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Can We Diagnose a Patient's Caries Activity Based on Lesion Activity Assessment? Findings from a Cohort Study

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Keywords
Dental caries · Permanent dentition · Disease progression · Cohort studies · Risk assessment

Abstract
This cohort study evaluated the fate of sound surfaces and inactive non-cavitated (INC) and active non-cavitated (ANC) caries lesions in a population-based sample of South Brazilian adolescents, in answer to the question: "Is lesion activity assessment a reliable criterion to diagnose a patient's caries activity?" A total of 801 schoolchildren were examined at baseline (aged 12 years) and after a mean time interval of 2.5 years. Data collection included a questionnaire and clinical examination. Patients were classified as caries-free (patients without any lesion), caries-inactive (patients with only inactive lesions), and caries-active (patients with at least one active lesion). The primary outcome was caries progression (presence of cavity, underlying dentin shadow, filling, or extraction at the follow-up exam). Negative binomial regression models were used to estimate the risk for caries progression. The main predictor variable was status of the surface at baseline: sound, INC, or ANC. Progression rates of 1.0, 9.0, and 12.6% were found for sound surfaces, INC, and ANC, respectively. INC (incidence risk ratio [IRR] 5.37, 95% CI 4.22–6.83) and ANC (IRR 4.96, 95% CI 3.43–7.17) had greater risk for caries progression than sound surfaces. Similar risks for progression were found for ANC and INC (IRR 0.92, 95% CI 0.64–1.32). Progression rates were 0.6, 1.1, and 2.2% for caries-free, caries-inactive, and caries-active individuals, respectively ($p < 0.05$). The risk for caries progression of sound surfaces was higher among caries-active adolescents (caries-free: IRR 2.78, 95% CI 1.63–4.72; caries-inactive: IRR 2.19, 95% CI 1.65–2.90). Caries-inactive patients behaved similarly to caries-free individuals (IRR 1.27, 95% CI 0.73–2.20). This study demonstrated the possibility of defining a patient's caries activity profile based on lesion features.

Introduction

It is well established that caries is a localized chemical dissolution of the tooth surface, resulting from metabolic events taking place in the biofilm covering the affected area. The caries lesion is the sign of this process [Fejer-

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skov et al., 2008]. If the metabolic events that cause demineralization are controlled, the lesion progression can be halted. A lesion under progression has some clinical features distinct from those of an arrested lesion [Holmen et al., 1987a, 1987b]. In this respect, lesion features should be assessed to determine whether or not there is ongoing mineral loss, and ensure proper diagnosis and treatment of the dental caries disease. Caries activity is widely assessed in clinical practice to classify caries lesions, and ultimately diagnose a patient's caries activity. It is assumed that patients with active lesions have caries disease, whereas those with only inactive lesions are considered as no longer having the disease.

Despite attempts to propose objective methods to classify caries lesion activity [Ekstrand et al., 2007], the most accepted criterion is based on visual inspection and evaluation of the clinical characteristics of the lesion, such as surface roughness, color, and light reflection [Holmen et al., 1987a, 1987b]. Previous studies have tried to assess the predictive validity of this criterion by comparing the likelihood of progression of active non-cavitated (ANC) and inactive non-cavitated (INC) caries lesions over time. Guedes et al. [2014] evaluated 469 preschool children over a 2-year period, and showed that ANC lesions were twice as likely to become frankly cavitated, be restored, or missing than inactive ones. Therefore, their study succeeded in validating the caries activity assessment system in the primary dentition. However, regarding the permanent dentition, Nyvad et al. [2003] followed 273 12-year-old children over a period of 3 years, and found that INC and ANC caries lesions had a similar risk for progression in both fluoride-exposed and control groups. Additionally, similar progression rates for ANC and INC lesions in permanent teeth were observed in a 4-year observational study conducted in Puerto Rico [Ferreira Zandoná et al., 2012], and in a 2-year cohort study in Brazil [Cabral et al., 2017]. However, these studies did not take into consideration the patient's caries activity, only the lesion activity. They did not differentiate the behavior of sound surfaces in caries-free versus caries-inactive and caries-active patients.

