Prevalence, extent, risk indicators, and intraoral distribution of underlying dentin shadows (ICDAS 4) among 15–19-year-old South Brazilian adolescents

Patrícia Kolling Marquezan, Leticia Donato Comim¹, Débora Nunes De Oliveira Racki¹, Ângela Dalla Nora², Luana Severo Alves¹, Júlio Eduardo Do Amaral Zenkner²

Department of Microbiology and ²Department of Stomatology, School of Dentistry, Federal University of Santa Maria, Santa Maria, RS, ¹Department of Restorative Dentistry, School of Dentistry, Federal University of Santa Maria, Santa Maria, Brazil

Abstract

Background and Objective: This study aimed to assess the prevalence, extent, risk indicators, and intraoral distribution of underlying dentin shadows (UDS) in the occlusal surfaces of the permanent posterior teeth.

Subjects and Methods: A total of 1197 adolescents were included in the study (participation rate of 72.3%). The association between the independent variables, on the one hand, and the prevalence and extent of UDS were assessed using multilevel Poisson regression models. The prevalence ratios (PR), rate ratios (RR), and 95% confidence intervals (95% CIs) were estimated. The overall prevalence of UDS was 8.8% (95% CI = 6.0–11.5), with an overall mean of 0.13 (95% CI = 0.08–0.17) lesions per individual. Those with UDS exhibited a mean of 1.45 (95% CI = 1.28–1.62) lesions.

Results: Lower family income (PR = 1.58; 95% CI = 1.03–2.41) and caries activity (PR = 1.53; 95% CI = 1.01–2.31) were significantly associated with UDS prevalence, while age ≥17 years (RR = 1.43; 95% CI = 1.03–1.99) and caries activity (RR = 1.63; 95% CI = 1.55–2.30) were significantly associated with caries extent. The most commonly affected teeth were lower first molars, followed by upper first molars and lower second molars.

Conclusion: This study found a low prevalence and extent of UDS in the occlusal surface. Sociodemographic variables and caries activity were associated with the occurrence of UDS.

Keywords: Adolescent; cross-sectional study; dental caries; epidemiology; risk assessment

INTRODUCTION

Epidemiological studies are fundamental to understanding the distribution of diseases in different populations and enable the integration with public health, thus providing insights for devising and assessing methods for disease control. Despite the significant reduction in the prevalence and severity of dental caries observed worldwide in recent decades, as a result of public policies for health promotion, it is still highly prevalent. According to the World Health Organization, about 2.3 billion people worldwide suffer from dental caries in permanent teeth.

In addition to the detection of dental caries according to the WHO standards, several epidemiological studies have also included the detection of incipient and moderate lesions by using different detection criteria. More recently, the specific detection of underlying dentin shadows (UDS) has also called the attention of the dental literature. It is...
defined as a shadow of discolored dentin visible through an apparently intact enamel surface, which may or may not show signs of localized breakdown.\(^{[8-11]}\) According to the ICDAS group, UDS is classified as code 4.

Just a few studies have addressed this specific type of caries lesion. Despite the publication of in vitro studies\(^{[8-11]}\) and clinical studies including convenience samples,\(^{[12,13]}\) there is only one population-based epidemiological survey in the literature evaluating the prevalence and risk indicators for UDS in a representative sample.\(^{[14]}\) After assessing 1528 12-year-old schoolchildren in a southern Brazilian city, a low prevalence of UDS lesions (6.3%) was reported. The presence of UDS was associated with socioeconomic factors (individual’s school type), and clinical factors (Decayed, Missing, and Filled Teeth [cavity level] \(\text{DMFT} \geq 1\)). There is no other epidemiological study investigating UDS in other age groups. Understanding its distribution in different populations and the factors associated with its occurrence may help to comprehend better the mechanisms explaining this specific type of caries lesion.

Therefore, the aim of this population-based cross-sectional study was to assess the prevalence, extent, risk indicators, and intraoral distribution of UDS in the occlusal surfaces of permanent posterior teeth of a representative sample of 15–19-year-old adolescents from southern Brazil.

