographic characteristics, behavioral habits, and access to dental services was sent to the parents/legal guardians of each student selected. Clinical examinations were conducted at the schools, using portable equipment (artificial light, air compressor and suction), a sterile clinical mirror and a periodontal probe, and the students were placed in a supine position. First, a trained examiner (NDT) recorded the gingival bleeding index.[10] The schoolchildren were submitted to professional tooth brushing and flossing prior to being examined for caries. Cotton rolls were applied to ensure proper conditions for moisture control, the teeth were dried, and the dental caries and dental fluorosis were recorded by a single calibrated examiner (LSA). Caries examination included the recording of non-cavitated and cavitated lesions, and assessing caries activity.[11] In addition, the presence of UDS was also recorded, as defined by the ICDAS Group.[1] Fluorosis was recorded according to the Thylstrup and Fejerskov Index.[12]

Training sessions using photographs and clinical exams were performed to detect caries and fluorosis, under the supervision of a benchmark examiner. The

examiner's calibration was assessed before initiating the study, and was checked during the survey by examinations repeated on 5% of the sample (10 out of every 200 schoolchildren were reexamined). The minimal time interval between examinations was 2 days. Cohen's kappa values of 0.80 and 0.70 were obtained for caries and fluorosis, respectively.

Data analysis

The primary outcomes of this study were UDS prevalence and extent. Prevalence was defined as the percentage of schoolchildren presenting at least one permanent posterior tooth with UDS in the occlusal surface. Extent was defined as the number of occlusal UDS per individual.

Socioeconomic status used the cutoff points proposed by the standard Brazilian economic classification,[13] and households were classified into high/mid-high or mid-low/low. Mother's and father's education were classified into > 8 years or ≤ 8 years, according to the years of formal education. Tooth brushing frequency was categorized into ≤ 1 time/day, 2 times/day, or ≥3 times/day. Flossing and soft drink consumption were dichotomized as non-daily or daily. Last dental visit was categorized as ≤1 year ago, ≥2 years ago, or never visited a dentist. Type of dental service was classified as insurance/private, public health system, or never visited a dentist. Caries experience at the cavity level was classified as DMFT = 0, DMFT 1–2, or DMFT ≥ 3 (UDS not computed). The schoolchildren were classified in relation to their caries activity, as absent (no active lesion) or present (at least one active lesion). Gingivitis was classified into ≤ 45%, 45–60%, or > 60%, according to the percentage of bleeding sites. Fluorosis was dichotomized as TF ≤ 2 or TF ≥ 3.

Data analysis was performed using a STATA software program (Stata 11.1 for Windows; Stata Corporation, College Station, USA), taking into account the survey design. Given the discrepancy in some of the demographic and socioeconomic features of the study participants and subjects who did not participate, a weight variable was used in the statistical analysis to adjust for the potential bias in the population estimates,[14] as detailed elsewhere.[15] Pairwise comparisons for sociodemographics, behavioral characteristics, dental assistance, and clinical variables were made using the Wald test. The association between predictor variables and UDS prevalence was assessed using survey Poisson regression models. The preliminary analysis was carried out using unadjusted models, and variables showing associations with P<0.25 were selected to perform the adjusted analysis. A forward selection approach was adopted, based on the magnitude of the associations, and only those variables significantly associated with the outcome (P<0.05) were maintained in the final model. Confounding and effect modifications were assessed. In the event of collinearity, the criterion adopted to select the variable to be included in the final model was the magnitude of the association; for this reason, the type of school was included instead of socioeconomic status or the father's education. All the predictors included in the present study were chosen based on a theoretical framework, and on the previous literature on cariology. The level of statistical significance was set at 5%.