The aim of the present cohort study was to evaluate the progression of sound surfaces, and both INC and ANC caries lesions in a population-based sample of South Brazilian adolescents with different caries activity profiles over a 2.5-year period, in order to answer the following question: "Is lesion activity assessment a reliable criterion to diagnose a patient's caries activity?" No previous study has evaluated the predictive value of caries activity assessment at the patient level.

Methods

Sample

At baseline, a cross-sectional study was conducted in southern Brazil, from September 2009 to December 2010, with schoolchildren aged 12 years, who were attending public and private schools. A multistage probability sampling strategy was used. The primary sampling unit consisted of 5 geographical areas. The schools within each area were randomly selected proportional to the number of its private and public schools (42 schools: 33 public and 9 private). Schoolchildren born in 1997 or 1998 were then randomly selected proportional to school size. The following parameters were used for the sample calculation: caries prevalence of 60% [Barbachan e Silva and Maltz, 2001] with a precision level of ±3% for a 95% CI and for a design effect of 1.3. The minimum sample size required for this study was 1,331 schoolchildren. A nonresponse error of 40% was added, and a final sample size of 1,837 was estimated. A total of 1,528 schoolchildren were examined, yielding a response rate of 83.2%.

A total of 801 schoolchildren were reexamined between August 2012 and May 2013, after a mean period of 2.5 years (SD 0.3), representing 52.4% of the sample initially examined. The flowchart of the study is presented in Figure 1, including the reasons for nonparticipation.

This study was conducted following STROBE guidelines.

Data Collection

Data collection included the application of a questionnaire and a clinical examination. At baseline, a structured questionnaire containing questions on sociodemographic information and oral health-related habits was sent to the parents/legal guardians of the selected students.

The clinical examination was conducted at the schools, with the students in a supine position, using artificial light, an air compressor, and suction. After professional tooth cleaning and drying, the examiner recorded the presence of caries lesions according to the following criteria: (1) ANC lesion = opaque enamel with a dull-whitish surface; (2) INC lesion = shiny appearance of the surface area with white or different brownish degrees of discoloration; (3) active cavitated lesion = localized surface destruction with active characteristics (dull-whitish enamel and soft dentin); and (4) inactive cavitated lesion = localized surface destruction with arrested characteristics (shiny enamel and hard dentin) [Maltz et al., 2003]. Underlying dentin shadows and missing or filled teeth were also recorded. Clinical examinations were performed at baseline and at follow-up, using the same protocol.

Examiners and Reproducibility

Caries examination was performed at baseline by a single calibrated examiner (L.S.A.). Training and calibration were performed before the study began. During the survey, calibration was monitored by repeated examinations conducted on 5% of the sample. The overall unweighted Cohen's kappa value was 0.84 (95% CI 0.82–0.87). The following unweighted Cohen's kappa values were obtained per category: sound surfaces 0.90 (95% CI 0.88–0.93), INC lesions 0.75 (95% CI 0.70–0.81), and ANC lesions 0.81 (95% CI 0.73–0.90).

At follow-up, the clinical examination was conducted by another examiner (C.D.B.), who was trained and calibrated by the first examiner (L.S.A.). The interexaminer unweighted Cohen's kappa value was 0.78. During the survey, calibration was also monitored by re-