**SUBJECTS AND METHODS**

**Study design and sample**

A population-based cross-sectional study assessed the oral health status of 15–19-year-old students from Santa Maria, a mid-sized city located in southern Brazil. A sample of 1066 adolescents was considered necessary to estimate a caries prevalence of 50% (worst-case scenario), with 95% confidence intervals (CIs), given a power of 80% and a precision level of 3%. A total of 1600 adolescents were invited to participate, assuming a 50% nonparticipation rate. Students born from 1999 to 2003 attending any school period (morning, afternoon, or night) from all 37 urban high schools (26 public and 11 private) were considered eligible for the study. A simple random sampling strategy was used considering enrolled students as the survey unit. Participants were randomly selected proportional to school size, using a table of random numbers. Students using fixed orthodontic appliances or those with special needs were not considered eligible.

**Data collection**

Data collection was conducted from March to November 2018. First, a self-administered questionnaire with closed questions was applied to collect data on demographic, socioeconomic, and behavioral characteristics.

Then, two calibrated examiners performed clinical oral examinations to record dental caries.\(^{[15]}\) In addition, the presence of UDS was recorded as defined by the ICDAS group.\(^{[17]}\) Clinical examinations were conducted at the schools, with the students in a supine position, using portable equipment (artificial light, air compressor, and suction); with the aid of clinical mirrors, periodontal probes, and cotton rolls. Caries examination was performed after tooth cleaning with a toothbrush and drying.

The examiners’ reproducibility regarding the caries index was assessed after theoretical training exercises under the supervision of a benchmark examiner. The values of the intra-examiner kappa coefficient were 0.97 and 0.81, and the interexaminer kappa value was 0.86. During the data collection, the calibration of the examiners was checked by double examinations in 5% of the sample. The minimal kappa values were 0.81 (intraexaminer) and 0.80 (inter-examiner).

**Data analysis**

The outcomes of this study were UDS prevalence and extent. Prevalence was defined as the percentage of adolescents presenting at least one occlusal surface with UDS. The extent was defined as the number of UDS per individual.

Sociodemographic variables included sex, age, skin color, mother’s education, and family income, measured through the Brazilian minimum wage (BMW) (1 BMW corresponded to approximately USD 250 during the period of data collection). Behavioral variables were tooth brushing and consumption of sugary food and drinks. Clinical variables were caries prevalence and caries activity. To be classified as caries active, the adolescent had to present at least one active caries lesion, either noncavitated or cavitated.

Data analysis was performed using STATA software (Stata 14.2; Stata Corporation, College Station, TX, USA), taking into account the survey design. A weight variable to gender and school type was used to adjust for the potential bias in the population estimates. Pairwise comparisons for sociodemographics, behavioral characteristics, and clinical variables were carried out using the Wald test.

The association between independent variables and UDS prevalence and extent was assessed using multilevel Poisson regression models. The multilevel model considered the adolescent as the first-level unit and the school as the second-level unit. The multilevel model used the scheme of fixed effect with random intercept. Unadjusted and adjusted prevalence ratios (PR), rate ratios (RR), and 95% CIs were estimated. Variables showing associations with \(P < 0.20\) in the unadjusted models were selected for and maintained in the adjusted model. The chosen level of statistical significance was 5%.
Ethical aspects
The study protocol was approved by the Research Ethics Committee of the Federal University of Santa Maria (CAAE 69901917.5.0000.5346). 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 to dental treatment when necessary.

RESULTS
Out of 1656 adolescents who were invited to take part in the study, a total of 1197 were included (72.3%). As six schools refused to participate, this sample was gathered in 31 participating schools (22 public and nine private). The study flowchart can be found elsewhere.[14] The overall prevalence of UDS was 8.8% (95% CI = 6.0–11.5), corresponding to 106 individuals. Most of them had only one lesion (n = 72), after two lesions (n = 23); three (n = 8) or four (n = 3) lesions. Overall, this adolescent population had 0.13 (95% CI = 0.08–0.17) lesion per individual, on average. Among those who had UDS, they had a mean of 1.45 (95% CI = 1.28–1.62) lesions.

Sample distribution, UDS prevalence, and extent by independent variables are described in Table 1. UDS prevalence was significantly higher among adolescents with lower family income and among those classified as caries active. Regarding UDS extent, caries-active patients had a significantly higher mean number of UDS than their counterparts classified as carried free or caries inactive.

In the unadjusted models [Table 2], UDS prevalence was significantly associated with family income and caries activity. The adjusted model showed that adolescents with lower family income were 58% more likely to present UDS than those with higher family income (PR = 1.58; 95% CI = 1.03–2.41). In addition, caries-active adolescents were 53% more likely to have UDS lesions than caries-free or caries inactive ones (PR = 1.53; 95% CI = 1.01–2.31).