Ethical aspects

The study protocol was approved by the Research Ethics Committee of the Federal University of Rio Grande do Sul (299/08), and by the Ethics Committee of the Municipal Health Department of Porto Alegre Research (001.049155.08.3/288). All procedures complied with the ethical standards of these research committees, and with the 1964 Helsinki Declaration, and its later amendments or comparable ethical standards. All participants and their parents/legal guardians signed a written informed consent form. Students received a report of their oral health status, and were referred for dental treatment when necessary.

Results

Of the 21,207 eligible schoolchildren, 1,837 were invited to participate, and 1,528 were included in the study (participation rate of 83.2%). Figure shows the study flowchart, and the reasons for non-participation. The mean DMFT of the schoolchildren population was 1.39 (95%CI = 1.07–1.71). The overall prevalence of UDS was 6.3% (95%CI = 1.2–11.3), corresponding to 98 schoolchildren. Most of them had only one

lesion (n = 63), followed by 2 lesions (n = 25); only few individuals had three (n = 8), four (n = 1), or six (n = 1) lesions. The mean number of affected teeth among the schoolchildren presenting UDS was 1.51 (95%CI = 1.40–1.61). The sample distribution and UDS prevalence are described in Table 1. UDS prevalence was significantly higher among public school attendees, schoolchildren with a DMFT≥1, and caries-active individuals.

The association between predictor variables and UDS prevalence is shown in Table 2. The prevalence of UDS in the unadjusted models was significantly associated with socioeconomic variables (mid-low/low socioeconomic status, lower father's education, and public school), the use of the public health system, and clinical variables (caries experience and caries activity). The adjusted model showed that type of school (public, PR [prevalence ratio] = 2.23, 95%CI = 1.22-4.07) and caries experience (DMFT 1–2, PR = 2.41, 95%CI = 1.15–5.04; DMFT ≥ 3, PR = 3.09, 95%CI = 1.52–6.27) were significantly associated with UDS prevalence in this population.

Discussion

This cross-sectional study was conducted to assess the prevalence, extent, and associated factors of UDS among southern Brazilian schoolchildren. UDS were observed in 6.3% of the sample, and their prevalence was associated with socioeconomic variables and overall caries experience. To the best of our knowledge, this is the first population-based