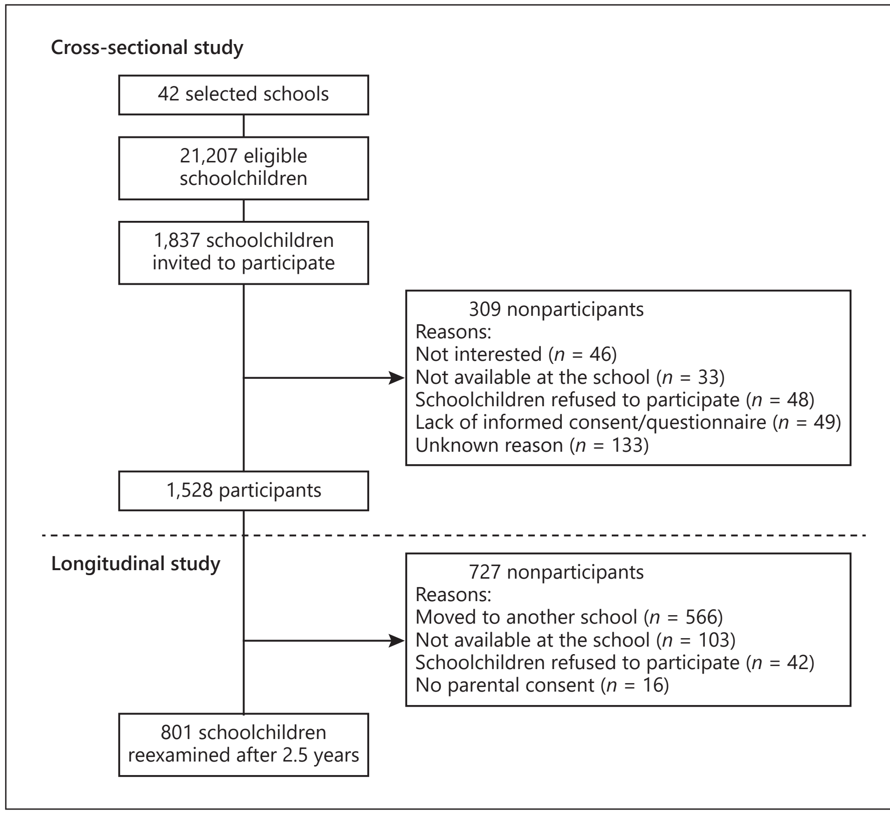

Fig. 1. Study flowchart.

peated examinations of 5% of the sample (10 double examinations at every 200 schoolchildren included in the sample). The lowest intraexaminer unweighted Cohen's kappa value was 0.81 (C.D.B.).

Data Analysis

Baseline characteristics of schoolchildren lost to follow-up and those who remained in the study were compared using the chi-square test (qualitative variables) and the Wald test (quantitative variables).

The primary outcome of this study was caries progression, defined as the presence of a cavity, underlying dentin shadow, filling, or extraction at the follow-up exam. Our main predictor variable was the following status of the surface at baseline: sound, INC lesion, or ANC lesion. Other predictor variables included in the study were sex (female vs. male), mother's education (>8 vs. ≤8 years), school (private vs. public), claimed tooth brushing frequency (≥3 vs. 2 times/day or ≤1 time/day), caries experience (DMF-S = 0 vs. DMF-S 1–4 or DMF-S ≥5), tooth type (anterior vs. posterior), arch (upper vs. lower), and surface type (buccal vs. palatal or occlusal).

Data analysis was performed using SPSS, version 18.0. Negative binomial regression models (unadjusted and adjusted) were used to estimate the risk for caries progression over the study period. Incidence risk ratios (IRR) and their respective 95% CI were estimated. Regression models were fitted using the generalized estimating equation with exchangeable working correlation matrices to account for the clustering of surfaces within the teeth and within the individuals. All predictor variables were included and maintained in the adjusted model, irrespective of their *p* values, with the exception of mother's education (due to collinearity between the variables of school and mother's education). The surface was used as the unit of analysis.

Progression rates for sound surfaces, and INC and ANC lesions, according to a patient's caries activity at baseline, were compared using the chi-square test. For this purpose, individuals were classified as caries-free (all sound surfaces), caries-inactive (sound, INC lesion, filled, and missed surfaces), or caries-active (at least one ANC lesion). The risk for progression of sound surfaces among caries-free, caries-inactive, and caries-active patients was assessed to evaluate the predictive value of the caries activity assessment at the patient level. Negative binomial regression models with generalized estimating equation was used to manage clustering of data. Only variables at the tooth level (tooth type, arch, and surface type) were included as adjusting variables, since variables at the patient level may influence or be influenced by a patient's caries activity. If caries activity assessment is a reliable criterion to distinguish healthy/controlled individuals from sick ones, sound surfaces should progress more often among subjects classified as caries-active than among those classified as caries-free or caries-inactive.