The association between independent variables and UDS extent is presented in Table 3. The adjusted model showed that adolescents aged ≥17 years had a 43% higher mean number of UDS than those aged ≤16 years (RR = 1.43; 95% CI = 1.03–1.99). Corroborating the prevalence analysis, adolescents classified as caries active had a 63% higher mean number of UDS than those classified as caries free or caries inactive (RR = 1.63; 95% CI = 1.55–2.30).

As shown in Figure 1, the most commonly affected teeth were lower first molars, followed by upper first molars and lower second molars. Premolars were rarely affected. From a total of 154 UDS lesions, the vast majority of cases (84%, n = 129) had no enamel breakdown.

| Table 1: Frequency distribution of the sample, underlying dentin shadows prevalence, and extent by independent variables (n=1197) |
|---|
| n (%) | Prevalence¹ | Extent² |
| --- | --- | --- |
| **Sociodemographics** | | |
| Sex | | |
| Boys | 513 (42.9) | 8.2 (4.8-11.6) | 0.12 (0.07-0.17) |
| Girls | 684 (57.1) | 9.3 (6.0-12.5) | 0.13 (0.08-0.18) |
| Age (years) | | |
| ≤16 | 655 (54.9) | 7.7 (5.2-10.1) | 0.10 (0.07-0.14) |
| >17 | 542 (45.3) | 10.1 (6.0-14.2) | 0.15 (0.08-0.22) |
| Skin color* | | |
| Nonwhite | 779 (67.0) | 8.7 (5.7-11.7) | 0.15 (0.08-0.21) |
| White | 384 (33.0) | 8.9 (5.3-12.6) | 0.12 (0.07-0.16) |
| Mother’s education* | | |
| ≤Primary school | 577 (50.2) | 9.2 (5.6-12.9) | 0.13 (0.07-0.19) |
| High school | 380 (33.1) | 7.8 (4.3-11.3) | 0.12 (0.06-0.17) |
| University | 192 (16.8) | 10.4 (5.5-15.3) | 0.15 (0.08-0.21) |
| Family income* (BMW) | | |
| >2 | 509 (43.5) | 6.9 (3.2-10.7) | 0.12 (0.06-0.18) |
| ≤2 | 602 (54.2) | 10.9 (7.4-14.3) | 0.15 (0.10-0.20) |
| **Behavioral habits** | | |
| Tooth brushing* | | |
| ≤Once/day | 116 (9.7) | 9.7 (2.4-17.0) | 0.15 (0.02-0.27) |
| ≥Twice/day | 512 (42.9) | 7.5 (4.8-10.1) | 0.11 (0.07-0.15) |
| ≥3 times/day | 566 (47.4) | 9.7 (5.9-13.4) | 0.14 (0.07-0.20) |
| Consumption of sugary food* | | |
| ≤Twice/day | 684 (57.7) | 8.2 (4.3-12.1) | 0.13 (0.06-0.20) |
| ≥3 times/day | 501 (42.8) | 9.5 (6.7-12.3) | 0.13 (0.08-0.17) |
| Consumption of sugary drinks* | | |
| ≤Twice/day | 651 (55.1) | 7.8 (4.4-11.1) | 0.12 (0.06-0.17) |
| ≥3 times/day | 533 (44.9) | 10.0 (6.2-13.9) | 0.14 (0.07-0.20) |
| **Clinical variables** | | |
| Caries prevalence | | |
| DMFT=0 | 641 (53.5) | 8.3 (5.1-11.5) | 0.12 (0.07-0.17) |
| DMFT ≥1 | 556 (46.4) | 9.3 (6.1-12.6) | 0.13 (0.08-0.18) |
| Caries activity | | |
| Caries free/caries inactive | 610 (51.0) | 6.9 (3.6-10.1) | 0.09 (0.04-0.14) |
| Caries active | 587 (49.0) | 10.7 (7.6-13.9) | 0.16 (0.12-0.21) |
| Total | 1217 (100.0) | 8.8 (6.0-11.5) | 0.13 (0.08-0.17) |

¹ Figures do not totalize 1197 due to missing data. ² Taking into account the sampling weight. Different letters indicate statistically significant difference between categories (P<0.05, adjusted Wald test). CI: Confidence interval, DMFT: Decayed, Missing, and Filled Teeth (cavity level), BMW: Brazilian minimum wage

DISCUSSION
A total of 8.8% of the sample presented at least one UDS lesion. Sociodemographic variables and caries-activity were consistently found to be associated with UDS prevalence and extent. This is the first epidemiological study to assess this specific type of lesion in a population-based sample of adolescents.