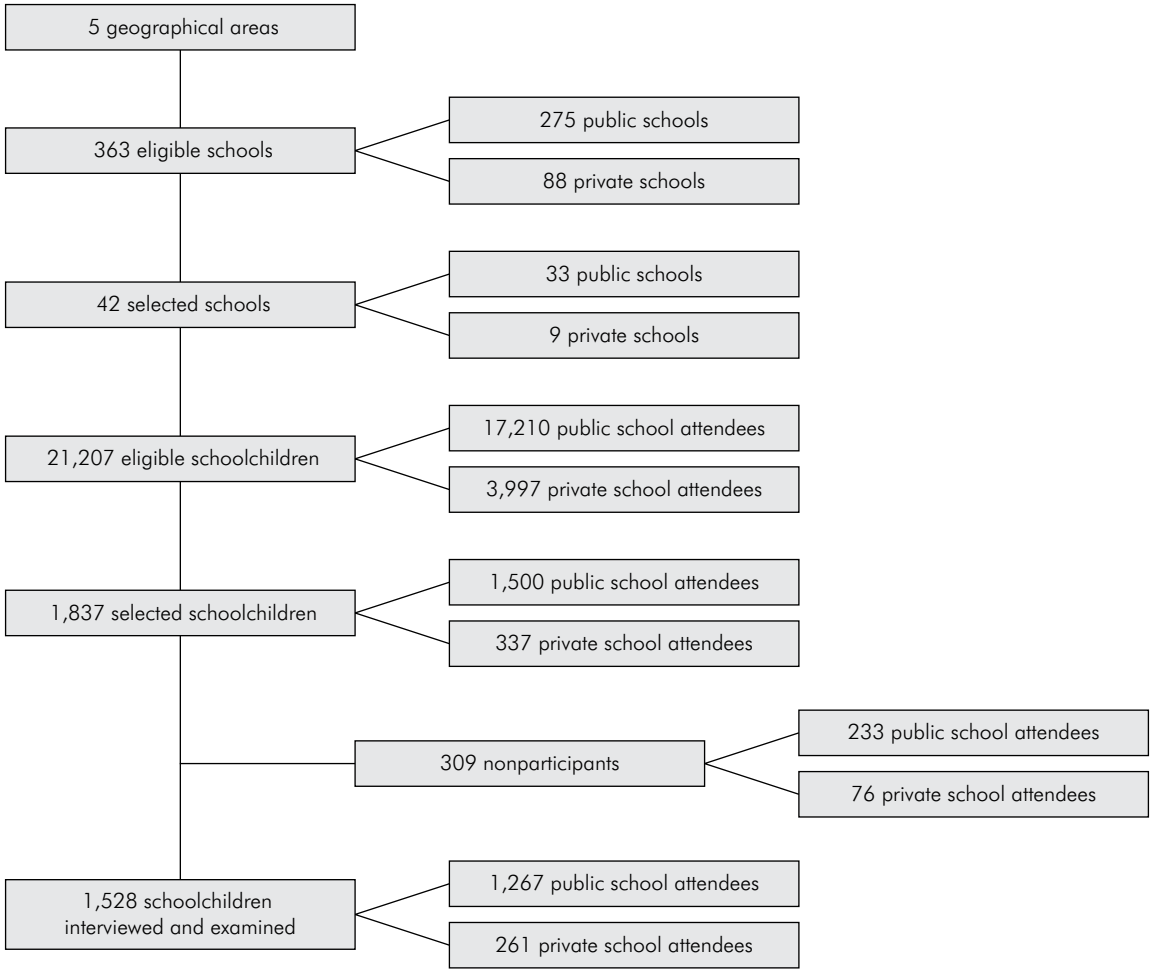

Figure. Flowchart of the study.

Table 1. Sample distribution and the prevalence of underlying dentin shadows (n =1,528).

Variable	n (%)	Prevalence (95%CI)
Sociodemographics		
Sex		
Female	758 (49.6)	8.3 (-0.2–-16.9)[a]
Male	770 (50.4)	4.3 (0.9–7.60)[a]
Socioeconomic status		
High/Mid-high	499 (32.7)	3.7 (-0.9–8.3)[a]
Mid-low/Low	1,029 (67.3)	7.7 (1.4–14.1)[a]
Mother's education*		
> 8 years	732 (48.1)	5.3 (2.9–7.8)[a]
≤ 8 years	789 (51.9)	7.2 (-1.1–15.5)[a]
Father's education*		
> 8 years	639 (44.8)	5.2 (1.5–8.8)[a]
≤ 8 years	788 (55.2)	7.7 (0.6–14.8)[a]
Type of school		
Private	261 (17.0)	2.6 (-0.9–6.1)[a]
Public	1,267 (83.0)	7.3 (1.5–13.1)[b]
Behavioral characteristics		
Tooth brushing		
≤ 1 time/day	341 (22.3)	7.2 (-1.1–15.6)[a]
2 times/day	677 (44.3)	6.3 (0.7–11.9)[a]
≥ 3 times/day	510 (33.4)	5.6 (2.3–8.2)[a]
Flossing		
Non-daily	1,348 (88.2)	6.1 (1.4-10.8)[a]
Daily	180 (11.8)	7.5 (-0.6-15.7)[a]
Soft drink consumption*		
Non-daily	1,079 (70.7)	6.0 (0.3–11.7)[a]
Daily	448 (29.3)	6.8 (3.0–10.7)[a]
Dental assistance		
Last dental visit		
≤ 1 year ago	844 (55.2)	6.4 (1.2–11.7)[a]
≥ 2 years ago	354 (23.2)	5.2 (-1.2–11.6)[a]
Never visited a dentist	330 (21.6)	6.9 (1.9–11.9)[a]
Type of dental service		
Insurance/Private	711 (46.5)	5.0 (0.8–9.3)[a]
Public health system	487 (31.9)	7.8 (-0.7–16.3)[a]
Never visited a dentist	330 (21.6)	6.9 (1.9–11.9)[a]
Clinical variables		
Caries experience (cavity level)		
DMFT = 0	663 (43.4)	3.0 (-1.6–7.6)[a]
DMFT 1–2	509 (33.3)	7.8 (1.9–13.7)[b]
DMFT ≥ 3	356 (23.3)	10.5 (2.3–18.8)[b]
Caries activity		
Absent	902 (59.0)	4.7 (-0.3–9.6)[a]
Present	626 (41.0)	8.6 (3.3–-13.8)[b]
Gingivitis (% bleeding sites)		
≤ 45%	507 (33.2)	5.4 (-1.7–12.5)[a]
45–60%	516 (33.8)	5.4 (2.7–8.1)[a]
> 60%	502 (33.0)	8.2 (-0.2–16.6)[a]
Fluorosis		
TF ≤ 2	1,012 (66.2)	6.4 (1.7–11.1)[a]
TF ≥ 3	516 (33.8)	6.0 (0.1–11.9)[a]
TOTAL	1,528 (100)	6.3 (1.2–11.3)