Results

Comparing the baseline characteristics of adolescents lost to follow-up with those who remained in the study, the authors observed a significantly lower proportion of private school attendees among the participants than among

Table 1. Baseline characteristics of the sample

Variables – individual level	
Sex	
Female	387 (48.3)
Male	414 (51.7)
School	
Private	117 (14.6)
Public	684 (85.4)
Mother's education*	
>8 years	383 (48.0)
≤8 years	415 (52.0)
Tooth brushing	
≥3 times/day	275 (34.3)
2 times/day	349 (43.6)
≤1 time/day	177 (22.1)
Caries experience (cavity level)	
DMF-S = 0	370 (46.2)
DMF-S 1–4	313 (39.1)
DMF-S ≥5	118 (14.7)
Total	801 (100)
Variables – tooth level	
Tooth type	
Anterior	9,028 (46.4)
Posterior	10,410 (53.6)
Arch	
Upper	9,445 (48.6)
Lower	9,993 (51.4)
Total	19,438 (100)
Variables – surface level	
Surface type	
Buccal	17,485 (37.8)
Palatal	19,067 (41.2)
Occlusal	9,686 (20.9)
Caries status	
Sound	44,017 (95.2)
Inactive non-cavitated lesion	1,872 (4.0)
Active non-cavitated lesion	349 (0.8)
Total	46,238 (100)

Data are presented as *n* (%). * Missing data.

those lost to follow-up. There were no significant differences in regard to sex, socioeconomic status, or tooth brushing frequency. Individuals lost to follow-up had a significantly higher caries experience (prevalence and mean DMF-S) than the schoolchildren followed. The baseline characteristics of the sample included in this study (n = 801) are described in Table 1. At the individual level, boys represented 51.7% of the sample, and girls, 48.3%. The majority of the schoolchildren were public schools attendees, had less educated mothers, and reported a brushing frequency of twice a day. In regard to caries experience (cavity level) at baseline, 46.2% had a DMF-S = 0. A total of 19,438 permanent teeth were included. On average, each individual contributed with 24.3 permanent teeth (SD 4.2), ranging from 10 to 28. A total of 46,238 tooth surfaces were included in the study. The great majority of the surfaces were classified as sound at the baseline examination (95.2%, n = 44,017), followed by INC lesions (4%, n = 1,872) and ANC lesions (0.8%, n = 349).

Table 2 describes the transitions of sound surfaces and INC and ANC caries lesions from baseline to follow-up. Regarding the surfaces classified as sound at the baseline examination, 93.6% remained sound at follow-up, with the majority of transitions to INC lesions (4.9%). The vast majority of INC lesions remained unaltered or regressed to sound surfaces (77.4 and 12.9%, respectively), whereas 4.2% were cavitated at the follow-up examination, but became inactive. Approximately 87% of the ANC lesions reverted to sound surfaces, became INC lesions, or remained in the same category. Progression rates were 1.0, 9.0, and 12.6% for sound surfaces, INC lesions, and ANC lesions, respectively.

Table 3 shows the association between the caries status at baseline and the caries progression. After adjustment for important cofactors, both INC lesions (IRR 5.37, 95% CI 4.22–6.83) and ANC lesions (IRR 4.96, 95% CI 3.43–7.17) showed a significantly greater risk for caries progression than sound surfaces. When ANC lesions were compared with INC lesions, similar risks for progression were found (IRR 0.92, 95% CI 0.64–1.32). These findings were consistent for occlusal and free smooth surfaces, when assessed separately.

Progression rates for sound surfaces, INC lesions, and ANC lesions, according to a patient's caries activity, are described in Table 4. Overall progression rates were 0.6, 1.1, and 2.2% for caries-free, caries-inactive, and caries-active individuals, respectively ($p < 0.05$). In regard to the status of the tooth surfaces at baseline, sound surfaces and INC lesions showed significantly higher progression rates among caries-active patients than among caries-inactive patients. As shown in Table 5, the risk for caries progression was higher among caries-active adolescents (caries-free: IRR 2.78, 95% CI 1.63–4.72; and caries-inactive: IRR 2.19, 95% CI 1.65–2.90). Caries-inactive patients behaved similarly to caries-free individuals (IRR 1.27, 95% CI 0.73–2.20).