This study found a low prevalence rate of UDS (8.8%), similar found in the study conducted with 12 year old (6.3%).[14] It is possible to speculate that this higher rate may be attributed, in part, with the present sample being exposed to risk factors for a longer period. This explanation is aligned with
the significant association between age and UDS extent found in this study, with older adolescents having a 43% higher mean number of UDS lesions than younger ones. It is also important to consider that some UDS lesions may have been restored due to their clinical aspect as well as to the lack of knowledge on their likelihood of progression, contributing to the low prevalence of UDS found in this adolescent’s population.

Risk assessment analysis showed that a lower family income was significantly associated with a greater UDS prevalence in this population. This finding corroborates the association between type of school and UDS observed among 12-year-old schoolchildren from southern Brazil. Three of which had an ecological design, and two used multilevel modelings. Both critical and systematic reviews have also stressed this relationship.

The association between caries activity and UDS was consistently found in both the prevalence and extent analyses. Caries-active adolescents were 53% more likely to present at least one UDS and had a 63% higher mean number of UDS lesions. The possibility of defining a patient’s caries activity profile based on lesion features has recently proved to be valid.

Table 2. Association between independent variables and underlying dentin shadow prevalence (unadjusted and adjusted multilevel Poisson regression analysis)

|                          | Unadjusted PR (95% CI) | P  | Adjusted PR (95% CI) | P  |
|--------------------------|------------------------|----|----------------------|----|
| **Sociodemographics**    |                        |    |                      |    |
| Sex                      |                        |    |                      |    |
| Male                     | 1.00                   |    |                      |    |
| Female                   | 1.11 (0.75-1.64)       | 0.61|
| Age (year-old)           |                        |    |                      |    |
| ≤16                      | 1.00                   |    |                      |    |
| ≥17                      | 1.29 (0.87-1.89)       | 0.20|
| Skin color               |                        |    |                      |    |
| Nonwhite                 | 1.00                   |    |                      |    |
| White                    | 0.97 (0.64-1.47)       | 0.90|
| Mother’s education       |                        |    |                      |    |
| ≤Primary school          | 1.00                   |    |                      |    |
| High school              | 0.93 (0.60-1.47)       | 0.77|
| University               | 1.11 (0.65-1.93)       | 0.69|
| Family income (BMW)      |                        |    |                      |    |
| > 2                      | 1.00                   |    |                      |    |
| ≤2                       | 1.65 (1.08-2.53)       | 0.02|
| **Behavioral characteristics** |                    |    |                      |    |
| Tooth brushing           |                        |    |                      |    |
| ≤Once/day                | 1.00                   |    |                      |    |
| Twice/day                | 0.80 (0.41-1.56)       | 0.50|
| ≥3 times/day             | 0.99 (0.51-1.90)       | 0.97|
| Consumption of sugary food|                      |    |                      |    |
| ≤Twice/day               | 1.00                   |    |                      |    |
| ≥3 times/day             | 1.20 (0.82-1.77)       | 0.34|
| Consumption of sugary drinks|                    |    |                      |    |
| ≤Twice/day               | 1.00                   |    |                      |    |
| ≥3 times/day             | 1.30 (0.88-1.90)       | 0.18|
| **Clinical variables**   |                        |    |                      |    |
| Caries experience        |                        |    |                      |    |
| DMFT=0                   | 1.00                   |    |                      |    |
| DMFT ≥1                  | 1.08 (0.74-1.59)       | 0.68|
| Caries activity          |                        |    |                      |    |
| Caries free/caries inactive| 1.00           |    |                      |    |
| Caries active            | 1.54 (1.03-2.29)       | 0.03|

Bold numbers identify P<0.05. PR: Prevalence ratio; CI: Confidence interval; DMFT: Decayed, Missing, and Filled Teeth (cavity level); BMW: Brazilian minimum wage.
et al. including 12 year old, in which both caries experience and caries activity were significantly associated with UDS prevalence in the unadjusted analysis, but only the former remained associated in the final model. It suggests that the accumulated history of the disease was a stronger predictor of UDS lesions in that 12-year-old population, whereas the current ongoing disease was more relevant in this 15–19-year-old population. Indeed, a previous systematic review by Mejäre et al. showed that baseline caries experience had moderate/good accuracy to predict future caries in preschool children but limited accuracy in schoolchildren/adolescents. It suggests that the discriminatory power of this predictor may decrease with increasing age. The fact that no association was found with tooth brushing frequency and dietary habits in the present study reinforce the complexity and the comprehensiveness of the concept of caries activity as well as its multifactorial nature. It is also important to highlight that caries activity remained significantly associated with UDS prevalence and extent even after the adjustment for age and family income, which evidences its independent effect on the study outcomes.