*Figures do not totalize 1,528 due to missing data; CI: confidence interval; TF: Thylstrup-Fejerskov Index. Different letters indicate a statistically significant difference among categories using the Wald test ($p < 0.05$).

study to assess the prevalence and factors associated with this specific type of lesion. Considering that UDS have gained the attention of the dental profession in recent years, it would seem important to the field of oral epidemiology to gain greater knowledge of the distribution of these lesions at the population level, and the factors associated with their occurrence.

The present study found a low prevalence of UDS in this 12-year-old population. We could speculate that studies investigating this topic among older adolescents or young adults would find higher prevalence rates resulting from the longer time exposed to the oral environment. In addition to the issue of the age group, the possibility that some UDS could have been previously restored cannot be ruled out, thus reducing the prevalence. Previous studies conducted by our research group showed that most lesions would not demand restorative treatment, because no evident image in dentin was detected.[6,7] However, we recognize that the clinical aspect of some UDS may lead the dentist to opt for restorative treatment, mainly in the absence of a radiographic examination. Considering the lack of previous studies investigating this issue, the comparison of our results with those of other studies is not possible. The prevalence of only 6.3% of UDS in the studied population may have hindered the authors from finding statistically significant associations with PR < 1.5 between the predictors and the outcome.

A poorer socioeconomic condition was significantly associated with a greater prevalence of UDS in this population. Although only the type of school was included in the adjusted model, father's education and socioeconomic status were also significantly associated with the outcome in the unadjusted models. In addition, the association of UDS prevalence with the use of the public health system in the unadjusted analysis may also be interpreted as a socioeconomic indicator in this population. These findings are in agreement with the association between socioeconomic variables and the overall prevalence of dental caries observed in both this sample[16] and that of other schoolchildren populations from Brazil.[17,18,19] This evidence points to social inequality as an important determinant of the health-disease process.[20]

Table 2. Association between predictor variables and the prevalence of underlying dentin shadows. Unadjusted and adjusted Poisson regression models (n = 1,528).