Discussion

This study was undertaken to evaluate how well the lesion activity assessment criterion can be used to diagnose a patient's caries activity by analyzing the progression of

Table 2. Transitions of sound surfaces, inactive, and active non-cavitated caries lesions from baseline to follow-up

	Follow-up								
	sound	INC	ANC	IC	AC	UDS	filled	missing	Total
Baseline									
Sound	41,225 (93.6)	2,174 (4.9)	180 (0.4)	108 (0.2)	140 (0.3)	39 (0.1)	112 (0.3)	39 (0.1)	44,017 (100)
INC	242 (12.9)	1,449 (77.4)	12 (0.6)	78 (4.2)	34 (1.8)	9 (0.5)	45 (2.4)	3 (0.2)	1,872 (100)
ANC	147 (42.1)	106 (30.4)	52 (14.9)	6 (1.7)	20 (5.7)	2 (0.6)	15 (4.3)	1 (0.3)	349 (100)
Total	41,614 (90.0)	3,729 (8.1)	244 (0.5)	192 (0.4)	194 (0.4)	50 (0.1)	172 (0.4)	43 (0.1)	46,238 (100)

Data are presented as *n* (%). Caries progression is highlighted in gray. INC, inactive non-cavitated lesion; ANC, active non-cavitated lesion; IC, inactive cavitated lesion; AC, active cavitated lesion; UDS, underlying dentin shadow.

Table 3. Association between caries status at baseline and progression (adjusted negative binomial regression models)

	Surface type	Unadjusted		Adjusted*	
		IRR (95% CI)	*p*	IRR (95% CI)	*p*
INC vs. sound	Occlusal	3.50 (2.71–4.52)	<0.001	3.43 (2.66–4.43)	<0.001
	Free smooth	15.86 (11.69–21.52)	<0.001	12.01 (8.78–16.46)	<0.001
	All	9.09 (7.43–11.11)	<0.001	5.37 (4.22–6.83)	<0.001
ANC vs. sound	Occlusal	4.80 (3.12–7.38)	<0.001	4.13 (2.76–6.18)	<0.001
	Free smooth	13.87 (6.39–30.13)	<0.001	6.80 (3.26–14.16)	<0.001
	All	10.43 (7.15–15.21)	<0.001	4.96 (3.43–7.17)	<0.001
ANC vs. INC	Occlusal	1.37 (0.88–2.13)	0.16	1.20 (0.79–1.83)	0.38
	Free smooth	0.87 (0.39–1.96)	0.75	0.57 (0.26–1.22)	0.14
	All	1.15 (0.79–1.67)	0.47	0.92 (0.64–1.32)	0.67

* Estimates are adjusted for sex, school, tooth brushing frequency, caries experience, tooth type, arch, and surface type. ANC, active non-cavitated caries lesion; INC, inactive non-cavitated caries lesion.

Table 4. Progression rates for sound, INC, and ANC lesions according to patient's caries activity

	Caries-free (*n* = 155)	Caries-inactive (*n* = 346)	Caries-active (*n* = 300)
Sound	0.6^{a} (52/8,902)	0.7^{aA} (135/18,717)	1.5^{bA} (251/16,398)
INC	–	7.3^{aB} (79/1,080)	11.4^{bB} (90/792)
ANC	–	–	12.6^{B} (44/349)
Total	0.6^{a} (52/8,902)	1.1^{b} (214/19,797)	2.2^{c} (385/17,539)

Different lowercase superscripts indicate statistically significant difference in rows; different uppercase superscripts indicate statistically significant difference in columns (chi-square test, $p < 0.05$). INC, inactive non-cavitated caries lesion; ANC, active non-cavitated caries lesion.

sound surfaces, INC lesions, and ANC lesions among South Brazilian adolescents. The caries activity assessment of non-cavitated lesions was unable to predict lesion progression (since INC and ANC lesions showed similar progression rates, taking into account all the schoolchildren); however, it proved to be a useful tool in identifying a patient's caries activity profile since sound surfaces of caries-active individuals had higher progression rates than that of caries-inactive and caries-free individuals. To the best of our knowledge, this was the first population-based cohort study assessing the validity of this criterion at both tooth surface and patient levels.