The strengths of our study include its large representative population-based sample of 15–19-year-old adolescents, including individuals attending any school period in high schools in the municipality, its clinical examination protocol and the high reproducibility of the examiners. The hypothesis of causality cannot be accomplished because of the cross-sectional nature of the study. However, cross-sectional studies are useful for identifying risk indicators to be investigated as definitive risk factors in further longitudinal assessments.

**CONCLUSION**

This population-based cross-sectional study found a low prevalence and extent of UDS in the occlusal surfaces of the permanent posterior teeth of 15–19-year-old Brazilian adolescents. Sociodemographic variables and caries activity were significantly associated with UDS prevalence and extent in 15–19-year-old adolescents. "Underlying dentin shadows among adolescents..." Marquezan, et al. Journal of Conservative Dentistry | Volume 25 | Issue 6 | November-December 2022

| Sex | Unadjusted | P | Adjusted | P |
|-----|------------|---|----------|---|
| Male | 1.00 | | 1.00 | |
| Female | 1.08 (0.78-1.50) | 0.63 | 1.43 (1.03-1.99) | 0.03 |

| Age (year-old) | Unadjusted | P | Adjusted | P |
|----------------|------------|---|----------|---|
| ≤16 | 1.00 | | 1.00 | |
| ≥17 | 1.42 (1.03-1.96) | 0.03 | 1.43 (1.03-1.99) | 0.03 |

| Skin color | Unadjusted | P | Adjusted | P |
|-------------|------------|---|----------|---|
| Nonwhite | 1.00 | | 1.00 | |
| White | 0.84 (0.60-1.18) | 0.31 | |

| Mother’s education | Unadjusted | P | Adjusted | P |
|-------------------|------------|---|----------|---|
| ≤ Primary school | 1.00 | | 1.00 | |
| High school | 0.99 (0.68-1.44) | 0.97 | |
| University | 1.12 (0.70-1.80) | 0.63 | |

| Family income (BMW) | Unadjusted | P | Adjusted | P |
|---------------------|------------|---|----------|---|
| >2 | 1.00 | | 1.00 | |
| ≤2 | 1.31 (0.93-1.85) | 0.12 | 1.25 (0.89-1.77) | 0.19 |

| Behavioral characteristics | Unadjusted | P | Adjusted | P |
|----------------------------|------------|---|----------|---|
| Tooth brushing | ≤ Once/day | 1.00 | | 1.00 | |
| ≥3 times/day | 0.77 (0.44-1.32) | 0.34 | 0.90 (0.53-1.53) | 0.69 |

| Consumption of sugary food | Unadjusted | P | Adjusted | P |
|----------------------------|------------|---|----------|---|
| ≤ Twice/day | 1.00 | | 1.00 | |
| ≥3 times/day | 1.02 (0.74-1.41) | 0.91 | |

| Consumption of sugary drinks | Unadjusted | P | Adjusted | P |
|-------------------------------|------------|---|----------|---|
| ≤ Twice/day | 1.00 | | 1.00 | |
| ≥3 times/day | 1.13 (0.82-1.55) | 0.46 | |

| Clinical variables | Unadjusted | P | Adjusted | P |
|--------------------|------------|---|----------|---|
| Caries experience | DMFT=0 | 1.00 | | 1.00 | |
| DMFT≥1 | 1.03 (0.75-1.42) | 0.86 | |

| Caries activity | Unadjusted | P | Adjusted | P |
|----------------|------------|---|----------|---|
| Caries free/caries inactive | 1.00 | | 1.00 | |
| Caries active | 1.62 (1.16-2.26) | 0.005 | 1.63 (1.15-2.30) | 0.005 |

Bold numbers identify \( P<0.05 \). RR: Rate ratio, CI: Confidence interval, DMFT: Decayed, Missing, and Filled Teeth (cavity level), BMW: Brazilian minimum wage.
activity were associated with the occurrence of UDS in this adolescent population.

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Conflicts of interest
There are no conflicts of interest.

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Figure 1: Intraoral distribution of UDS according to the presence/absence of enamel breakdown (n = 154 lesions). UDS: Underlying dentin shadows.