Variable	Unadjusted	p-value	Adjusted	p-value
	PR (95%CI)		PR (95%CI)	
Sociodemographics				
Sex				
Female	1.00			
Male	0.51 (0.23–1.11)	0.09		
Socioeconomic status				
High/Mid-high	1.00			
Mid-low/Low	2.11 (1.15–3.89)	0.02		
Mother's education				
> 8 years	1.00			
≤ 8 years	1.34 (0.76–2.36)	0.31		
Father's education				
> 8 years	1.00			
≤ 8 years	1.48 (1.05–2.09)	0.02		
Type of school				
Private	1.00		1.00	
Public	2.83 (1.34–5.96)	0.01	2.23 (1.22-4.07)	0.01
Behavioral characteristics				
Tooth brushing				
≤ 1 time/day	1.00			
2 times/day	0.87 (0.59–1.29)	0.49		
≥ 3 times/day	0.77 (0.46-1.30)	0.33		
Flossing				
Non-daily	1.00			
Daily	1.24 (0.85–1.80)	0.27		
Soft drink consumption				
Non-daily	1.00			
Daily	1.13 (0.76–1.70)	0.54		
Dental assistance				
Last dental visit				
≤ 1 year ago	1.00			
≥ 2 years ago	0.80 (0.52–1.24)	0.32		
Never visited a dentist	1.07 (0.64–1.80)	0.78		
Type of dental service				
Insurance/Private	1.00			
Public health system	1.55 (1.07–2.25)	0.02		
Never visited a dentist	1.37 (0.75–2.51)	0.30		
Clinical variable				
Caries experience (cavity level)				
DMFT = 0	1.00		1.00	
DMFT 1–2	2.60 (1.14–5.95)	0.02	2.41 (1.15-5.04)	0.01
DMFT ≥ 3	3.53 (1.62–7.70)	0.01	3.09 (1.52-6.27)	0.02
Caries activity				
Absent	1.00			
Present	1.84 (1.26–2.69)	0.01		
Gingivitis (% bleeding sites)				
≤ 45%	1.00			
45–60%	1.00 (0.47–2.13)	0.99		
> 60%	1.52 (0.67–3.45)	0.31		
Fluorosis				
TF ≤ 2	1.00			
TF ≥ 3	0.94 (0.71–1.25)	0.68		

PR: prevalence ratios; CI: confidence interval; TF: Thylstrup-Fejerskov Index.

Fluorosis experience was included in this study as a proxy for fluoride access. We hypothesized that greater access to fluoride over time could prevent enamel breakdown and cavitation, thus increasing the prevalence of "closed dentin lesions" (UDS) compared with "open dentin lesions." However, no association was found between fluorosis and UDS prevalence. In accordance with this finding, tooth brushing frequency was not associated with UDS prevalence, despite its significant relationship with the overall caries experience previously found in this population.[15]

Among the other clinical variables evaluated in this study, only caries experience remained statistically associated with the prevalence of UDS after the adjustment for other cofactors. These findings corroborate those of the systematic review by Mejàre et al.,[21] which reported that baseline caries experience was the most accurate predictor among the methods for caries risk assessment, in all age groups.

The strengths of our study include its large population-based sample of 12-year-old schoolchildren, its clinical examination protocol (with professional tooth cleaning and drying), and the high reproducibility of the examiner. In addition, the pioneering nature of this study must also be acknowledged, since this is the first study to assess the prevalence of and factors associated with this type of caries lesion at the population level. Causality cannot be hypothesized, because of the cross-sectional nature of the study. However, cross-sectional studies are useful for identifying associated factors to be investigated in future longitudinal assessments, such as definitive risk factors. We also acknowledge that the low prevalence of UDS found in this population may have affected the statistical power of the study, as previously discussed. Considering that the occlusal surfaces of permanent posterior teeth are those most commonly affected by caries,[22] we opted to include only the UDS located on these surfaces. Further studies including other tooth surfaces, as well as anterior teeth, may strengthen the body of evidence on this topic.

Conclusion

In conclusion, this population-based cross-sectional study found a low prevalence of UDS in the occlusal surfaces of permanent posterior teeth of 12-year-old southern Brazilian schoolchildren. Overall caries experience and type of school were associated with UDS in this population. These findings show that UDS have similar etiological factors of noncavitated and cavitated caries lesions. This understanding is important to provide the control and management needed for this type of lesion.

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