Inactive lesions, by definition, do not undergo mineral loss; therefore, they do not tend to progress, but are merely considered scars of past episodes of caries activity. Some in situ studies [Koulourides and Cameron, 1980; Iijima and Takagi, 2000; Maltz et al., 2006] found evi-

Table 5. Association between patient's caries activity at baseline and progression of sound surfaces (adjusted negative binomial regression models)

	Unadjusted		Adjusted*	
	IRR (95% CI)	*p*	IRR (95% CI)	*p*
Caries-inactive vs. caries-free	1.22 (0.71–2.09)	0.46	1.27 (0.73–2.20)	0.40
Caries-active vs. caries-free	2.56 (1.53–4.29)	<0.001	2.78 (1.63–4.72)	<0.001
Caries-active vs. caries-inactive	2.10 (1.60–2.76)	<0.001	2.19 (1.65–2.90)	<0.001

* Estimates are adjusted for tooth type, arch, and surface type.

dence that tooth surfaces which had undergone cariogenic attacks and were later arrested showed greater resistance toward new acid challenges than sound surfaces. This added resistance attributed to INC lesions may be attributed to the remineralization of the enamel, which occurs when more soluble minerals are replaced by minerals with greater resistance to acids. On the other hand, clinical studies have shown that INC lesions have a greater likelihood of progression than sound surfaces [Nyvad et al., 2003; Zenkner et al., 2019]. Even in the presence of fluoride, INC lesions presented an approximately eightfold greater risk for progression to cavitation, filling, or extraction than sound enamel, among Lithuanian schoolchildren [Nyvad et al., 2003]. More recently, this evidence was corroborated by Zenkner et al. [2019], who showed that inactive lesions tend to progress twice as often as sound surfaces among schoolchildren from South Brazil. The results of the present study are in agreement with these previous findings, since inactive lesions had a higher risk for progression than sound surfaces. In the present population-based study, surfaces classified as INC lesions at baseline showed a fivefold greater risk of cavities, underlying dentin shadow, filling, or extraction at the follow-up examination, than surfaces classified as sound. In conjunction with the previously named studies by Nyvad et al. [2003] and Zenkner et al. [2019], our study corroborates the evidence that INC lesions should receive background level care and appropriate monitoring.

Our findings also suggested that INC and ANC lesions have similar progression rates, which is in agreement with the findings by Nyvad et al. [2003], who found no significant difference between the risk for progression of INC and ANC lesions in either the fluoride or the control groups (RR 1.04, 95% CI 0.8–1.3 for fluoride; RR 1.24, 95% CI 0.9–1.26 for the control). One possible explanation for the progression of INC lesions could be the mechanical disruption of the surface zone, exposing the less mineralized body of the lesion. During this process, a previous INC caries lesion could turn into an inactive cavitated lesion without a new caries activity episode. In fact, the most frequent type of progression of INC lesions observed in our study was the migration to inactive cavities (4.2%). On the other hand, in primary dentition, Guedes et al. [2014] showed a higher risk for progression to cavity, restoration, or filling in ANC lesions, compared with INC lesions. However, the extrapolation of their findings to other populations is difficult due to the great disparity in the distribution of active and inactive lesions, with approximately 15% of INC lesions and 85% of ANC lesions. In our study, about 84% of a total of 2,221 non-cavitated lesions detected at baseline were INC lesions, and 16% were ANC lesions. It is important to emphasize that dental caries is a chronic and dynamic disease, with many cases regressing from baseline to follow-up; these are considered biologically plausible, and are referred to as "reversals" [Ismail et al., 2011]. An example of a biologically plausible reversal is the transition of non-cavitated lesions to sound surfaces, as we observed in our study. Of a total of 1,872 surfaces classified as INC lesions at baseline, 12.9% (n = 242) reverted to sound at the follow-up examination. In regard to ANC lesions, 147 out of 349 (42.1%) ANC lesions regressed to sound at follow-up. The reversals of non-cavitated lesions to sound surfaces may be explained by the polishing or wear of the surface until the non-cavitated lesion disappears [Holmen et al., 1988], which is more likely to occur with white ANC lesions than with brown/pigmented INC lesions. This dynamic behavior of dental caries, with recurrent episodes of de-remineralization, added to the long time between detection of the first signs of a non-cavitated lesion up to cavity formation, leads to a wide range of possibilities from an obvious active to an obvious inactive lesion, with several intermediate aspects that make the caries activity assessment a complex process.

According to our study, the condition of caries activity of the patient was found to influence the progression of sound surfaces and both INC and ANC lesions. Whereas sound surfaces behaved similarly in caries-free and caries-inactive patients, a two-fold greater progression rate was found in caries-active patients. These trends were confirmed in the risk assessment analysis stratified by a patient's caries activity. Individuals who were caries-active at baseline had a greater risk for progression of sound surfaces than those who were caries-free or caries-inactive. Similarly, INC lesions also had a significantly lower progression rate among caries-inactive than among caries-active individuals. In caries-active patients, both INC and ANC lesions showed similar progression rates, thus suggesting that a patient's caries activity can promote the progression of both types of lesions. Therefore, this evidence supports the classification of a patient's caries activity based on lesion features. According to our findings, treatment to control caries activity (fluoride, diet, oral hygiene, etc.) would be indicated to control the progression of both INC and ANC lesions in a caries-active patient. Patient classification regarding caries activity should be used as the clinical parameter to define the need for treatment. It could be argued that only 2.2% of all sites showed caries development/progression in individuals classified as caries-active and that this classification could lead to overtreatment in many cases. We recognize this low progression rate; however, 12% of non-cavitated lesions progressed among caries-active individuals compared with a progression rate of 7.3% of non-cavitated lesions among caries-inactive individuals over 2.5 years. In addition, it is important to emphasize that this overall progression rate of 2.2% among caries-active patients was twice the progression rate of 1.1% found among caries-inactive patients, and approximately 3.6-fold greater than that found among caries-free patients (0.6%).

Much has been discussed about the difficulty and reliability of detecting non-cavitated lesions in epidemiological surveys. As previously commented by Carvalho and Mestrinho [2014], when participants are accommodated in suitable conditions for professional cleaning of their teeth, with suitable lighting and drying equipment, the obstacles imposed by field conditions can be overcome, and a reliable diagnosis of non-cavitated lesions can be obtained. In the present study, we were able to obtain high kappa coefficients by categories, including those for INC lesions. It is noteworthy to point out that only 2 examiners were involved in the data collection, one calibrated by the other, and that we used a population-based sample. This population can be classified as a low-caries population (mean DMF-T at the cavity level of 1.39 at 12 years of age [Alves et al., 2018]) with frank access to fluoridated water and to fluoridated toothpaste. In this respect, the present paper differs from the previous studies assessing lesion activity. Nyvad et al. [2003] used a convenience sample derived from an intervention study, whereas Ferreira Zandoná et al. [2012] included a high-caries prevalence population, a condition which could definitively influence the caries progression. Among the shortcomings of this study, we should recognize the high proportion of schoolchildren lost to follow-up. This is mainly because many students, over the study period, completed elementary school and went to a high school at a different location. It is well known that high attrition rates are a major challenge in cohort studies; however, the significant associations between a patient's caries activity at baseline and progression of sound surfaces (in both unadjusted and adjusted models) lead us to infer that the sample size was not an issue in our study. In addition, significant differences were detected regarding some baseline characteristics, between individuals lost to follow-up and those who remained in the study. Although a lower proportion of private school attendees was observed in the study sample, no significant difference was detected regarding socioeconomic status. On the other hand, the significantly greater caries experience among schoolchildren lost to follow-up may have biased the study sample and reduced the proportion of active caries lesions for analysis. The lack of dietary data may be regarded as another limitation of our study.

In conclusion, the results of this population-based cohort study demonstrated that a patient's profile regarding caries activity may be defined based on lesion features. Diagnosis of a patient's caries activity is essential for the clinical management of dental caries.

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Statement of Ethics

The study protocol was approved by the Federal University of Rio Grande do Sul Research Ethics Committee (process No. 299/08) and by the Municipal Health Department of Porto Alegre

Research Ethics Committee (process No. 001.049155.08.3/register No. 288 and process No. 001.028618.12.2/register No. 807). The research was conducted ethically, in accordance with the World Medical Association Declaration of Helsinki. 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.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

M.M. and J.E.A.Z.: study design, data analysis and drafting of the paper. F.L.L. and M.B.W.: data analysis and drafting of the paper. C.D.B.: data collection and drafting of the paper. L.S.A.: study design, data collection, data analysis, and drafting of the paper.

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